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NUCLEAR CRITICALITY SAFETY EVALUATION
FOR THE HANDLING AND STORAGE OF FISSILE-BEARING DEBRIS IN THE HEAD END CELLS
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West Valley Nuclear Services Co.

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NUCLEAR CRITICALITY SAFETY EVALUATION FOR THE HANDLING AND STORAGE OF FISSILE-BEARING DEBRIS IN THE HEAD END CELLS

1.0 INTRODUCTION

This nuclear criticality safety evaluation (NCSE) provides the criticality and contingency analyses that have been performed to support the safe handling, processing, and storage of waste forms bearing fissile materials that are located in the Head End Cells (HECs) of the Main Plant at the West Valley Demonstration Project (WVDP).

2.0 DESCRIPTION

The Head End Cells are located in the north end of the Main Plant at plant elevations ranging from 73 ft to 125 ft, with 100 ft being essentially "at grade." These cells, which were used by NFS to mechanically process and handle irradiated nuclear fuel assemblies, include the following cells and rooms:

- Process Mechanical Cell (PMC) and Process Mechanical Crane Room (PMCR);
- General Purpose Cell (GPC), GPC Crane Room (GCR), and GCR Extension (GCRX);
- Miniature Cell (MC);
- Scrap Removal Room (SRR); and
- Manipulator Repair Room (MRR)

As a result of routine NFS operations, a significant amount of high-activity debris accumulated in these cells and rooms, the majority of which is in the PMC and the GPC. This debris includes fine particulate material such as fuel and saw fines that was generated during the mechanical processing of the fuel assemblies and the fuel elements; fuel assembly hardware; small equipment used to support operations; and leached and potentially unleached fuel hulls. Additional debris, principally laboratory equipment and other laboratory waste, was introduced into the PMC by the WVDP during cleanup activities in the Sample Storage Cell in the 1980s.

The *Head End Cell Material Handling and Processing Plan* presents a conceptual approach for collecting, sorting, packaging, and managing debris that is present in the HECs of the former Nuclear Fuel Services Inc. (NFS) spent nuclear fuel reprocessing facility and has been used here as the basis for the evaluation of the handling, processing, and storage of debris in the HECs. After packaging, fissile-bearing debris from the HECs will likely be stored in one or more of the at-grade or above-grade cells or rooms within the Main Plant until a disposal facility becomes available; however, the option to store the fissile-bearing debris at-grade or above-grade in a facility other than the Main Plant is not prohibited. The benefit of collecting, packaging, and storing this debris is that the HECs will be placed in a safer and more stable condition that can be economically monitored and maintained until final closure activities begin in the Main Plant.

2.1 Characteristics of HEC Debris

The loose debris in the HECs contain a variety of different waste types with the majority of the waste found in the PMC and the GPC. In 1996, the Head End Cells Stabilization Project identified the following eight waste streams in the PMC and the GPC:

- Particles
- Miscellaneous fuel-bearing objects
- Leached hulls
- Fuel assembly hardware
- Contaminated equipment and scrap
- Sump liquid
- Laboratory wastes
- Containerized CPC floor debris

Each of these wastes streams are elaborated on below.

Particles
Particles include the fine particulate material (located mostly on floor areas) that were generated during the sawing of the fuel assemblies and the shearing of the fuel elements in the PMC. These particles may include activated metal generated during the sawing of end fittings, and fission products and irradiated fuel from the shearing of the fuel elements.

Miscellaneous Fuel-bearing Objects
Miscellaneous fuel-bearing objects are pieces of fuel elements that contain irradiated nuclear fuel that did not enter the fuel dissolution stage of the process cycle. Fuel-bearing objects may have fallen on the floor in the PMC during repairs to the shear, which experienced frequent failures of its shear gag mechanism. Fuel-bearing debris may also be located in the GPC as a result of overfilling the chopped fuel baskets.

Leached Hulls
Leached hulls are 0.50- to 2.0-inch long pieces of sheared fuel elements that have had their fuel largely removed by chemical dissolution in the dissolvers that were formerly located in the Chemical Process Cell (CPC). The leached hulls inadvertently spilled to the floor in both the PMC and GPC during routine transfer and inspection operations. The hulls are composed of either stainless steel or Zircaloy, an alloy composed of zirconium (98.5%) and minor amounts of tin, iron, chromium, and nickel. Zircaloy is pyrophoric and, on occasion during the NFS reprocessing operation, Zircaloy hulls self-ignited. However, the pyrophoricity of Zircaloy decreases through an oxidation process which forms an external oxide layer. In addition, NFS immersed Zircaloy hulls in a sodium hydroxide bath to oxidize the hulls and thereby minimize the pyrophoricity of these hulls.

Fuel Assembly Hardware
Fuel assembly hardware includes end fittings, spacers, and pieces of casing that were removed and size reduced at the disassembly saw table in the PMC.

Contaminated Equipment and Scrap
Contaminated equipment and scrap includes hoses, cords, mop handles, lifting bales, shear components, drums, and drum lids that are expected to be radioactively contaminated. These were introduced into the cells to support routine operations.

Sump Liquid
In 1996, the GPC sump contained a measurable volume of liquid believed to be water that was thought to have originated from precipitation infiltrating through the PMCR roof. The PMCR roof was repaired in 1996-1997. At present, the GPC sump level indicator reads "zero," and, based on video examination, no water appears to be in the GPC or GPC sump. It is noted that the GPC sump level indicating instrumentation is calibrated annually.

Laboratory Wastes
Laboratory wastes from the analytical labs, including vials, bottles, cans, and equipment such as mixers, were disposed of in the PMC by the WVDP during clean-up of the analytical labs and Sample Storage Cell during the mid-1980s. The laboratory waste is largely in the south end of the PMC and in 114-liter (30-gallon) drums on the disassembly saw table and the inspection table.

CPC Floor Debris
The GPC also contains three vacuum canisters that contain particulate material vacuumed from the floor of the CPC during decontamination and decommissioning (D&D) operations in the mid-1980s.

The characteristics of the material debris in the PMC and GPC have been inferred through assessment of general area exposure rate measurements and video surveys performed in the cells in 1986, as well as through assessment of numerous subsequent video surveys of the cells. Process knowledge has also been relied upon for the assessment of material in the cells. Based on information from these sources, it is reasonable to conclude that the presence of significant quantities of unreprocessed fuel in the PMC or GPC (i.e., one or more 30-gallon drum volumes) is extremely unlikely. Video examination of in-situ spent nuclear fuel hulls, particularly in the GPC, has not revealed any clearly unleached fuel segments. Hulls in both the PMC and GPC are most likely leached hulls that were inadvertently spilled during transfer from the spent fuel dissolver basket to the waste burial drum. This is consistent with historical records, which indicate that the transfer process employed by NFS was prone to material losses of this type.

General area gamma radiation survey data collected in the PMC and GPC in 1986 suggest that the potentially fuel-bearing debris in the HEC has been exposed to neutron irradiation. A systematic survey of both the PMC and GPC conducted in 1986 indicated that radiation levels in both cells were strongly correlated with the volume of material accumulated below the detector, indicating that if the material does contain fuel, it has been irradiated. Furthermore, the magnitude of the elevated readings (tens to hundreds of roentgens per hour) suggest that the material has been highly irradiated.

In spite of this evidence, there is no characterization data for the material in the PMC or GPC that has been acquired through the implementation of a formal, systematic characterization program. Consequently, for the purposes of this analysis, it has been assumed that small particulate debris in the HECs is comprised of unirradiated nuclear fuel. Specific fuel characteristics have been selected through evaluation of historical processing records, as discussed below.

WVDP-EIS-014, *Characterization of Reactor Fuel Reprocessed at West Valley*, provides detailed physical and radiological characteristics of the nuclear fuel that was reprocessed by NFS. During operations from 1966 to 1972, NFS reprocessed approximately 640 metric tons of nuclear fuel. There were a total of 27 reprocessing campaigns during this period; however, only the first 26 campaigns reprocessed intact reactor fuel. The last campaign involved processing a liquid uranium/plutonium solution.

Fuel initially reprocessed by NFS was received from the New Production Reactor at Hanford due to an insufficient backlog of fuel at commercial nuclear facilities. Fuel received from this reactor, which ultimately accounted for over half of the total mass reprocessed by NFS, had an initial U-235 enrichment between 0.71 and 1.0 weight percent. The majority of the balance of fuel reprocessed by NFS (approximately 38% of the total by mass) had an initial U-235 enrichment less than 4.0 weight percent. Only 2.5% of the fuel reprocessed by NFS had an initial U-235 enrichment greater than 5.0 weight percent and no fuel had an initial U-235 enrichment higher than 5.83 weight percent.

Initial U-235 enrichments misrepresent the actual reactivity of fuel received by NFS, however, as historical records indicate that most of the higher initially enriched commercial fuel was irradiated through reactor operation, thereby significantly decreasing the inventory of U-235 present in the fuel. When burnup of this commercial fuel is accounted for, it is found that only about 5% of post-irradiated fuel had an effective U-235 enrichment greater than 3 weight percent, and with only one exception, none of the post-irradiated fuel had an effective U-235 enrichment greater than 4 weight percent. Fuel associated with Campaign number 11, which was comprised of a thorium-uranium fuel in an approximately 15 to 1 ratio of thorium to uranium is the one exception. The U-233 plus U-235 equivalent enrichment of the thorium-uranium fuel after irradiation was approximately 6.39 weight percent. Hence, 2.5% of the fuel reprocessed by NFS had an effective U-235 enrichment of about 6.39 weight percent, while the rest had a maximum effective U-235 enrichment of 3.327 weight percent.

Despite the reduction in reactivity presented by irradiation, no credit for burnup has been taken in the criticality analyses referenced in this NCSE. For the purposes of this analysis, potentially fuel-bearing debris in the PMC and GPC is assumed to be unirradiated fuel having an initial U-235 enrichment of 5 weight percent, unless otherwise specified. Although the selected enrichment is not the maximum for fuel reprocessed by NFS, it is believed to be adequately conservative in light of process history and the fact that no burnup credit has been taken.

To assure the adequacy of the selection of this evaluation basis enrichment, historical records were reviewed to determine whether there is any basis for believing that a disproportionate amount of fuel from Campaign 11 (i.e., the campaign associated with the thorium/uranium mixed oxide fuel) exists in the debris in the HECs. Specifically, the eleventh and twelfth NFS Quarterly Reports were reviewed. These Quarterly Reports address the time period between October 1, 1968, and March 31, 1969, and include information on Campaign 11.

The processing of Campaign 11 involved fuel with a higher enrichment than any previously processed by NFS. Consequently, "significant preparation and checkout of processing and waste storage facilities were performed." The only unplanned shutdowns associated with mechanical operations during the quarter involved (1) replacement of a dissolver off-gas blower, (2) awaiting approval from the applicable governmental entity to process Campaign number 11 fuel, and (3) repair of the GPC crane. The Quarterly Report for the quarter starting January 1, 1969 contains the following relevant information:

- A "thorough flushout of the processing plant" was required between Campaign 11 and Campaign 12 since less than 5 grams of Campaign 11 uranium processed would cause tons of Campaign 12 uranium to be out of specification.
- No significant malfunctions of plant equipment occurred during this reporting period.
- The shear ram had to be replaced because of failure of its lubrication system, which resulted in an unplanned shutdown. (This failure occurred after all Campaign 11 fuel had been mechanically processed, but prior to mechanical processing of Campaign 12 fuel.)
- Under the "Measured Waste and Adjustments" section of the subject Quarterly Report, the statement is made that "adjustments" to Campaign 11 include "(1) 33.7 kilograms of uranium for the differences between the material quantities reported by the shipper and the measured input and (2) 6.7 kilograms of uranium for material unaccounted for." (It is noted that many of the Quarterly Reports address "material unaccounted for." For example, the Quarterly Report for the period starting April 1, 1969, reports an "adjustment" of "26 kilograms of uranium and 1,499 grams plutonium for material unaccounted for in processing.")

The information from the Quarterly Reports indicates that "extra measures" were taken to prepare for the processing of Campaign 11 fuel, as well as upon the completion of Campaign 11. These extra measures apparently included waste removal and cleanup activities beyond the norm for a campaign. There were no significant or important mechanical equipment malfunctions during Campaign 11, and there is no reason to believe that an unusual amount of debris (due to equipment malfunction or maintenance activities) was created in the HECs from Campaign 11.

Campaign 11 was followed by 15 more campaigns involving intact reactor. Waste removal, cleanup, and limited decontamination efforts associated with each of these campaigns and post-reprocessing activities would have contributed to the removal of any mixed oxide fuel remaining from that campaign. In consideration of these facts, there is no basis for believing that there is any debris remaining from Campaign 11, much less a disproportionate amount of debris. The selection of an evaluation basis fuel having a U-235 enrichment of 5 weight percent is therefore believed to be adequately conservative for evaluating potentially fuel-bearing material in the HECs.

2.2 Head End Cell Inventory Estimates

Estimates of both the physical and radiological inventories in the HEC have been made based on several video surveys of the PMC and GPC, as well as radiation surveys of the cells in 1986. Based on estimates from various sources, it is anticipated that approximately 17 m^3 (600 ft^3) of LLW and 2.3 m^3 (80 ft^3) of TRU waste will be collected from the combined debris of the PMC and GPC. Approximately twenty 114-liter (30-gallon) drums would be needed to accommodate 2.3 m^3 (80 ft^3) of TRU waste, much of which is cell fissile-bearing debris.

Table B.8.7-6 of WVNS-SAR-002 shows that the estimated amount of fissile material in the GPC is 8,055 grams and that the estimated amount of fissile material in the PMC is 2,381 grams. This estimate was based on correlating the measured exposure rates in the cell to Cs-137 activity in debris on cell surfaces. The inventory of other nuclides was then determined through ratios to Cs-137. The accuracy of this assumption, while predicated on an assumed fuel burnup, is supported by the measured proportion of nuclides in samples collected in the cells in 1986. As indicated earlier, this estimate has not been derived from data acquired through the implementation of a formal, systematic characterization program; however, it is believed to represent a reasonable estimate of fissile material in the HEC and is presented here to provide a sense of the margin of safety incorporated in the analysis.

2.3 Summary of Decontamination Activities

Various types of equipment will be used to collect, size reduce, decontaminate, and package the debris in the HECs. This equipment will be operated remotely using the PaR and manipulators. Grapples, clam shell scoops, and vacuums tethered to the PaRs and manipulators may be used to collect loose debris. Once collected, the fissile-bearing debris will be dried by means such as steam or electrical jacketed heating around the collection container. Saws, shears, or thermal cutting equipment may be required to size reduce larger debris to facilitate its packaging. Decontamination equipment may be installed in the cell or room if a cost benefit analysis indicates an economic benefit in reducing the amount of radioactivity associated with some of the debris.

It is anticipated that most of the debris will be packaged in conventional drums and boxes that can be easily transferred through the hatches connecting individual cells and rooms. Fissile-bearing debris, such as the hulls (leached or unleached), other fuel-bearing debris, and particulate material will be stored in 114-liter (30-gallon) drums to ensure criticality safety is provided, as documented in this NCSE. The 114-liter (30-gallon) storage drums containing fissile-bearing debris removed from the PMC and GPC will be vented with a HEPA filter that can withstand at least 122 cm (48 in) water column without allowing water entry into a container (Nuclear Filter Technology Incorporated NucFil 013 filter with Gore-Tex, or equivalent). Drums used for storage of HEC fissile-bearing debris are approximately 72 cm (28.5 in) high outside with an inside diameter of approximately 46 cm (18 in).

2.4 Flooding Potential Due to Natural Phenomena

The likelihood of flooding the inside or outside of drums in storage that contain fissile material from the HECs is extremely small because (1) "the site's topographic setting renders the likelihood of major flooding not credible, and local run-off and flooding is adequately accommodated by natural and man-made drainage systems in and around the WVDP," as stated in WVNS-SAR-001, *Safety Analysis Report for Project Overview and General Information*; (2) the drums will not be stored in locations below grade such as the GPC or Miniature Cell, and (3) the drums will be vented with a HEPA filter that can withstand at least 122 cm (48 in) water column without allowing water entry into a container (Nuclear Filter Technology Incorporated NucFil 013 filter with Gore-Tex, or equivalent).

Section A.3.4 of WVNS-SAR-001 provides an extensive discussion of surface hydrology phenomena associated with the WVDP site and surrounding area, and presents facts and analyses that support the conclusion that major flooding is not considered credible. For example, Section A.3.4.2.1 of WVNS-SAR-001 states the following:

> Cattaraugus and Buttermilk creeks lie in deep, narrow valleys. Therefore, the effects on the WVDP of flooding by these creeks is negligible, as supported by historical data. Frank's Creek, Quarry Creek, and Erdman Brook are also located in deep valleys. Historical evidence and computer modeling indicate that flood conditions (including the probable maximum flood) will not result in stream flows overtopping their banks and flooding the plateau. Constriction of the stream channels is not likely to result in flooding. Major constriction points on the WVDP site are the culverts through the railroad spur, the wreckage of the old Rock Springs Road bridge, and the remnants of a road embankment that crossed Erdman Brook downstream of the SDA. There are also numerous culverts for drainage ditches throughout the site.

Regarding the probable maximum flood (PMF) and its effect on streams, Section A.3.4.3 of WVNS-SAR-001 states "The lowest portion of the Main Plant is approximately 1,410 feet NGVD, whereas under PMF conditions, the nearest stream would rise to only 1347.2 feet NGVD." Also regarding the PMF, Section A.3.4.2.2 of WVNS-SAR-001 states the following:

> In the case of the hypothetical PMF, which has a peak discharge nearly eight times that of the 100-year flood, it was demonstrated using the TR-20 program (Soil Conservation Service, 1983) that culvert headwaters would overtop Rock Springs Road and some part of the floodwaters would flow across the plant area. Based on the topography in the plant area, it is likely that some portions of the site would experience shallow flows of moderate velocity. Flows would recede quickly, however, since the ditches that drain the site have gradients of up to 5%.

Regarding a probable maximum precipitation (PMP) event, Section A.3.4.2.3 of WVNS-SAR-001 states the following:

> The 24-hour PMP for this watershed as supplied by the U.S. Weather Bureau is 24.9 inches. The effects of the PMP on site drainage systems would be overwhelming. Capacities of storm drain inlets at grade and in sumps would be exceeded. Ditches along open section roadways would overflow, flooding roadways and adjacent areas. None of the culverts within the watershed would be expected to prevent overtopping of its embankments, which raises the possibility of embankment failures. In the case of the 24-inch corrugated metal pipe (CMP) culvert beneath the railroad embankment along Frank's Creek (structure 1 in the TR-20 computer model), flow would be directed to the water supply reservoirs before the embankment elevation was exceeded. Failures of culvert embankments would not threaten any safety-related facilities in the plant area.

3.0 REQUIREMENTS DOCUMENTATION

There are no requirements that are unique to this evaluation; however, significant discussion has been provided in Section 2 and Section 6 of this document to respond to a Nuclear Regulatory Commission (NRC) request for "additional justification for assuming a 5 weight percent versus 6 weight percent enriched fuel." This request is contained in the NRC letter from Larry W. Camper, Chief of the Decommissioning Branch of the Division of Waste Management of the Office of Nuclear Material Safety and Safeguards, to Barbara A. Mazurowski, Director of the West Valley Area Office of the U. S. Department of Energy, dated February 25, 2000. It is noted that this NCSE has been developed in accordance with WVDP-162, *WVDP Nuclear Criticality Safety Program Manual.*

4.0 METHODOLOGY

The calculations that provide the basis for this NCSE were performed with Monte Carlo N-Particle (MCNP) 4A. MCNP is a general purpose, continuous energy, generalized geometry, time-dependent, coupled neutron-photon-electron Monte Carlo transport code system. MCNP treats an arbitrary three-dimensional configuration of materials in geometric cells bounded by first- and second-degree surfaces and some special fourth-degree surfaces. For neutrons, all reactions in a particular cross-section evaluation are accounted for. Both free gas and S (alpha, beta) thermal treatments are used. Criticality sources as well as fixed and surface sources are available. MCNP is distributed by the Radiation Safety Information Computational Center (RSICC) located in Oak Ridge, Tennessee.

Documentation for MCNP 4A is provided in LA-12625, *MCNP - A General Monte Carlo N-Particle Transport Code*, which was issued in November 1993. A primer for performing criticality calculations with MCNP 4A is provided in LA-12827, *Criticality Calculations with MCNP: A Primer*, which was issued in August 1994. Appendix G of LA-12625 contains information pertaining to neutron cross section libraries associated with the execution of MCNP. Continuous energy (or pointwise) neutron cross section data for use in Monte Carlo calculations are available to MCNP from several libraries. Appendix G of LA-12625 states the following: "In general, cross sections (whether continuous or discrete) based on ENDF/B-V evaluations are believed to be the best available to MCNP users at this time. Therefore, the

default cross sections for MCNP are based upon the ENDF/B-V evaluations, although in some cases the ENDF/B-V sets are supplemented by more recent evaluations from T-2 (the Applied Nuclear Science Group)." Table G.2 of Appendix G of LA-12625 lists "all the cross section sets maintained by X-6 on the standard Monte Carlo neutron libraries." The arrow that precedes certain nuclides listed in Table G.2 "indicates what we believe to be the best available evaluation."

The October 22, 1993 edition of the RSICC newsletter states the following regarding MCNP 4A.

> The last version of MCNP released to RSICC, MCNP4.2, was so robust that in over two years of use by over a thousand users at hundreds of institutions around the world, no important errors were found. MCNP4A raises the standard of quality even higher. The code can be made to track MCNP4.2 identically (except for MCNP4.2 bugs), indicating that no new bugs have been added. The test set has been upgraded, and the installation procedure has been tightened further and includes a new data library specifically for test problems using internationally unrestricted ENDF/B-VI and ENDL data. There has been more testing and benchmarking of MCNP4A than any prerelease MCNP version in history. The code has undergone eight months of testing with preliminary versions at Los Alamos. Many significant changes from MCNP4.2 have been documented and can be traced. Most Software Quality Assurance guidelines of the IEEE and European ISO-9000 have been applied, including for the first time, multiple review of all coding.

The personal computer (PC) version of MCNP 4A was run on a Compaq Pentium III, 550 MHZ system, operating in a Windows NT environment. *MCNP 4A Software Validation Plan and Report for Criticality Calculations* provides documentation of the validation activities that were performed to support the criticality calculations addressed in this NCSE. The bias and bias uncertainty related to the use of MCNP for evaluation of moderated and unmoderated systems containing low-enriched uranium are addressed in *MCNP 4A Software Validation Plan and Report for Criticality Calculations*. Through an evaluation of the code bias, a subcritical limit of 0.93 that was selected for use in this NCSE in assessing the criticality safety of normal operations.

The criticality safety of HEC operations has been determined through the performance of a significant number of parametric analyses. These analyses evaluate a spectrum of conditions to envelope a broad range of potential decontamination operations. By design, these analyses range from a set of credible and anticipated conditions representing highly subcritical systems, to incredible configurations representing systems having the maximum reactivity for a given parameter or set of parameters such as geometry, enrichment, or moderation.

The intent of a criticality analysis is to demonstrate, in writing, to the satisfaction of qualified criticality analysts and reviewers, that a criticality concern has been satisfactorily evaluated and addressed through the imposition of appropriate controls as necessary. The analyses provided herein are considered to more than meet such an intent.

5.0 DISCUSSION OF CONTINGENCIES

The PMC and GPC were designed as heavily-shielded cells in order to protect workers from the high radiation levels associated with spent nuclear fuel. As indicated in Table B.8.3-4 of WVNS-SAR-002, the GPC has been provided with high density concrete shield walls having a typical thickness of 4 feet and a minimum thickness of 3 feet near transfer hatches and above Elevation 87 feet (i.e., head level). An evaluation documented in Section B.8.7.3.3 of WVNS-SAR-002 has concluded that a worker in an operating aisle adjacent to the GPC would receive an approximate whole body exposure of 98 mrem due to an inadvertent criticality in the GPC resulting in a 2E+19 fission event. The corresponding dose to the maximally exposed off-site individual would receive approximately 1 mrem from the release of fission gases.

Per DOE O 420.1, Section 4.3, "An exception to the application of double contingency, where single contingency operations are permissible, is presented in paragraph 5.1 of ANSI/ANS-8.10-1983. This exception applies to operations with shielding and confinement (*e.g.*, hot cells or other shielded facilities)." ANSI/ANS-8.10-1983, *Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement*, states that "The number of contingencies may be reduced to unity where the principles of this standard are met and the probability of failure of any primary control is shown to be low." The dose limits associated with the single contingency provision are 25 rem "whole body radiation dose received by an individual located at any point outside the shielded and confined area," and 0.5 rem "whole body radiation dose received by an individual outside the restricted area surrounding the facility." Therefore, for certain areas in the Main Plant such as the GPC and PMC (and CPC [currently designated the High-Level Waste Interim Staging Area], which is an area where drums containing HEC fissile-bearing debris may be stored), single contingency would be sufficient based on the above discussion. Nevertheless, a double contingency analysis is provided to demonstrate that controls are provided beyond the minimum required.

A contingency is defined as "a possible but unlikely change in a condition/control important to the nuclear criticality safety of a fissionable material operation that would, if it occurred, reduce the number of barriers (either administrative or physical) that are intended to prevent an accidental nuclear criticality" (DOE-STD-3007-93). Based on the analyses presented in Sections 6.1 and 6.2, the following contingencies exist for the collection, packaging, handling, and storage of fissile-bearing debris in the HECs.

(1) ***Fissile Mass*** - There would have to be much more fissile mass than that estimated to be present in the HECs (i.e., estimates of the fissile mass in the HECs would have to be in extreme error).

(2) ***Moderation*** - At any one time, no more than two drums of HEC fissile-bearing debris shall contain a significant quantity (greater than 5 v/o) of water.

(3) ***Spacing*** - HEC fissile debris waste shall be contained only in 114-liter (30-gallon) carbon steel drums

An analysis of these contingencies is provided in Table 1 below.

Table 1
Double Contingency Analysis for Handling and Processing Activities

Contingency	Description of Abnormal Operation or Accident Event	Barriers
Fissile Mass	1. One or more HEC fissile-bearing debris containers contain a significant amount of unreprocessed, unirradiated, 5 w/o U-235-enriched fuel (i.e., contain a significant amount of evaluation basis fuel)	1. No documented evidence of a significant loss of unreprocessed fuel to the HEC is documented in the NFS operating history, including Quarterly Reports to the AEC 2. Video inspection of hull debris in both the PMC and GPC indicates that a significant quantity of the hull debris in the cells has been reprocessed. No fuel can be seen in any of the video images of the hull end sections and all of the hulls viewed appear to be fully leached. 3. Only one campaign of unirradiated fuel (no. 14 of 26) was reprocessed by NFS. This fuel was 1.77 w/o U-235-enriched NPR fuel and represented approximately 5 percent of the total mass of uranium reprocessed by NFS. 4. Cell radiation measurements indicate that some, if not all, of the debris waste in the PMC and GPC have been subjected to significant neutron irradiation, in contradiction to the assumption that the fuel is unirradiated. 5. Only one campaign of fuel reprocessed by NFS (no. 11 of 26) had an initial U-235 enrichment in excess of 5 w/o. Operating history suggests that burnup of the fuel received by NFS would have reduced this enrichment to less than 3.4 w/o for all campaigns except campaign 11. 6. Operating history suggests that significant decontamination and cleanup by NFS occurred in the HECs following reprocessing, indicating that the material remaining in the HECs should not be from any particular campaign, but is due to an accumulation of wastes over several campaigns.
Moderation	1. Multiple drums containing a significant amount of water are placed in a storage array	1. No significant amount of moderator is believed to exist in the HECs, including the GPC sump. 2. Administrative controls require that drums be dried prior to transfer to storage array. 3. Administrative controls require that no more than 2 drums of undried waste be present in any cell at a given time.
	2. Dried drums in storage array become re-wetted due to flooding of array.	1. No credible potential exists for flooding of at-grade or above-grade cells or areas due to external surface flooding. 2. Extremely unlikely potential for flooding of below grade cells due to external surface flooding or due to a leak of a process line or roof leak 3. Storage drums provided with water-resistant HEPA filters
	3. Storage array becomes externally moderated due to flooding of array.	1. No credible potential for flooding of at-grade or above-grade cells or areas due to external surface flooding. 2. Extremely unlikely potential for flooding of below grade cells due to external surface flooding or due to a leak of a process line or roof leak

Table 1
Double Contingency Analysis for Handling and Processing Activities

Contingency	Description of Abnormal Operation or Accident Event	Barriers
Spacing	1. Collection activities result in piling up of debris.	1. Equipment to be used for fissile debris collection such as vacuums and clam shell scoops has been selected based on the limited potential such equipment has for piling up debris during collection. 2. Criticality analyses (BUF-2001-021) have shown that a hemispherical pile of fissile debris in the GPC sump is subcritical, provided that the level of moderator in the sump does not exceed the capacity of the sump (i.e., that the cell is so flooded that moderator extends into the cell - an extremely unlikely event).
	2. Material is packaged in non-critically safe waste packages	1. Administrative controls require that HEC fissile debris waste shall be contained only in 114-liter (30-gallon) carbon steel drums.
	3. Seismic activity or operational accident results in the dislodging of a drum from a storage array, resulting in a reconfiguration of dried wastes	1. Debris piles formed from breaching a container in such a way is only a criticality concern in those areas where significant moderator exists. 2. Administrative controls require that the storage of drums in the GPC be limited to single-tier arrays.

6.0 EVALUATION AND RESULTS

This NCSE has been developed to assess the criticality safety of the handling, processing, and storage of fissile bearing materials located in the HECs of the Main Plant. Four situations or scenarios have been considered:

- Normal collection, packaging, and handling
- Normal storage
- Collection, packaging, and handling under abnormal operations and accident conditions
- Storage under abnormal operations and accident conditions

Evaluations for both normal and abnormal and accident conditions have assumed that the small particulate debris in both the PMC and GPC is unirradiated fuel having an enrichment of 5 w/o U-235. In all cases the optimum fuel-to-moderator ratio or fuel density is selected for comparison to the upper subcritical limit, with the differentiation between normal and accident conditions primarily being the quantity of moderator in the waste drum. This methodology ensures a conservative analysis and is necessitated by the limited amount of characterization data available for the area. Specific, conservative assumptions made in the analyses include:

- *Small particulate debris is fuel*

The PMC and GPC both contain a significant amount of small particulate debris. Accumulations in the PMC are concentrated on the floor near the saw station and on and between the disassembly and inspection tables. Fuel received in the PMC from the Fuel Storage Pool was placed on the disassembly table, where straps and end hardware were removed through the use of a saw. The fuel was then fed to the shear where a sliding knife sheared the end of the fuel assembly into approximately 5cm (2 inch) sections which dropped via a shear chute into a dissolver basket staged at the filling station in the GPC. The sliding knife (or shear gag), fuel assembly end, and shear chute end were all enclosed in the shear head.

Small particulate debris in the PMC has been identified as fines and fuel hulls. The fuel disassembly and preparation process resulted in the accumulation of saw fines in the region around the saw. It is not expected that a significant amount of fuel fines would be present in this material because the process did not involve size reduction of the fuel. However, for the purposes of the analysis, this material has been assumed to be fuel due to the lack of characterization data for the material.

As noted above, shearing in the PMC was performed in a sealed shear head. Sections sheared from the end of the fuel assembly fell by gravity into a basket in the GPC. The presence of fuel hull sections in the PMC is most likely due to losses occurring as a result of transfer of leached hull sections through the cell. NFS transferred leached hulls that had been discharged from the dissolvers in the Chemical Process Cell (CPC) to the analytical chemistry lab via the GPC and PMC. These transfers were conducted routinely in order to confirm the effectiveness of the dissolution process on batches of spent nuclear fuel. Because fuel shearing was conducted in a sealed head and because the transfer of hull samples from the GPC to the analytical lab required a significant amount of handling (with the associated potentials for spills) the assumption that hull sections in the PMC are unleached (and therefore contain fuel) is very conservative.

The GPC also contains significant particulate debris accumulations which are concentrated in the sump region at the east end of the cell and in the region of the basket tipping fixture. NFS utilized the GPC as a loading and staging area for dissolver baskets and as an area for the receipt and packaging of leached hulls returned from the dissolvers. Dissolver basket loading was accomplished at the basket loading station, which is collocated with the GPC sump at the east end of the cell. Dissolver baskets to be filled were staged under the shear chute from the PMC, where sheared hull sections fell by gravity into the shear basket. Shearing continued until an interlock associated with the high level sensor was activated. NFS records indicate only one episode of over-filling a basket in this area and this occurred in the first reprocessing campaign. (NFS employed a gamma detector as a level sensor. Due to the low irradiation of the NPR fuel initially reprocessed by NFS, the fuel was not sufficiently radioactive to actuate the high level alarm.) No other instances of basket overfilling were recorded and records indicate that the material spilled in this campaign were collected and reprocessed.

Fuel hull debris on the floor in the GPC most likely originated at the basket tipping station located near the center of the cell. Leached hulls returned from the dissolvers in the CPC were placed in the tipping fixture which operated by upending the basket, dumping the contents into a 114-liter (30-gallon) scrap drum. This process was inherently prone to loss of material to the cell and video inspection of the area reveals an accumulation of hull sections in the area of the tipping fixture. It is reasonable to assume that losses of material in this area could also be the source of debris in the sump. Historical records indicate

the presence of a significant amount of scrap in the HEC at the termination of processing and it is likely that this material was located throughout the cell. NFS operating records indicate that twelve (12) 4-ft x 4-ft x 8-ft waste boxes and one hundred and sixty four (164) 30-gallon drums containing scrap wastes were removed from the HECs by NFS during facility decontamination activities following the cessation of reprocessing. It is very likely that the material currently in the sump originated from this accumulated scrap, which would not be expected to contain any unleached fuel.

Finally, several videos of material in both the PMC and GPC have recorded hull sections with sufficient clarity that the ends of the hulls are clearly visible. These sections clearly appear to be leached and no hulls appearing to contain fuel were observed. It is therefore concluded that the assumption that the small particulate debris in the PMC and GPC is fuel or is fuel-bearing is highly conservative.

- *The fuel in the HEC is unirradiated*

Historical records indicate that the commercial fuel constituting the latter campaigns of fuel reprocessed by NFS was significantly irradiated. The presence of irradiated fuel in the HEC is consistent with general area exposure rates measured in the cells in 1986. Nevertheless, the criticality analyses contained as attachments to this report have assumed that the fuel is unirradiated.

- *The enrichment of the fuel is 5 weight percent*

The conservatism associated with the selection of the enrichment assumed for the evaluation basis fuel has been discussed in Section 2.1.

- *Fuel in storage drums or in accumulations in the cell are heterogeneously distributed*

Standard criticality safety references (e.g., LA-10860-MS) and confirmatory Monte Carlo analyses have indicated that fuel sections are more reactive when heterogeneously distributed than when distributed in an homogeneous mixture. This effect is optimized when fuel rods are arranged in a hexagonal array. For all the analyses, parametric calculations have been performed to determine the optimum pitch of the array. In this way, the optimum fuel-to-moderator ratio is determined for moderated systems and the optimum fuel density (i.e., the optimum number of fuel rods per unit area) for unmoderated systems are determined.

Individual analyses contain additional conservative assumptions specific to the evaluated condition. These assumptions, which include optimum fuel-to-moderator ratios, full external reflection, infinite two-dimensional storage arrays, and optimum fuel density in unmoderated containers, are discussed in the following sections.

6.1 Normal Collection, Packaging, and Handling

Under normal collection conditions small particulate debris will be collected with a clam shell scoop, vacuum, or similar device which will be selected to minimize the potential for creating a more geometrically favorable arrangement of fissile material. It is expected that the sump area of the GPC will contain little or no water throughout the decontamination of the cell. Although historical evidence of water infiltration into the area exists, current video of cell conditions indicates that the cell appears to be dry and the cell sump level indicator registers zero water level in the sump. Consequently, it is expected that under normal collection and packaging operations, little water will be transferred to a collection

container. This is consistent with operational objectives as well, which would limit the amount of water in a drum because of the subsequent drying that will be required for any container of fissile-bearing material packaged in the GPC.

Unmoderated or low moderated systems containing low-enriched uranium present a minimal risk of inadvertent criticality. Per ANSI 8.1, criticality cannot be achieved for unmoderated systems containing uranium with U-235 enrichments less than 5 weight percent. Analyses in BUF-2000-067 (included in Appendix A) indicate that a drum of damp (i.e., approximately 10% water by volume) 5 w/o U-235 enriched fuel has a $k_{eff} + 2\sigma$ of 0.56.

Under normal packaging conditions containers used for the collection of fissile material will be located in areas that reduce the potential for interaction of collected material with other fissile material accumulations. The interaction of material in the collection container with accumulations of fissile-bearing debris in the GPC sump, in containers of dried waste in storage arrays, or in waste containers in the drum dryer will be minimized by locating the collection container in an area away from other accumulations. During material collection in the GPC sump the collection container will be located in an area outside the sump region and the presence of a collection container in the GPC sump during material collection is considered an abnormal condition. The interaction of the collection container with the small accumulations of debris scattered on the cell floor or surfaces is not a criticality concern because the configuration of this material (low density slab) is such that the material does not have the potential to significantly affect the reactivity of the system.

6.2 Normal Storage

Fissile-bearing debris will be stored in 114-liter (30-gallon) carbon steel drums. Any moisture or free liquid will be removed from the drum to the greatest extent practicable during drying operations prior to placement of the drum in a storage array. In addition, storage locations for drum arrays are not expected to be susceptible to flooding, as discussed in Section 2.4. Even the GPC, which has experienced periods of water accumulation due to roof leaks, is not susceptible to water intrusion due to surface flooding. Therefore, under normal conditions, there will be minimal internal and external moderation.

Calculation BUF-2000-052 (included in Appendix A) documents the input, assumptions, and results of MCNP runs for this situation. A k-inf value is calculated by evaluating infinite two-dimensional storage arrays of various heights. The model determines the optimum fuel density for fuel in the storage array by determining the optimum pitch for fuel rod sections while in drums in the array, as opposed to determining the optimum pitch for rods in an isolated drum. Fuel rods were modeled with stainless steel cladding because historical records show that in nearly all instances fuel reprocessed by NFS having higher initial enrichments (*e.g.*, 4.0 to 5.0 w/o) were stainless steel clad, whereas reprocessed fuel rods with lower initial enrichments (*e.g.*, 1.5 to 2.4 w/o) were Zircaloy clad. The analysis concludes that even stacked three high and with reflection from concrete below, the storage array has a maximum $k_{\infty} + 2\sigma$ of 0.71, which is far below the established upper subcritical limit of 0.93.

The analysis in BUF-2000-052 assumes a completely unmoderated condition inside the drums. It is recognized that even under normal storage conditions, some water that is internal to the wastes may be carried over into the storage array. Although the drum dryer will be operated in manner to ensure that water internal to the storage container is minimized to the greatest extent practicable, it is possible that some water in internal voids may not be completely removed. To evaluate this possibility, calculation BUF-2000-059 was performed to assess the reactivity of a storage array containing damp fuel.

The model contained in BUF-2000-059 considered the very likely possibility that many of the fuel hulls in debris in the cells are leached. For the analysis it was assumed that two thirds of the fuel was leached and that the void space of the leached hull contained water. It was further assumed that the success of removing water by drying a drum containing a combination of leached and unleached hulls would only be partially successful and that following drying, some residual water would remain in the void region of the leached hulls. The residual volume of water in the drum was expressed as a fraction of the total volume of the drum. As can be seen in BUF-2000-059, an entire storage array, infinite in two dimensions and three tiers high, containing waste containers with a residual volume fraction of water up to 7 percent (i.e., 2-gallons) is safe.

6.3 Collection, Packaging, and Handling Under Abnormal Operation and Accident Conditions

Accidents and abnormal operations that could occur during the collection and packaging of fissile-bearing particulate debris include dropping collected material onto debris in the sump area of the GPC, collection of a significant amount of water into a storage container, and collection of material into a waste container located in the sump area of the GPC. Calculation BUF-2001-021 evaluates the condition in which fissile-bearing debris in the sump is rearranged into a hemispherical configuration. It is assumed that moderator exists in the sump up to an elevation of 74 ft 3 in. This elevation corresponds to the point at which the floor of the GPC intersects the west side of the sump. Water rising above this elevation would extend onto the floor of the GPC, and, as discussed in Section 2, no mechanism for this amount of water infiltration into the cell has been identified. Per BUF-2001-021, this condition, in which all the fissile-bearing debris in the GPC sump is reconfigured into a hemispherical pile with the bottom of the pile fully moderated conservatively bounds any spill of material or reconfiguration of the fissile-bearing debris, including filling of a waste container in the sump. The calculated $k_{eff} + 2\sigma$ for the condition in which fuel is relatively densely packed is 0.70, which is less than the upper subcritical limit of 0.93. This system remains safe even when up to one third of the volume of the sump is occupied with water, with the remainder occupied by uniformly arranged evaluation basis fuel.

Accidents and abnormal operations that could occur during the handling of fissile debris containers in the HECs include placing two drums containing moderated fissile-bearing material in proximity to each other and placing multiple drums of moderated fissile material in proximity to a storage array. Calculation BUF-2000-067 has evaluated the condition in which two drums of moderated fissile material are placed in proximity to each other. The analysis concludes that this system will remain subcritical, even when the fuel in the drum is configured to optimize reactivity and over a third of the volume of the drum is water. Calculation BUF-2001-019 evaluates the condition in which two drums of moderated fissile material are brought into proximity with an array of dried fissile debris storage containers. The size of the array, 7 drums x 7 drums x 3 tiers, was selected to represent the maximum number of waste containers that could

reasonably be stored in the GPC. Furthermore, the number of containers in the array is nearly an order of magnitude greater than has been estimated as being necessary to package all of the small particulate debris in the GPC. The analysis assumes that fuel is optimally arranged in both the containers in the storage array, as well as in the moderated waste drums, and has assumed that the moderated containers contain 33% water by volume. The moderated container/waste storage array system is bounded on all sides and on the bottom by concrete of sufficient thickness to appear infinite. Based on these assumptions it has been found that the $k_{eff} + 2\sigma$ for the system is 0.92, which is below the upper subcritical limit of 0.93.

6.4 Storage Under Abnormal Operations and Accident Conditions

Arrays of HEC fissile debris storage containers will typically be located in above grade storage locations where the potential for flooding is incredible; however, containers of dried fissile debris wastes may also be staged in the GPC prior to transfer to an above grade storage location. Abnormal operations and accidents important to criticality safety that may involve an array of fissile debris storage containers include external moderation of the storage array (with or without subsequent internal moderation of the containers in the array), inadvertent placement of undried (i.e., potentially moderated) waste packages in proximity to the storage array, and breaching of containers in the array due to fire or falling as a result of a seismic event or due to striking.

The external moderation of an array of waste drums containing dried fissile materials has been evaluated in calculation BUF-2000-052. As can be seen in Figures 3 through 5 of BUF-2000-052, an infinite array of storage containers limited to one tier is subcritical under all conditions of external package moderation. Significant external moderation of a storage array is only a concern in the GPC, where the possibility of flooding of the cell is extremely unlikely. In other locations where HEC fissile debris may potentially be stored, full flooding of the array is incredible. Consequently, arrays of storage containers in the GPC are limited to one tier, whereas the height of an array of HEC fissile debris outside of the GPC is limited to three tiers.

The internal moderation of wastes packages contributes significantly to the reactivity of a storage array. Normal operations will minimize the quantity of water in a storage drum through evaporation. These wastes are not expected to be rewetted following processing, although the potential exists due to the fact that drums containing high concentrations of alpha contamination must be vented to prevent the accumulation of explosive gases, which may be generated through processes such as the radiolytic decomposition of water. Drums containing dried HEC fissile-bearing debris will be ventilated with a HEPA filter that can withstand at least 120 cm (48 in) water column without allowing water entry into a container (Nuclear Filter Technology Incorporated NucFil 013 filter with Gore-Tex, or equivalent) to minimize the potential for introducing water into a sealed, dried waste drum.

Water moderator in an unprocessed collection container may also affect the reactivity of a dry, unmoderated storage array if a collection container containing a sufficient amount of water is brought in proximity to the array. Although it is not anticipated that unprocessed wastes will be placed in the vicinity of the storage array because of pragmatic operational constraints, there are no physical barriers or administrative controls that would prevent a drum of moderated waste material from being placed near an array of dried drums. Calculation BUF-2001-019 evaluates the condition in which a drum of optimally

moderated fissile debris waste is placed in proximity to a storage array in the GPC. The size of the array is selected based on the physical constraints of the cell; that is, the maximum width of the GPC cannot contain more than 7 drums. The array selected for evaluation is therefore 7 drums x 7 drums x 3 tiers. Based on the analysis contained in BUF-2001-019, it is shown that even when two drums of moderated fissile debris wastes are placed adjacent to a 7 x 7 x 3 array of dried waste containers, the $k_{eff} + 2\sigma$ is 0.92, which is less than the selected upper subcritical limit of 0.93.

Finally, breaching a container, either through increased internal pressure as a result of a fire or through rupture due to falling, presents the potential for moderation of a previously unmoderated accumulation of fissile material. The potential for a fire in the HEC is minimal due to the low amount of combustible material in the area. Furthermore, activities in the HEC that present the potential for increased fire risk, such as cutting operations, will be conducted in engineered enclosures that contain hot sparks. Fire suppression systems that will be employed in the HECs will not have sufficient volume or pressure to disturb a drum in its storage location. (The external moderation of the waste storage array due to activation of a fire suppression system has been evaluated in calculation BUF-2000-052.) Dislocation of a drum from the storage array due to a seismic event or impact with a handling device such as a PaR or manipulator arm is a credible abnormal operation or accident event due to the fact that there will be no mechanical restraint around the storage area to prevent such an occurrence. However, debris piles formed from breaching a container in such a way is only a criticality concern in those areas where moderator exists. As discussed earlier, this is only the case in the GPC, and as stated, the storage of drums in the GPC is limited to single-tier arrays.

7.0 DESIGN FEATURES (PASSIVE AND ACTIVE) AND ADMINISTRATIVELY CONTROLLED LIMITS AND REQUIREMENTS

The following design features and administratively controlled limits and requirements shall be provided to reduce the likelihood of a criticality event during the handling, processing, and storage of HEC fissile-bearing debris.

7.1 Design Features

- Only 114-liter (30-gallon) carbon steel drums, 72.4 cm $\pm$ 1 cm (28.5 in $\pm$ 0.4 in) high (outside) with an inside diameter of 46.0 cm $\pm$ 1 cm (18.1 in $\pm$ 0.4 in), shall be used for the storage of HEC fissile-bearing debris. (The selected tolerance of 1 cm (0.4 in) corresponds to a variation in geometry having an insignificant affect on reactivity for a waste package or array of packages.)

- Each 114-liter (30-gallon) HEC fissile-bearing debris storage drum shall be vented with a HEPA filter that can withstand at least 122 cm (48 in) water column without allowing water entry into a container (Nuclear Filter Technology Incorporated NucFil 013 filter with Gore-Tex, or equivalent).

- The volume of an HEC fissile material debris collection or processing container shall not exceed the dimensions of an HEC storage container specified above.

7.2 Administratively Controlled Limits and Requirements

- No more than two containers of moderated (i.e., unprocessed) fissile material may exist in any HEC at a given time.
- Free liquid in HEC fissile-bearing debris storage containers shall be removed to the greatest extent practicable and in no case shall exceed 5 v/o water.
- Drums in the GPC containing HEC fissile-bearing debris shall not be stacked more than one tier high.
- Drums outside the GPC containing HEC fissile-bearing debris shall not be stacked more than three tiers high.

8.0 SUMMARY AND CONCLUSIONS

The lack of characterization data for the small particulate debris in the GPC and PMC has required that conservative assumptions be made about several parameters important to criticality safety. Although less conservative values for each parameter could have been used, these values would have been selected arbitrarily due to the lack of characterization data and therefore could not be rigorously defended. Consequently, the reactivity of the fissile material modeled to support development of this NCSE is very conservative relative to the reactivity of the actual fissile material in the HECs, and the conditions and configurations modeled are very conservative relative to the conditions and configurations that are reasonably considered possible during the handling, processing, and storage of HEC fissile-bearing debris. Additionally, the number of contingencies developed for HEC decontamination activities exceeds that required for heavily shielded rooms and cells, as single contingency analysis is all that is required for such rooms and cells. The handling, processing, and storage requirements presented in this NCSE, which are based on analyses discussed in Section 6.0, provide levels of control that are more than sufficient for the criticality hazard associated with the handling, processing, and storage of HEC fissile-bearing debris. A very large margin of safety will exist. Storage area(s), and areas where handling and processing activities will occur, will remain subcritical under all normal and credible abnormal and accident conditions.

9.0 REFERENCES

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MCNP 4A SOFTWARE VALIDATION PLAN AND REPORT FOR CRITICALITY CALCULATIONS

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Appendix 1 - File comparison report generated by test problems for verification included in the MCNP 4A package

Appendix 2 - MCNP input file for calculation of effective neutron multiplication factor for a 69 L sphere of $U(4.89)O_2F_2$ solution without reflection.

Appendix 3 - MCNP output file for calculation of effective neutron multiplication factor for a 69 L sphere $U(4.89)O_2F_2$ solution without reflection.

Appendix 4 - MCNP4A Calculation Method Bias and Bias uncertainty of criticality calculations for low enriched uranium systems

MCNP 4A SOFTWARE VALIDATION PLAN

Software and Hardware Identification

The software being tested for validation purposes is MCNP 4A Monte Carlo N-Particle Transport Code System. MCNP 4A was developed by the Radiation Transport Group (X-6) of the Applied Theoretical Physics Division (X Division) at Los Alamos National Laboratory, Los Alamos, New Mexico. The software is distributed by the Radiation Safety Information Computational Center (RSICC), Oak Ridge, Tennessee.

MCNP 4A is a general-purpose, continuos-energy, generalized geometry, time dependent, coupled neutron-photon-electron Monte Carlo transport code system. MCNP 4A treats an arbitrary three-dimensional configuration of materials in geometric cells bounded by first- and second-degree surfaces and some special fourth-degree surfaces. Pointwise or continuous-energy cross section data are used, although multigroup data may also be used. Fixed-source adjoint calculations may be made with the multigroup data option. For neutrons, all reactions in a particular cross-section evaluation are accounted for. Both free gas and S(alpha, beta) thermal treatments are used. Criticality sources as well as fixed and surface sources are available.

MCNP 4A is operable on Cray computers, IBM mainframes, UNIX workstations, VAX computers and all computers in general with at least 150 megabytes of hard disk. Executable files for the PC version are proved for running on 8MB memory on 80486, 80386 or higher computer with a coprocessor.

Compilation of MCNP requires both FORTRAN 77 and ANSI C standard compilers. The PC version requires DOS Version 4 or higher. The PC executables included in the package were created with Lahey Fortran F77L-EM/32 version 5.10 compiler under DOS 6.0.

Validation testing is to be performed on a 550-megahertz Pentium III PC with 64 MB of random access memory and sufficient hard disk space to perform a complete installation, operating in a Windows NT environment.

Purpose and Scope of Testing

Testing is being performed to validate MCNP 4A for the purpose of estimating neutron multiplication factors for systems with low-enriched uranium fuel.

Specific Tests to be Performed

The test problems for verification included in the MCNP 4A package are to be run. The test problems are neither good nor typical examples of MCNP problems. Rather, they are highly irregular test configurations designed to exercise as many features as possible. The INPnn files are the same for all systems, but the answers, MCTL?? (?? = 01, 02, etc.), differ slightly from system to system because of differences in arithmetic processors. The test set works on the basis of "particle tracking" in which the random walks must be identical.

MCNP 4A comes with 25 test problems (TESTINP.TAR) and other files shown in Table 1.

Table 1. Verification files in MCNP 4A package.

File	Description
RUNPROB	Script file for MCNP verification. Named RUNPROB.SYS for non-UNIX systems
TESTINP.TAR	Compressed input files for MCNP verification. Named TESTINP.SYS for non-UNIX systems
TESTMCTL.SYS	Compressed tally output files for MCNP verification
TESTOUTP.SYS	Compressed MCNP output files for MCNP verification
XSDIR	Cross-section directory for MCNP verification
TESTLIB1	Cross-section data for MCNP verification

The system identifier "DOS" for PCs operating in WindowsNT environment is to be substituted for the "SYS" suffix. The following commands will uncompress the input/output files and execute the test problem scrip:

PKARC TESTINP.DOS
PKARC TESTMCTL.DOS
PKXARC TESTOUP.DOS
COPY RUNPROB.DOS RUNPROB.BAT
RUNPROB

MCNP 4A is to be further validated by calculating the effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without reflection. The $H/^{235}U$ atomic ratio is 524 and ^{235}U density is 0.0425 g/cm^3.

Evaluation Methods to be Used

The script of the test problem for verification included in MCNP 4A package performs the following steps for the test problems:

1. Execute MCNP for the 1st test problem
2. Compare the tally output file (inp01m) with the standard (mctl01)
3. Compare the output file (inp01o) with the standard (outp01)
4. Remove the RUNTPE file (inp01r)
5. Repeat steps 1-4 for each of the rest of 25 test problems

File comparison results are to be printed out for documentation purposes.

The calculated effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without a reflector outside is to be compared to the value $k_{eff} = 1$ published in H.C. Paxton, N.L. Provost. *Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U*, LA-10860-MS, 1986 Revision, LANL Los Alamos NM. The critical dimension for this sphere is based on the Oak Ridge critical experiments.

Acceptance Criteria to be Used

Upon completion of the test problems for verification included into MCNP 4A package, there should be 25 inp??m and inp??o files (?? = 01, 02, etc.). If any of these are missing, test ?? failed. Differences between these runs and the standard shown up in the DIF?? files. Exact tracking is required for MCNP 4A verification, thus significant differences (i.e., other than round-off in the last digit) may prove to be serious (e.g., compiler bugs, etc.). In such cases, the cause of the difference should be fully understood.

In the case of calculating the effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in 69 L aluminum sphere without reflection, the MCNP calculated result should fall into the range:

$$k_{eff} = 1 \pm (2\sigma + \Delta k_b + \sigma_b)$$

Where:
k_{eff} = neutron multiplication factor predicted by MCNP
σ = standard deviation of MCNP predicted k_{eff}
Δk_b = calculation method bias
σ_b = bias uncertainty

For the case of low enriched uranium fuel, calculation method bias together with bias uncertainty ($\Delta k_b + \sigma_b$) is chosen to be 0.02 based on criticality experiments published in *International Handbook of Evaluated Criticality Safety Benchmark Experiments, Volume IV Low Enriched Uranium Systems*, NEA Nuclear Science Committee, OECD Paris 1995. The derivation of calculation method bias and bias uncertainty values can be found in Appendix 4. Thus, the acceptance criterion can be modified as:

$$k_{eff} = 1 \pm (2\sigma + 0.02)$$

Where:

k_{eff} = neutron multiplication factor predicted by MCNP
σ = standard deviation of MCNP predicted k_{eff}

Based on the above discussion, and using 0.95 as the established "safe" threshold neutron multiplication factor, the results of MCNP 4A calculations should be compared to a subcritical limit of 0.93 (i.e. calculated $k_{\infty} + 2\sigma \leq 0.93$ and $k_{eff} + 2\sigma \leq 0.93$)

If applicable published results of criticality experiment(s) involving low enriched uranium systems without moderation or reflection are found, MCNP4A validation is to be performed against one of these experiments also.

Documentation Required

The file comparison report generated by test problems for verification included in the MCNP 4A package is to be printed out and attached to this document.

The MCNP input and output files for the calculation of the effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without reflector outside are also to be printed out and attached to this document.

If applicable published results of criticality experiments(s) involving low enriched uranium systems without moderation or reflection are found, the MCNP input and output files for the calculation of the effective neutron multiplication factor associated with one such experiment are to be printed out and attached to this document.

MCNP 4A SOFTWARE VALIDATION TEST REPORT

Test Personnel

The test plan was implemented by Igor V. Chichkov of URS.

Description of Test Performance

The MCNP 4A software operated/executed well. No difficulties were encountered in this regard. The MCNP 4A documentation was adequate for developing input decks and provided adequate discussions on those parameters that can significantly impact the calculated outputs. No difficulties or problems arose that were not satisfactorily resolved by a close examination of the MCNP 4A documentation. The MCNP 4A documentation and sample problems were of sufficient quality to provide a high degree of confidence that the input deck was properly developed and the modeling satisfactory in regard to the problem on calculation of an effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without reflection.

Evaluation of Results

Part of the Validation Plan for MCNP 4A was to compare the generated output (i.e., the output generated by the hardware and software being validated) from the execution of input decks provided with the MCNP 4A software with output provided with the MCNP 4A software. The software provided by the Radiation Safety Information Computational Center (RSICC) to URS contains both the input decks to be run, and the outputs. The acceptance criterion for this part of the Validation Plan is that generated output files must be identical to the output files provided with the MCNP 4A software. The byte size of the files must be the same, and all the lines in the output files must be the same too. These criteria were met. Appendix 1 contain the required documentation for this part of the Validation Plan.

The other part of the Validation Plan was to compare the calculated effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without reflection with criterion $1 \pm (2\sigma + 0.02)$ where σ is the standard deviation of the MCNP predicted k_{eff} value. The input file for the model is attached to Appendix 2, and the output file is attached to Appendix 3. The neutron multiplication factor calculation results are shown in Table 2.

Table 2 The MCNP 4A calculation results for the effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in 69 L aluminum sphere without reflection.

k_{eff}	σ	$1 + (2\sigma + 0.02)$	$1 - (2\sigma + 0.02)$
0.99174	0.00099	1.02198	0.97802

As can be seen from Table 2, the criterion $k_{eff} = 1 \pm (2\sigma + 0.02)$ was met.

An extensive literature search was performed, but no published results of criticality experiments involving low enriched uranium systems without moderation or reflection were found. Additionally, consultation with criticality experts (e.g., the primary author of the KENO criticality code) did not prove beneficial. However, the October 22, 1993 edition of the RSICC newsletter states the following regarding MCNP4A:

> The last version of MCNP released to RSICC, MCNP4.2, was so robust that in over two years of use by over a thousand users at hundreds of institutions around the world, no important errors were found. MCNP4A raises the standard of quality even higher. The code can be made to track MCNP4.2 identically (except for MCNP4.2 bugs), indicating that no new bugs have been added. The test set has been upgraded, and the installation procedure has been tightened further and includes a new data library specifically for test problems using internationally unrestricted ENDF/B-VI and ENDL data. There has been more testing and benchmarking of MCNP4A than any prerelease MCNP version in history. The code has undergone eight months of testing with preliminary versions at Los Alamos. Many significant changes from MCNP4.2 have been documented and can be traced. Most Software Quality Assurance guidelines of the IEEE and European ISO-9000 have been applied, including for the first time multiple review of all coding.

This statement, coupled with the established sound performance of MCNP 4A for low enriched moderated systems, provides a large measure of assurance that the code produces reliable results for various systems with fissile materials including low enriched uranium systems without moderation or reflection.

Conclusions

The modules of MCNP 4A that are being considered for use in criticality calculations met all acceptance criteria during validation testing. Furthermore, there was good agreement between the MCNP 4A calculated effective neutron multiplication factor for $U(4.89)O_2F_2$ solution in a 69 L aluminum sphere without reflection and the reference value $k_{eff} = 1$. It is concluded that the MCNP 4A modules under consideration are suitable for the desired application, i.e., criticality calculations.

Appendix 1

File comparison report generated by test problems for verification included in the MCNP 4A package

delta

```
Comparing files INP01M and MCTL01
FC: no differences encountered

Comparing files INP02M and MCTL02
FC: no differences encountered

Comparing files INP03M and MCTL03
FC: no differences encountered

Comparing files INP04M and MCTL04
FC: no differences encountered

Comparing files INP05M and MCTL05
FC: no differences encountered

Comparing files INP06M and MCTL06
FC: no differences encountered

Comparing files INP07M and MCTL07
FC: no differences encountered

Comparing files INP08M and MCTL08
FC: no differences encountered

Comparing files INP09M and MCTL09
FC: no differences encountered

Comparing files INP10M and MCTL10
FC: no differences encountered

Comparing files INP11M and MCTL11
FC: no differences encountered

Comparing files INP12M and MCTL12
FC: no differences encountered

Comparing files INP13M and MCTL13
FC: no differences encountered

Comparing files INP14M and MCTL14
FC: no differences encountered

Comparing files INP15M and MCTL15
FC: no differences encountered

Comparing files INP16M and MCTL16
FC: no differences encountered

Comparing files INP17M and MCTL17
FC: no differences encountered

Comparing files INP18M and MCTL18
FC: no differences encountered

Comparing files INP19M and MCTL19
FC: no differences encountered

Comparing files INP20M and MCTL20
FC: no differences encountered

Comparing files INP21M and MCTL21
FC: no differences encountered

Comparing files INP22M and MCTL22
FC: no differences encountered

Comparing files INP23M and MCTL23
FC: no differences encountered

Comparing files INP24M and MCTL24
FC: no differences encountered

Comparing files INP25M and MCTL25
FC: no differences encountered
```

Appendix 2

MCNP input file for calculation of effective neutron multiplication factor for a 69 L sphere of $U(4.89)O_2F_2$ solution without reflection.

S69a2

```
Al Sphere with UO2F2 water solut. V=69L, unrefl., fwU235=4.89, H/U235 = 524
C
C Cell cards
C
C ------------------------------------------------------------------------
1 1 9.6588e-2  -1     imp:n=1 $ sphere with solution
2 2 -2.70       1 -2 imp:n=1 $ Al shpere
3 0             2    imp:n=0 $ Outside world
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
1 so 25.44408     $ 69 L sphere
2 so 25.60283     $ Al sphere (1/16 inch thickness)
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c 4.89% enrichment UO2F2 water solution H/U235 = 524
c (H-1, O-16, F-19, U-235, U-238)
m1      1001.50c  5.7058e-2
        8016.50c  3.2929e-2
        9019.50c  4.3996e-3
       92235.50c  1.0889e-4
       92238.50c  2.0911e-3
mt1 lwtr.01t
c Al
m2     13027.50c  1.0
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 200
ksrc  0 0 0
```

Appendix 3

MCNP output file for calculation of effective neutron multiplication factor for a 69 L sphere of $U(4.89)O_2F_2$ solution without reflection.

```
1mcnp     version 4a    ld=10/01/93                    12/21/99 15:23:51
 ************************************************************************                probid =   12/21/99 15:23:51
 name=s69a1

    1-        Al Sphere with UO2F2 water solut. V=69L, unrefl., fwU235=4.89, H/U235 = 524
    2-        C
    3-        C Cell cards
    4-        C
    5-        C ------------------------------------------------------------------------
    6-        1 1 9.6588e-2  -1    imp:n=1 $ sphere with solution
    7-        2 2 -2.70      1 -2 imp:n=1 $ Al shpere
    8-        3 0            2    imp:n=0 $ Outside world
    9-        C ------------------------------------------------------------------------
   10-        c
   11-        c Note: next line must be completely blank
   12-
   13-        c Surface cards
   14-        C ------------------------------------------------------------------------
   15-        1 so 25.44408    $ 69 L sphere
   16-        2 so 26.07908    $ Al sphere (1/4 inch thickness)
   17-        C ------------------------------------------------------------------------
   18-        c
   19-        c Note: next line must be completely blank
   20-
   21-        c Data cards
   22-        c
   23-        c Materials
   24-        c
   25-        c
   26-        c 4.89% enrichment UO2F2 water solution H/U235 = 524
   27-        c (H-1, O-16, F-19, U-235, U-238)
   28-        m1      1001.50c  5.7058e-2
   29-                8016.50c  3.2929e-2
   30-                9019.50c  4.3996e-3
   31-               92235.50c  1.0889e-4
   32-               92238.50c  2.0911e-3
   33-        mt1 lwtr.01t
   34-        c Al
   35-        m2    13027.50c  1.0
   36-        c
   37-        mode n
   38-        print 40 60 80 100 110 126
   39-        kcode 4000 1. 20 120
   40-        ksrc  0 0 0
   41-
 total fission nubar data are being used.
1material composition                                                                    print table 40

 the sum of the fractions of material    1 was 9.658659E-02

 material
  number     component nuclide, atom fraction

     1            1001,  0.59074       8016,  0.34093       9019,  0.04555      92235,  0.00113
                 92238,  0.02165
 associated thermal s(a,b) data sets:    lwtr.01t
     2           13027,  1.00000
```

```
material
 number     component nuclide, mass fraction

    1           1001,  0.04828       8016,  0.44217       9019,  0.07017      92235,  0.02149
               92238,  0.41790
    2          13027,  1.00000

 warning.    1 of the materials had unnormalized fractions.
1cells                                                                                          print table 60

                     atom        gram                                        neutron
       cell  mat    density     density     volume       mass     pieces importance

    1     1    1s 9.65880E-02 1.97804E+00 6.90000E+04 1.36485E+05     1  1.0000E+00
    2     2    2  6.02616E-02 2.70000E+00 5.29603E+03 1.42993E+04     1  1.0000E+00
    3     3    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00     0  0.0000E+00

 total                                   7.42960E+04 1.50784E+05

         1 warning message so far.
1cross-section tables                                                                           print table 100

    table    length

                      tables from file critxs

  1001.50c    1153  njoy                                                                  (  1301)      79/07/31.
  8016.50c   23669  njoy                                                                   ( 1276)     05/14/81
  9019.50c   20657  njoy                                                                  (  1309)      79/06/22.
 13027.50c   22891  njoy                                                                  (  1313)      79/09/08.
 92235.50c   44188  njoy                                          total nu                 (  1395)      79/09/12.
 92238.50c   66440  njoy                                          total nu                 (  1398)      79/09/13.
  lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                      1001     0     010/22/85

 total      189191

 warning.  neutron energy cutoff is below some cross-section tables.



 decimal words of dynamically allocated storage

    general             107908
    tallies                  0
    bank                  6403
    cross sections      189191

    total               303502

*****************************************************************************************************************
 dump no.    1 on file s69a1r       nps =         0     coll =              0     ctm =    0.00     nrn =              0


 source distribution written to file s69a1s          cycle =     0

         2 warning messages so far.
1   starting mcrun.      field length =      0      cp0 =  0.01                                      print table 110

     A1 Sphere with UO2F2 water solut. V=69L, unrefl., fwU235-4.89, H/U235 = 524
```

nps	x	y	z	cell	surf	u	v	w	energy	weight	time
1	0.000E+00	0.000E+00	0.000E+00	1	0	5.085E-01	4.733E-01	7.193E-01	2.209E+00	1.000E+00	0.000E+00
2	0.000E+00	0.000E+00	0.000E+00	1	0	8.952E-01	-4.447E-01	-2.944E-02	4.904E+00	1.000E+00	0.000E+00
3	0.000E+00	0.000E+00	0.000E+00	1	0	-6.184E-01	-4.495E-01	6.446E-01	3.809E-01	1.000E+00	0.000E+00
4	0.000E+00	0.000E+00	0.000E+00	1	0	9.710E-01	-5.665E-02	-2.323E-01	1.331E+00	1.000E+00	0.000E+00
5	0.000E+00	0.000E+00	0.000E+00	1	0	5.861E-01	1.496E-01	-7.963E-01	1.902E+00	1.000E+00	0.000E+00
6	0.000E+00	0.000E+00	0.000E+00	1	0	-6.489E-02	-1.626E-01	9.845E-01	4.410E-01	1.000E+00	0.000E+00
7	0.000E+00	0.000E+00	0.000E+00	1	0	-7.068E-02	3.263E-02	-9.970E-01	4.750E-01	1.000E+00	0.000E+00
8	0.000E+00	0.000E+00	0.000E+00	1	0	-3.915E-01	4.664E-01	-7.932E-01	4.136E+00	1.000E+00	0.000E+00
9	0.000E+00	0.000E+00	0.000E+00	1	0	-2.368E-01	9.215E-01	-3.079E-01	7.453E-02	1.000E+00	0.000E+00
10	0.000E+00	0.000E+00	0.000E+00	1	0	1.946E-01	-3.204E-01	9.271E-01	3.128E+00	1.000E+00	0.000E+00
11	0.000E+00	0.000E+00	0.000E+00	1	0	-6.698E-01	-7.177E-01	-1.905E-01	1.014E+00	1.000E+00	0.000E+00
12	0.000E+00	0.000E+00	0.000E+00	1	0	-8.398E-01	-4.129E-01	3.524E-01	1.395E+00	1.000E+00	0.000E+00
13	0.000E+00	0.000E+00	0.000E+00	1	0	-1.714E-01	-8.572E-01	4.857E-01	7.748E-01	1.000E+00	0.000E+00
14	0.000E+00	0.000E+00	0.000E+00	1	0	-2.489E-01	-5.118E-01	-8.222E-01	1.101E+00	1.000E+00	0.000E+00
15	0.000E+00	0.000E+00	0.000E+00	1	0	-2.959E-01	2.119E-01	9.314E-01	1.951E+00	1.000E+00	0.000E+00
16	0.000E+00	0.000E+00	0.000E+00	1	0	1.395E-01	-9.829E-01	1.202E-01	2.186E+00	1.000E+00	0.000E+00
17	0.000E+00	0.000E+00	0.000E+00	1	0	6.909E-01	-7.110E-01	1.307E-01	1.865E+00	1.000E+00	0.000E+00
18	0.000E+00	0.000E+00	0.000E+00	1	0	-6.580E-01	5.320E-01	-5.329E-01	1.229E+00	1.000E+00	0.000E+00
19	0.000E+00	0.000E+00	0.000E+00	1	0	-9.903E-01	-1.380E-01	1.353E-02	1.305E+00	1.000E+00	0.000E+00
20	0.000E+00	0.000E+00	0.000E+00	1	0	7.462E-01	4.859E-01	-4.551E-01	1.000E+00	1.000E+00	0.000E+00
21	0.000E+00	0.000E+00	0.000E+00	1	0	-1.977E-01	9.797E-01	3.360E-02	3.990E+00	1.000E+00	0.000E+00
22	0.000E+00	0.000E+00	0.000E+00	1	0	-9.117E-01	-3.647E-01	-1.891E-01	2.665E-01	1.000E+00	0.000E+00
23	0.000E+00	0.000E+00	0.000E+00	1	0	-4.287E-01	8.361E-01	-3.423E-01	1.156E+00	1.000E+00	0.000E+00
24	0.000E+00	0.000E+00	0.000E+00	1	0	1.080E-01	3.412E-01	-9.338E-01	2.669E+00	1.000E+00	0.000E+00
25	0.000E+00	0.000E+00	0.000E+00	1	0	-9.111E-01	-9.012E-03	-4.122E-01	2.185E+00	1.000E+00	0.000E+00
26	0.000E+00	0.000E+00	0.000E+00	1	0	-2.568E-01	-6.391E-01	-7.249E-01	4.225E+00	1.000E+00	0.000E+00
27	0.000E+00	0.000E+00	0.000E+00	1	0	-2.912E-01	8.086E-01	5.113E-01	1.079E+00	1.000E+00	0.000E+00
28	0.000E+00	0.000E+00	0.000E+00	1	0	1.472E-01	-9.514E-01	2.705E-01	3.461E+00	1.000E+00	0.000E+00
29	0.000E+00	0.000E+00	0.000E+00	1	0	-6.135E-01	-7.645E-01	-1.978E-01	1.836E+00	1.000E+00	0.000E+00
30	0.000E+00	0.000E+00	0.000E+00	1	0	-5.702E-01	5.651E-01	-5.963E-01	4.556E-01	1.000E+00	0.000E+00
31	0.000E+00	0.000E+00	0.000E+00	1	0	-6.607E-01	5.373E-01	-5.242E-01	6.415E-01	1.000E+00	0.000E+00
32	0.000E+00	0.000E+00	0.000E+00	1	0	-9.742E-02	-3.639E-01	-9.263E-01	2.764E+00	1.000E+00	0.000E+00
33	0.000E+00	0.000E+00	0.000E+00	1	0	-1.965E-01	-3.145E-01	-9.287E-01	2.785E-01	1.000E+00	0.000E+00
34	0.000E+00	0.000E+00	0.000E+00	1	0	4.097E-01	8.465E-01	-3.399E-01	9.097E-01	1.000E+00	0.000E+00
35	0.000E+00	0.000E+00	0.000E+00	1	0	-4.048E-02	8.831E-01	4.675E-01	3.360E-01	1.000E+00	0.000E+00
36	0.000E+00	0.000E+00	0.000E+00	1	0	3.371E-01	-9.269E-01	-1.652E-01	6.376E-01	1.000E+00	0.000E+00
37	0.000E+00	0.000E+00	0.000E+00	1	0	-1.867E-01	9.756E-01	-1.155E-01	2.186E+00	1.000E+00	0.000E+00
38	0.000E+00	0.000E+00	0.000E+00	1	0	-2.616E-01	2.336E-01	-9.365E-01	7.314E-01	1.000E+00	0.000E+00
39	0.000E+00	0.000E+00	0.000E+00	1	0	9.780E-01	-7.641E-02	-1.939E-01	2.997E-01	1.000E+00	0.000E+00
40	0.000E+00	0.000E+00	0.000E+00	1	0	2.580E-01	-7.076E-01	6.578E-01	1.444E+00	1.000E+00	0.000E+00
41	0.000E+00	0.000E+00	0.000E+00	1	0	-3.212E-01	-7.678E-01	-5.543E-01	1.914E+00	1.000E+00	0.000E+00
42	0.000E+00	0.000E+00	0.000E+00	1	0	5.039E-01	-1.460E-01	8.513E-01	1.502E+00	1.000E+00	0.000E+00
43	0.000E+00	0.000E+00	0.000E+00	1	0	6.080E-01	5.487E-01	5.738E-01	5.971E+00	1.000E+00	0.000E+00
44	0.000E+00	0.000E+00	0.000E+00	1	0	-2.932E-01	9.304E-01	-2.199E-01	1.827E+00	1.000E+00	0.000E+00
45	0.000E+00	0.000E+00	0.000E+00	1	0	-8.475E-01	-3.993E-01	-3.497E-01	1.928E+00	1.000E+00	0.000E+00
46	0.000E+00	0.000E+00	0.000E+00	1	0	1.200E-01	-9.195E-01	-3.743E-01	1.351E+00	1.000E+00	0.000E+00
47	0.000E+00	0.000E+00	0.000E+00	1	0	7.085E-01	5.879E-01	3.904E-01	2.288E+00	1.000E+00	0.000E+00
48	0.000E+00	0.000E+00	0.000E+00	1	0	4.261E-01	9.046E-01	9.254E-03	1.230E+00	1.000E+00	0.000E+00
49	0.000E+00	0.000E+00	0.000E+00	1	0	5.431E-01	4.270E-01	-7.230E-01	1.433E+00	1.000E+00	0.000E+00
50	0.000E+00	0.000E+00	0.000E+00	1	0	-1.053E-01	-9.805E-01	1.658E-01	6.572E-01	1.000E+00	0.000E+00

lestimated keff results by cycle print table 175

source distribution written to file s69a1s cycle = 20

source distribution written to file s69a1s cycle = 32

source distribution written to file s69a1s cycle = 44

source distribution written to file s69a1s cycle = 56

```
source distribution written to file s69a1s          cycle =    67

source distribution written to file s69a1s          cycle =    79

source distribution written to file s69a1s          cycle =    90

 estimator      cycle   100   ave of    80 cycles      combination          simple average     combined average      corr
k(collision)       0.991674        0.994665 0.0020    k(col/abs)          0.994264 0.0015     0.994091 0.0015    0.4317
k(absorption)      0.995177        0.993863 0.0016    k(abs/tk ln)        0.994159 0.0016     0.994024 0.0015    0.4326
k(trk length)      0.992363        0.994456 0.0021    k(tk ln/col)        0.994560 0.0021     0.994756 0.0021    0.9919
rem life(col)    2.9347E+03      2.9624E+03 0.0036    k(col/abs/tk ln)    0.994328 0.0017     0.994170 0.0015
rem life(abs)    2.9698E+03      2.9687E+03 0.0022    life(col/abs)     2.9655E+03 0.0028   2.9727E+03 0.0018    0.8987
source points generated   3978

source distribution written to file s69a1s          cycle =   102

source distribution written to file s69a1s          cycle =   114

 estimator      cycle   116   ave of    96 cycles      combination          simple average     combined average      corr
k(collision)       0.990348        0.993893 0.0019    k(col/abs)          0.993702 0.0014     0.993595 0.0013    0.4458
k(absorption)      0.985722        0.993511 0.0014    k(abs/tk ln)        0.993566 0.0014     0.993534 0.0013    0.4427
k(trk length)      0.993287        0.993621 0.0019    k(tk ln/col)        0.993757 0.0019     0.993968 0.0019    0.9910
rem life(col)    2.9433E+03      2.9614E+03 0.0033    k(col/abs/tk ln)    0.993675 0.0015     0.993637 0.0013
rem life(abs)    2.9479E+03      2.9673E+03 0.0021    life(col/abs)     2.9644E+03 0.0026   2.9714E+03 0.0018    0.9079
source points generated   3977

 estimator      cycle   117   ave of    97 cycles      combination          simple average     combined average      corr
k(collision)       0.995541        0.993910 0.0019    k(col/abs)          0.993739 0.0014     0.993643 0.0013    0.4458
k(absorption)      0.998962        0.993567 0.0014    k(abs/tk ln)        0.993612 0.0014     0.993586 0.0013    0.4430
k(trk length)      0.997061        0.993656 0.0019    k(tk ln/col)        0.993783 0.0019     0.993981 0.0019    0.9909
rem life(col)    3.0025E+03      2.9619E+03 0.0033    k(col/abs/tk ln)    0.993711 0.0015     0.993685 0.0013
rem life(abs)    2.9791E+03      2.9675E+03 0.0021    life(col/abs)     2.9647E+03 0.0026   2.9713E+03 0.0018    0.9077
source points generated   3973

 estimator      cycle   118   ave of    98 cycles      combination          simple average     combined average      corr
k(collision)       0.974978        0.993717 0.0019    k(col/abs)          0.993663 0.0014     0.993633 0.0013    0.4399
k(absorption)      0.997738        0.993609 0.0013    k(abs/tk ln)        0.993539 0.0014     0.993579 0.0013    0.4374
k(trk length)      0.975193        0.993468 0.0019    k(tk ln/col)        0.993593 0.0019     0.993783 0.0019    0.9910
rem life(col)    2.8824E+03      2.9610E+03 0.0032    k(col/abs/tk ln)    0.993598 0.0015     0.993675 0.0013
rem life(abs)    2.9315E+03      2.9671E+03 0.0020    life(col/abs)     2.9641E+03 0.0026   2.9713E+03 0.0017    0.9079
source points generated   3923

 estimator      cycle   119   ave of    99 cycles      combination          simple average     combined average      corr
k(collision)       0.987840        0.993658 0.0019    k(col/abs)          0.993695 0.0014     0.993716 0.0013    0.4348
k(absorption)      1.005781        0.993732 0.0013    k(abs/tk ln)        0.993584 0.0014     0.993668 0.0013    0.4338
k(trk length)      0.990288        0.993436 0.0019    k(tk ln/col)        0.993547 0.0019     0.993710 0.0019    0.9909
rem life(col)    2.9706E+03      2.9611E+03 0.0032    k(col/abs/tk ln)    0.993609 0.0015     0.993760 0.0013
rem life(abs)    2.9833E+03      2.9673E+03 0.0020    life(col/abs)     2.9642E+03 0.0026   2.9715E+03 0.0017    0.9078
source points generated   3978

 estimator      cycle   120   ave of   100 cycles      combination          simple average     combined average      corr
k(collision)       1.008208        0.993803 0.0018    k(col/abs)          0.993786 0.0013     0.993777 0.0013    0.4355
k(absorption)      0.997434        0.993769 0.0013    k(abs/tk ln)        0.993666 0.0014     0.993725 0.0013    0.4346
k(trk length)      1.006200        0.993563 0.0019    k(tk ln/col)        0.993683 0.0019     0.993849 0.0019    0.9909
rem life(col)    2.9760E+03      2.9613E+03 0.0032    k(col/abs/tk ln)    0.993712 0.0015     0.993820 0.0013
rem life(abs)    2.9972E+03      2.9676E+03 0.0020    life(col/abs)     2.9644E+03 0.0025   2.9719E+03 0.0017    0.9073
source points generated   4045

 source distribution written to file s69a1s          cycle =   120
1problem summary
```

run terminated when 120 kcode cycles were done.

1 12/21/99 15:34:45

Al Sphere with UO2F2 water solut. V=69L, unrefl., fwU235=4.89, H/U235 = 524 probid = 12/21/99 15:23:51

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	479719	1.0006E+00	2.0293E+00	escape	137203	2.7019E-01	3.1912E-01
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	2.2412E-02	1.4583E-07	weight cutoff	342706	2.2227E-02	1.3979E-07
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	1.4348E-07	downscattering	0	0.	1.6690E+00
				capture	0	3.2118E-01	1.9522E-02
(n,xn)	380	6.4671E-04	4.6574E-04	loss to (n,xn)	190	3.2335E-04	2.6913E-03
fission	0	0.	0.	loss to fission	0	4.0973E-01	1.9461E-02
total	480099	1.0236E+00	2.0298E+00	total	480099	1.0236E+00	2.0298E+00

number of neutrons banked	190	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0008E+00	escape	4.4308E+02	tco	1.0000E+34
neutron collisions per source particle	4.6358E+01	capture	3.9201E+03	eco	0.0000E+00
total neutron collisions	22238584	capture or escape	2.9817E+03	wc1	-5.0000E-01
net multiplication	1.0003E+00 0.0001	any termination	3.0250E+03	wc2	-2.5000E-01

computer time so far in this run	10.89 minutes	maximum number ever in bank	1
computer time in mcrun	10.88 minutes	bank overflows to backup file	0
source particles per minute	4.4078E+04	field length	0
random numbers generated	255684430	most random numbers used was	5397 in history 113746

range of sampled source weights = 7.7549E-01 to 1.1114E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	1	487025	479909	22214118	3.6820E+01	3.1044E-04	6.6968E-01	8.8114E-01	1.6088E+00
2	2	144526	139772	24466	4.9105E-02	1.3521E-03	1.0802E+00	9.4420E-01	8.0553E+00
total		631551	619681	22238584	3.6870E+01				

1keff results for: Al Sphere with UO2F2 water solut. V=69L, unrefl., fwU235=4.89, H/U235 = 524 probid = 12/21/99 15:23:51

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 80114 neutron histories and 100 active cycles with 399605 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 479719 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
warning. the k(absorption) cycle values do not appear normally distributed at the 99 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

the final estimated combined collision/absorption/track-length keff = 0.99382 with an estimated standard deviation of 0.00127

the estimated 68, 95, & 99 percent keff confidence intervals are 0.99255 to 0.99509, 0.99129 to 0.99635, and 0.99047 to 0.99718

the estimated collision/absorption neutron removal lifetime = 2.97E-05 seconds with an estimated standard deviation of 5.09E-08

the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.99380	0.00184	0.99196 to 0.99564	0.99014 to 0.99746	0.98895 to 0.99866	
absorption	0.99377	0.00131	0.99246 to 0.99508	0.99116 to 0.99638	0.99031 to 0.99723	
track length	0.99356	0.00186	0.99170 to 0.99543	0.98986 to 0.99727	0.98865 to 0.99848	
col/absorp	0.99378	0.00126	0.99252 to 0.99504	0.99127 to 0.99628	0.99045 to 0.99710	0.4355
abs/trk len	0.99373	0.00126	0.99246 to 0.99499	0.99121 to 0.99624	0.99039 to 0.99706	0.4346
col/trk len	0.99385	0.00185	0.99199 to 0.99571	0.99015 to 0.99754	0.98895 to 0.99875	0.9909
col/abs/trk len	0.99382	0.00127	0.99255 to 0.99509	0.99129 to 0.99635	0.99047 to 0.99718	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.99421	0.00186	0.99234 to 0.99607	0.99049 to 0.99792	0.98928 to 0.99913
absorption	0.99403	0.00132	0.99271 to 0.99535	0.99139 to 0.99666	0.99053 to 0.99752
track length	0.99400	0.00189	0.99211 to 0.99590	0.99023 to 0.99777	0.98900 to 0.99900
col/abs/trk len	0.99414	0.00129	0.99285 to 0.99542	0.99157 to 0.99670	0.99073 to 0.99754

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	2.9719E-05	5.0863E-08	2.9668E-05 to 2.9770E-05	2.9617E-05 to 2.9820E-05	2.9584E-05 to 2.9853E-05
capture	3.9183E-05	6.3916E-08	3.9119E-05 to 3.9247E-05	3.9055E-05 to 3.9310E-05	3.9014E-05 to 3.9352E-05
fission	4.4509E-05	6.5339E-08	4.4443E-05 to 4.4574E-05	4.4379E-05 to 4.4639E-05	4.4336E-05 to 4.4681E-05
escape	4.4203E-06	3.8884E-08	4.3814E-06 to 4.4593E-06	4.3429E-06 to 4.4978E-06	4.3176E-06 to 4.5231E-06

average individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/trk	average k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.9938	0.0018	0.9938	0.0013	0.9936	0.0019	95/no/95	0.99382	0.00127	0.99129-0.99635	0.99047-0.99718
2	50	0.9938	0.0019	0.9938	0.0014	0.9936	0.0019	95/95/95	0.99387	0.00132	0.99121-0.99653	0.99032-0.99742
4	25	0.9938	0.0023	0.9938	0.0014	0.9936	0.0023	95/95/95	0.99357	0.00148	0.99051-0.99663	0.98941-0.99773
5	20	0.9938	0.0023	0.9938	0.0016	0.9936	0.0023	95/95/95	0.99391	0.00165	0.99044-0.99738	0.98914-0.99868
10	10	0.9938	0.0020	0.9938	0.0016	0.9936	0.0020	95/95/95	0.99386	0.00159	0.99009-0.99763	0.98828-0.99943
20	5	0.9938	0.0023	0.9938	0.0015	0.9936	0.0023	95/95/95	0.98884	0.00392	0.97196-1.00572	0.94990-1.02778
25	4	0.9938	0.0026	0.9938	0.0011	0.9936	0.0028	95/95/95	0.99311	0.00182	0.97004-1.01619	0.87753-1.10869

individual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	1.31767	1.31711	1.31373									

2	5158	1.18798	1.17979	1.18991							
3	3601	1.08129	1.09581	1.08205							
4	3599	1.02271	1.02145	1.01667							
5	3741	1.05063	1.00284	1.05056							
6	4160	0.98054	0.99709	0.97737							
7	3715	1.01562	1.00433	1.01301							
8	4255	1.01396	1.01742	1.00784							
9	4008	0.97064	0.98651	0.96838							
10	3861	0.98534	1.00920	0.98623							
11	3940	0.98943	1.00624	0.99156							
12	4047	1.00198	0.98525	1.00554							
13	4015	0.97777	0.99863	0.97725							
14	3980	0.96636	1.01925	0.96464							
15	3956	0.97688	1.02998	0.97672							
16	4116	1.00130	0.99214	1.00626							
17	3990	1.00780	1.02155	1.00358							
18	3969	1.00585	0.97131	1.00857							
19	4021	1.00020	0.99391	0.99788							
20	3982	0.96746	0.98604	0.95896							
		begin active keff cycles									
21	3878	0.97697	1.00551	0.97402							
22	4006	0.99252	1.00340	0.99280	0.98474	0.00777	1.00446	0.00105	0.98341	0.00939	
23	4060	1.01541	0.99095	1.01325	0.99497	0.01116	0.99995	0.00454	0.99336	0.01133	
24	4012	0.98840	0.98935	0.99242	0.99332	0.00806	0.99730	0.00416	0.99312	0.00801	0.99592 0.00285 339933
25	3910	1.03154	0.99927	1.03003	1.00097	0.00987	0.99770	0.00325	1.00050	0.00964	0.99755 0.00296 251304
26	4049	0.98072	0.98671	0.98241	0.99759	0.00874	0.99587	0.00322	0.99749	0.00843	0.99591 0.00287 223177
27	3660	0.97371	0.97838	0.97357	0.99418	0.00813	0.99337	0.00370	0.99407	0.00790	0.99324 0.00395 101678
28	3924	1.00967	1.00609	1.01218	0.99612	0.00731	0.99496	0.00357	0.99633	0.00721	0.99523 0.00413 81423
29	4191	0.96972	0.98488	0.97127	0.99318	0.00708	0.99384	0.00334	0.99355	0.00694	0.99421 0.00379 85218
30	3848	0.97017	0.99174	0.96820	0.99088	0.00674	0.99363	0.00300	0.99101	0.00671	0.99374 0.00337 97415
31	4093	0.94713	0.98203	0.94514	0.98691	0.00728	0.99257	0.00291	0.98684	0.00736	0.99305 0.00332 91490
32	3993	0.97307	0.95855	0.97108	0.98575	0.00674	0.98974	0.00389	0.98553	0.00685	0.98965 0.00434 48572
33	4005	0.99677	0.99117	0.99533	0.98660	0.00626	0.98985	0.00358	0.98628	0.00634	0.98989 0.00397 53657
34	4148	0.97573	0.98527	0.97505	0.98582	0.00585	0.98952	0.00333	0.98548	0.00593	0.98958 0.00369 57364
35	3853	0.98960	0.97692	0.99091	0.98607	0.00545	0.98868	0.00321	0.98584	0.00553	0.98855 0.00348 60348
36	4027	0.97492	0.98689	0.97856	0.98538	0.00514	0.98857	0.00300	0.98539	0.00519	0.98830 0.00325 64851
37	3929	1.00144	1.00305	1.00158	0.98632	0.00492	0.98942	0.00295	0.98634	0.00497	0.98917 0.00318 63952
38	4147	0.99732	0.99441	0.99600	0.98693	0.00468	0.98970	0.00279	0.98688	0.00472	0.98950 0.00300 67796
39	4001	1.00832	0.99911	1.00796	0.98806	0.00457	0.99019	0.00269	0.98799	0.00460	0.99009 0.00287 70078
40	4126	1.01671	1.00541	1.01534	0.98949	0.00457	0.99096	0.00266	0.98935	0.00457	0.99092 0.00283 68277
41	4048	1.02470	0.99788	1.02195	0.99117	0.00466	0.99129	0.00255	0.99091	0.00462	0.99120 0.00271 70902
42	4012	1.00270	0.98202	1.00077	0.99169	0.00447	0.99086	0.00247	0.99136	0.00442	0.99082 0.00263 71560
43	3922	0.98098	0.97976	0.97903	0.99123	0.00430	0.99038	0.00241	0.99082	0.00426	0.99041 0.00258 71323
44	3911	1.03445	1.00748	1.03773	0.99303	0.00449	0.99109	0.00241	0.99277	0.00452	0.99116 0.00253 70912
45	4213	0.96570	0.99392	0.96655	0.99194	0.00444	0.99121	0.00232	0.99172	0.00446	0.99132 0.00241 74981
46	3643	0.99775	1.00439	1.00072	0.99216	0.00428	0.99171	0.00228	0.99207	0.00430	0.99179 0.00234 76780
47	4113	0.97808	0.99285	0.97752	0.99164	0.00415	0.99176	0.00220	0.99153	0.00418	0.99186 0.00225 79923
48	3808	0.98818	0.99259	0.98583	0.99151	0.00400	0.99179	0.00212	0.99133	0.00403	0.99196 0.00218 82703
49	4043	1.01409	1.01054	1.01075	0.99229	0.00394	0.99243	0.00214	0.99200	0.00394	0.99256 0.00224 75498
50	4070	1.02177	0.99154	1.02195	0.99328	0.00393	0.99240	0.00207	0.99300	0.00394	0.99249 0.00216 78223
51	3987	1.02040	0.99220	1.02090	0.99415	0.00390	0.99240	0.00200	0.99390	0.00392	0.99246 0.00209 80684
52	4049	1.02817	0.99716	1.02478	0.99521	0.00392	0.99254	0.00195	0.99486	0.00391	0.99255 0.00205 81296
53	4122	1.02426	0.99403	1.02325	0.99609	0.00390	0.99259	0.00189	0.99572	0.00389	0.99257 0.00200 82699
54	3965	1.01224	0.99682	1.01774	0.99657	0.00381	0.99271	0.00183	0.99637	0.00383	0.99264 0.00193 86337
55	3912	1.01582	0.98156	1.01656	0.99712	0.00374	0.99240	0.00181	0.99695	0.00376	0.99240 0.00192 84387
56	3967	0.98061	0.94582	0.97881	0.99666	0.00367	0.99110	0.00218	0.99644	0.00369	0.99174 0.00231 56851
57	3804	0.98237	0.98497	0.98170	0.99627	0.00359	0.99094	0.00213	0.99604	0.00361	0.99154 0.00225 58399
58	4098	0.99645	0.99634	1.00071	0.99628	0.00349	0.99108	0.00208	0.99617	0.00352	0.99160 0.00218 60558

59	4105	0.97592	0.96579	0.97584	0.99576	0.00344	0.99043	0.00213	0.99565	0.00346	0.99101	0.00223	56111
60	3811	0.99295	0.99912	0.99429	0.99569	0.00335	0.99065	0.00208	0.99561	0.00338	0.99120	0.00217	57814
61	4075	0.98633	0.98221	0.98670	0.99546	0.00328	0.99044	0.00204	0.99539	0.00330	0.99098	0.00213	58578
62	3957	1.01561	1.00434	1.01700	0.99594	0.00324	0.99077	0.00202	0.99591	0.00326	0.99127	0.00211	58247
63	4140	1.01008	1.01014	1.01137	0.99627	0.00318	0.99122	0.00202	0.99627	0.00320	0.99171	0.00211	57223
64	3949	0.98894	0.99445	0.99138	0.99610	0.00311	0.99130	0.00198	0.99616	0.00313	0.99171	0.00205	58894
65	3941	0.99847	1.00486	1.00158	0.99615	0.00304	0.99160	0.00196	0.99628	0.00307	0.99194	0.00202	59738
66	3991	0.98466	1.01889	0.98493	0.99590	0.00298	0.99219	0.00200	0.99603	0.00301	0.99266	0.00201	58902
67	3937	0.99120	0.99863	0.99156	0.99580	0.00292	0.99233	0.00197	0.99594	0.00294	0.99276	0.00196	60387
68	4077	1.01938	1.01107	1.01445	0.99629	0.00290	0.99272	0.00196	0.99632	0.00291	0.99329	0.00198	57907
69	4123	1.01869	0.99288	1.02154	0.99675	0.00288	0.99272	0.00192	0.99684	0.00289	0.99332	0.00195	58429
70	3937	0.99043	0.98895	0.99242	0.99663	0.00282	0.99265	0.00189	0.99675	0.00284	0.99322	0.00192	59402
71	3878	0.97619	0.98337	0.97529	0.99622	0.00280	0.99246	0.00186	0.99633	0.00281	0.99298	0.00189	60262
72	3761	0.99555	1.00087	0.99708	0.99621	0.00274	0.99263	0.00183	0.99634	0.00276	0.99311	0.00185	61401
73	4109	0.98337	0.99418	0.97830	0.99597	0.00270	0.99266	0.00179	0.99600	0.00273	0.99316	0.00181	63274
74	4025	1.03141	1.00923	1.03097	0.99663	0.00273	0.99296	0.00179	0.99665	0.00275	0.99345	0.00182	61289
75	4142	0.97967	0.99597	0.97657	0.99632	0.00270	0.99302	0.00175	0.99628	0.00273	0.99349	0.00178	62969
76	3928	0.98347	0.97809	0.98105	0.99609	0.00266	0.99275	0.00174	0.99601	0.00269	0.99326	0.00176	62782
77	4008	0.98508	0.97778	0.98503	0.99589	0.00262	0.99249	0.00173	0.99582	0.00265	0.99302	0.00175	62388
78	4007	0.99401	0.97459	0.99559	0.99586	0.00257	0.99218	0.00173	0.99582	0.00261	0.99278	0.00175	61355
79	4053	0.97760	0.99035	0.97384	0.99555	0.00255	0.99215	0.00170	0.99544	0.00259	0.99274	0.00172	62683
80	3861	1.00169	1.01067	1.00006	0.99566	0.00251	0.99246	0.00170	0.99552	0.00255	0.99305	0.00171	62089
81	4052	1.02678	0.99192	1.02287	0.99617	0.00252	0.99245	0.00167	0.99597	0.00254	0.99311	0.00170	62138
82	4140	0.98977	0.99071	0.98887	0.99606	0.00248	0.99242	0.00165	0.99585	0.00250	0.99307	0.00167	63158
83	3797	0.98786	1.02004	0.98681	0.99593	0.00244	0.99286	0.00168	0.99571	0.00247	0.99353	0.00167	62151
84	4016	1.01162	1.01726	1.01525	0.99618	0.00242	0.99324	0.00169	0.99602	0.00245	0.99393	0.00167	61046
85	4078	1.00504	1.01610	1.00282	0.99631	0.00238	0.99359	0.00170	0.99612	0.00241	0.99427	0.00168	59720
86	3981	0.99880	0.99790	1.00119	0.99635	0.00235	0.99366	0.00168	0.99620	0.00238	0.99431	0.00165	60799
87	3972	1.00789	1.01594	1.00858	0.99652	0.00232	0.99399	0.00169	0.99638	0.00235	0.99464	0.00165	59953
88	4180	0.97267	0.98623	0.96722	0.99617	0.00231	0.99388	0.00167	0.99595	0.00235	0.99452	0.00163	60395
89	3955	0.98462	0.99329	0.98492	0.99601	0.00228	0.99387	0.00164	0.99579	0.00232	0.99447	0.00161	61425
90	4093	0.98244	0.98569	0.97797	0.99581	0.00226	0.99375	0.00162	0.99554	0.00231	0.99439	0.00159	61854
91	3893	0.99186	1.00448	0.99284	0.99576	0.00223	0.99390	0.00161	0.99550	0.00227	0.99449	0.00157	62847
92	4088	0.98205	1.00214	0.98424	0.99557	0.00220	0.99402	0.00159	0.99534	0.00225	0.99452	0.00154	64162
93	3925	0.98657	1.00356	0.98500	0.99544	0.00218	0.99415	0.00157	0.99520	0.00222	0.99461	0.00152	64943
94	3926	0.99109	0.97710	0.98919	0.99538	0.00215	0.99392	0.00157	0.99512	0.00219	0.99446	0.00151	64730
95	4112	0.99779	0.99118	0.99685	0.99542	0.00212	0.99388	0.00155	0.99514	0.00216	0.99445	0.00149	65490
96	3981	0.97884	1.01353	0.97756	0.99520	0.00210	0.99414	0.00155	0.99491	0.00215	0.99461	0.00148	65882
97	4037	0.98746	1.00792	0.98853	0.99510	0.00208	0.99432	0.00154	0.99483	0.00212	0.99472	0.00146	66733
98	4024	0.96720	0.95272	0.97088	0.99474	0.00208	0.99378	0.00161	0.99452	0.00211	0.99414	0.00153	59886
99	3938	0.99190	0.99873	0.99133	0.99470	0.00206	0.99385	0.00159	0.99448	0.00209	0.99417	0.00151	60670
100	4044	0.99167	0.99518	0.99236	0.99467	0.00203	0.99386	0.00157	0.99446	0.00206	0.99417	0.00149	61530
101	3978	0.99044	0.98525	0.99578	0.99461	0.00201	0.99376	0.00155	0.99447	0.00204	0.99404	0.00147	62206
102	3942	1.00987	1.00568	1.00851	0.99480	0.00199	0.99390	0.00154	0.99464	0.00202	0.99419	0.00147	62179
103	3967	0.97530	0.99442	0.97783	0.99456	0.00198	0.99391	0.00152	0.99444	0.00200	0.99412	0.00145	63009
104	3969	0.98551	0.99235	0.98562	0.99446	0.00196	0.99389	0.00151	0.99434	0.00198	0.99407	0.00143	63768
105	4148	0.98868	0.99483	0.99392	0.99439	0.00194	0.99390	0.00149	0.99433	0.00196	0.99405	0.00141	64658
106	3982	1.00233	0.99501	0.99805	0.99448	0.00192	0.99391	0.00147	0.99437	0.00194	0.99409	0.00140	65281
107	4030	0.94696	0.98645	0.94596	0.99393	0.00197	0.99383	0.00146	0.99382	0.00199	0.99388	0.00140	64635
108	3733	0.99055	0.98763	0.98690	0.99390	0.00195	0.99376	0.00144	0.99374	0.00197	0.99383	0.00138	65224
109	4141	0.95297	0.97873	0.95085	0.99344	0.00198	0.99359	0.00143	0.99326	0.00201	0.99361	0.00139	63967
110	3776	1.01267	1.00202	1.01093	0.99365	0.00197	0.99368	0.00142	0.99345	0.00200	0.99372	0.00138	64132
111	4334	1.03179	1.00472	1.02997	0.99407	0.00199	0.99380	0.00141	0.99385	0.00201	0.99390	0.00138	63443
112	4100	0.99997	0.99181	1.00112	0.99413	0.00197	0.99378	0.00140	0.99393	0.00199	0.99390	0.00136	64196
113	4002	0.98972	0.99181	0.98458	0.99409	0.00195	0.99376	0.00138	0.99383	0.00198	0.99388	0.00135	64674
114	3976	0.99339	0.97402	0.99345	0.99408	0.00193	0.99355	0.00138	0.99383	0.00195	0.99372	0.00135	64313

115	4057	0.98005	0.99749	0.97437	0.99393	0.00192	0.99359	0.00137	0.99362	0.00194	0.99373 0.00133	64733
116	4025	0.99035	0.98572	0.99329	0.99389	0.00190	0.99351	0.00136	0.99362	0.00192	0.99364 0.00132	65390
117	3977	0.99554	0.99896	0.99706	0.99391	0.00188	0.99357	0.00134	0.99366	0.00190	0.99369 0.00131	66122
118	3973	0.97498	0.99774	0.97519	0.99372	0.00187	0.99361	0.00133	0.99347	0.00189	0.99367 0.00129	66878
119	3923	0.98784	1.00578	0.99029	0.99366	0.00185	0.99373	0.00132	0.99344	0.00188	0.99376 0.00128	67499
120	3978	1.00821	0.99743	1.00620	0.99380	0.00184	0.99377	0.00131	0.99356	0.00186	0.99382 0.00127	67932

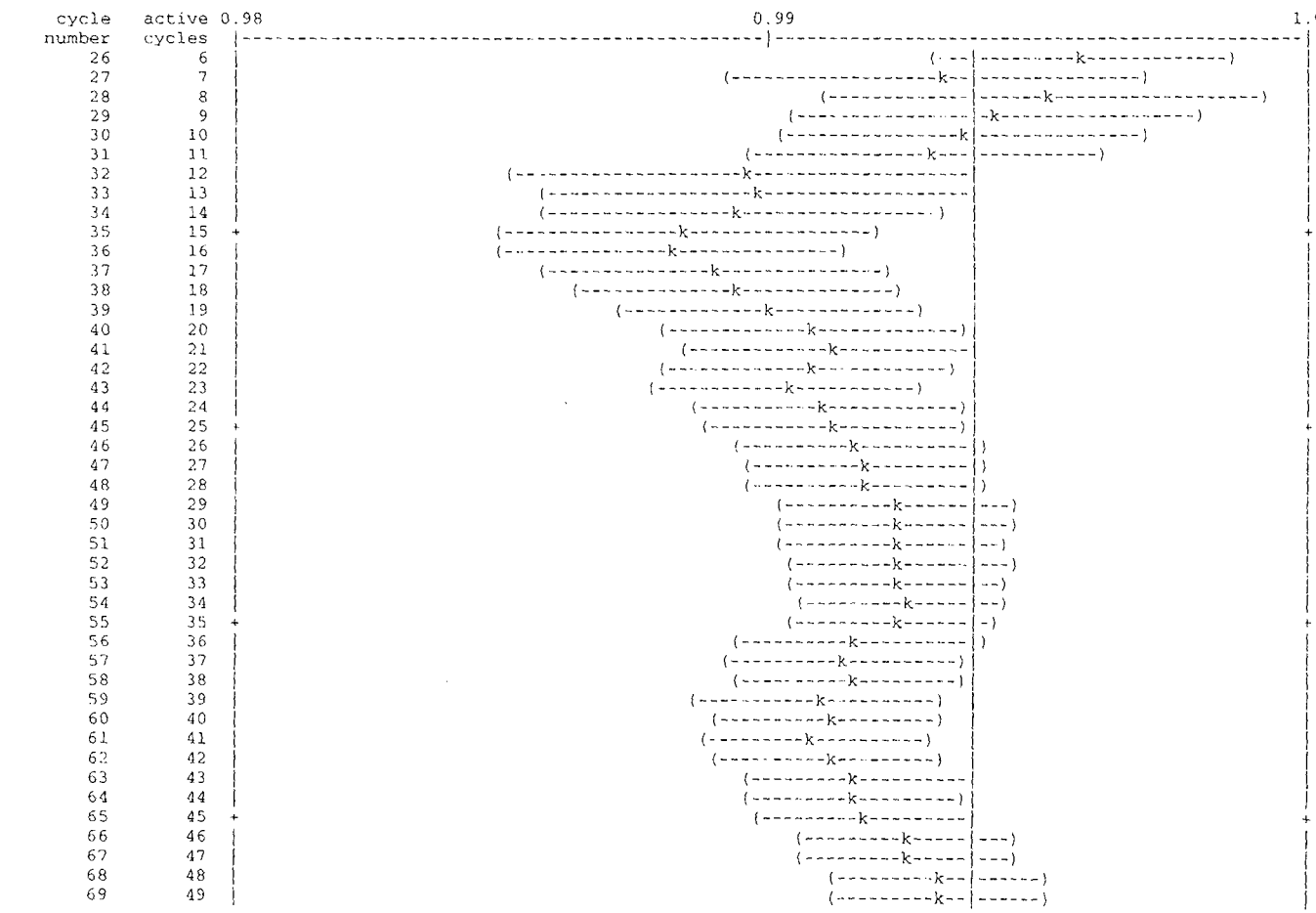
the largest active cycle keffs by estimator are:

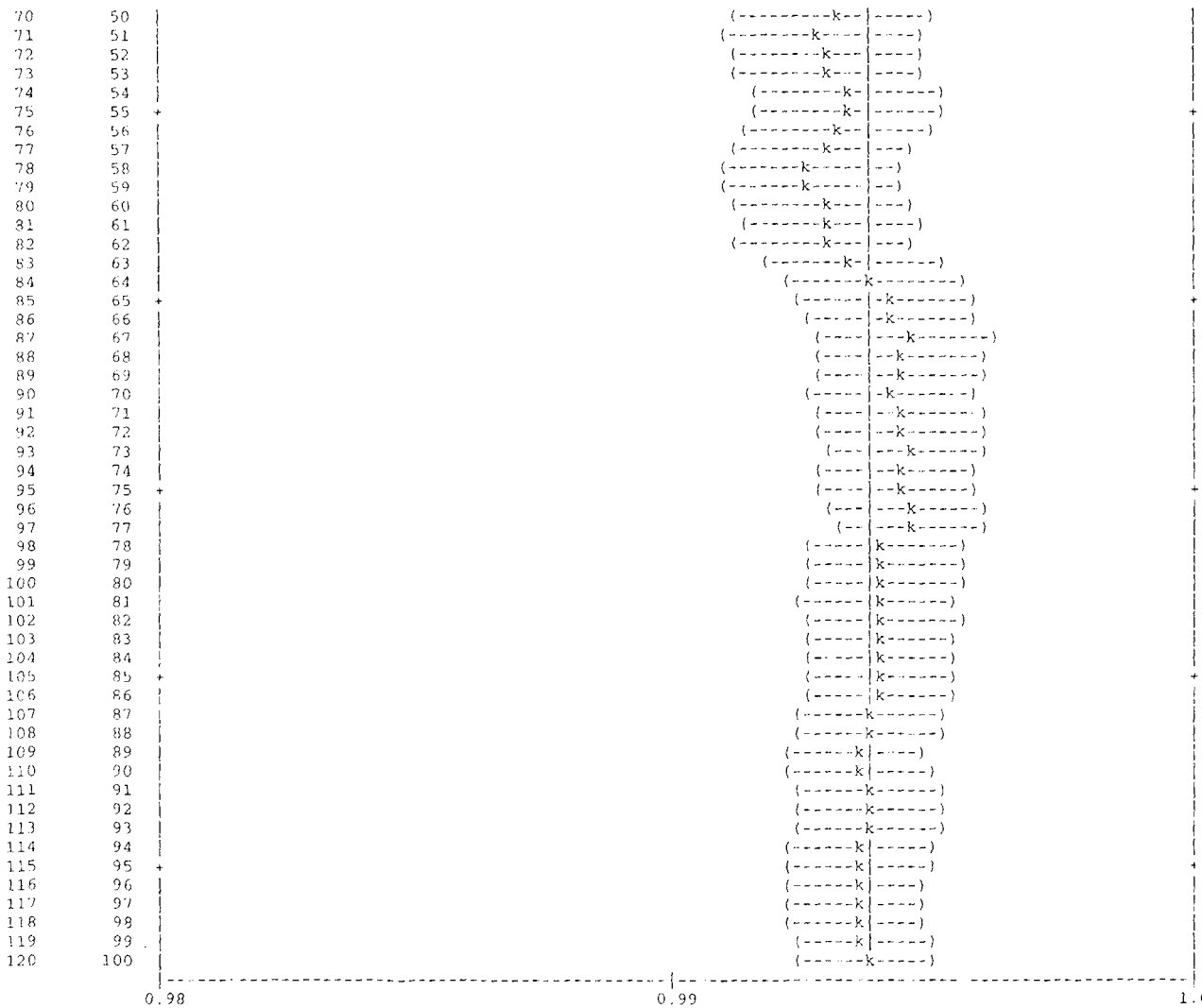
collision 1.03445 on cycle 44
absorption 1.02004 on cycle 83
track length 1.03773 on cycle 44

the smallest active cycle keffs by estimator are:

collision 0.94696 on cycle 107
absorption 0.94582 on cycle 56
track length 0.94514 on cycle 31

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.99382)





lindividual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	479719	0.9992 0.0036	1.0001 0.0034	0.9988 0.0036	no/no/no	0.99952 0.00346	0.99263-1.00640	0.99038-1.00865
1	119	475719	0.9965 0.0025	0.9974 0.0022	0.9961 0.0025	no/no/no	0.99735 0.00216	0.99305-1.00165	0.99165-1.00305
2	118	470561	0.9949 0.0019	0.9959 0.0015	0.9945 0.0019	no/no/99	0.99556 0.00147	0.99264-0.99849	0.99169-0.99944
3	117	466960	0.9941 0.0018	0.9950 0.0013	0.9937 0.0018	95/99/95	0.99471 0.00121	0.99229-0.99713	0.99151-0.99792

4	116	463361	0.9939	0.0017	0.9948	0.0013	0.9935	0.0018	95/99/95	0.99455	0.00120	0.99216-0.99694	0.99138-0.99772
5	115	459620	0.9934	0.0017	0.9947	0.0013	0.9930	0.0017	95/99/95	0.99434	0.00120	0.99195-0.99672	0.99118-0.99750
6	114	455460	0.9935	0.0017	0.9947	0.0013	0.9932	0.0017	95/99/95	0.99435	0.00120	0.99195-0.99675	0.99117-0.99754
7	113	451745	0.9933	0.0017	0.9946	0.0013	0.9930	0.0017	95/99/95	0.99424	0.00121	0.99183-0.99665	0.99105-0.99744
8	112	447490	0.9931	0.0017	0.9944	0.0013	0.9929	0.0018	95/99/95	0.99409	0.00120	0.99170-0.99648	0.99092-0.99726
9	111	443482	0.9933	0.0017	0.9945	0.0013	0.9931	0.0018	95/99/95	0.99419	0.00120	0.99179-0.99658	0.99100-0.99737
10	110	439621	0.9934	0.0017	0.9944	0.0013	0.9932	0.0018	95/99/95	0.99412	0.00121	0.99170-0.99653	0.99091-0.99732
11	109	435681	0.9934	0.0017	0.9943	0.0013	0.9932	0.0018	95/no/95	0.99405	0.00122	0.99161-0.99649	0.99082-0.99728
12	108	431634	0.9934	0.0018	0.9943	0.0013	0.9931	0.0018	95/no/95	0.99410	0.00124	0.99163-0.99656	0.99083-0.99736
13	107	427619	0.9935	0.0018	0.9943	0.0013	0.9932	0.0018	95/99/95	0.99411	0.00125	0.99162-0.99660	0.99081-0.99741
14	106	423639	0.9938	0.0018	0.9941	0.0013	0.9935	0.0018	95/no/95	0.99403	0.00125	0.99153-0.99652	0.99071-0.99734
15	105	419683	0.9939	0.0018	0.9937	0.0013	0.9936	0.0018	95/99/95	0.99381	0.00125	0.99132-0.99630	0.99051-0.99711
16	104	415567	0.9939	0.0018	0.9937	0.0013	0.9935	0.0018	95/99/95	0.99381	0.00126	0.99129-0.99633	0.99047-0.99715
17	103	411577	0.9937	0.0018	0.9935	0.0013	0.9934	0.0018	95/99/95	0.99361	0.00125	0.99112-0.99610	0.99031-0.99691
18	102	407608	0.9936	0.0018	0.9937	0.0013	0.9933	0.0019	95/no/95	0.99378	0.00125	0.99128-0.99627	0.99047-0.99709
19	101	403587	0.9935	0.0018	0.9937	0.0013	0.9932	0.0019	95/no/95	0.99376	0.00126	0.99124-0.99628	0.99042-0.99710
20	100*	399605	0.9938	0.0018	0.9938	0.0013	0.9936	0.0019	95/no/95	0.99382	0.00127	0.99129-0.99635	0.99047-0.99718
22	98	391721	0.9940	0.0019	0.9936	0.0013	0.9938	0.0019	95/no/95	0.99369	0.00129	0.99112-0.99626	0.99028-0.99710
24	96	383649	0.9938	0.0019	0.9936	0.0014	0.9936	0.0019	95/99/95	0.99373	0.00132	0.99110-0.99635	0.99024-0.99721
26	94	375690	0.9936	0.0019	0.9936	0.0014	0.9933	0.0019	95/99/95	0.99369	0.00134	0.99103-0.99636	0.99017-0.99722
28	92	368106	0.9936	0.0019	0.9937	0.0014	0.9933	0.0019	95/no/95	0.99372	0.00135	0.99104-0.99641	0.99016-0.99728
30	90	360067	0.9941	0.0019	0.9938	0.0014	0.9938	0.0019	95/no/95	0.99395	0.00137	0.99122-0.99667	0.99033-0.99756
32	88	351981	0.9949	0.0019	0.9943	0.0014	0.9947	0.0019	95/no/95	0.99450	0.00133	0.99186-0.99714	0.99099-0.99801
34	86	343828	0.9951	0.0019	0.9945	0.0014	0.9949	0.0019	95/no/95	0.99466	0.00135	0.99197-0.99735	0.99109-0.99822
36	84	335948	0.9954	0.0019	0.9948	0.0014	0.9951	0.0020	95/no/95	0.99500	0.00137	0.99227-0.99772	0.99138-0.99861
38	82	327872	0.9953	0.0020	0.9947	0.0015	0.9950	0.0020	95/no/95	0.99490	0.00140	0.99211-0.99768	0.99120-0.99859
40	80	319745	0.9949	0.0020	0.9945	0.0015	0.9946	0.0020	95/no/95	0.99465	0.00142	0.99183-0.99748	0.99091-0.99840
42	78	311685	0.9944	0.0020	0.9946	0.0015	0.9942	0.0020	95/no/95	0.99460	0.00144	0.99172-0.99747	0.99079-0.99841
44	76	303852	0.9940	0.0020	0.9946	0.0015	0.9938	0.0020	95/no/95	0.99447	0.00144	0.99159-0.99735	0.99065-0.99829
46	74	295996	0.9944	0.0020	0.9945	0.0016	0.9941	0.0020	95/no/95	0.99448	0.00148	0.99154-0.99743	0.99057-0.99839
48	72	288075	0.9947	0.0020	0.9945	0.0016	0.9944	0.0021	95/99/95	0.99461	0.00151	0.99159-0.99763	0.99060-0.99862
50	70	279962	0.9940	0.0020	0.9944	0.0017	0.9938	0.0021	95/99/95	0.99429	0.00153	0.99123-0.99734	0.99022-0.99835
52	68	271926	0.9931	0.0020	0.9943	0.0017	0.9930	0.0020	95/99/95	0.99395	0.00156	0.99084-0.99707	0.98981-0.99809
54	66	263839	0.9924	0.0020	0.9943	0.0018	0.9921	0.0020	99/99/95	0.99360	0.00160	0.99039-0.99680	0.98934-0.99785
56	64	255960	0.9922	0.0020	0.9953	0.0016	0.9919	0.0020	99/95/95	0.99432	0.00157	0.99118-0.99747	0.99015-0.99850
58	62	248058	0.9923	0.0021	0.9954	0.0017	0.9920	0.0021	99/95/95	0.99445	0.00162	0.99121-0.99769	0.99014-0.99876
60	60	240142	0.9925	0.0021	0.9959	0.0016	0.9922	0.0021	99/95/95	0.99491	0.00161	0.99168-0.99814	0.99061-0.99921
62	58	232110	0.9923	0.0021	0.9959	0.0017	0.9919	0.0022	99/95/95	0.99485	0.00165	0.99154-0.99817	0.99044-0.99926
64	56	224021	0.9920	0.0022	0.9957	0.0017	0.9915	0.0022	99/95/95	0.99458	0.00169	0.99118-0.99798	0.99005-0.99911
66	54	216089	0.9920	0.0023	0.9951	0.0017	0.9915	0.0023	99/95/95	0.99421	0.00172	0.99075-0.99766	0.98960-0.99881
68	52	208075	0.9915	0.0023	0.9947	0.0018	0.9910	0.0023	99/95/95	0.99386	0.00174	0.99036-0.99735	0.98920-0.99852
70	50	200015	0.9910	0.0023	0.9949	0.0018	0.9904	0.0024	95/95/95	0.99376	0.00184	0.99006-0.99746	0.98883-0.99869
72	48	192376	0.9912	0.0024	0.9950	0.0019	0.9906	0.0024	95/95/95	0.99387	0.00189	0.99006-0.99768	0.98878-0.99895
74	46	184242	0.9905	0.0023	0.9947	0.0019	0.9899	0.0024	95/95/95	0.99321	0.00190	0.98937-0.99704	0.98808-0.99833
76	44	176172	0.9909	0.0024	0.9951	0.0020	0.9904	0.0024	95/95/95	0.99357	0.00194	0.98964-0.99749	0.98831-0.99882
78	42	168157	0.9910	0.0025	0.9960	0.0020	0.9905	0.0025	95/95/95	0.99445	0.00202	0.99037-0.99854	0.98899-0.99992
80	40	160243	0.9910	0.0026	0.9957	0.0020	0.9906	0.0026	95/95/95	0.99430	0.00205	0.99014-0.99846	0.98873-0.99987
82	38	152051	0.9901	0.0026	0.9960	0.0021	0.9898	0.0026	95/95/95	0.99403	0.00219	0.98957-0.99849	0.98805-1.00001
84	36	144238	0.9896	0.0027	0.9947	0.0021	0.9892	0.0027	95/95/95	0.99319	0.00213	0.98885-0.99752	0.98736-0.99901
86	34	136179	0.9889	0.0028	0.9940	0.0021	0.9885	0.0028	95/95/95	0.99254	0.00216	0.98814-0.99694	0.98661-0.99846
88	32	128027	0.9888	0.0028	0.9935	0.0021	0.9885	0.0028	95/99/95	0.99210	0.00210	0.98779-0.99640	0.98630-0.99790
90	30	119979	0.9891	0.0030	0.9938	0.0022	0.9890	0.0030	95/99/95	0.99243	0.00220	0.98791-0.99694	0.98633-0.99853
92	28	111998	0.9893	0.0032	0.9931	0.0023	0.9890	0.0032	95/99/95	0.99194	0.00230	0.98721-0.99667	0.98554-0.99834
94	26	104147	0.9893	0.0035	0.9934	0.0024	0.9891	0.0034	95/99/95	0.99238	0.00240	0.98741-0.99735	0.98564-0.99912
96	24	96054	0.9894	0.0037	0.9926	0.0024	0.9893	0.0037	95/no/95	0.99211	0.00250	0.98690-0.99731	0.98501-0.99920
98	22	87993	0.9905	0.0039	0.9937	0.0018	0.9902	0.0039	95/95/95	0.99378	0.00189	0.98983-0.99774	0.98838-0.99919
100	20	80011	0.9904	0.0043	0.9934	0.0019	0.9900	0.0043	95/95/95	0.99345	0.00206	0.98910-0.99781	0.98747-0.99944

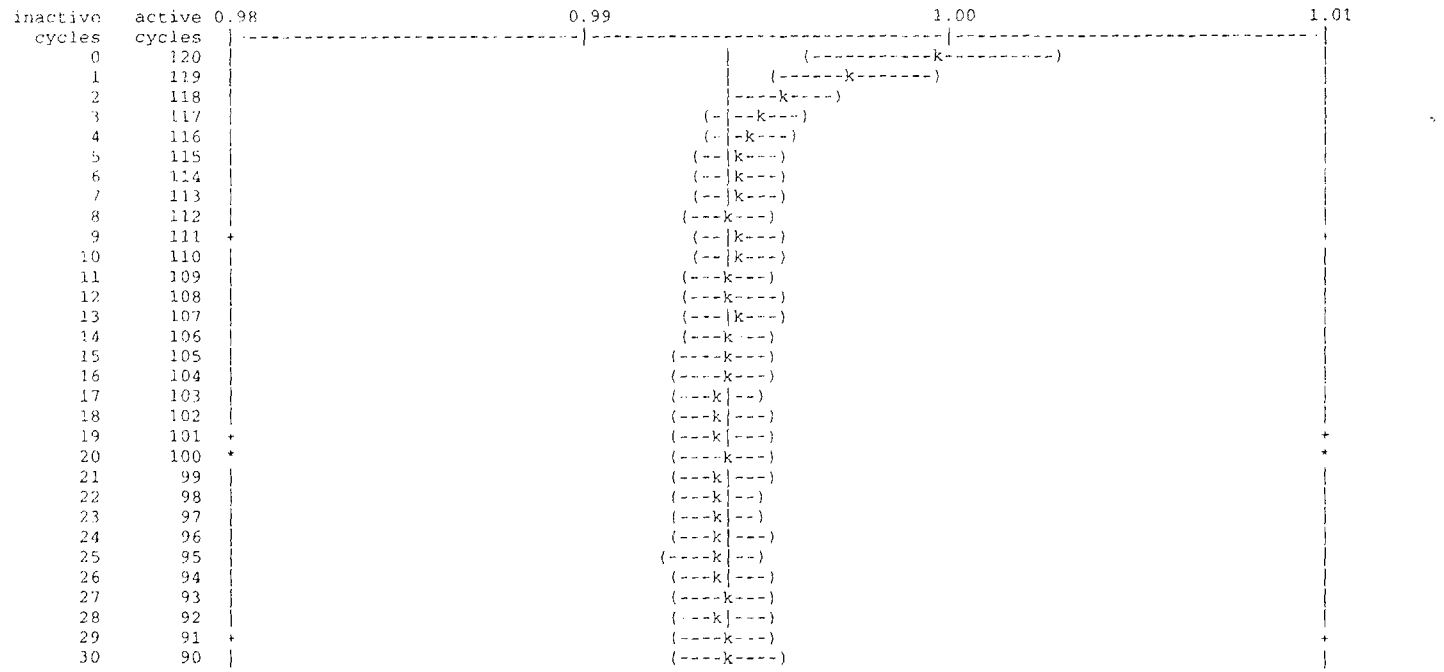
102	18	72091	0.9893	0.0047	0.9932	0.0020	0.9886	0.0047	95/95/95	0.99342	0.00219	0.98874-0.99809	0.98696-0.99988
104	16	64155	0.9904	0.0052	0.9931	0.0022	0.9895	0.0052	95/95/95	0.99335	0.00250	0.98795-0.99875	0.98583-1.00088
106	14	56025	0.9896	0.0059	0.9929	0.0025	0.9886	0.0059	95/95/95	0.99310	0.00301	0.98649-0.99972	0.98377-1.00244
108	12	48262	0.9931	0.0057	0.9939	0.0029	0.9923	0.0058	95/95/95	0.99376	0.00334	0.98621-1.00132	0.98292-1.00461
110	10	40345	0.9952	0.0050	0.9945	0.0030	0.9946	0.0051	95/95/95	0.99452	0.00322	0.98691-1.00213	0.98326-1.00578
112	8	31911	0.9900	0.0035	0.9936	0.0035	0.9893	0.0038	95/95/95	0.99192	0.00286	0.98456-0.99927	0.98038-1.00345
114	6	23933	0.9895	0.0048	0.9972	0.0026	0.9894	0.0051	95/95/95	0.99533	0.00343	0.98442-1.00624	0.97531-1.01535
116	4	15851	0.9916	0.0070	1.0000	0.0020	0.9922	0.0065	95/95/95	0.99930	0.00261	0.96618-1.03243	0.83340-1.16521
117	3	11874	0.9903	0.0097	1.0003	0.0027	0.9906	0.0090					
118	2	7901	0.9980	0.0102	1.0016	0.0042	0.9982	0.0080					

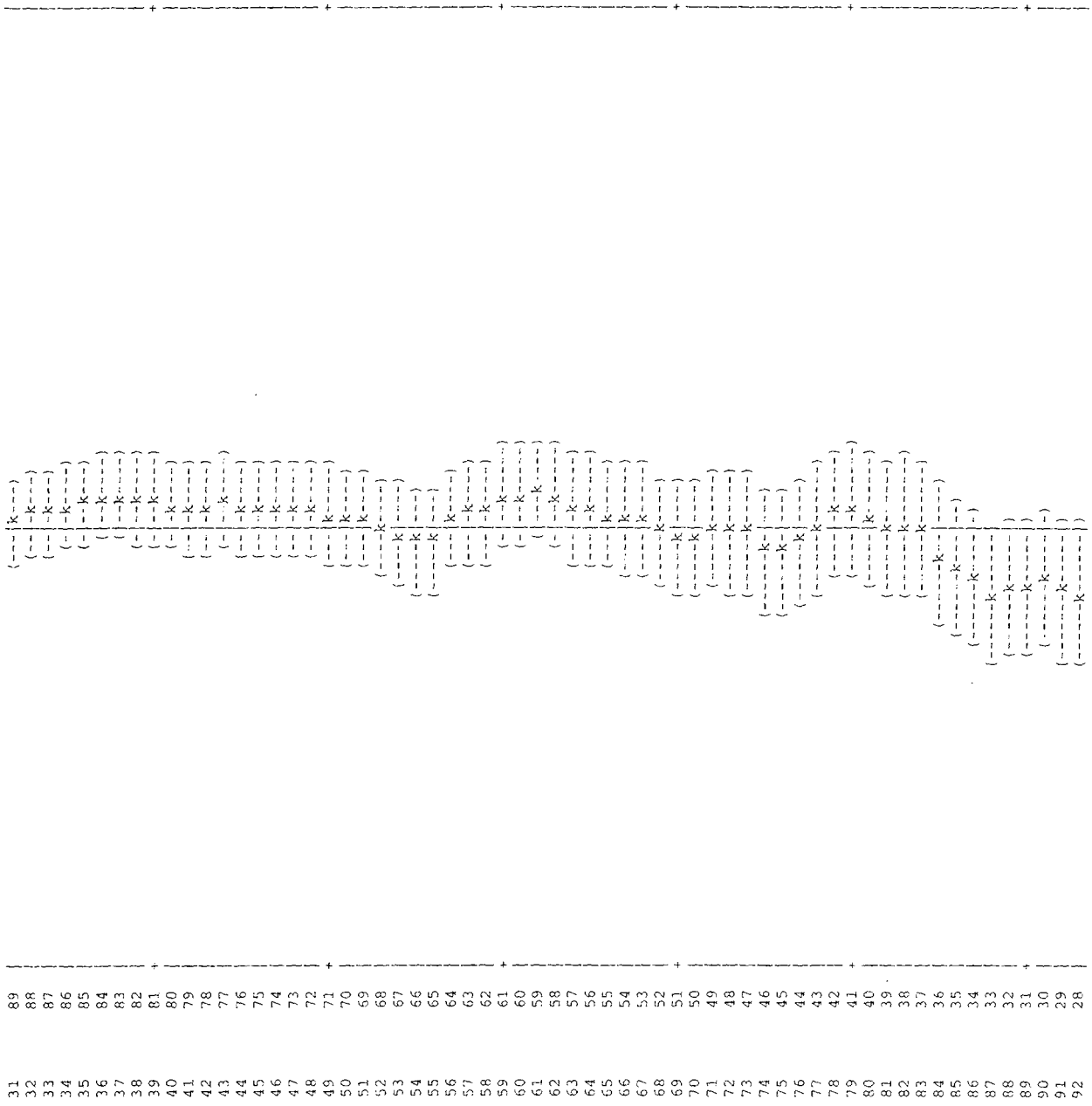
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 5 inactive cycles and 115 active cycles.

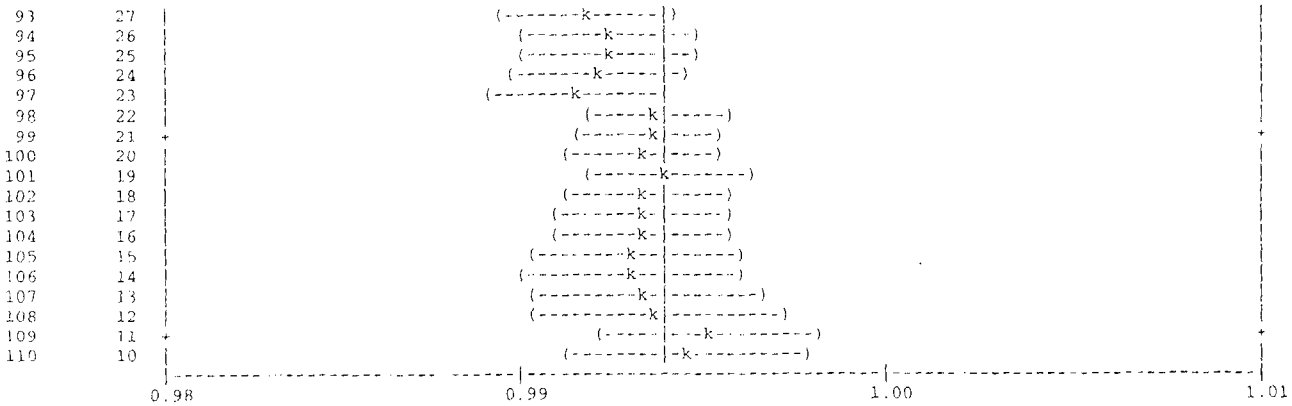
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.99322	0.00192	0.99129 to 0.99515	0.98936 to 0.99708	0.98807 to 0.99837
second half	0.99376	0.00184	0.99191 to 0.99561	0.99006 to 0.99746	0.98883 to 0.99869
final result	0.99382	0.00127	0.99255 to 0.99509	0.99129 to 0.99635	0.99047 to 0.99718

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.99382)







dump no. 2 on file s69a1r nps = 479719 coll = 22238584 ctm = 10.88 nrn = 255684430

3 warning messages so far.

run terminated when 120 kcode cycles were done.

computer time = 10.89 minutes

mcnp version 4a 10/01/93 12/21/99 15:34:45 probid = 12/21/99 15:23:51

Appendix 4

MCNP4A Calculation Method Bias and Bias uncertainty for criticality calculations for low enriched uranium systems

MCNP 4A calculation bias and bias uncertainty for criticality calculations for low enriched uranium systems

MCNP 4A calculation bias and bias uncertainty for criticality calculations for low enriched uranium systems were determined based on the data published in *International Handbook of Evaluated Criticality Safety Benchmark Experiments, Volume IV Low Enriched Uranium Systems*, NEA Nuclear Science Committee, OECD Paris 1995. The publication contains the results of the neutron multiplication factor experimental measurements and associated calculations with Monte Carlo computer codes including MCNP 4A. For every experiment several computer runs were performed. The mean MCNP 4A calculation bias and bias uncertainty for each experiment were defined as in equation 1 and 2 respectively.

$$\Delta k_b = \frac{\sum_{i=1}^{N} (\Delta k_b)_i}{N} = \frac{\sum_{i=1}^{N} ((k_{eff})_{\exp} - (k_{eff})_{MCNPi})}{N} \qquad (1)$$

$$\sigma_b = 2\sqrt{\frac{\sum_{i=1}^{N} (\Delta k_b - (\Delta k_b)_i)^2}{N}} \qquad (2)$$

where
Δk_b = the MCNP 4A calculation method bias for a given experiment
$(\Delta k_b)_i = (k_{eff})_{exp} - (k_{eff})_{MCNP\,i}$ = the MCNP 4A calculation method bias for *i*-calculation
$(k_{eff})_{exp}$ = the effective neutron multiplication factor measured in experiment
$(k_{eff})_{MCNP\,i}$ = the effective neutron multiplication factor predicted by MCNP 4A *i*-calculation
N = total number of MCNP 4A calculations
σ_b = the calculation method bias uncertainty

The positive bias only ($(k_{eff})_{exp} > (k_{eff})_{MCNP\,i}$) was considered. In case $(k_{eff})_{exp} < (k_{eff})_{MCNP\,i}$, the calculation method bias ($(\Delta k_b)_i$) was assumed to be equal to zero.

Tables 1 through 3 show the data necessary for MCNP 4A calculation method bias and bias uncertainty determination. The data in Table 1 is based on report LEU-COMP-THERM-001 *Water-moderated U(2.35)O_2 Fuel Rods in 2.032-cm Square-pitched Arrays*, Table 2 - LEU-COMP-THERM-002 *Water-moderated U(4.31)O_2 Fuel Rods in 2.54-cm Square-pitched Arrays*, and Table 3 - LEU-COMP-THERM-001 *Critical Arrays of Low-Enriched U O_2 Fuel Rods with Water-to-fuel Volume Ratios Ranging from 1.5 to 3.0*. The values of the calculation method bias and bias uncertainty can be found in Table 4.

Table 1 The data necessary for MCNP 4A calculation method bias and bias uncertainty determination based on report LEU-COMP-THERM-001 *Water-moderated U(2.35)O_2 Fuel Rods in 2.032-cm Square-pitched Arrays*

Case number, *i*	$(k_{eff})_{exp}$	$(k_{eff})_{MCNP\,i}$	$(\Delta k_b)_i$
1	0.9998	0.9921	0.0077
2	0.9998	0.996	0.0038
3	0.9998	0.9958	0.004
4	0.9998	0.9943	0.0055
5	0.9998	0.9974	0.0024
6	0.9998	0.9921	0.0077
7	0.9998	0.993	0.0068
8	0.9998	0.9922	0.0076

Table 2 The data necessary for MCNP 4A calculation method bias and bias uncertainty determination based on report LEU-COMP-THERM-002 *Water-moderated U(4.31)O_2 Fuel Rods in 2.54-cm Square-pitched Arrays*

Case number, *i*	$(k_{eff})_{exp}$	$(k_{eff})_{MCNP\,i}$	$(\Delta k_b)_i$
1	0.9997	0.997	0.0027
2	0.9997	1.0016	0
3	0.9997	0.9951	0.0046
4	0.9997	0.9975	0.0022
5	0.9997	0.9975	0.0022

Table 3 The data necessary for MCNP 4A calculation method bias and bias uncertainty determination based on report LEU-COMP-THERM-001 *Critical Arrays of Low-Enriched U O_2 Fuel Rods with Water-to-fuel Volume Ratios Ranging from 1.5 to 3.0*

Case number, *i*	$(k_{eff})_{exp}$	$(k_{eff})_{MCNP\,i}$	$(\Delta k_b)_i$
1	1	1.0017	0
2	1	1.0014	0
3	1	1.0024	0
4	1	1.0026	0
5	1	0.9998	0.0002
6	1	1.0024	0
7	1	1.0025	0
8	1	1.0021	0
9	1	1.0018	0
10	1	1.0011	0
11	1	1.0024	0
12	1	1.0025	0
13	1	1.0017	0
14	1	1.0022	0
15	1	1.0015	0
16	1	1.0028	0
17	1	1.0023	0
18	1	1.0037	0

Table 4 The MCNP 4A calculation method bias (Δk_b) and bias uncertainty (σ_b)

Report number	Δk_b	σ_b	$\Delta k_b + \sigma_b$
LEU-COMP-THERM-001	0.00569	0.00389	0.00958
LEU-COMP-THERM-002	0.00234	0.00293	0.00527
LEU-COMP-THERM-006	0.00001	0.00009	0.00010

As can be seen from Table 4, $\Delta k_b + \sigma_b$ value never exceeded 0.02. In fact it even did not exceed 0.01, and choosing 0.02 as a sum of the MCNP 4A calculation method bias and bias uncertainty gives additional safety margin to the performed MCNP 4A calculations.

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Calculation Cover Page

Job No: **30822-244-023 /7150** Calculation No: **BUF-2000-052/Rev. 1** Date: **June 2, 2000**

Problem Statement & Calculation Objectives:

Determine the neutron multiplication factors for 30 gallon drum arrays with 5 w/o U-235 enriched uranium dioxide (UO_2) fuel arranged in a hexagonal lattice. The 30 gallon drums are 72.39 cm (28 1/2 inches) high and arranged in an infinite hexagonal array. Drum walls are made of 0.175 cm carbon steel. The drums stand on a concrete floor. The drums are absolutely dry inside, and air fills the space between the fuel elements in the drum.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993

Attachments:

Attachment 1: 30 gallon drum dimensions
Attachment 2: The model cross section with MCNP surface and cell numbers
Attachment 3: The model longitudinal section with MCNP surface and cell numbers
Attachment 4: MCNP input file
Attachment 5: MCNP output file

Prepared by:

Signature Igor V. Chichkov — Date 06/02/00

Checked by:

Signature Joseph C. Wolniewicz — Date 06/22/00

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Job No 30822-244-023 /7150 Job: HEC Support Activities By JVC Date 06/02/00
Client WVNS Subject: drum arrays dry inside Chk'd [illegible] Date 06/22/00

Analysis

Assumptions

The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is fresh (not irradiated) with 5% enrichment
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel rods are arranged in a hexagonal array and fill the 30 gallon drum
- The drum and fuel element heights are 72.39 cm (28 1/2 inches)
- The drums are arranged in an infinite hexagonal array without any gap between two adjacent drums
- The space between the fuel pins is filled with air
- Drum walls are made of 0.175 cm carbon steel
- The drums stand on a concrete floor
- The thickness of the concrete floor is 30 m

MCNP Model

Neutron multiplication factors were calculated with MCNP4A code. To model an infinite hexagonal array of drums without any gap between two adjacent drums, one drum filled with fuel elements was surrounded by a hexagon prism. The hexagon prism sides surrounding the drum were set up as having absolutely reflective surfaces for neutrons to mock up the infinite array. Figure 1 illustrates the adopted MCNP model. The cylinder representing the drum does not touch the hexagon to account for the rings around the cylindrical drums. The rings were not modeled.

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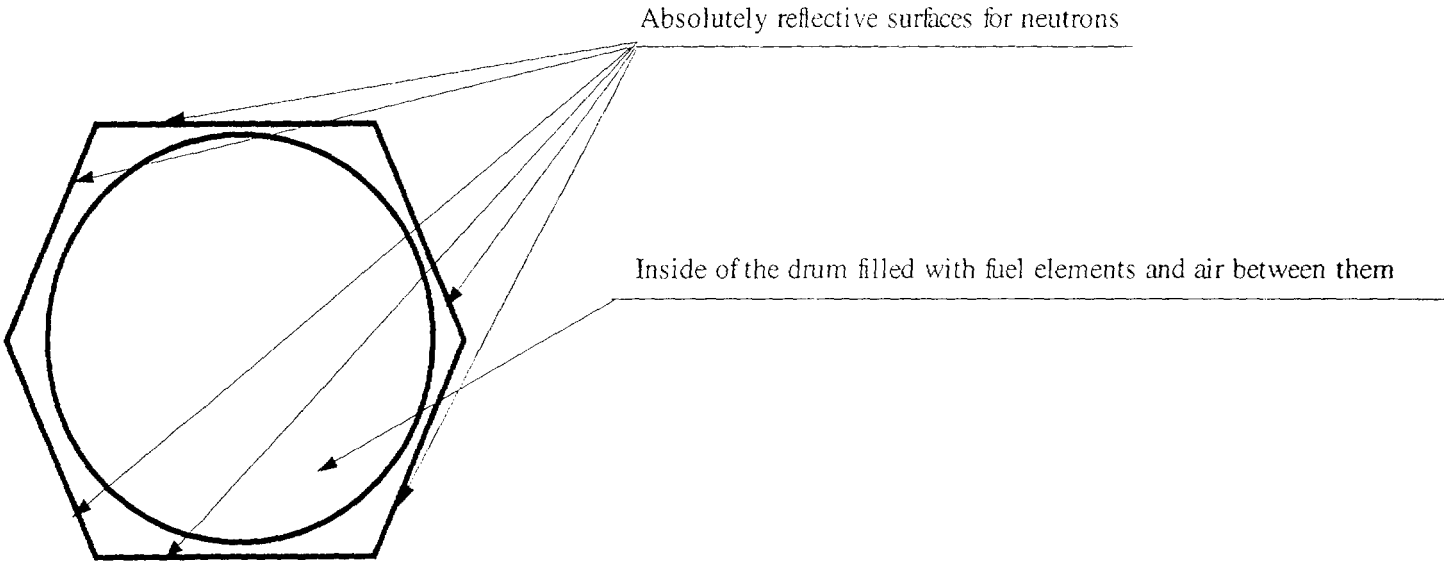
Figure 1. Top view of the MCNP geometry set up.



An example of an MCNP input file is presented in Attachment 4, and an MCNP output file is in Attachment 5. The calculations of neutron multiplication factor were performed for three different cases:

- Case 1. The drum array is infinite in horizontal direction and is 1 drum high (∞ x ∞ x 1).
- Case 2. The drum array is infinite in horizontal direction and is 2 drum high (∞ x ∞ x 2).
- Case 3. The drum array is infinite in horizontal direction and is 3 drum high (∞ x ∞ x 3).

The calculations of neutron multiplication factor were performed also for two different conditions in each case:

1. Air fills the space outside the drums
2. Water with density 1 g/cm^3 fills the space outside the drums.

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for air (Attix F.H., 1986). Table 2 and 3 show the element weigl fractions for stainless steel 304 used in the fuel clad and the carbon steel used in the drum walls, respectivel (Harmon C. D., II et al., 1993). Table 4 shows the element composition of concrete (Harmon C. D., II et al

1993). The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 5. Molar mass of uranium dioxide (UO_2) can be determined from equation (1).

$$M_{UO_2} = A_U + 2A_{O-16} = f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16} \qquad (1)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)

A_{U-235} = uranium-235 molar mass (g/mole)

A_{U-238} = uranium-238 molar mass (g/mole)

A_{O-16} = oxygen-16 molar mass (g/mole)

f = uranium-235 enrichment

Then the weigh fractions for uranium-235 (w_{U-235}), uranium-238 (w_{U-238}), and oxygen-16 (w_{O-16}) are:

$$w_{U-235} = \frac{f\,A_{U-235}}{M_{UO_2}} = \frac{f\,A_{U-235}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (2)$$

$$w_{U-238} = \frac{(1-f)\,A_{U-238}}{M_{UO_2}} = \frac{(1-f)\,A_{U-238}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (3)$$

$$w_{O-16} = \frac{2A_{O-16}}{M_{UO_2}} = \frac{2A_{O-16}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (4)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012828

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02
Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Carbon Steel Composition

Element	Weight Fraction
Iron (Fe)	0.995
Carbon (C)	0.005

Table 4. Concrete composition

Element	Weight Fraction
Hydrogen (H)	0.006
Oxygen (O)	0.500
Sodium (Na)	0.017
Aluminum (Al)	0.048
Silicon (Si)	0.315
Potassium (K)	0.019
Calcium (Ca)	0.083
Iron (Fe)	0.012

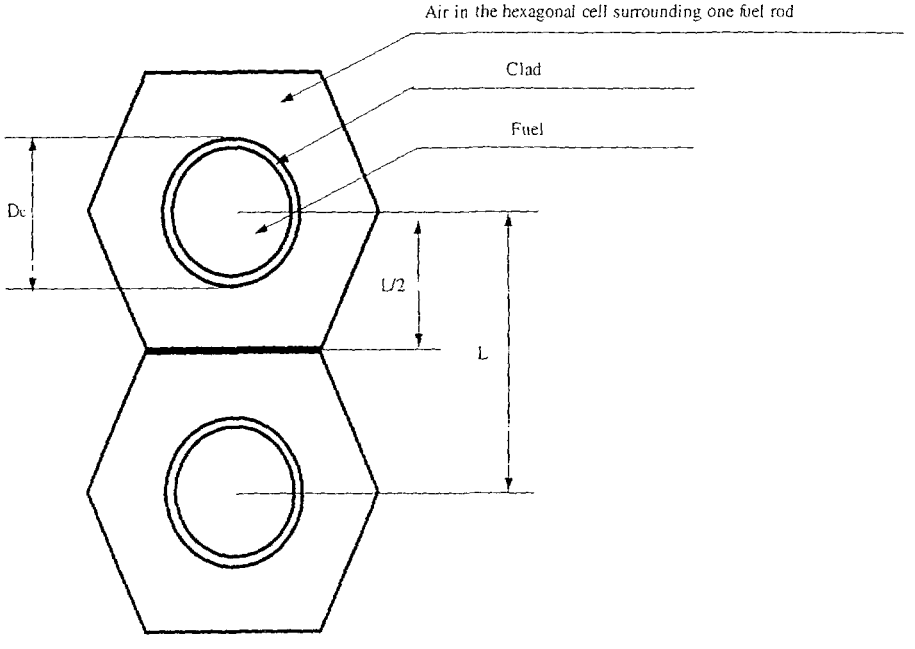
Table 5. Fuel Composition

Element	Weight Fraction
Uranium-235 (^{235}U)	0.0435427
Uranium-238 (^{238}U)	0.8378729
Oxygen (O)	0.1185844

Air to pin Ratio and Half-distance Between Two Adjacent Rods

To find the optimum moderation configuration, the calculations for fuel rod arrangements with different air to pin ratio (a/p) were performed. The parameter, which is needed to be entered into the MCNP input deck is the half-distance between two adjacent rods. Figure 2 shows the horizontal cross-section of two adjacent fuel rods with water surrounding each rod. This figure shows also the dimension used for the following equations.

Figure 2. Horizontal cross-section of two adjacent fuel rods with air each rod.



Air to pin ratio can be determined as:

$$a/p = \frac{S_a}{S_p} = \frac{6(L/2)^2 \tan(30^o) - \pi D_c^2/4}{\pi D_c^2/4} = \frac{24(L/2)^2 \tan(30^o)}{\pi D_c^2} - 1 \qquad (5)$$

Where:

S_a = cross-section area of the air in the hexagonal cell surrounding a pin;

S_p = cross-section area of the pin;

D_c = clad diameter;

$L/2$ = half-distance between two adjacent pins (fuel rods).

Thus, the half-distance between two adjacent pins can be calculated from equation (6) and Table 6 presents the half-distance values corresponding to some mixture to pin ratios.

$$L/2 = \sqrt{\frac{(a/p+1)\pi D_c^2}{24\tan(30^o)}} \qquad (6)$$

Table 6. Half-distance values (L/2) corresponding to air to pin ratios (a/p)

a/p	0.1	1	2	3	4	5
L/2, cm	0.4318	0.581537	0.712234	0.82242	0.919491	1.007251

Results

The k_∞ values were calculated for several air to pin ratios (a/p) using MCNP 4A code. Tables 7, 8 and 9 show these calculated neutron multiplication factors for cases 1, 2, and 3 respectively. Figures 3, 4, and 5 plc the calculated $k_\infty + 2\sigma$ values for cases 1, 2, and 3 respectively.

Table 7. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ for Case 1 (∞ x ∞ x 1)

a/p	dry outside the drum			water outside the drum		
	k_∞	σ	$k_\infty + 2\sigma$	k_∞	σ	$k_\infty + 2\sigma$
0.1	0.6617	0.0007	0.6630	0.9134	0.0008	0.9149
1	0.5988	0.0007	0.6002	0.8945	0.0009	0.8963
2	0.5323	0.0007	0.5337	0.8611	0.0009	0.8629
3	0.4796	0.0008	0.4812	0.8259	0.0011	0.8281
4	0.4366	0.0008	0.4382	0.7982	0.0009	0.8000

Table 8. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ for Case 2 (∞ x ∞ x 2)

a/p	dry ouside drum			water outside drum		
	k_∞	σ	$k_\infty + 2\sigma$	k_∞	σ	$k_\infty + 2\sigma$
0.1	0.7	0.0007	0.7014	0.9612	0.0008	0.9627
1	0.6706	0.0006	0.6717	0.9744	0.0009	0.9762
2	0.6342	0.0007	0.6356	0.9664	0.0009	0.9681
3	0.5981	0.0008	0.5997	0.9500	0.0010	0.9520
4	0.5657	0.0008	0.5672	0.9314	0.0009	0.9333

Table 9. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ for Case 3 (∞ x ∞ x 3)

a/p	dry outside the drum			water outside the drum		
	k_∞	σ	$k_\infty + 2\sigma$	k_∞	σ	$k_\infty + 2\sigma$
0.1	0.7097	0.0005	0.7107	0.9706	0.0009	0.9725
1	0.6922	0.0007	0.6935	0.9993	0.0009	1.0010
2	0.6678	0.0006	0.6690	0.9973	0.0009	0.9991
3	0.6431	0.0007	0.6444	0.9889	0.0009	0.9907
4	0.6187	0.0006	0.6199	0.9767	0.0009	0.9785

Figure 3. $k_\infty + 2\sigma$ values for Case 1 (∞ x ∞ x 1)

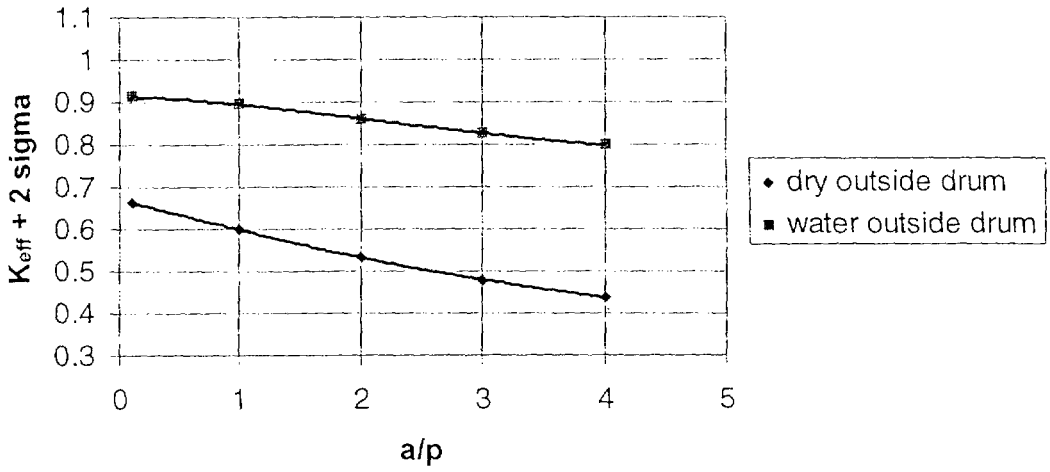


Figure 4. $k_\infty + 2\sigma$ values for Case 2 (∞ x ∞ x 2)

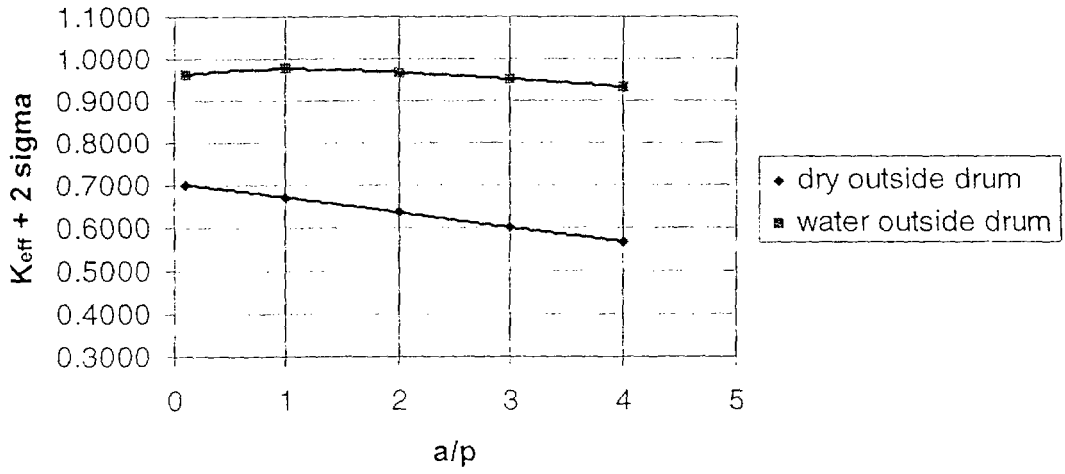
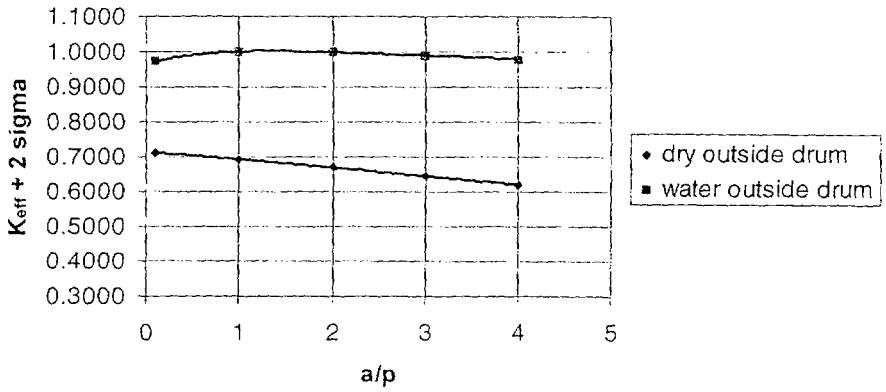


Figure 5. $k_\infty + 2\sigma$ values for Case 3 (∞ x ∞ x 3)



The criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq k_a - \Delta k_b - \sigma_b \qquad (7)$$

Where:

k_∞ = neutron multiplication factor predicted by MCNP

σ = standard deviation of predicted k_∞

$k_a = 0.95$ = established allowable limiting neutron multiplication factor

Δk_b = calculation method bias

σ_b = bias uncertainty

For this case, calculation method bias together with bias uncertainty ($\Delta k_b + \sigma_b$) is equal to 0.02. Thus the criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq 0.93 \qquad (8)$$

Where:

k_∞ = neutron multiplication factor predicted by MCNP

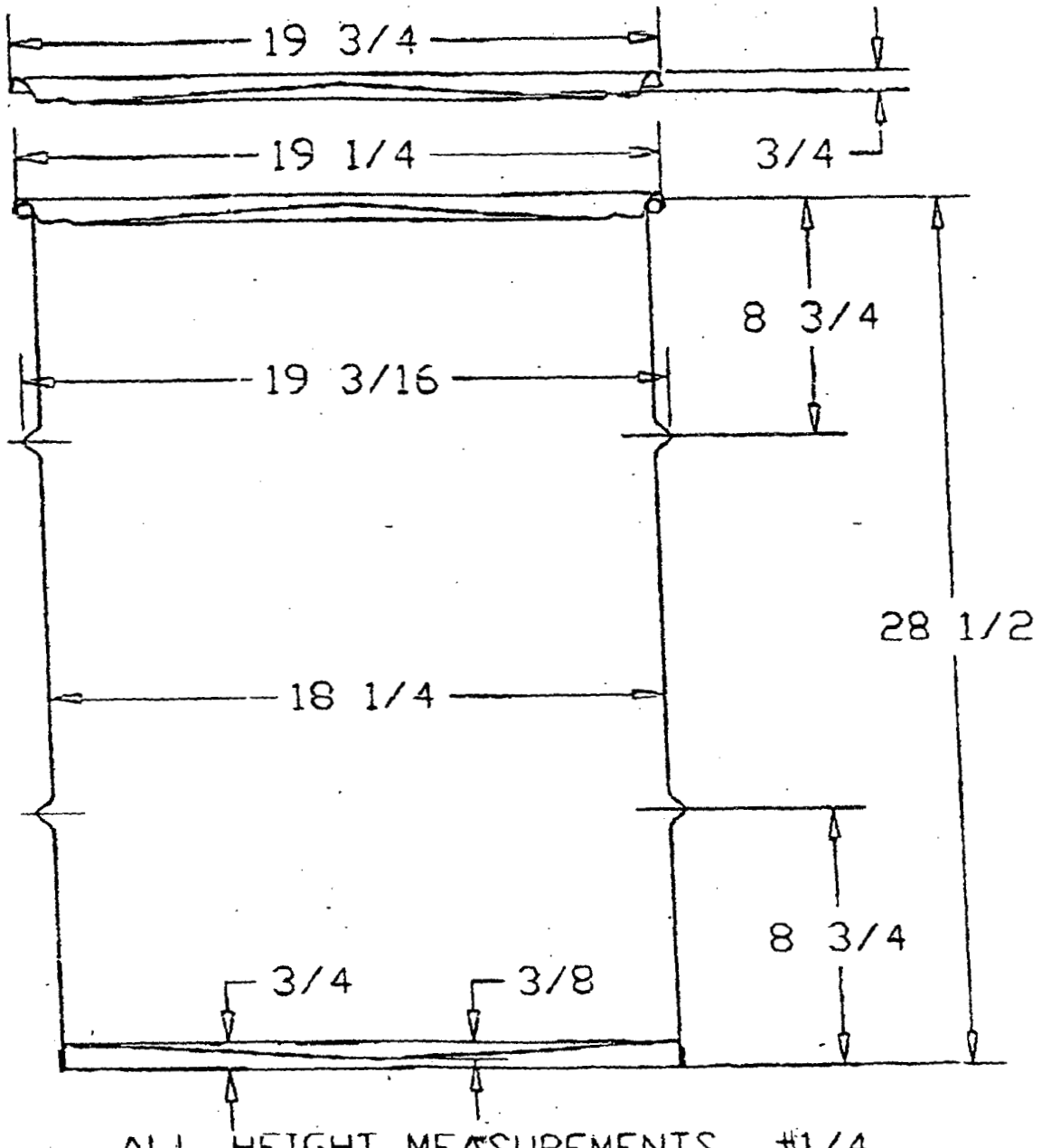
σ = standard deviation of predicted k_∞

As it can be seen from the data in Tables 7, 8 and 9, and Figures 3, 4, and 5 the criterion 8 is met for case 1 and is not met for cases 2 and 3.

Attachment 1: 30 gallon drum dimensions

COPY

30 GAL 1.5/1.2/1.2mm OPEN HEAD DRUM
UN 1A2/Y1.5/150



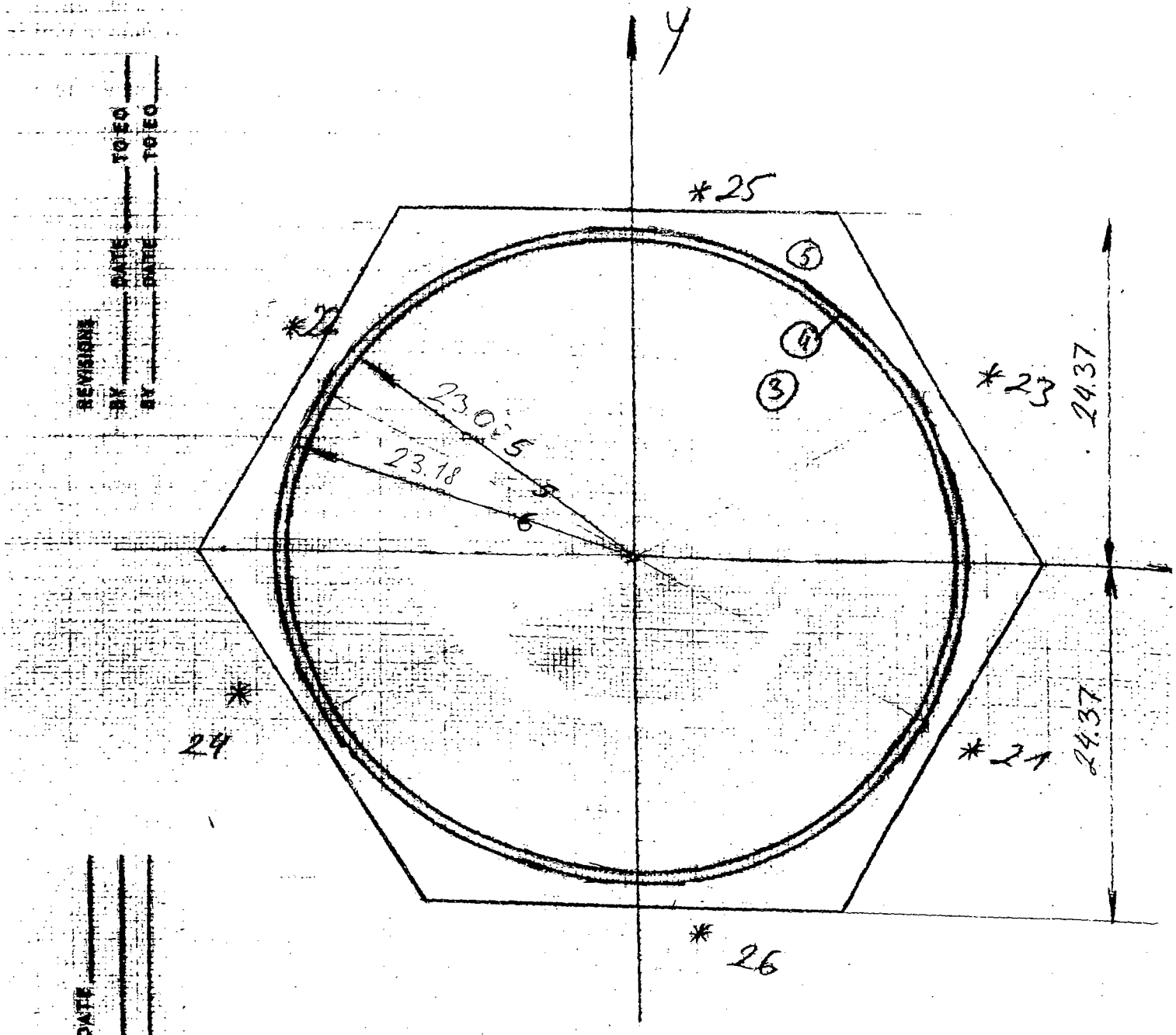
ALL HEIGHT MEASUREMENTS ±1/4
ALL OTHERS ±1/8
PRODUCT#:ST3004 , DATE:1/23/95

SKOLNIK INDUSTRIES,INC

Attachment 2: The model cross section with MCNP surface and cell numbers

FILE _____
SUBJECT _____

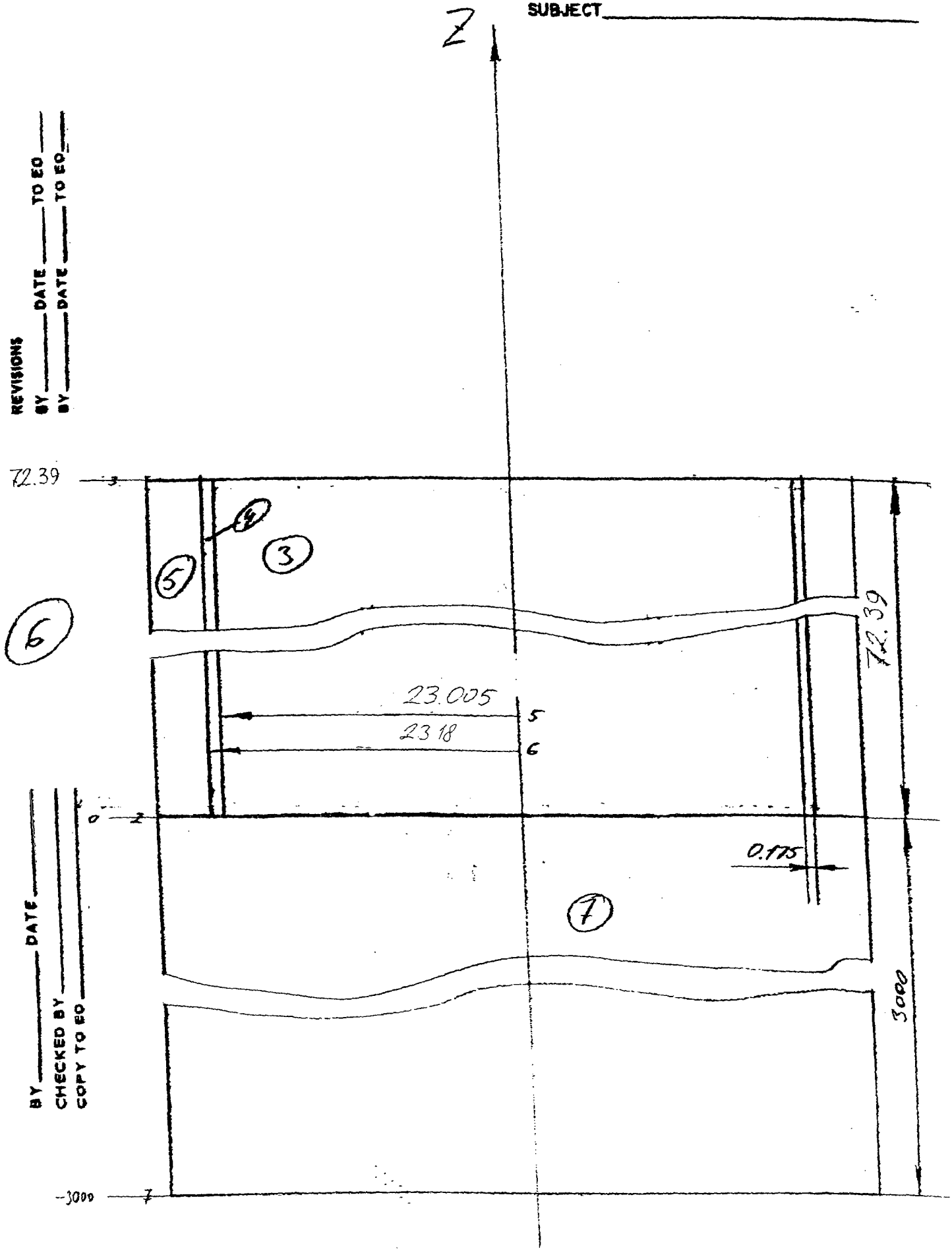
REVISIONS
BY _____ DATE _____ TO EQ _____
BY _____ DATE _____ TO EQ _____



BY _____ DATE _____
CHECKED BY _____
COPY TO EQ _____

Attachment 3: The model longitudinal section with MCNP surface and cell numbers

FILE _____
SUBJECT _____



```
                                                        C10191
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
11  0         -11 12 -13 14 -15 16 u=1
                  lat=2 fill=2 imp:n=1 $ Hexagonal lattice
12 61 -10.4   -17    u=2       imp:n=1 $ fuel rod
13 62  -7.92  -18 17 u=2       imp:n=1 $ SS-304 clad
14 64 -0.001293  18 u=2        imp:n=1 $ air in the lattice cell
c
3  0  2 -3 -5  fill=1  imp:n=1 $ drum filled with fuel lattice
c
c outside the drum:
c
4  65  -7.82       5 -6 2 -3    imp:n=1 $ drum wall
5  64 -0.001293 -21 22 -23 24 -25 26 2 -3 6 imp:n=1 $  air ouside the drum
6  0         21 : -22 : 23 : -24 : 25 : -26 : -7 : 3 imp:n=0 $ Outside world
7  67 -2.35     -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0        $ drum bottom plane
3  pz 72.39    $ drum top plane
5  cz 23.005   $ internal wall of the drum
6  cz 23.180   $ external wall of the drum
7  pz -3000    $ concrete bottom plane
c
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.581537
12 p 0.8660254 -0.5 0 -0.581537
13 p 0.8660254  0.5 0  0.581537
14 p 0.8660254  0.5 0 -0.581537
15 py  0.581537
16 py -0.581537
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
c (simulates infinite array of the drums)
c begin the lattice surfaces
*21 p 0.8660254 -0.5 0  24.37
*22 p 0.8660254 -0.5 0 -24.37
*23 p 0.8660254  0.5 0  24.37
*24 p 0.8660254  0.5 0 -24.37
*25 py  24.37
*26 py -24.37
c end of lattice surfaces
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185844
      92235.50c -0.0435427
      92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
      24000.50c -0.19
      25055.50c -0.02
      26000.55c -0.68
      28000.50c -0.10
c Air (C, N, O, Ar) composition from Attix p.523
```

Attachment 4: MCNP input file

C10191

```
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
       18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65     6000.50c -0.005
       26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67     1001.50c -0.006
        8016.50c -0.5
       11023.50c -0.017
       13027.50c -0.048
       14000.50c -0.315
       19000.50c -0.019
       20000.50c -0.083
       26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 5: MCNP output file

```
lmcnp     version 4a    ld=10/01/93                    06/01/00 15:01:37
 ***********************************************************************          probid =   06/01/00 15:01:37
 name=c10191

     1-       WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
     2-       C The drum height is 28 1/2 inches (72.39 cm)
     3-       c drum wall thickness is 0.157 cm
     4-       c
     5-       C Cell cards
     6-       C
     7-       C ---------------------------------------------------------------------
     8-       c inside the drum:
     9-       c
    10-       11  0         -11 12 -13 14 -15 16 u=1
    11-                         lat=2 fill=2 imp:n=1 $ Hexagonal lattice
    12-       12 61 -10.4   -17    u=2       imp:n=1 $ fuel rod
    13-       13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
    14-       14 64 -0.001293  18 u=2       imp:n=1 $ air in the lattice cell
    15-       c
    16-       3  0  2 -3 -5  fill=1  imp:n=1 $ drum filled with fuel lattice
    17-       c
    18-       c outside the drum:
    19-       c
    20-       4  65  -7.82       5 -6 2 -3    imp:n=1 $ drum wall
    21-       5  64 -0.001293 -21 22 -23 24 -25 26 2 -3 6 imp:n=1 $  air ouside the drum
    22-       6  0         21 : -22 : 23 : -24 : 25 : -26 : -7 : 3 imp:n=0 $ Outside world
    23-       7  67 -2.35      -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
    24-       C ---------------------------------------------------------------------
    25-       c
    26-       c Note: next line must be completely blank
    27-
    28-       c Surface cards
    29-       C ---------------------------------------------------------------------
    30-       2  pz 0        $ drum bottom plane
    31-       3  pz 72.39    $ drum top plane
    32-       5  cz 23.005   $ internal wall of the drum
    33-       6  cz 23.180   $ external wall of the drum
    34-       7  pz -3000    $ concrete bottom plane
    35-       c
    36-       c begin the lattice surfaces
    37-       11 p 0.8660254 -0.5 0  0.581537
    38-       12 p 0.8660254 -0.5 0 -0.581537
    39-       13 p 0.8660254  0.5 0  0.581537
    40-       14 p 0.8660254  0.5 0 -0.581537
    41-       15 py  0.581537
    42-       16 py -0.581537
    43-       c end of lattice surfaces
    44-       c
    45-       17 cz 0.3785 $ fuel wall cylinder
    46-       18 cz 0.4318 $ clad outer wall cylinder
    47-       c
    48-       c hexagonal cell with reflecting surfaces outside the drum
    49-       c (simulates infinite array of the drums)
    50-       c begin the lattice surfaces
    51-       *21 p 0.8660254 -0.5 0  24.37
    52-       *22 p 0.8660254 -0.5 0 -24.37
    53-       *23 p 0.8660254  0.5 0  24.37
    54-       *24 p 0.8660254  0.5 0 -24.37
    55-       *25 py  24.37
    56-       *26 py -24.37
    57-       c end of lattice surfaces
    58-       c
```

```
C ------------------------------------------------------------ --------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61     8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62    14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
       28000.50c -0.10
c Air (C, N, O, Ar) composition from Attix p.523
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
       18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65     6000.50c -0.005
       26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67     1001.50c -0.006
        8016.50c -0.5
       11023.50c -0.017
       13027.50c -0.048
       14000.50c -0.315
       19000.50c -0.019
       20000.50c -0.083
       26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10

total fission nubar data are being used.
1material composition                                                    print table 40

 material
  number     component nuclide, atom fraction

    61          8016,  0.66678     92235,  0.01666     92238,  0.31655
    62         14000,  0.01950     24000,  0.20018     25055,  0.01994     26000,  0.66703
               28000,  0.09334
    64          6000,  0.00015      7014,  0.78443      8016,  0.21075     18000,  0.00467
    65          6000,  0.02283     26000,  0.97717
    67          1001,  0.11082      8016,  0.58191     11023,  0.01377     13027,  0.03312
               14000,  0.20878     19000,  0.00905     20000,  0.03855     26000,  0.00400
```

material
 number component nuclide, mass fraction

61	8016,	0.11858	92235,	0.04354	92238,	0.83787			
62	14000,	0.01000	24000,	0.19000	25055,	0.02000	26000,	0.68000	
	28000,	0.10000							
64	6000,	0.00012	7014,	0.75527	8016,	0.23178	18000,	0.01283	
65	6000,	0.00500	26000,	0.99500					
67	1001,	0.00600	8016,	0.50000	11023,	0.01700	13027,	0.04800	
	14000,	0.31500	19000,	0.01900	20000,	0.08300	26000,	0.01200	

1cells print table 60

	cell	mat	atom density	gram density	volume	mass	neutron pieces	neutron importance
1	11	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
2	12	61	6.96366E-02	1.04000E+01	0.00000E+00	0.00000E+00	0	1.0000E+00
3	13	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
4	14	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
5	3	0	0.00000E+00	0.00000E+00	1.20357E+05	0.00000E+00	1	1.0000E+00
6	4	65	8.58651E-02	7.82000E+00	1.83809E+03	1.43739E+04	1	1.0000E+00
7	5	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
8	6	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	0.0000E+00
9	7	67	7.60226E-02	2.35000E+00	6.17196E+06	1.45041E+07	0	1.0000E+00
total					6.29415E+06	1.45185E+07		

1cross-section tables print table 100

table	length			
		tables from file critxs		
1001.50c	1153	njoy		(1301) 79/07/31.
6000.50c	16126	njoy		(1306) 79/07/31.
7014.50c	22772	njoy		(1275) 79/09/08.
8016.50c	23669	njoy		(1276) 05/14/81
11023.50c	36270	njoy		(1311) 79/06/21.
13027.50c	22891	njoy		(1313) 79/09/08.
14000.50c	48275	njoy		(1314) 79/06/21.
18000.35c	2182	endl85		(18) 11/01/85
19000.50c	9766	njoy		(1150) 79/10/29.
20000.50c	26104	njoy		(1320) 79/06/22.
24000.50c	89104	njoy		(1324) 79/06/21.
25055.50c	60097	njoy		(1325) 79/06/21.
26000.55c	84136	njoy		(260) 10/21/82
28000.50c	82267	njoy		(1328) 79/06/21.
92235.50c	44188	njoy	total nu	(1395) 79/09/12.
92238.50c	66440	njoy	total nu	(1398) 79/09/13.
total	635440			

warning. neutron energy cutoff is below some cross-section tables.

decimal words of dynamically allocated storage

general	113670
tallies	0
bank	12403

```
    cross sections      635440

    total               761513

************************************************************************************************************************
dump no.    1 on file c10191r      nps =         0     coll =              0     ctm =    0.00     nrn =              0


source distribution written to file c10191s         cycle =     0

        1 warning message so far.
1   starting mcrun.      field length =      0      cp0 =  0.02                                        print table 110

     WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air

 nps    x          y          z        cell lattice(i,j,k)  surface    u          v          w          energy     weight     time

   1  0.000E+00  0.000E+00  1.000E+01    3                             5.085E-01  4.733E-01  7.193E-01  2.209E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)           5.085E-01  4.733E-01  7.193E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0   5.085E-01  4.733E-01  7.193E-01
   2  0.000E+00  0.000E+00  1.000E+01    3                             8.952E-01 -4.447E-01 -2.944E-02  4.904E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)           8.952E-01 -4.447E-01 -2.944E-02
      0.000E+00  0.000E+00  1.000E+01   12                       0   8.952E-01 -4.447E-01 -2.944E-02
   3  0.000E+00  0.000E+00  1.000E+01    3                            -6.184E-01 -4.495E-01  6.446E-01  3.809E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -6.184E-01 -4.495E-01  6.446E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -6.184E-01 -4.495E-01  6.446E-01
   4  0.000E+00  0.000E+00  1.000E+01    3                             9.710E-01 -5.665E-02 -2.323E-01  1.331E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)           9.710E-01 -5.665E-02 -2.323E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0   9.710E-01 -5.665E-02 -2.323E-01
   5  0.000E+00  0.000E+00  1.000E+01    3                             5.861E-01  1.496E-01 -7.963E-01  1.902E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)           5.861E-01  1.496E-01 -7.963E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0   5.861E-01  1.496E-01 -7.963E-01
   6  0.000E+00  0.000E+00  1.000E+01    3                            -6.489E-02 -1.626E-01  9.845E-01  4.410E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -6.489E-02 -1.626E-01  9.845E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -6.489E-02 -1.626E-01  9.845E-01
   7  0.000E+00  0.000E+00  1.000E+01    3                            -7.068E-02  3.263E-02 -9.970E-01  4.750E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -7.068E-02  3.263E-02 -9.970E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -7.068E-02  3.263E-02 -9.970E-01
   8  0.000E+00  0.000E+00  1.000E+01    3                            -3.915E-01  4.664E-01 -7.932E-01  4.136E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -3.915E-01  4.664E-01 -7.932E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -3.915E-01  4.664E-01 -7.932E-01
   9  0.000E+00  0.000E+00  1.000E+01    3                            -2.368E-01  9.215E-01 -3.079E-01  7.453E-02  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -2.368E-01  9.215E-01 -3.079E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -2.368E-01  9.215E-01 -3.079E-01
  10  0.000E+00  0.000E+00  1.000E+01    3                             1.946E-01 -3.204E-01  9.271E-01  3.128E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)           1.946E-01 -3.204E-01  9.271E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0   1.946E-01 -3.204E-01  9.271E-01
  11  0.000E+00  0.000E+00  1.000E+01    3                            -6.698E-01 -7.177E-01 -1.905E-01  1.014E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -6.698E-01 -7.177E-01 -1.905E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -6.698E-01 -7.177E-01 -1.905E-01
  12  0.000E+00  0.000E+00  1.000E+01    3                            -8.398E-01 -4.129E-01  3.524E-01  1.395E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -8.398E-01 -4.129E-01  3.524E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -8.398E-01 -4.129E-01  3.524E-01
  13  0.000E+00  0.000E+00  1.000E+01    3                            -1.714E-01 -8.572E-01  4.857E-01  7.748E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -1.714E-01 -8.572E-01  4.857E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -1.714E-01 -8.572E-01  4.857E-01
  14  0.000E+00  0.000E+00  1.000E+01    3                            -2.489E-01 -5.118E-01 -8.222E-01  1.101E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -2.489E-01 -5.118E-01 -8.222E-01
      0.000E+00  0.000E+00  1.000E+01   12                       0  -2.489E-01 -5.118E-01 -8.222E-01
  15  0.000E+00  0.000E+00  1.000E+01    3                            -2.959E-01  2.119E-01  9.314E-01  1.951E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)          -2.959E-01  2.119E-01  9.314E-01
```

```
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -2.959E-01  2.119E-01  9.314E-01
16  0.000E+00  0.000E+00  1.000E+01    3                                    1.395E-01 -9.829E-01  1.202E-01  2.186E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   1.395E-01 -9.829E-01  1.202E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  1.395E-01 -9.829E-01  1.202E-01
17  0.000E+00  0.000E+00  1.000E+01    3                                    6.909E-01 -7.110E-01  1.307E-01  1.865E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   6.909E-01 -7.110E-01  1.307E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  6.909E-01 -7.110E-01  1.307E-01
18  0.000E+00  0.000E+00  1.000E+01    3                                   -6.580E-01  5.320E-01 -5.329E-01  1.229E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -6.580E-01  5.320E-01 -5.329E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -6.580E-01  5.320E-01 -5.329E-01
19  0.000E+00  0.000E+00  1.000E+01    3                                   -9.903E-01 -1.380E-01  1.353E-02  1.305E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -9.903E-01 -1.380E-01  1.353E-02
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -9.903E-01 -1.380E-01  1.353E-02
20  0.000E+00  0.000E+00  1.000E+01    3                                    7.462E-01  4.859E-01 -4.551E-01  1.000E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   7.462E-01  4.859E-01 -4.551E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  7.462E-01  4.859E-01 -4.551E-01
21  0.000E+00  0.000E+00  1.000E+01    3                                   -1.977E-01  9.797E-01  3.360E-02  3.990E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -1.977E-01  9.797E-01  3.360E-02
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -1.977E-01  9.797E-01  3.360E-02
22  0.000E+00  0.000E+00  1.000E+01    3                                   -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -9.117E-01 -3.647E-01 -1.891E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -9.117E-01 -3.647E-01 -1.891E-01
23  0.000E+00  0.000E+00  1.000E+01    3                                   -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -4.287E-01  8.361E-01 -3.423E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -4.287E-01  8.361E-01 -3.423E-01
24  0.000E+00  0.000E+00  1.000E+01    3                                    1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   1.080E-01  3.412E-01 -9.338E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  1.080E-01  3.412E-01 -9.338E-01
25  0.000E+00  0.000E+00  1.000E+01    3                                   -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -9.111E-01 -9.012E-03 -4.122E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -9.111E-01 -9.012E-03 -4.122E-01
26  0.000E+00  0.000E+00  1.000E+01    3                                   -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -2.568E-01 -6.391E-01 -7.249E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -2.568E-01 -6.391E-01 -7.249E-01
27  0.000E+00  0.000E+00  1.000E+01    3                                   -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -2.912E-01  8.086E-01  5.113E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -2.912E-01  8.086E-01  5.113E-01
28  0.000E+00  0.000E+00  1.000E+01    3                                    1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   1.472E-01 -9.514E-01  2.705E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  1.472E-01 -9.514E-01  2.705E-01
29  0.000E+00  0.000E+00  1.000E+01    3                                   -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -6.135E-01 -7.645E-01 -1.978E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -6.135E-01 -7.645E-01 -1.978E-01
30  0.000E+00  0.000E+00  1.000E+01    3                                   -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -5.702E-01  5.651E-01 -5.963E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -5.702E-01  5.651E-01 -5.963E-01
31  0.000E+00  0.000E+00  1.000E+01    3                                   -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -6.607E-01  5.373E-01 -5.242E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -6.607E-01  5.373E-01 -5.242E-01
32  0.000E+00  0.000E+00  1.000E+01    3                                   -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -9.742E-02 -3.639E-01 -9.263E-01
33  0.000E+00  0.000E+00  1.000E+01    3                                   -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -1.965E-01 -3.145E-01 -9.287E-01
34  0.000E+00  0.000E+00  1.000E+01    3                                    4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   4.097E-01  8.465E-01 -3.399E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  4.097E-01  8.465E-01 -3.399E-01
35  0.000E+00  0.000E+00  1.000E+01    3                                   -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                  -4.048E-02  8.831E-01  4.675E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -4.048E-02  8.831E-01  4.675E-01
36  0.000E+00  0.000E+00  1.000E+01    3                                    3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
```

```
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         3.371E-01 -9.269E-01 -1.652E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  3.371E-01 -9.269E-01 -1.652E-01
 37  0.000E+00  0.000E+00  1.000E+01    3                          -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -1.867E-01  9.756E-01 -1.155E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -1.867E-01  9.756E-01 -1.155E-01
 38  0.000E+00  0.000E+00  1.000E+01    3                          -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -2.616E-01  2.336E-01 -9.365E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -2.616E-01  2.336E-01 -9.365E-01
 39  0.000E+00  0.000E+00  1.000E+01    3                           9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         9.780E-01 -7.641E-02 -1.939E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  9.780E-01 -7.641E-02 -1.939E-01
 40  0.000E+00  0.000E+00  1.000E+01    3                           2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         2.580E-01 -7.076E-01  6.578E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  2.580E-01 -7.076E-01  6.578E-01
 41  0.000E+00  0.000E+00  1.000E+01    3                          -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -3.212E-01 -7.678E-01 -5.543E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -3.212E-01 -7.678E-01 -5.543E-01
 42  0.000E+00  0.000E+00  1.000E+01    3                           5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         5.039E-01 -1.460E-01  8.513E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  5.039E-01 -1.460E-01  8.513E-01
 43  0.000E+00  0.000E+00  1.000E+01    3                           6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         6.080E-01  5.487E-01  5.738E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  6.080E-01  5.487E-01  5.738E-01
 44  0.000E+00  0.000E+00  1.000E+01    3                          -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -2.932E-01  9.304E-01 -2.199E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -2.932E-01  9.304E-01 -2.199E-01
 45  0.000E+00  0.000E+00  1.000E+01    3                          -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -8.475E-01 -3.993E-01 -3.497E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -8.475E-01 -3.993E-01 -3.497E-01
 46  0.000E+00  0.000E+00  1.000E+01    3                           1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         1.200E-01 -9.195E-01 -3.743E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  1.200E-01 -9.195E-01 -3.743E-01
 47  0.000E+00  0.000E+00  1.000E+01    3                           7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         7.085E-01  5.879E-01  3.904E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  7.085E-01  5.879E-01  3.904E-01
 48  0.000E+00  0.000E+00  1.000E+01    3                           4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         4.261E-01  9.046E-01  9.254E-03
     0.000E+00  0.000E+00  1.000E+01   12                        0  4.261E-01  9.046E-01  9.254E-03
 49  0.000E+00  0.000E+00  1.000E+01    3                           5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)         5.431E-01  4.270E-01 -7.230E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0  5.431E-01  4.270E-01 -7.230E-01
 50  0.000E+00  0.000E+00  1.000E+01    3                          -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(    0,    0,    0)        -1.053E-01 -9.805E-01  1.658E-01
     0.000E+00  0.000E+00  1.000E+01   12                        0 -1.053E-01 -9.805E-01  1.658E-01
lestimated keff results by cycle                                                                    print table 175

 ************************************************************************************************************************
 dump no.     2 on file c10191r      nps =      62394     coll =        5109658     ctm =    15.48     nrn =       98312032


 source distribution written to file c10191s         cycle =    20

 source distribution written to file c10191s         cycle =    21

 source distribution written to file c10191s         cycle =    22

 source distribution written to file c10191s         cycle =    24

 source distribution written to file c10191s         cycle =    26

 source distribution written to file c10191s         cycle =    28
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source distribution written to file c10191s         cycle =    30

source distribution written to file c10191s         cycle =    31

********************************************************************************************************************
dump no.     3 on file c10191r      nps =     122355     coll =        9916545     ctm =    30.52     nrn =      191211692

source distribution written to file c10191s         cycle =    32

source distribution written to file c10191s         cycle =    34

source distribution written to file c10191s         cycle =    35

source distribution written to file c10191s         cycle =    37

source distribution written to file c10191s         cycle =    39

source distribution written to file c10191s         cycle =    40

source distribution written to file c10191s         cycle =    41

source distribution written to file c10191s         cycle =    43

source distribution written to file c10191s         cycle =    44

source distribution written to file c10191s         cycle =    45

source distribution written to file c10191s         cycle =    46

********************************************************************************************************************
dump no.     4 on file c10191r      nps =     182244     coll =       14739733     ctm =    45.56     nrn =      284273807

source distribution written to file c10191s         cycle =    47

source distribution written to file c10191s         cycle =    48

source distribution written to file c10191s         cycle =    49

source distribution written to file c10191s         cycle =    50

source distribution written to file c10191s         cycle =    52

source distribution written to file c10191s         cycle =    54

source distribution written to file c10191s         cycle =    56

source distribution written to file c10191s         cycle =    57

source distribution written to file c10191s         cycle =    59

source distribution written to file c10191s         cycle =    61

********************************************************************************************************************
dump no.     5 on file c10191r      nps =     246238     coll =       19880164     ctm =    61.54     nrn =      383457176

source distribution written to file c10191s         cycle =    63

source distribution written to file c10191s         cycle =    65
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source distribution written to file c10191s         cycle =    66

source distribution written to file c10191s         cycle =    67

source distribution written to file c10191s         cycle =    69

source distribution written to file c10191s         cycle =    71

source distribution written to file c10191s         cycle =    73

source distribution written to file c10191s         cycle =    75

source distribution written to file c10191s         cycle =    77

source distribution written to file c10191s         cycle =    78

************************************************************************************************************************
dump no.    6 on file c10191r      nps =    310590     coll =       25040456     ctm =   77.22     nrn =      483120427

source distribution written to file c10191s         cycle =    80

source distribution written to file c10191s         cycle =    82

source distribution written to file c10191s         cycle =    84

source distribution written to file c10191s         cycle =    86

source distribution written to file c10191s         cycle =    87

source distribution written to file c10191s         cycle =    89

source distribution written to file c10191s         cycle =    91

source distribution written to file c10191s         cycle =    93

************************************************************************************************************************
dump no.    7 on file c10191r      nps =    374676     coll =       30207386     ctm =   92.86     nrn =      582798974

source distribution written to file c10191s         cycle =    95

source distribution written to file c10191s         cycle =    97

source distribution written to file c10191s         cycle =    99

 estimator      cycle   100   ave of    80 cycles      combination          simple average    combined average     corr
k(collision)      0.608771       0.598072 0.0014     k(col/abs)          0.598314 0.0013     0.598277 0.0013    0.6486
k(absorption)     0.603830       0.598557 0.0015     k(abs/tk ln)        0.598495 0.0013     0.598499 0.0013    0.4913
k(trk length)     0.612121       0.598434 0.0015     k(tk ln/col)        0.598253 0.0014     0.598185 0.0014    0.7807
rem life(col)   9.2312E+03     9.0312E+03 0.0050     k(col/abs/tk ln)    0.598354 0.0013     0.598376 0.0013
rem life(abs)   9.1106E+03     9.0425E+03 0.0046     life(col/abs)     9.0368E+03 0.0047   9.0508E+03 0.0045    0.9684
source points generated   4055

source distribution written to file c10191s         cycle =   101

source distribution written to file c10191s         cycle =   103

source distribution written to file c10191s         cycle =   105

source distribution written to file c10191s         cycle =   107
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 source distribution written to file c10191s         cycle =   109

 source distribution written to file c10191s         cycle =   110

 ************************************************************************************************************
 dump no.    8 on file c10191r      nps =    438845     coll =       35371089     ctm =  108.57     nrn =      682536158


 source distribution written to file c10191s         cycle =   112

 source distribution written to file c10191s         cycle =   113

 source distribution written to file c10191s         cycle =   115

  estimator      cycle   116   ave of     96 cycles       combination          simple average     combined average      corr
 k(collision)       0.601300        0.598325 0.0013     k(col/abs)          0.598799 0.0012     0.598729 0.0012    0.6632
 k(absorption)      0.598258        0.599274 0.0013     k(abs/tk ln)        0.598902 0.0012     0.598935 0.0012    0.4916
 k(trk length)      0.605561        0.598529 0.0014     k(tk ln/col)        0.598427 0.0012     0.598385 0.0012    0.7718
 rem life(col)    9.9096E+03      9.0446E+03 0.0048     k(col/abs/tk ln)    0.598709 0.0012     0.598778 0.0012
 rem life(abs)    9.6936E+03      9.0473E+03 0.0044     life(col/abs)     9.0459E+03 0.0046   9.0493E+03 0.0043    0.9693
 source points generated   3882

  estimator      cycle   117   ave of     97 cycles       combination          simple average     combined average      corr
 k(collision)       0.603522        0.598378 0.0012     k(col/abs)          0.598813 0.0012     0.598752 0.0012    0.6587
 k(absorption)      0.596766        0.599248 0.0013     k(abs/tk ln)        0.598910 0.0012     0.598941 0.0012    0.4890
 k(trk length)      0.602591        0.598571 0.0014     k(tk ln/col)        0.598475 0.0012     0.598435 0.0012    0.7725
 rem life(col)    8.9845E+03      9.0440E+03 0.0047     k(col/abs/tk ln)    0.598732 0.0011     0.598798 0.0012
 rem life(abs)    9.0242E+03      9.0470E+03 0.0043     life(col/abs)     9.0455E+03 0.0045   9.0493E+03 0.0043    0.9692
 source points generated   4066

 source distribution written to file c10191s         cycle =   117

  estimator      cycle   118   ave of     98 cycles       combination          simple average     combined average      corr
 k(collision)       0.599179        0.598386 0.0012     k(col/abs)          0.598843 0.0012     0.598777 0.0012    0.6580
 k(absorption)      0.604345        0.599300 0.0013     k(abs/tk ln)        0.598973 0.0011     0.599005 0.0012    0.4920
 k(trk length)      0.605970        0.598647 0.0014     k(tk ln/col)        0.598517 0.0012     0.598462 0.0012    0.7701
 rem life(col)    9.5998E+03      9.0497E+03 0.0047     k(col/abs/tk ln)    0.598778 0.0011     0.598836 0.0012
 rem life(abs)    9.7076E+03      9.0538E+03 0.0044     life(col/abs)     9.0517E+03 0.0045   9.0566E+03 0.0043    0.9692
 source points generated   4047

  estimator      cycle   119   ave of     99 cycles       combination          simple average     combined average      corr
 k(collision)       0.595187        0.598354 0.0012     k(col/abs)          0.598808 0.0011     0.598742 0.0012    0.6587
 k(absorption)      0.595589        0.599263 0.0013     k(abs/tk ln)        0.598870 0.0011     0.598923 0.0012    0.4910
 k(trk length)      0.581902        0.598477 0.0014     k(tk ln/col)        0.598416 0.0012     0.598386 0.0012    0.7621
 rem life(col)    9.5761E+03      9.0550E+03 0.0047     k(col/abs/tk ln)    0.598698 0.0011     0.598762 0.0011
 rem life(abs)    9.6176E+03      9.0595E+03 0.0044     life(col/abs)     9.0572E+03 0.0045   9.0624E+03 0.0043    0.9696
 source points generated   3930

 source distribution written to file c10191s         cycle =   119

  estimator      cycle   120   ave of    100 cycles       combination          simple average     combined average      corr
 k(collision)       0.601448        0.598385 0.0012     k(col/abs)          0.598824 0.0011     0.598761 0.0011    0.6580
 k(absorption)      0.599202        0.599262 0.0013     k(abs/tk ln)        0.598899 0.0011     0.598950 0.0011    0.4897
 k(trk length)      0.604360        0.598536 0.0014     k(tk ln/col)        0.598461 0.0012     0.598423 0.0012    0.7625
 rem life(col)    9.1120E+03      9.0555E+03 0.0047     k(col/abs/tk ln)    0.598728 0.0011     0.598787 0.0011
 rem life(abs)    9.2258E+03      9.0611E+03 0.0043     life(col/abs)     9.0583E+03 0.0045   9.0647E+03 0.0043    0.9692
 source points generated   4143

 source distribution written to file c10191s         cycle =   120
1problem summary

      run terminated when   120 kcode cycles were done.
```

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 06/01/00 15:01:37

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	478686	1.0027E+00	2.0332E+00	escape	127393	1.8136E-01	1.0428E-01
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	1.2599E-01	6.2395E-04	weight cutoff	352604	1.2542E-01	5.6951E-04
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	9.4555E-08	downscattering	0	0.	1.6230E+00
				capture	0	5.8634E-01	9.2071E-02
(n,xn)	2619	4.0904E-03	2.9254E-03	loss to (n,xn)	1308	2.0429E-03	1.6986E-02
fission	0	0.	0.	loss to fission	0	2.3766E-01	1.9982E-01
total	481305	1.1328E+00	2.0368E+00	total	481305	1.1328E+00	2.0368E+00

number of neutrons banked	1311	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0055E+00	escape	1.4584E+02	tco	1.0000E+34
neutron collisions per source particle	8.0618E+01	capture	1.1011E+04	eco	0.0000E+00
total neutron collisions	38590674	capture or escape	9.0508E+03	wc1	-5.0000E-01
net multiplication	1.0020E+00 0.0001	any termination	1.1132E+04	wc2	-2.5000E-01

computer time so far in this run	118.31 minutes	maximum number ever in bank	2
computer time in mcrun	118.30 minutes	bank overflows to backup file	0
source particles per minute	4.0465E+03	field length	0
random numbers generated	744597784	most random numbers used was	30911 in history 59765

range of sampled source weights = 9.4854E-01 to 1.5337E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	12	46782506	479997	15069460	2.0664E+01	2.7744E-02	5.1845E-01	6.8528E-01	2.5434E+00
3	13	97667978	477806	5331520	6.7138E+00	2.5251E-02	5.1494E-01	6.8507E-01	3.1570E+00
4	14	130056142	477382	10690	1.3712E-02	2.3085E-02	5.1443E-01	6.8508E-01	5.7148E+03
5	3	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	4	3808045	404105	549091	7.1954E-01	1.2280E-02	5.0563E-01	6.8751E-01	4.6874E+00
7	5	2007200	401610	4745	6.1856E-03	8.3453E-03	5.0142E-01	6.8735E-01	5.6269E+03
9	7	539058	287612	17625168	2.1933E+01	9.4198E-05	2.1473E-01	6.2385E-01	2.7471E+00
total		280860929	2528512	38590674	5.0051E+01				

1keff results for: WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 06/01/00 15:01:37

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 78285 neutron histories and 100 active cycles with 400401 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 478686 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

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the final estimated combined collision/absorption/track-length keff = 0.59879 with an estimated standard deviation of 0.00068

the estimated 68, 95, & 99 percent keff confidence intervals are 0.59811 to 0.59947, 0.59744 to 0.60014, and 0.59700 to 0.60058

the estimated collision/absorption neutron removal lifetime = 9.06E-05 seconds with an estimated standard deviation of 3.88E-07

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the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.59839	0.00073	0.59766 to 0.59911	0.59694 to 0.59983	0.59647 to 0.60030	
absorption	0.59926	0.00076	0.59850 to 0.60002	0.59774 to 0.60078	0.59725 to 0.60128	
track length	0.59854	0.00082	0.59772 to 0.59936	0.59691 to 0.60017	0.59637 to 0.60070	
col/absorp	0.59876	0.00069	0.59807 to 0.59945	0.59739 to 0.60013	0.59695 to 0.60057	0.6580
abs/trk len	0.59895	0.00069	0.59826 to 0.59964	0.59758 to 0.60032	0.59714 to 0.60076	0.4897
col/trk len	0.59842	0.00072	0.59771 to 0.59914	0.59700 to 0.59985	0.59653 to 0.60032	0.7625
col/abs/trk len	0.59879	0.00068	0.59811 to 0.59947	0.59744 to 0.60014	0.59700 to 0.60058	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.59853	0.00073	0.59779 to 0.59926	0.59707 to 0.59999	0.59659 to 0.60046
absorption	0.59946	0.00078	0.59868 to 0.60024	0.59790 to 0.60101	0.59740 to 0.60151
track length	0.59871	0.00083	0.59788 to 0.59954	0.59706 to 0.60036	0.59652 to 0.60090
col/abs/trk len	0.59893	0.00069	0.59824 to 0.59963	0.59755 to 0.60032	0.59710 to 0.60077

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	9.0647E-05	3.8787E-07	9.0259E-05 to 9.1035E-05	8.9874E-05 to 9.1420E-05	8.9622E-05 to 9.1672E-05
capture	1.1018E-04	4.4104E-07	1.0974E-04 to 1.1063E-04	1.0930E-04 to 1.1106E-04	1.0902E-04 to 1.1135E-04
fission	5.4614E-05	2.6091E-07	5.4353E-05 to 5.4875E-05	5.4094E-05 to 5.5134E-05	5.3925E-05 to 5.5303E-05
escape	1.4322E-06	5.9096E-08	1.3730E-06 to 1.4913E-06	1.3144E-06 to 1.5499E-06	1.2760E-06 to 1.5883E-06

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.5984 0.0007	0.5993 0.0008	0.5985 0.0008	95/95/95	0.59879 0.00068	0.59744-0.60014	0.59700-0.60058
2	50	0.5984 0.0007	0.5993 0.0007	0.5985 0.0008	95/95/95	0.59886 0.00065	0.59756-0.60016	0.59713-0.60059
4	25	0.5984 0.0006	0.5993 0.0007	0.5985 0.0007	95/95/95	0.59878 0.00059	0.59756-0.59999	0.59713-0.60043
5	20	0.5984 0.0006	0.5993 0.0007	0.5985 0.0007	95/95/95	0.59867 0.00063	0.59735-0.59999	0.59686-0.60049
10	10	0.5984 0.0006	0.5993 0.0009	0.5985 0.0007	95/95/99	0.59859 0.00081	0.59666-0.60051	0.59574-0.60144
20	5	0.5984 0.0005	0.5993 0.0009	0.5985 0.0005	95/95/95	0.59822 0.00070	0.59519-0.60125	0.59124-0.60521
25	4	0.5984 0.0005	0.5993 0.0010	0.5985 0.0005	95/95/95	0.59809 0.00071	0.58906-0.60712	0.55287-0.64331

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	0.65667	0.64814	0.65137									
2	2608	0.61101	0.62506	0.60912									
3	3723	0.61209	0.60412	0.61119									
4	3952	0.61488	0.61347	0.61854									
5	4079	0.60277	0.60271	0.59613									
6	3985	0.59622	0.59773	0.59188									
7	3988	0.60365	0.59983	0.60211									
8	3960	0.59270	0.59283	0.59548									
9	3872	0.59912	0.60198	0.59846									
10	4051	0.58559	0.58504	0.58248									
11	4012	0.60266	0.59948	0.60359									
12	4159	0.60378	0.59713	0.60293									
13	4013	0.61127	0.61449	0.60833									
14	4075	0.61439	0.61007	0.61058									
15	3951	0.60414	0.61225	0.59681									
16	3966	0.59026	0.59441	0.58378									
17	3919	0.60743	0.58941	0.60677									
18	4116	0.59292	0.59312	0.59222									
19	3874	0.60010	0.59786	0.60265									
20	3982	0.61263	0.60911	0.61135									
	begin active keff cycles												
21	4161	0.60009	0.60523	0.59882									
22	4046	0.59592	0.59223	0.60408	0.59800	0.00208	0.59873	0.00650	0.60145	0.00263			
23	3971	0.59680	0.59936	0.59772	0.59760	0.00127	0.59894	0.00376	0.60021	0.00196			
24	4002	0.58763	0.58508	0.59177	0.59511	0.00265	0.59548	0.00437	0.59810	0.00253	0.58430	0.00033	800883
25	3926	0.60864	0.60969	0.60370	0.59782	0.00340	0.59832	0.00442	0.59922	0.00225	0.59980	0.00371	5219
26	4081	0.60202	0.59128	0.60657	0.59852	0.00286	0.59715	0.00379	0.60044	0.00221	0.60042	0.00261	8772
27	3909	0.60425	0.59488	0.60065	0.59934	0.00255	0.59682	0.00322	0.60047	0.00187	0.59969	0.00232	9547
28	4014	0.58431	0.59757	0.59009	0.59746	0.00290	0.59692	0.00279	0.59917	0.00207	0.59923	0.00194	11845
29	3801	0.60126	0.59573	0.59770	0.59788	0.00259	0.59678	0.00247	0.59901	0.00184	0.59859	0.00173	13249
30	4073	0.61007	0.60425	0.60660	0.59910	0.00262	0.59753	0.00233	0.59977	0.00181	0.59912	0.00162	13642
31	4086	0.60248	0.59729	0.60131	0.59941	0.00239	0.59751	0.00211	0.59991	0.00164	0.59908	0.00146	15166
32	3988	0.58179	0.58684	0.57783	0.59794	0.00263	0.59662	0.00212	0.59807	0.00237	0.59705	0.00208	6794
33	3796	0.60260	0.60670	0.59866	0.59830	0.00244	0.59740	0.00210	0.59812	0.00218	0.59752	0.00193	7331
34	4035	0.59788	0.58975	0.59834	0.59827	0.00226	0.59685	0.00202	0.59813	0.00202	0.59725	0.00184	7529
35	4043	0.59013	0.59491	0.59530	0.59772	0.00218	0.59672	0.00188	0.59794	0.00189	0.59727	0.00168	8357
36	4007	0.59295	0.58975	0.59673	0.59743	0.00206	0.59628	0.00181	0.59787	0.00177	0.59711	0.00160	8738
37	4121	0.59802	0.60700	0.59955	0.59746	0.00193	0.59691	0.00182	0.59797	0.00167	0.59762	0.00155	8740
38	3920	0.58840	0.58118	0.59478	0.59696	0.00189	0.59604	0.00192	0.59779	0.00158	0.59738	0.00153	8398
39	3870	0.59634	0.59890	0.58747	0.59693	0.00179	0.59619	0.00183	0.59725	0.00159	0.59682	0.00148	8530
40	3993	0.59789	0.59564	0.60127	0.59697	0.00170	0.59616	0.00173	0.59745	0.00152	0.59695	0.00141	8883
41	3963	0.58964	0.60059	0.58325	0.59662	0.00165	0.59637	0.00166	0.59677	0.00160	0.59659	0.00136	9121
42	3869	0.60751	0.59798	0.60801	0.59712	0.00165	0.59645	0.00159	0.59728	0.00161	0.59682	0.00133	9180
43	4116	0.59951	0.60262	0.59629	0.59722	0.00158	0.59671	0.00154	0.59724	0.00154	0.59692	0.00127	9635
44	4034	0.59803	0.59952	0.59751	0.59726	0.00151	0.59683	0.00148	0.59725	0.00147	0.59699	0.00121	10098
45	4024	0.60555	0.60141	0.59722	0.59759	0.00149	0.59701	0.00143	0.59725	0.00141	0.59699	0.00117	10463
46	4110	0.60378	0.60227	0.61273	0.59783	0.00145	0.59722	0.00139	0.59784	0.00148	0.59747	0.00121	9376
47	4021	0.60512	0.60394	0.60922	0.59810	0.00142	0.59747	0.00136	0.59827	0.00149	0.59780	0.00121	8959
48	4009	0.60070	0.59971	0.60112	0.59819	0.00137	0.59755	0.00131	0.59837	0.00144	0.59789	0.00117	9265
49	4030	0.61280	0.61887	0.60463	0.59869	0.00142	0.59828	0.00146	0.59858	0.00140	0.59840	0.00123	8144
50	4065	0.58884	0.59639	0.59128	0.59837	0.00141	0.59822	0.00142	0.59834	0.00138	0.59826	0.00119	8392
51	3803	0.60209	0.60254	0.59731	0.59849	0.00137	0.59836	0.00138	0.59831	0.00133	0.59829	0.00115	8698
52	4107	0.59053	0.58833	0.58595	0.59824	0.00135	0.59804	0.00137	0.59792	0.00135	0.59794	0.00118	7999
53	3938	0.59467	0.59121	0.59166	0.59813	0.00131	0.59784	0.00134	0.59773	0.00132	0.59775	0.00116	7959

54	4101	0.58994	0.59031	0.59647	0.59789	0.00129	0.59762	0.00132	0.59769	0.00128	0.59763	0.00113	8182
55	3905	0.60577	0.60197	0.60618	0.59811	0.00128	0.59774	0.00129	0.59794	0.00127	0.59780	0.00111	8202
56	4187	0.60403	0.59655	0.59901	0.59828	0.00125	0.59771	0.00125	0.59797	0.00123	0.59779	0.00109	8371
57	3899	0.60095	0.61006	0.60651	0.59835	0.00122	0.59804	0.00126	0.59820	0.00122	0.59813	0.00109	8075
58	4045	0.59605	0.58586	0.59004	0.59829	0.00119	0.59772	0.00127	0.59798	0.00121	0.59793	0.00110	7799
59	3981	0.58530	0.58895	0.58104	0.59796	0.00120	0.59750	0.00126	0.59755	0.00125	0.59760	0.00112	7263
60	3873	0.59964	0.60802	0.59846	0.59800	0.00117	0.59776	0.00125	0.59757	0.00122	0.59773	0.00110	7397
61	4016	0.60450	0.60592	0.60101	0.59816	0.00116	0.59796	0.00124	0.59765	0.00119	0.59787	0.00108	7439
62	4014	0.60277	0.61091	0.60222	0.59827	0.00113	0.59827	0.00125	0.59776	0.00117	0.59805	0.00107	7409
63	3954	0.59182	0.59518	0.60141	0.59812	0.00112	0.59819	0.00122	0.59785	0.00115	0.59803	0.00104	7666
64	3972	0.58223	0.58377	0.57730	0.59776	0.00115	0.59787	0.00124	0.59738	0.00121	0.59766	0.00109	6778
65	4043	0.59837	0.58601	0.61304	0.59777	0.00112	0.59760	0.00124	0.59773	0.00124	0.59769	0.00107	6980
66	4160	0.60543	0.59982	0.60637	0.59794	0.00111	0.59765	0.00121	0.59792	0.00122	0.59782	0.00105	7024
67	4130	0.58978	0.59320	0.59642	0.59776	0.00110	0.59756	0.00119	0.59789	0.00120	0.59772	0.00103	7129
68	3943	0.60282	0.59388	0.59836	0.59787	0.00108	0.59748	0.00117	0.59790	0.00117	0.59772	0.00101	7278
69	4145	0.59651	0.61137	0.60052	0.59784	0.00106	0.59776	0.00118	0.59795	0.00115	0.59785	0.00100	7353
70	3956	0.59772	0.59439	0.60170	0.59784	0.00104	0.59770	0.00116	0.59802	0.00113	0.59785	0.00098	7509
71	3996	0.60916	0.60698	0.60858	0.59806	0.00104	0.59788	0.00115	0.59823	0.00112	0.59805	0.00098	7334
72	4041	0.60374	0.60254	0.60657	0.59817	0.00103	0.59797	0.00113	0.59839	0.00111	0.59817	0.00097	7367
73	3972	0.60458	0.59823	0.60434	0.59829	0.00102	0.59797	0.00111	0.59850	0.00110	0.59824	0.00095	7465
74	3892	0.60268	0.60817	0.60575	0.59837	0.00100	0.59816	0.00110	0.59864	0.00109	0.59838	0.00094	7456
75	4026	0.59520	0.59351	0.59794	0.59831	0.00098	0.59808	0.00109	0.59862	0.00107	0.59833	0.00093	7568
76	4069	0.59068	0.58987	0.59389	0.59818	0.00098	0.59793	0.00108	0.59854	0.00105	0.59821	0.00092	7558
77	3963	0.60322	0.59895	0.59207	0.59827	0.00096	0.59795	0.00106	0.59843	0.00104	0.59821	0.00090	7730
78	4090	0.59007	0.59329	0.58572	0.59812	0.00096	0.59787	0.00104	0.59821	0.00104	0.59805	0.00090	7670
79	3958	0.60229	0.61420	0.61304	0.59819	0.00094	0.59815	0.00106	0.59846	0.00106	0.59824	0.00090	7449
80	4191	0.60141	0.59769	0.59982	0.59825	0.00093	0.59814	0.00104	0.59848	0.00104	0.59827	0.00089	7574
81	3961	0.59121	0.60134	0.58863	0.59813	0.00092	0.59819	0.00103	0.59832	0.00103	0.59820	0.00088	7664
82	3905	0.60574	0.61009	0.60284	0.59826	0.00091	0.59838	0.00103	0.59839	0.00102	0.59833	0.00087	7616
83	4146	0.58958	0.60127	0.58918	0.59812	0.00091	0.59843	0.00101	0.59825	0.00101	0.59826	0.00086	7663
84	3878	0.58646	0.59150	0.58588	0.59794	0.00091	0.59832	0.00100	0.59805	0.00102	0.59810	0.00087	7512
85	3950	0.59492	0.60538	0.59250	0.59789	0.00090	0.59843	0.00099	0.59797	0.00100	0.59810	0.00085	7615
86	4005	0.60514	0.60508	0.60027	0.59800	0.00089	0.59853	0.00098	0.59800	0.00099	0.59819	0.00084	7657
87	4116	0.59654	0.59611	0.59591	0.59798	0.00088	0.59849	0.00097	0.59797	0.00098	0.59816	0.00083	7769
88	3944	0.60294	0.60514	0.61625	0.59805	0.00087	0.59859	0.00096	0.59824	0.00100	0.59828	0.00083	7692
89	3970	0.59070	0.60543	0.58876	0.59794	0.00086	0.59869	0.00095	0.59810	0.00099	0.59825	0.00082	7754
90	3953	0.60552	0.59769	0.60540	0.59805	0.00086	0.59868	0.00094	0.59821	0.00098	0.59832	0.00081	7861
91	4148	0.58051	0.58995	0.59329	0.59781	0.00088	0.59855	0.00093	0.59814	0.00097	0.59820	0.00082	7619
92	3871	0.59723	0.59224	0.59448	0.59780	0.00087	0.59846	0.00092	0.59809	0.00096	0.59814	0.00081	7728
93	4090	0.59676	0.60288	0.59798	0.59778	0.00086	0.59853	0.00091	0.59809	0.00095	0.59816	0.00080	7815
94	4000	0.60158	0.60607	0.60202	0.59783	0.00085	0.59863	0.00091	0.59814	0.00094	0.59823	0.00079	7845
95	4090	0.60498	0.59724	0.60655	0.59793	0.00084	0.59861	0.00089	0.59825	0.00093	0.59829	0.00078	7944
96	3953	0.60518	0.60290	0.59702	0.59802	0.00084	0.59867	0.00088	0.59823	0.00092	0.59834	0.00077	8046
97	4077	0.58410	0.57865	0.59053	0.59784	0.00084	0.59841	0.00091	0.59813	0.00091	0.59815	0.00078	7665
98	3828	0.61003	0.60768	0.61239	0.59800	0.00085	0.59852	0.00091	0.59832	0.00092	0.59830	0.00079	7485
99	4217	0.59293	0.59580	0.59385	0.59794	0.00084	0.59849	0.00090	0.59826	0.00091	0.59825	0.00078	7539
100	3971	0.60877	0.60383	0.61212	0.59807	0.00084	0.59856	0.00089	0.59843	0.00091	0.59838	0.00078	7464
101	4055	0.59328	0.59641	0.59658	0.59801	0.00083	0.59853	0.00088	0.59841	0.00090	0.59834	0.00077	7530
102	3855	0.60540	0.60367	0.59450	0.59810	0.00083	0.59859	0.00087	0.59836	0.00089	0.59839	0.00076	7641
103	4112	0.60493	0.61143	0.61286	0.59818	0.00082	0.59875	0.00087	0.59854	0.00090	0.59850	0.00076	7454
104	3958	0.58660	0.59969	0.58292	0.59805	0.00082	0.59876	0.00086	0.59835	0.00091	0.59843	0.00076	7415
105	3775	0.59859	0.60737	0.59713	0.59805	0.00081	0.59886	0.00086	0.59834	0.00090	0.59846	0.00075	7467
106	4108	0.58960	0.59487	0.58964	0.59795	0.00081	0.59881	0.00085	0.59824	0.00089	0.59839	0.00075	7457
107	3895	0.60101	0.60221	0.58930	0.59799	0.00080	0.59885	0.00084	0.59813	0.00089	0.59839	0.00074	7560
108	4109	0.59430	0.59710	0.59888	0.59795	0.00079	0.59883	0.00083	0.59814	0.00088	0.59838	0.00073	7632
109	4049	0.60714	0.61154	0.60204	0.59805	0.00079	0.59898	0.00083	0.59819	0.00087	0.59847	0.00073	7550
110	4117	0.60070	0.60211	0.60419	0.59808	0.00078	0.59901	0.00082	0.59825	0.00086	0.59851	0.00073	7606

111	3921	0.59279	0.59815	0.59238	0.59802	0.00078	0.59900	0.00081	0.59819	0.00085	0.59848	0.00072	7653
112	3957	0.61078	0.61341	0.61052	0.59816	0.00078	0.59916	0.00082	0.59832	0.00086	0.59862	0.00073	7416
113	4124	0.60303	0.60230	0.60422	0.59821	0.00077	0.59919	0.00081	0.59839	0.00085	0.59867	0.00072	7469
114	3940	0.59976	0.60136	0.60455	0.59823	0.00077	0.59921	0.00080	0.59845	0.00084	0.59870	0.00072	7530
115	3986	0.60424	0.60588	0.59879	0.59829	0.00076	0.59928	0.00080	0.59846	0.00083	0.59875	0.00071	7576
116	3988	0.60130	0.59826	0.60556	0.59832	0.00075	0.59927	0.00079	0.59853	0.00083	0.59878	0.00070	7661
117	3882	0.60352	0.59677	0.60259	0.59838	0.00075	0.59925	0.00078	0.59857	0.00082	0.59880	0.00069	7773
118	4066	0.59918	0.60434	0.60597	0.59839	0.00074	0.59930	0.00078	0.59865	0.00082	0.59884	0.00069	7799
119	4047	0.59519	0.59559	0.58190	0.59835	0.00073	0.59926	0.00077	0.59848	0.00082	0.59876	0.00068	7810
120	3930	0.60145	0.59920	0.60436	0.59839	0.00073	0.59926	0.00076	0.59854	0.00082	0.59879	0.00068	7892

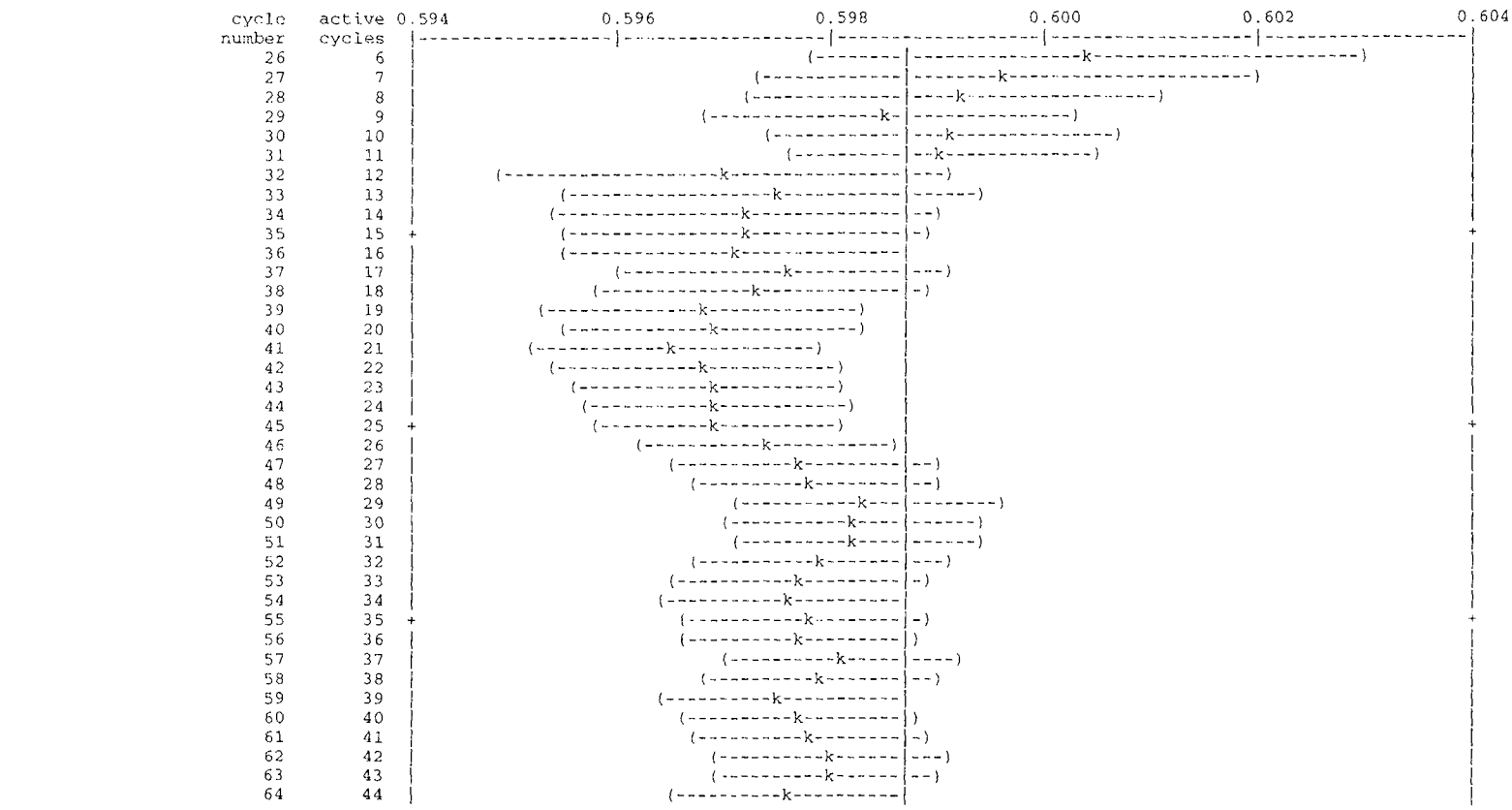
the largest active cycle keffs by estimator are:

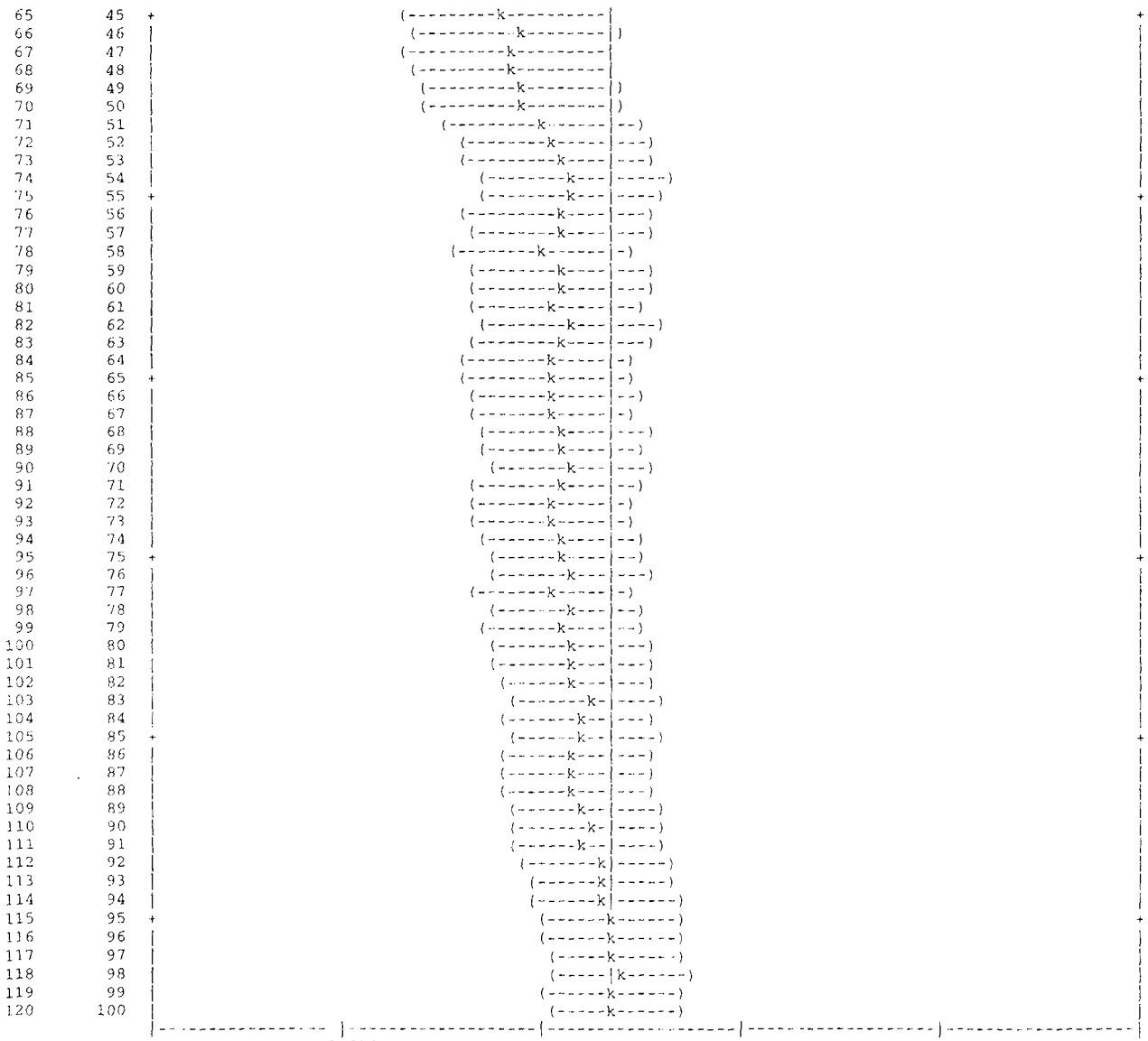
collision 0.61280 on cycle 49
absorption 0.61887 on cycle 49
track length 0.61625 on cycle 88

the smallest active cycle keffs by estimator are:

collision 0.58051 on cycle 91
absorption 0.57865 on cycle 97
track length 0.57730 on cycle 64

lplot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.59879)





lindividual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence

0	120	478686	0.5996	0.0008	0.6001	0.0008	0.5994	0.0009	no/no/no	0.59981	0.00078	0.59824-0.60137	0.59773-0.60188
1	119	474686	0.5991	0.0007	0.5997	0.0007	0.5990	0.0008	95/95/95	0.59933	0.00066	0.59802-0.60064	0.59760-0.60107
2	118	472078	0.5990	0.0007	0.5995	0.0007	0.5989	0.0008	95/95/95	0.59922	0.00065	0.59793-0.60050	0.59751-0.60092
3	117	468355	0.5989	0.0007	0.5995	0.0007	0.5988	0.0008	95/95/95	0.59913	0.00065	0.59784-0.60042	0.59742-0.60084
4	116	464403	0.5988	0.0007	0.5993	0.0007	0.5986	0.0008	95/95/95	0.59898	0.00064	0.59772-0.60025	0.59730-0.60067
5	115	460324	0.5987	0.0007	0.5993	0.0007	0.5986	0.0008	95/95/95	0.59897	0.00064	0.59769-0.60025	0.59727-0.60066
6	114	456339	0.5988	0.0007	0.5993	0.0007	0.5987	0.0008	95/95/95	0.59899	0.00065	0.59770-0.60028	0.59728-0.60070
7	113	452351	0.5987	0.0007	0.5993	0.0007	0.5987	0.0008	95/95/95	0.59897	0.00065	0.59767-0.60027	0.59724-0.60069
8	112	448391	0.5988	0.0007	0.5994	0.0007	0.5987	0.0008	95/95/95	0.59902	0.00066	0.59771-0.60033	0.59728-0.60075
9	111	444519	0.5988	0.0007	0.5994	0.0007	0.5987	0.0008	95/95/95	0.59901	0.00066	0.59769-0.60033	0.59726-0.60076
10	110	440468	0.5989	0.0007	0.5995	0.0007	0.5988	0.0008	95/95/95	0.59914	0.00065	0.59784-0.60045	0.59741-0.60087
11	109	436456	0.5989	0.0007	0.5995	0.0007	0.5988	0.0008	95/95/95	0.59912	0.00066	0.59780-0.60043	0.59737-0.60086
12	108	432297	0.5988	0.0007	0.5995	0.0008	0.5988	0.0008	95/95/95	0.59910	0.00067	0.59777-0.60043	0.59734-0.60087
13	107	428284	0.5987	0.0007	0.5994	0.0007	0.5987	0.0008	95/95/95	0.59899	0.00066	0.59767-0.60031	0.59724-0.60074
14	106	424209	0.5985	0.0007	0.5993	0.0007	0.5986	0.0008	95/95/95	0.59886	0.00066	0.59755-0.60017	0.59712-0.60060
15	105	420258	0.5985	0.0007	0.5991	0.0007	0.5986	0.0008	95/95/95	0.59880	0.00066	0.59748-0.60011	0.59706-0.60054
16	104	416292	0.5986	0.0007	0.5992	0.0007	0.5987	0.0008	95/95/95	0.59888	0.00066	0.59756-0.60019	0.59713-0.60062
17	103	412373	0.5985	0.0007	0.5993	0.0007	0.5986	0.0008	95/95/95	0.59887	0.00067	0.59753-0.60020	0.59710-0.60064
18	102	408257	0.5985	0.0007	0.5993	0.0008	0.5987	0.0008	95/95/95	0.59893	0.00067	0.59758-0.60027	0.59715-0.60071
19	101	404383	0.5985	0.0007	0.5994	0.0008	0.5987	0.0008	95/95/95	0.59892	0.00068	0.59756-0.60028	0.59712-0.60072
20	100*	400401	0.5984	0.0007	0.5993	0.0008	0.5985	0.0008	95/95/95	0.59879	0.00068	0.59744-0.60014	0.59700-0.60058
22	98	392194	0.5984	0.0007	0.5993	0.0008	0.5985	0.0008	95/95/95	0.59879	0.00069	0.59741-0.60016	0.59696-0.60061
24	96	384221	0.5985	0.0007	0.5994	0.0008	0.5986	0.0008	95/95/95	0.59892	0.00069	0.59754-0.60030	0.59709-0.60076
26	94	376214	0.5984	0.0008	0.5994	0.0008	0.5984	0.0009	95/95/95	0.59883	0.00070	0.59743-0.60024	0.59697-0.60070
28	92	368291	0.5985	0.0008	0.5995	0.0008	0.5985	0.0009	95/95/95	0.59888	0.00071	0.59746-0.60030	0.59699-0.60077
30	90	360417	0.5983	0.0008	0.5995	0.0008	0.5984	0.0009	95/95/95	0.59877	0.00073	0.59732-0.60022	0.59685-0.60070
32	88	352343	0.5984	0.0007	0.5996	0.0008	0.5986	0.0009	95/95/95	0.59891	0.00072	0.59747-0.60035	0.59701-0.60082
34	86	344512	0.5984	0.0008	0.5997	0.0008	0.5986	0.0009	95/95/95	0.59893	0.00074	0.59746-0.60039	0.59698-0.60087
36	84	336462	0.5986	0.0008	0.5998	0.0008	0.5987	0.0009	95/95/95	0.59908	0.00075	0.59759-0.60056	0.59711-0.60105
38	82	328421	0.5987	0.0008	0.6000	0.0008	0.5987	0.0009	95/95/95	0.59926	0.00075	0.59777-0.60074	0.59728-0.60123
40	80	320558	0.5987	0.0008	0.6000	0.0008	0.5988	0.0010	95/95/95	0.59932	0.00077	0.59779-0.60084	0.59730-0.60134
42	78	312726	0.5987	0.0008	0.6001	0.0009	0.5989	0.0009	95/95/95	0.59929	0.00078	0.59773-0.60084	0.59723-0.60135
44	76	304576	0.5987	0.0008	0.6000	0.0009	0.5989	0.0010	95/95/95	0.59929	0.00080	0.59769-0.60088	0.59717-0.60140
46	74	296442	0.5986	0.0008	0.6000	0.0009	0.5988	0.0010	95/95/95	0.59915	0.00082	0.59752-0.60079	0.59698-0.60132
48	72	288412	0.5985	0.0009	0.5999	0.0009	0.5986	0.0010	95/95/95	0.59904	0.00084	0.59737-0.60072	0.59682-0.60127
50	70	280317	0.5984	0.0008	0.5997	0.0009	0.5986	0.0010	95/95/95	0.59894	0.00082	0.59729-0.60058	0.59675-0.60112
52	68	272407	0.5985	0.0009	0.5998	0.0009	0.5988	0.0010	95/95/95	0.59906	0.00084	0.59739-0.60073	0.59684-0.60128
54	66	264368	0.5986	0.0009	0.6001	0.0009	0.5990	0.0011	95/95/95	0.59930	0.00085	0.59761-0.60099	0.59705-0.60155
56	64	256276	0.5984	0.0009	0.6001	0.0009	0.5989	0.0011	95/95/95	0.59918	0.00088	0.59742-0.60094	0.59684-0.60152
58	62	248332	0.5984	0.0009	0.6002	0.0009	0.5989	0.0011	95/95/95	0.59933	0.00089	0.59754-0.60112	0.59695-0.60172
60	60	240478	0.5986	0.0009	0.6003	0.0009	0.5992	0.0011	95/95/95	0.59950	0.00089	0.59772-0.60127	0.59713-0.60186
62	58	232448	0.5985	0.0010	0.6000	0.0010	0.5991	0.0011	95/95/95	0.59931	0.00090	0.59750-0.60112	0.59691-0.60171
64	56	224522	0.5989	0.0009	0.6004	0.0009	0.5994	0.0011	95/95/95	0.59970	0.00087	0.59796-0.60144	0.59738-0.60202
66	54	216319	0.5988	0.0010	0.6006	0.0009	0.5991	0.0011	95/95/95	0.59977	0.00091	0.59795-0.60159	0.59734-0.60220
68	52	208246	0.5989	0.0010	0.6009	0.0009	0.5991	0.0011	95/95/95	0.59997	0.00094	0.59808-0.60186	0.59745-0.60249
70	50	200145	0.5989	0.0010	0.6008	0.0010	0.5990	0.0012	95/95/95	0.60005	0.00096	0.59810-0.60199	0.59746-0.60264
72	48	192108	0.5986	0.0010	0.6007	0.0010	0.5987	0.0012	95/95/95	0. 59975	0.00099	0.59775-0.60176	0.59708-0.60243
74	46	184244	0.5984	0.0011	0.6006	0.0010	0.5984	0.0013	95/95/95	0.59960	0.00103	0.59751-0.60169	0.59681-0.60239
76	44	176149	0.5986	0.0011	0.6010	0.0010	0.5985	0.0013	95/95/95	0.60001	0.00106	0.59787-0.60215	0.59715-0.60288
78	42	168096	0.5987	0.0011	0.6012	0.0010	0.5990	0.0013	95/95/95	0.60021	0.00109	0.59800-0.60242	0.59726-0.60317
80	40	159947	0.5986	0.0012	0.6009	0.0010	0.5986	0.0013	95/95/95	0.60018	0.00110	0.59795-0.60241	0.59719-0.60317
82	38	152081	0.5986	0.0012	0.6007	0.0011	0.5988	0.0014	95/95/95	0.60004	0.00112	0.59777-0.60231	0.59700-0.60308
84	36	144057	0.5992	0.0012	0.6009	0.0011	0.5994	0.0014	95/95/95	0.60030	0.00111	0.59804-0.60256	0.59726-0.60334
86	34	136102	0.5991	0.0013	0.6007	0.0012	0.5996	0.0015	95/95/95	0.60017	0.00116	0.59779-0.60254	0.59697-0.60336
88	32	128042	0.5991	0.0013	0.6007	0.0012	0.5992	0.0014	95/95/95	0.60010	0.00121	0.59763-0.60256	0.59678-0.60342
90	30	120119	0.5992	0.0014	0.6006	0.0013	0.5993	0.0015	95/95/95	0.60008	0.00129	0.59742-0.60273	0.59649-0.60366

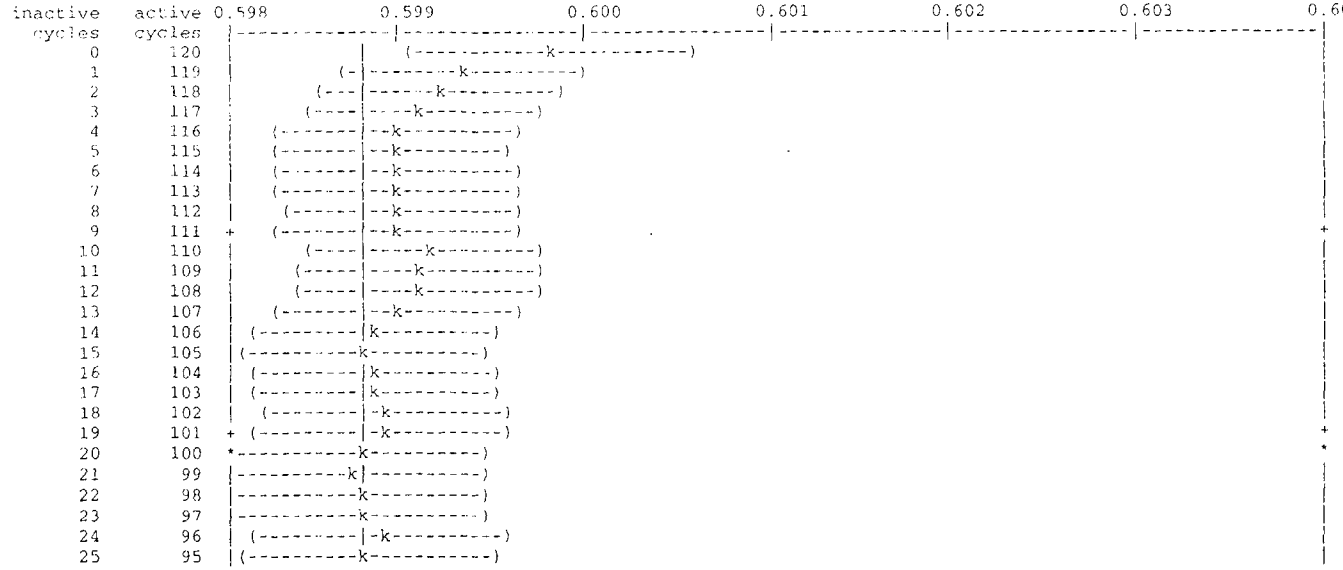
92	28	112100	0.5999	0.0013	0.6013	0.0013	0.5997	0.0016	95/99/95	0.60061	0.00129	0.59796-0.60327	0.59702-0.60420
94	26	104010	0.6000	0.0014	0.6011	0.0014	0.5997	0.0017	95/99/95	0.60051	0.00136	0.59769-0.60334	0.59668-0.60435
96	24	95967	0.5995	0.0015	0.6012	0.0015	0.5995	0.0018	95/99/95	0.60035	0.00153	0.59717-0.60354	0.59602-0.60469
98	22	88062	0.5997	0.0013	0.6019	0.0012	0.5993	0.0018	95/95/95	0.60136	0.00133	0.59858-0.60415	0.59756-0.60517
100	20	79874	0.5996	0.0014	0.6021	0.0012	0.5989	0.0019	95/95/95	0.60129	0.00146	0.59820-0.60438	0.59705-0.60553
102	18	71964	0.5997	0.0014	0.6023	0.0013	0.5993	0.0021	95/95/95	0.60136	0.00157	0.59802-0.60470	0.59674-0.60598
104	16	63894	0.6002	0.0013	0.6019	0.0014	0.5995	0.0019	95/95/95	0.60092	0.00151	0.59764-0.60419	0.59635-0.60548
106	14	56011	0.6010	0.0013	0.6020	0.0014	0.6004	0.0020	95/95/99	0.60127	0.00145	0.59807-0.60447	0.59676-0.60579
108	12	48007	0.6016	0.0014	0.6024	0.0016	0.6014	0.0022	95/95/no	0.60175	0.00157	0.59820-0.60530	0.59665-0.60685
110	10	39841	0.6011	0.0016	0.6015	0.0017	0.6011	0.0026	95/95/99	0.60129	0.00169	0.59730-0.60528	0.59538-0.60720
112	8	31963	0.6010	0.0010	0.6005	0.0013	0.6010	0.0028	95/95/no	0.60078	0.00105	0.59809-0.60347	0.59656-0.60500
114	6	23899	0.6008	0.0013	0.6000	0.0017	0.5999	0.0037	95/95/99	0.60072	0.00150	0.59596-0.60549	0.59199-0.60946
116	4	15925	0.5998	0.0018	0.5990	0.0019	0.5987	0.0056	95/95/99	0.59971	0.00030	0.59587-0.60355	0.58048-0.61895
117	3	12043	0.5986	0.0018	0.5997	0.0025	0.5974	0.0078					
118	2	7977	0.5983	0.0031	0.5974	0.0018	0.5931	0.0112					

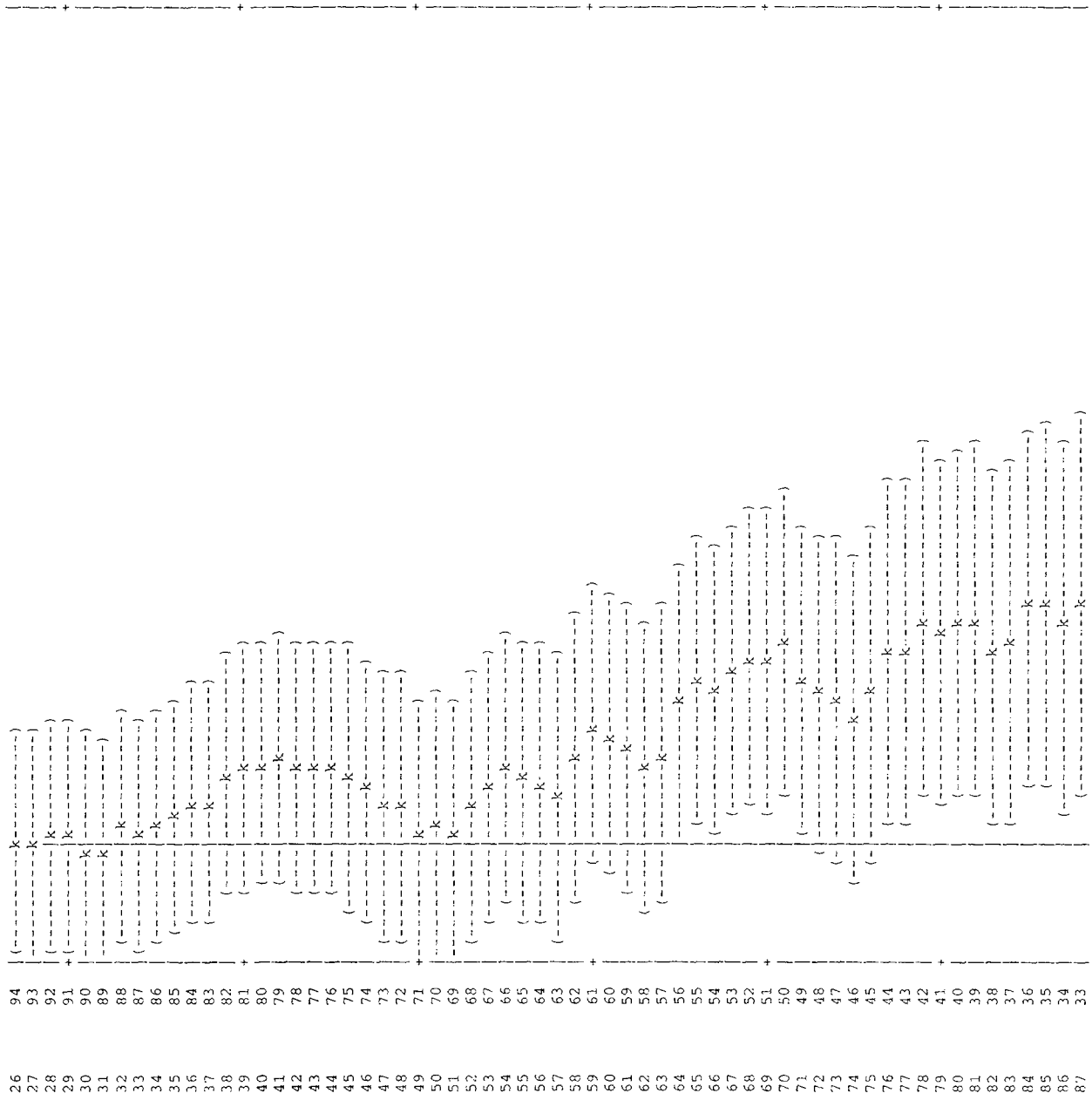
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 116 inactive cycles and 4 active cycles.

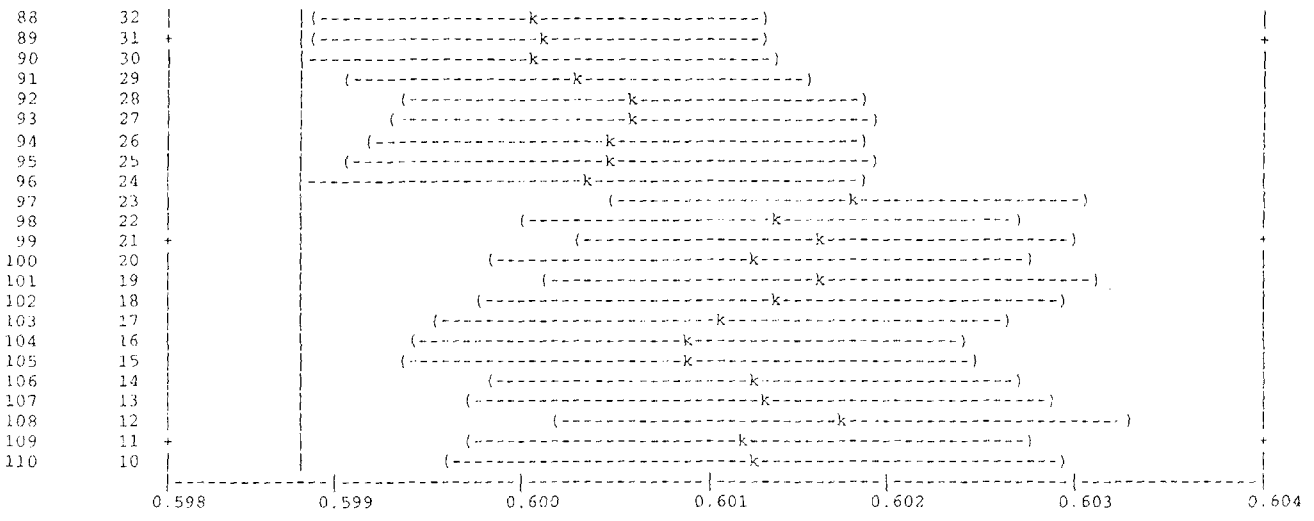
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.59785	0.00098	0.59687 to 0.59883	0.59589 to 0.59981	0.59523 to 0.60047
second half	0.60005	0.00096	0.59908 to 0.60102	0.59810 to 0.60199	0.59746 to 0.60264
final result	0.59879	0.00068	0.59811 to 0.59947	0.59744 to 0.60014	0.59700 to 0.60058

the first and second half values of k(collision/absorption/track length) appear to be the same at the 95 percent confidence level.
lplot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.59879)







dump no. 9 on file c10191r nps = 478686 coll = 38590674 ctm = 118.30 nrn = 744597784

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 118.31 minutes

mcnp version 4a 10/01/93 06/01/00 16:59:56 probid = 06/01/00 15:01:37

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3065 Southwestern Boulevard
Suite 202
Orchard Park, NY 14127
716 675 7130 Tel
716 675 7137 Fax

Calculation Cover Page

Job No: **30822-244-023 /7150** Calculation No: **BUF-2000-059/Rev. 1** Date: **June 4, 2000**

Problem Statement & Calculation Objectives:

Determine the safe amount of water present in 30 gallon drum arrays filled with fuel pins arranged in a hexagonal lattice. The fuel inside the drum is damp. The 30 gallon drums are 72.39 cm (28 1/2 inches) high and are arranged in an infinite hexagonal array. There is no water outside the fuel pins and air fills the space between the fuel elements in the drums. Water partially fills the height of the empty fuel elements. Drum walls are made of 0.175 cm carbon steel and the drums stand on a concrete floor. The model evaluates cases with and without external drum moderation.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993

Attachments:

Attachment 1: 30 gallon drum dimensions
Attachment 2: Case 1 with MCNP surface and cell numbers
Attachment 3: Case 1 MCNP input file
Attachment 4: Case 1 MCNP output file
Attachment 5: Case 2 with MCNP surface and cell numbers
Attachment 6: Case 2 MCNP input file
Attachment 7: Case 2 MCNP output file
Attachment 8: Derivation of the height of the water filling the empty clad

Prepared by:

Signature Igor V. Chichkov — Date 06/04/00

Checked by:

Signature Joseph C. Wolniewicz — Date 06/22/00

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Job No 30822-244-023 /7150 Job: HEC Support Activities By JVC Date 06/04/00
Client WVNS Subject: drum arrays with damp fuel Chk'd Jan Date 06/22/00

Analysis

Assumptions

The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is fresh (not irradiated) with 5% enrichment
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel pins are arranged in a hexagonal array and fill the 30 gallon drum
- There is no gap between two adjacent pins
- One out of three pins is completely filled with 5% enriched uranium dioxide (UO_2) fuel
- Two out of three pins do not have any fuel and contain water inside
- Water density is 1 g/cm^3
- The drum and fuel element heights are 72.39 cm (28 1/2 inches)
- The drums are arranged in an infinite hexagonal array without any gap between two adjacent drums
- The space between the fuel pins is filled with air
- Air density is 0.001293 g/cm^3
- Drum walls are made of 0.175 cm carbon steel
- The drums stand on a concrete floor
- The thickness of the concrete floor is 30 m
- Layers of drums are arranged concentrically with respect to other layers

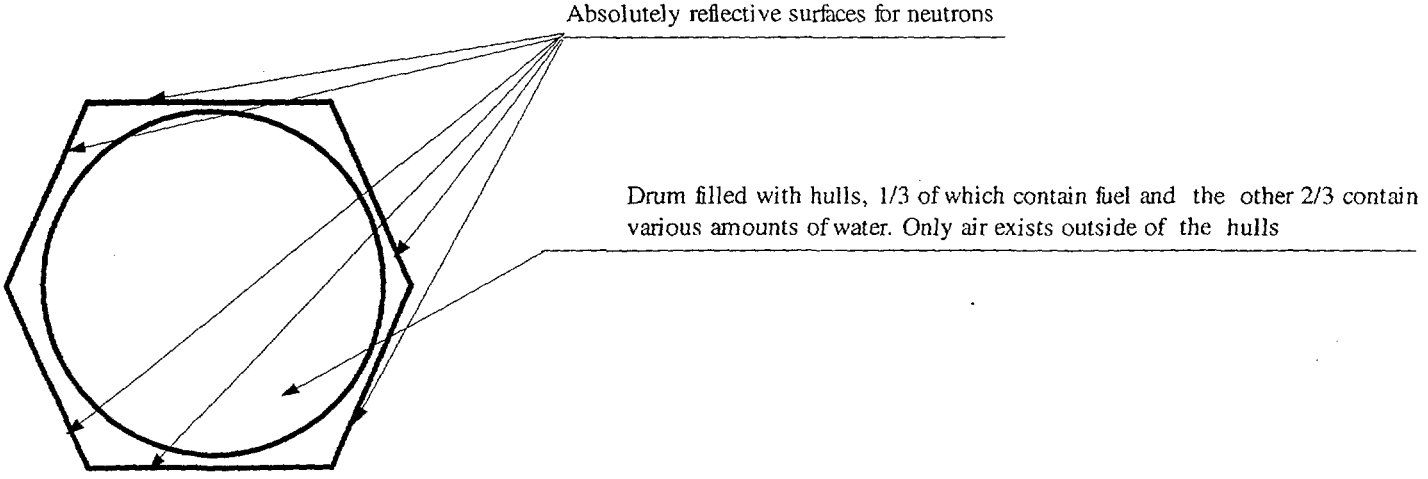
MCNP Model

The model considers the possibility that many of the fuel hulls in the debris in the HECs are leached. For the analysis, it is assumed that two thirds of the fuel is leached and that the void space of the leached hulls contains water. Furthermore, it is assumed that drying a drum containing both leached and unleached hulls

will only be partially successful so that following drying some residual water remains in the void region of the leached hulls.

Neutron multiplication factors were calculated with the MCNP4A code. To model the infinite hexagonal array of drums without any gap between two adjacent drums, one drum filled with fuel elements was surrounded by a hexagon prism. The hexagon prism sides surrounding the drum were set up having absolutely reflective surfaces for neutrons to model the infinite array. Figure 1 illustrates the adopted MCNP model. The cylinder representing the drum does not touch the hexagon to account for the rings around the cylindrical drums. The rings were not modeled.

Figure 1. Top view of the MCNP geometry set up.



Two different cases were considered:

- **Case 1.** The array is infinite in 2 horizontal directions and has 3 layers of drums standing on top of each other (∞ x ∞ x 3). The space outside the drums is filled either with air or water.
- **Case 2.** The array is infinite in 2 horizontal directions and has 2 layers of drums standing on top of each other (∞ x ∞ x 2). The space outside the drums is filled either with air or water.

Examples of MCNP input and output files for both cases are shown in the Attachments. In both cases, two out of three fuel pins were without fuel and water filled the lower part of the empty pin up to a certain heigh The upper part of the pin was filled with air. Attachments 2 and 5 have the fuel-empty clad lattice drawings The water density was assumed to be 1 g/cm^3. The studied volume fractions of the drum filled with water (were: 0.15, 0.1, 0.07, 0.05 and 0.03 for the 3 layer drum heigh array; and 0.15, 0.1, 0.07, and 0.05 for the 2 layer drum heigh array. The volume fractions of the drum filled with water (f_v) is defined as the ratio of the water volume in a drum to the total drum volume (equation 1) . The derivation of the height of the water

filling the empty clad can be found in Attachment 8.

$$f_v = \frac{V_w}{V_{total}} \qquad (1)$$

Where:

f_v = the volume fractions of the drum filled with water

V_w = the water volume in a drum

V_{total} = the total drum volume

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for air (Attix F.H., 1986). Table 2 and 3 show the element weight fractions for stainless steel 304 used in the fuel clad and the carbon steel used in the drum walls, respectively (Harmon C. D., II et al., 1993). Table 4 shows the element composition of concrete (Harmon C. D., II et al., 1993). The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 5. Molar mass of uranium dioxide (UO_2) can be determined from equation (2).

$$M_{UO_2} = A_U + 2A_{O-16} = f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16} \qquad (2)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)

A_{U-235} = uranium-235 molar mass (g/mole)

A_{U-238} = uranium-238 molar mass (g/mole)

A_{O-16} = oxygen-16 molar mass (g/mole)

f = uranium-235 enrichment

Then the weigh fractions for uranium-235 (w_{U-235}), uranium-238 (w_{U-238}), and oxygen-16 (w_{O-16}) are:

$$w_{U-235} = \frac{f\,A_{U-235}}{M_{UO_2}} = \frac{f\,A_{U-235}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (3)$$

$$w_{U-238} = \frac{(1-f)\,A_{U-238}}{M_{UO_2}} = \frac{(1-f)\,A_{U-238}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2\,A_{O-16}} \qquad (4)$$

$$w_{O-16} = \frac{2\,A_{O-16}}{M_{UO_2}} = \frac{2\,A_{O-16}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2\,A_{O-16}} \qquad (5)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012828

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02
Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Carbon Steel Composition

Element	Weight Fraction
Iron (Fe)	0.995
Carbon (C)	0.005

Table 4. Concrete composition

Element	Weight Fraction
Hydrogen (H)	0.006
Oxygen (O)	0.500
Sodium (Na)	0.017
Aluminum (Al)	0.048
Silicon (Si)	0.315
Potassium (K)	0.019
Calcium (Ca)	0.083
Iron (Fe)	0.012

Table 5. Fuel Composition

Element	Weight Fraction
Uranium-235 (^{235}U)	0.0435427
Uranium-238 (^{238}U)	0.8378729
Oxygen (O)	0.1185844

Results

The k_∞ values were calculated for all three models using MCNP 4A code. Tables 6 and 7 show the neutron multiplication factors for cases 1 and 2 respectively. Figures 2 and 3 plot the calculated $k_\infty + 2\sigma$ values for cases 1 and 2 respectively.

Table 6. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ for Case 1 (∞ x ∞ x 3).

water volume fraction in the drum f_v	air outside drums			water outside drums		
	k_∞	σ	$k_\infty + 2\sigma$	k_∞	σ	$k_\infty + 2\sigma$
0.03	0.7876	0.0009	0.7894	0.8588	0.0008	0.8604
0.05	0.8683	0.0009	0.8700	0.879	0.0009	0.8808
0.07	0.9191	0.0009	0.9208	0.8975	0.0008	0.8991
0.1	0.9693	0.0008	0.9710	0.9197	0.0009	0.9216
0.15	1.0194	0.0009	1.0211	0.9483	0.0009	0.9501

Table 7. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ for Case 2 (∞ x ∞ x 2).

water volume fraction in the drum f_v	air outside drums			water outside drums		
	k_∞	σ	$k_\infty + 2\sigma$	k_∞	σ	$k_\infty + 2\sigma$
0.05	0.8236	0.0009	0.8253	0.8565	0.0008	0.8580
0.07	0.8807	0.001	0.8827	0.878	0.0009	0.8798
0.1	0.9339	0.0009	0.9357	0.9024	0.0009	0.9041
0.15	0.9928	0.0009	0.9945	0.9358	0.0009	0.9376

Figure 2. $k_\infty + 2\sigma$ values for Case 1 (∞ x ∞ x 3).

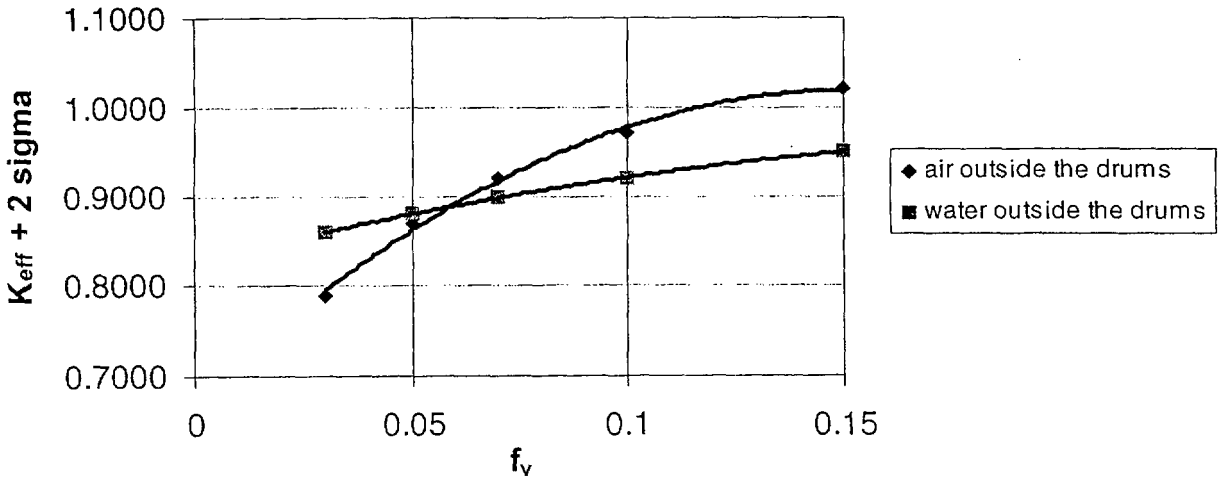
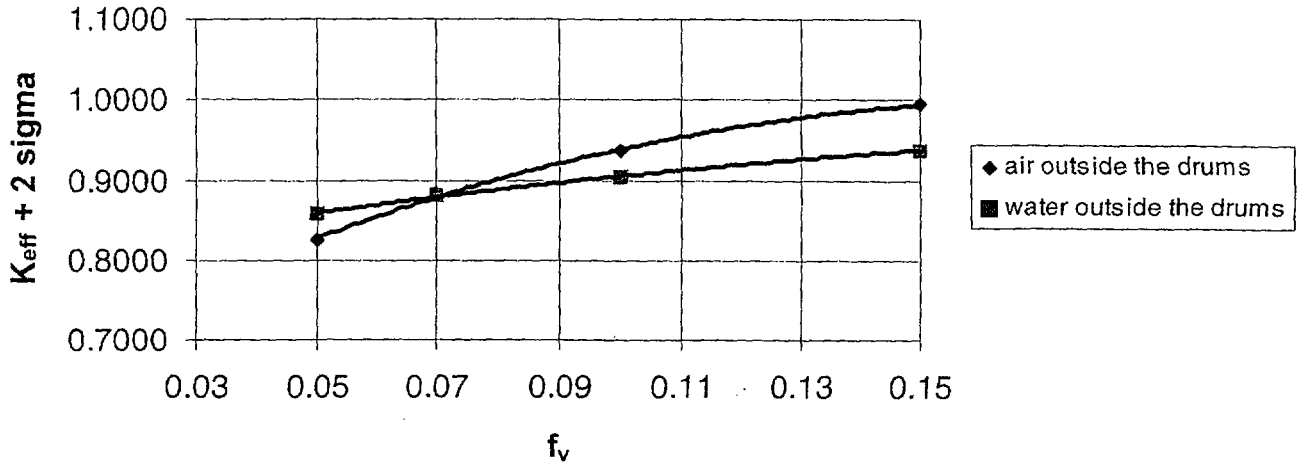


Figure 3. $k_\infty + 2\sigma$ values for Case 2 (∞ x ∞ x 2).



The criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq k_a - \Delta k_b - \sigma_b \qquad (7)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

σ = standard deviation of predicted k_∞

$k_a = 0.95$ = established allowable limiting neutron multiplication factor

Δk_b = calculation method bias

σ_b = bias uncertainty

For this case, calculation method bias together with bias uncertainty ($\Delta k_b + \sigma_b$) is equal to 0.02. Thus the criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq 0.93 \qquad (8)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

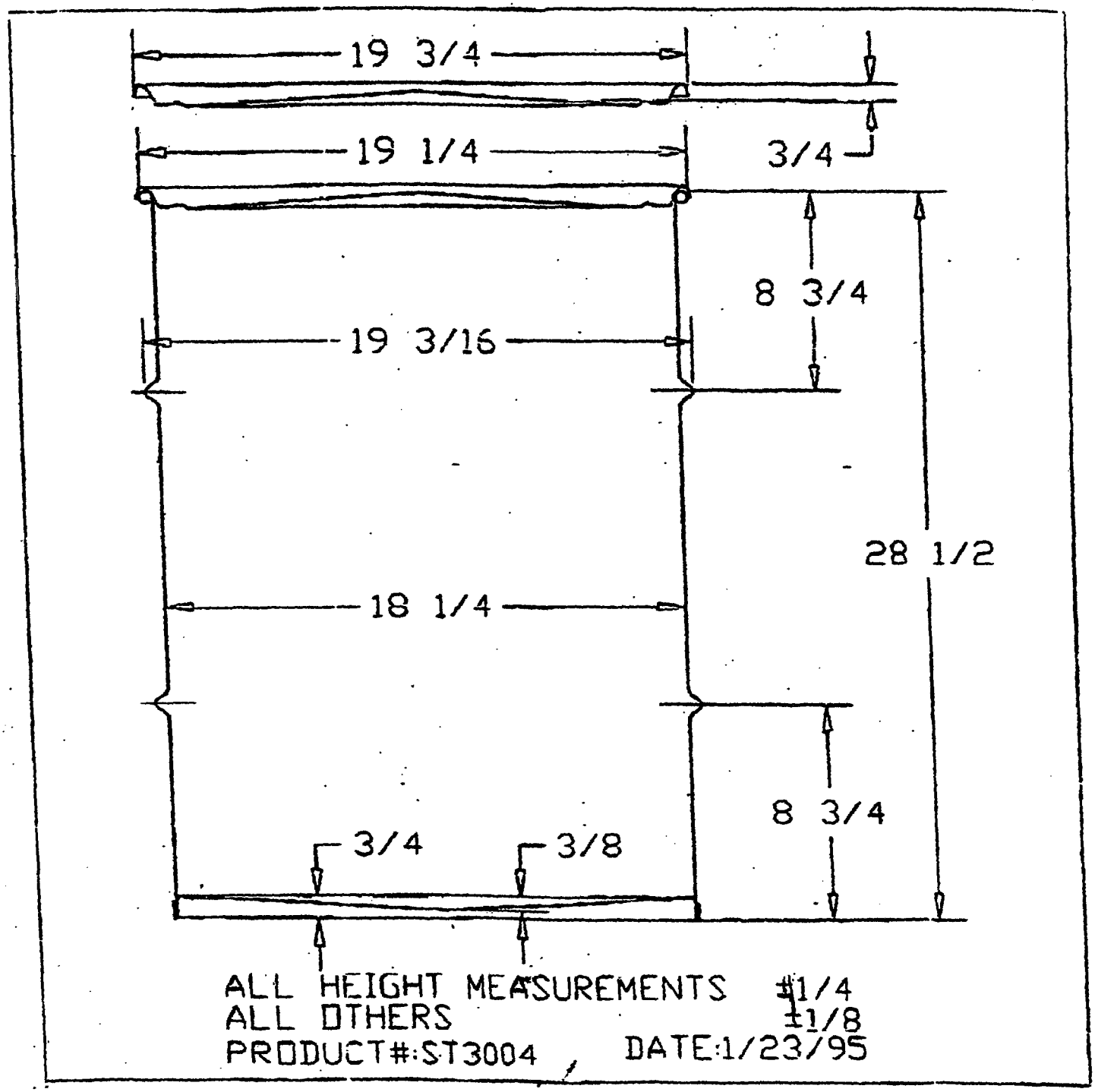
σ = standard deviation of predicted k_∞

As can be seen from the data in Tables 5 and 6 and Figures 2 and 3 criterion (8) is met and the system is safe when water fills no more than 7% of the drum volume assuming both models in Cases 1 and 2.

Attachment 1: 30 gallon drum dimensions

COPY

30 GAL 1.5/1.2/1.2mm OPEN HEAD DRUM
UN 1A2/Y1.5/150

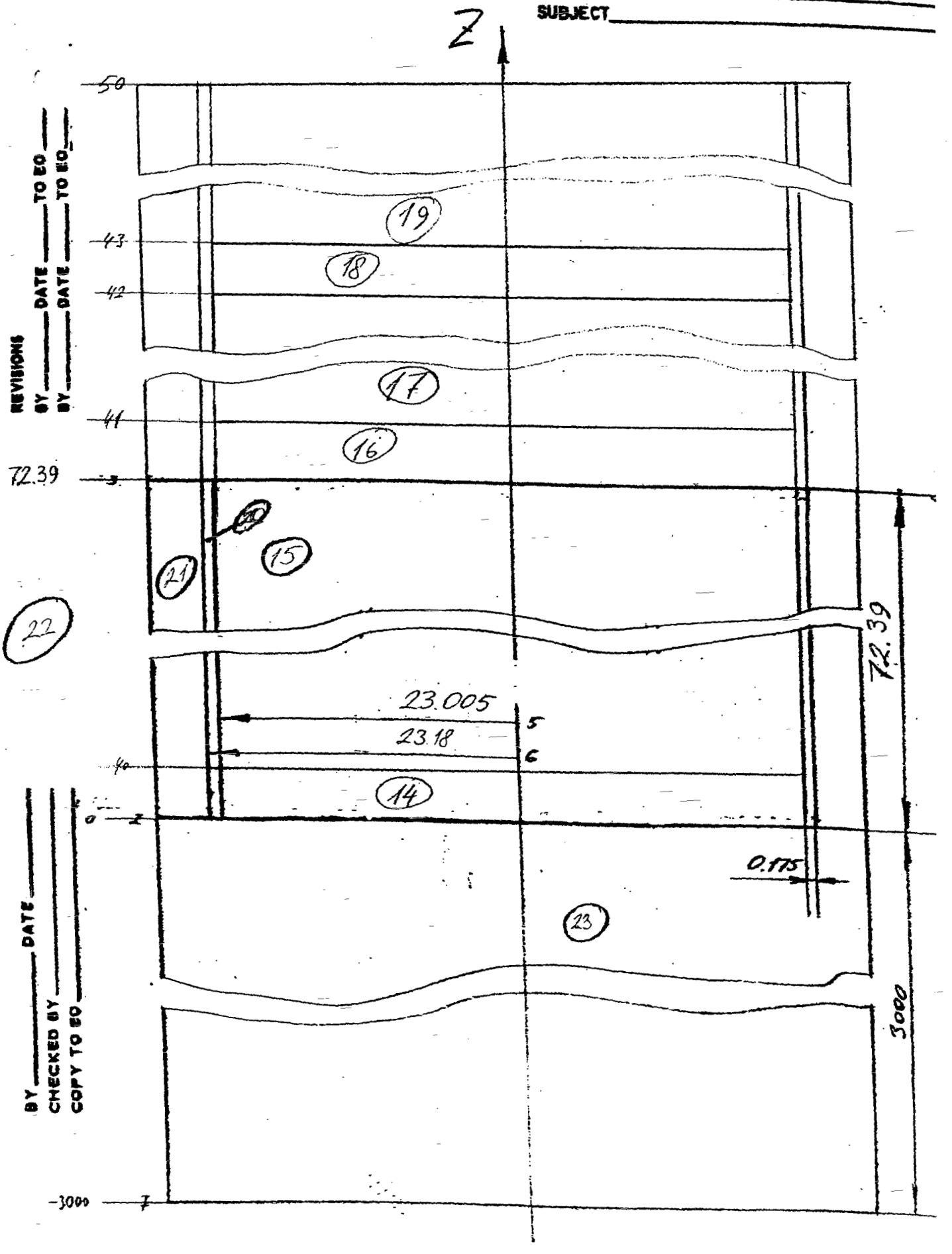


ALL HEIGHT MEASUREMENTS ±1/4
ALL OTHERS ±1/8
PRODUCT#:ST3004 DATE:1/23/95

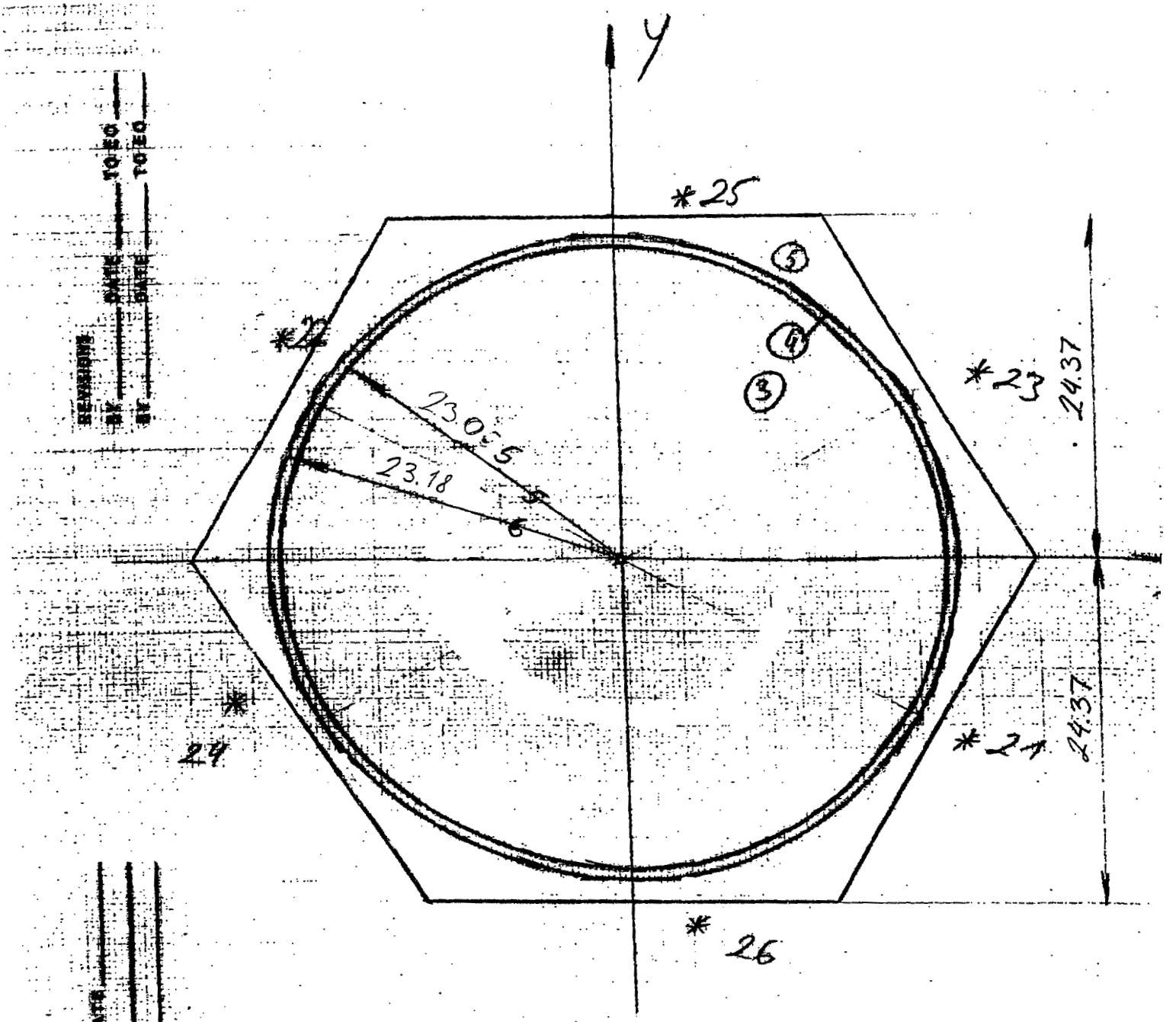
SKOLNIK INDUSTRIES,INC

Attachment 2: Case 1 with MCNP surface and cell numbers

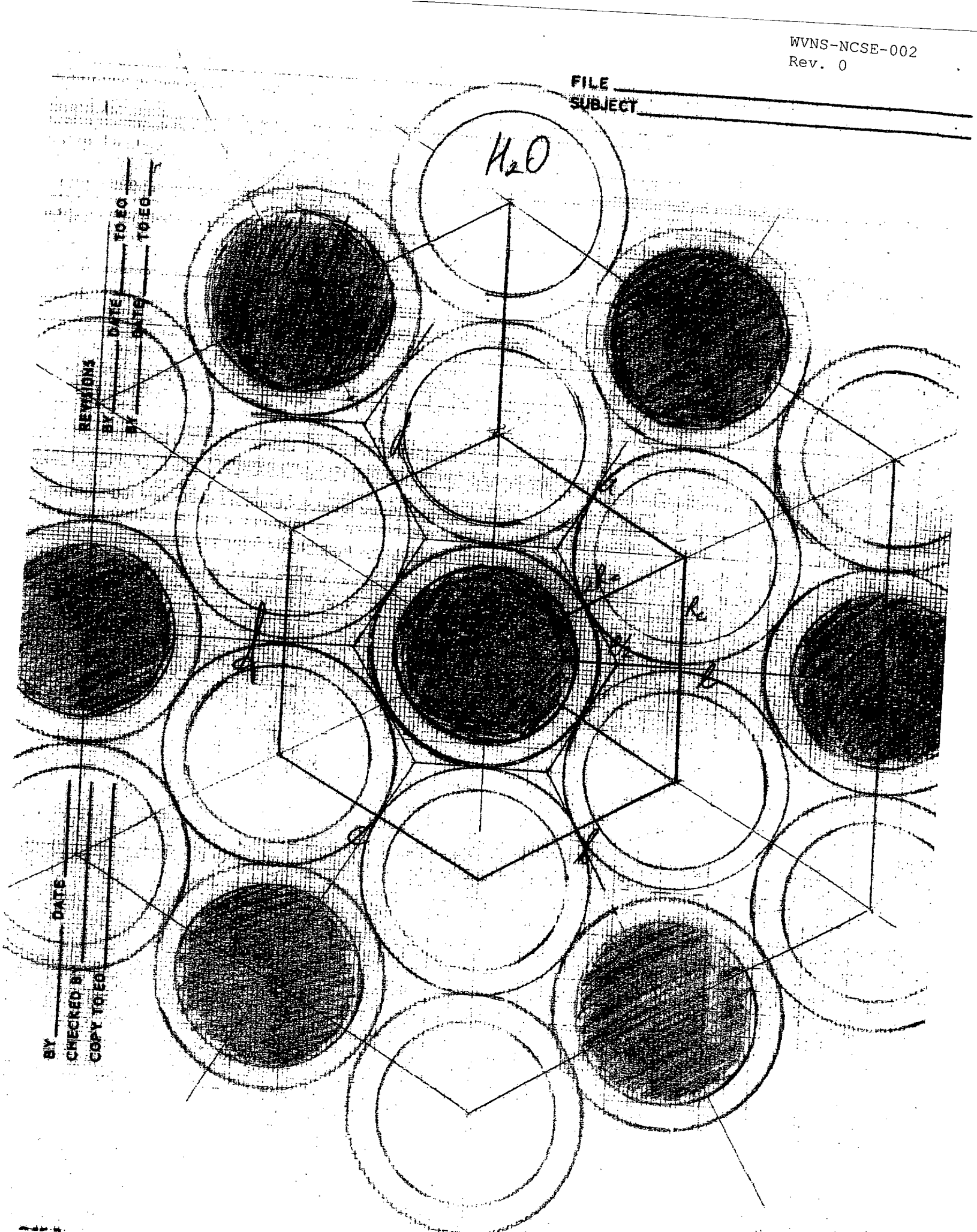
FILE _____
SUBJECT _____



FILE
SUBJECT



FILE
SUBJECT



Attachment 3: Case 1 MCNP input file

```
                                                                C01220
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
c ------------------------------------------------------------------------
c Universe 1. Fuel rod, clad and air outside the clad
c
1 61 -10.4  -17     u=1       imp:n=1 $ fuel rod
2 62 -7.92  -18 17 u=1        imp:n=1 $ SS-304 clad
3 64 -0.001293  18 u=1        imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 2. Water instead of the fuel, clad and air outside the clad
c
4 63 -1.0   -17     u=2       imp:n=1 $ water instead of fuel inside the clad
5 62 -7.92  -18 17 u=2        imp:n=1 $ SS-304 clad
6 64 -0.001293  18 u=2        imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 3. 1 fuel rod per 2 water rods hexagonal lattice arrangement
c
7  0        -11 12 -13 14 -15 16 u=3
                lat=2 fill= -1:1 -1:1 0:0
                1 2 2
                2 1 2
                2 2 1     imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 4. Water-fuel lattice filling the lower part of the drum
c
8 0    -35 36 -31 33 -34 32 u=4
                lat=2 fill=3 imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 5. Air instead of the fuel, clad and air outside the clad
c
9  64 -0.001293 -17 u=5       imp:n=1 $ air instead of fuel inside the clad
10 62 -7.92  -18 17 u=5       imp:n=1 $ SS-304 clad
11 64 -0.001293  18 u=5       imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 6. 1 fuel rod per 2 air rods hexagonal lattice arrangement
c
12  0        -11 12 -13 14 -15 16 u=6
                lat=2 fill= -1:1 -1:1 0:0
                1 5 5
                5 1 5
                5 5 1     imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 7. Air-fuel lattice filling the upper part drum
c
13 0    -35 36 -31 33 -34 32 u=7
                lat=2 fill=6 imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
14  0  2 -40 -5  fill=4  imp:n=1 $ lower part of the 1st drum filled with
c                                  water-fuel lattice
15  0  40 -3 -5  fill=7  imp:n=1 $ upper part of the 1st drum filled with
c                                  air-fuel lattice
16  0  3 -41 -5  fill=4  imp:n=1 $ lower part of the 2nd drum filled with
c                                  water-fuel lattice
17  0  41 -42 -5 fill=7  imp:n=1 $ upper part of the 2nd drum filled with
c                                  air-fuel lattice
18  0  42 -43 -5 fill=4  imp:n=1 $ lower part of the 3rd drum filled with
c                                  water-fuel lattice
19  0  43 -50 -5 fill=7  imp:n=1 $ upper part of the 3rd drum filled with
c                                  air-fuel lattice
c
c outside the drum:
c
20  65  -7.82       5 -6 2 -50    imp:n=1 $ drum wall
21  64 -0.001293 -21 22 -23 24 -25 26 2 -50 6 imp:n=1 $  air ouside the drum
22  0        21 : -22 : 23 : -24 : 25 : -26 : -7 : 50 imp:n=0 $ Outside world
23  67 -2.35      -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
```

C01220

```
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ 1st drum bottom plane
40 pz 15.58115 $ plane separating the lower and upper part of the 1st drum
c               (water level boundary corresponding to 0.1 volume fraction)
3  pz 72.39   $ 1st drum top plane
41 pz 87.97115 $ plane separating the lower and upper part of the 2nd drum
c               (water level boundary corresponding to 0.1 volume fraction)
42 pz 144.78  $ 2nd drum top plane
43 pz 160.36115 $ plane separating the lower and upper part of the 3rd drum
c               (water level boundary corresponding to 0.1 volume fraction)
50 pz 217.17  $ 3rd drum top plane
5  cz 23.005  $ internal wall of the drum
6  cz 23.180  $ external wall of the drum
7  pz -3000   $ concrete bottom plane
c
c 1st level lattice
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of lattice surfaces
c
c 2nd level lattice
c begin the lattice surfaces
31 p  1  1.73205  0  1.495798
32 p -1  1.73205  0 -1.495798
33 p  1  1.73205  0 -1.495798
34 p -1  1.73205  0  1.495798
35 px  0.747899
36 px -0.747899
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
c (simulates infinite array of the drums)
c begin the lattice surfaces
*21 p 0.8660254 -0.5 0  24.37
*22 p 0.8660254 -0.5 0 -24.37
*23 p 0.8660254  0.5 0  24.37
*24 p 0.8660254  0.5 0 -24.37
*25 py  24.37
*26 py -24.37
c end of lattice surfaces
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185844
      92235.50c -0.0435427
      92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
      24000.50c -0.19
      25055.50c -0.02
      26000.55c -0.68
      28000.50c -0.10
c Water (H, O)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64    6000.50c -0.000124
       7014.50c -0.755267
```

C01220

```
       8016.50c -0.231781
      18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65    6000.50c -0.005
      26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67    1001.50c -0.006
       8016.50c -0.5
      11023.50c -0.017
      13027.50c -0.048
      14000.50c -0.315
      19000.50c -0.019
      20000.50c -0.083
      26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 4: Case 1 MCNP output file

```
1mcnp     version 4a     ld=10/01/93                    05/31/00 19:39:39
 ******************************************************************************          probid =    05/31/00 19:39:39
 name=c01220

     1-       WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water
     2-       C The drum height is 28 1/2 inches (72.39 cm)
     3-       c drum wall thickness is 0.157 cm
     4-       c
     5-       C Cell cards
     6-       C
     7-       C ------------------------------------------------------------------------
     8-       c inside the drum:
     9-       c
    10-       c ------------------------------------------------------------------------
    11-       c Universe 1. Fuel rod, clad and air outside the clad
    12-       c
    13-       1 61 -10.4   -17     u=1       imp:n=1 $ fuel rod
    14-       2 62 -7.92   -18 17 u=1       imp:n=1 $ SS-304 clad
    15-       3 64 -0.001293  18 u=1        imp:n=1 $ air outside the clad
    16-       c
    17-       c ------------------------------------------------------------------------
    18-       c Universe 2. Water instead of the fuel, clad and air outside the clad
    19-       c
    20-       4 63 -1.0    -17     u=2       imp:n=1 $ water instead of fuel inside the clad
    21-       5 62 -7.92   -18 17 u=2       imp:n=1 $ SS-304 clad
    22-       6 64 -0.001293  18 u=2        imp:n=1 $ air outside the clad
    23-       c
    24-       c ------------------------------------------------------------------------
    25-       c Universe 3. 1 fuel rod per 2 water rods hexagonal lattice arrangement
    26-       c
    27-       7  0         -11 12 -13 14 -15 16 u=3
    28-                       lat=2 fill= -1:1 -1:1 0:0
    29-                       1 2 2
    30-                       2 1 2
    31-                       2 2 1     imp:n=1 $ Hexagonal lattice
    32-       c ------------------------------------------------------------------------
    33-       c Universe 4. Water-fuel lattice filling the lower part of the drum
    34-       c
    35-       8 0     -35 36 -31 33 -34 32 u=4
    36-                       lat=2 fill=3 imp:n=1 $ Hexagonal lattice
    37-       c ------------------------------------------------------------------------
    38-       c Universe 5. Air instead of the fuel, clad and air outside the clad
    39-       c
    40-       9  64 -0.001293 -17 u=5       imp:n=1 $ air instead of fuel inside the clad
    41-       10 62 -7.92  -18 17 u=5       imp:n=1 $ SS-304 clad
    42-       11 64 -0.001293  18 u=5       imp:n=1 $ air outside the clad
    43-       c
    44-       c ------------------------------------------------------------------------
    45-       c Universe 6. 1 fuel rod per 2 air rods hexagonal lattice arrangement
    46-       c
    47-       12  0         -11 12 -13 14 -15 16 u=6
    48-                       lat=2 fill= -1:1 -1:1 0:0
    49-                       1 5 5
    50-                       5 1 5
    51-                       5 5 1     imp:n=1 $ Hexagonal lattice
    52-       c ------------------------------------------------------------------------
    53-       c Universe 7. Air-fuel lattice filling the upper part drum
    54-       c
    55-       13 0     -35 36 -31 33 -34 32 u=7
    56-                       lat=2 fill=6 imp:n=1 $ Hexagonal lattice
    57-       c ------------------------------------------------------------------------
    58-       14  0  2 -40 -5  fill=4  imp:n=1 $ lower part of the 1st drum filled with
```

```
c                                       water-fuel lattice
15  0  40 -3 -5  fill=7  imp:n=1 $ upper part of the 1st drum filled with
c                                       air-fuel lattice
16  0  3 -41 -5  fill=4  imp:n=1 $ lower part of the 2nd drum filled with
c                                       water-fuel lattice
17  0  41 -42 -5 fill=7  imp:n=1 $ upper part of the 2nd drum filled with
c                                       air-fuel lattice
18  0  42 -43 -5 fill=4  imp:n=1 $ lower part of the 3rd drum filled with
c                                       water-fuel lattice
19  0  43 -50 -5 fill=7  imp:n=1 $ upper part of the 3rd drum filled with
c                                       air-fuel lattice
c
c outside the drum:
c
20  65  -7.82      5 -6 2 -50    imp:n=1 $ drum wall
21  64 -0.001293 -21 22 -23 24 -25 26 2 -50 6 imp:n=1 $  air ouside the drum
22  0        21 : -22 : 23 : -24 : 25 : -26 : -7 : 50 imp:n=0 $ Outside world
23  67 -2.35     -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ 1st drum bottom plane
40 pz 15.58115 $ plane separating the lower and upper part of the 1st drum
c                (water level boundary corresponding to 0.1 volume fraction)
3  pz 72.39   $ 1st drum top plane
41 pz 87.97115 $ plane separating the lower and upper part of the 2nd drum
c                (water level boundary corresponding to 0.1 volume fraction)
42 pz 144.78  $ 2nd drum top plane
43 pz 160.36115 $ plane separating the lower and upper part of the 3rd drum
c                (water level boundary corresponding to 0.1 volume fraction)
50 pz 217.17  $ 3rd drum top plane
5  cz 23.005  $ internal wall of the drum
6  cz 23.180  $ external wall of the drum
7  pz -3000   $ concrete bottom plane
c
c 1st level lattice
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of lattice surfaces
c
C 2nd level lattice
c begin the lattice surfaces
31 p  1  1.73205  0  1.495798
32 p -1  1.73205  0 -1.495798
33 p  1  1.73205  0 -1.495798
34 p -1  1.73205  0  1.495798
35 px  0.747899
36 px -0.747899
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
```

```
 121-       c (simulates infinite array of the drums)
 122-       c begin the lattice surfaces
 123-       *21 p 0.8660254 -0.5 0  24.37
 124-       *22 p 0.8660254 -0.5 0 -24.37
 125-       *23 p 0.8660254  0.5 0  24.37
 126-       *24 p 0.8660254  0.5 0 -24.37
 127-       *25 py  24.37
 128-       *26 py -24.37
 129-       c end of lattice surfaces
 130-       c
 131-       C ------------------------------------------------------------------------
 132-       c
 133-       c Note: next line must be completely blank
 134-
 135-       c Data cards
 136-       c
 137-       c Materials
 138-       c
 139-       c
 140-       c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
 141-       m61     8016.50c -0.1185844
 142-             92235.50c -0.0435427
 143-             92238.50c -0.8378729
 144-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
 145-       m62   14000.50c -0.01
 146-             24000.50c -0.19
 147-             25055.50c -0.02
 148-             26000.55c -0.68
 149-             28000.50c -0.10
 150-       c Water (H, O)
 151-       m63     1001.50c 0.66667
 152-             8016.50c 0.33333
 153-       mt63 lwtr.01t
 154-       c Air (C, N, O, Ar) composition from Attix p.523
 155-       m64     6000.50c -0.000124
 156-             7014.50c -0.755267
 157-             8016.50c -0.231781
 158-            18000.35c -0.012828
 159-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
 160-       m65     6000.50c -0.005
 161-            26000.55c -0.995
 162-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
 163-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
 164-       c adjusted to sum to unity without minor trace elements)
 165-       m67     1001.50c -0.006
 166-             8016.50c -0.5
 167-            11023.50c -0.017
 168-            13027.50c -0.048
 169-            14000.50c -0.315
 170-            19000.50c -0.019
 171-            20000.50c -0.083
 172-            26000.55c -0.012
 173-       c
 174-       mode n
 175-       print 40 60 80 100 110 126
 176-       kcode 4000 1. 20 120
 177-       ksrc  0 0 10
 178-
 total fission nubar data are being used.
1material composition                                                print table 40

 material
```

```
 number     component nuclide, atom fraction

   61            8016,  0.66678      92235,  0.01666      92238,  0.31655
   62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                28000,  0.09334
   63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
   64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
   65            6000,  0.02283      26000,  0.97717
   67            1001,  0.11082       8016,  0.58191      11023,  0.01377      13027,  0.03312
                14000,  0.20878      19000,  0.00905      20000,  0.03855      26000,  0.00400
```

```
 material
  number     component nuclide, mass fraction

   61            8016,  0.11858      92235,  0.04354      92238,  0.83787
   62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                28000,  0.10000
   63            1001,  0.11192       8016,  0.88808
   64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
   65            6000,  0.00500      26000,  0.99500
   67            1001,  0.00600       8016,  0.50000      11023,  0.01700      13027,  0.04800
                14000,  0.31500      19000,  0.01900      20000,  0.08300      26000,  0.01200
1cells                                                                          print table 60

                      atom        gram                                    neutron
      cell  mat     density     density      volume        mass        pieces importance

    1     1   61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
    2     2   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    3     3   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
    4     4  63s  1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    5     5   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    6     6   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
    7     7    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    8     8    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    9     9   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
   10    10   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
   11    11   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
   12    12    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
   13    13    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
   14    14    0  0.00000E+00 0.00000E+00 2.59056E+04 0.00000E+00      1  1.0000E+00
   15    15    0  0.00000E+00 0.00000E+00 9.44518E+04 0.00000E+00      1  1.0000E+00
   16    16    0  0.00000E+00 0.00000E+00 2.59056E+04 0.00000E+00      1  1.0000E+00
   17    17    0  0.00000E+00 0.00000E+00 9.44518E+04 0.00000E+00      1  1.0000E+00
   18    18    0  0.00000E+00 0.00000E+00 2.59056E+04 0.00000E+00      1  1.0000E+00
   19    19    0  0.00000E+00 0.00000E+00 9.44518E+04 0.00000E+00      1  1.0000E+00
   20    20   65  8.58651E-02 7.82000E+00 5.51428E+03 4.31217E+04      1  1.0000E+00
   21    21   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
   22    22    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  0.0000E+00
   23    23   67  7.60226E-02 2.35000E+00 6.17196E+06 1.45041E+07      0  1.0000E+00

 total                                    6.53854E+06 1.45472E+07
1cross-section tables                                                           print table 100

    table    length

                    tables from file critxs
```

```
   1001.50c    1153  njoy                                                          (  1301)      79/07/31.
   6000.50c   16126  njoy                                                          (  1306)      79/07/31.
   7014.50c   22772  njoy                                                          (  1275)      79/09/08.
   8016.50c   23669  njoy                                                           ( 1276)     05/14/81
  11023.50c   36270  njoy                                                          (  1311)      79/06/21.
  13027.50c   22891  njoy                                                          (  1313)      79/09/08.
  14000.50c   48275  njoy                                                          (  1314)      79/06/21.
  18000.35c    2182       endl85                                                   (  18)       11/01/85
  19000.50c    9766  njoy                                                          (  1150)      79/10/29.
  20000.50c   26104  njoy                                                          (  1320)      79/06/22.
  24000.50c   89104  njoy                                                          (  1324)      79/06/21.
  25055.50c   60097  njoy                                                          (  1325)      79/06/21.
  26000.55c   84136  njoy                                                          ( 260)       10/21/82
  28000.50c   82267  njoy                                                          (  1328)      79/06/21.
  92235.50c   44188  njoy                                    total nu              (  1395)      79/09/12.
  92238.50c   66440  njoy                                    total nu              (  1398)      79/09/13.
   lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                1001     0     010/22/85

  total       645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general              121940
     tallies                   0
     bank                  14403
     cross sections       645633

     total                781976

 ********************************************************************************************************************************
 dump no.     1 on file c01220r       nps =          0      coll =              0      ctm =     0.00      nrn =               0


 source distribution written to file c01220s          cycle =      0

          1 warning message so far.
1    starting mcrun.       field length =       0      cp0 =  0.02                                    print table 110

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water


 nps    x           y           z        cell lattice(i,j,k)  surface    u           v           w          energy      weight      time

   1  0.000E+00   0.000E+00   1.000E+01   14                          5.085E-01   4.733E-01   7.193E-01  2.209E+00   1.000E+00   0.000E+00
      0.000E+00   0.000E+00   1.000E+01    8(   0,    0,    0)       5.085E-01   4.733E-01   7.193E-01
      0.000E+00   0.000E+00   1.000E+01    7(   0,    0,    0)       5.085E-01   4.733E-01   7.193E-01
      0.000E+00   0.000E+00   1.000E+01    1                   0    5.085E-01   4.733E-01   7.193E-01
   2  0.000E+00   0.000E+00   1.000E+01   14                          8.952E-01  -4.447E-01  -2.944E-02  4.904E+00   1.000E+00   0.000E+00
      0.000E+00   0.000E+00   1.000E+01    8(   0,    0,    0)       8.952E-01  -4.447E-01  -2.944E-02
      0.000E+00   0.000E+00   1.000E+01    7(   0,    0,    0)       8.952E-01  -4.447E-01  -2.944E-02
      0.000E+00   0.000E+00   1.000E+01    1                   0    8.952E-01  -4.447E-01  -2.944E-02
   3  0.000E+00   0.000E+00   1.000E+01   14                         -6.184E-01  -4.495E-01   6.446E-01  3.809E-01   1.000E+00   0.000E+00
      0.000E+00   0.000E+00   1.000E+01    8(   0,    0,    0)      -6.184E-01  -4.495E-01   6.446E-01
      0.000E+00   0.000E+00   1.000E+01    7(   0,    0,    0)      -6.184E-01  -4.495E-01   6.446E-01
      0.000E+00   0.000E+00   1.000E+01    1                   0   -6.184E-01  -4.495E-01   6.446E-01
   4  0.000E+00   0.000E+00   1.000E+01   14                          9.710E-01  -5.665E-02  -2.323E-01  1.331E+00   1.000E+00   0.000E+00
      0.000E+00   0.000E+00   1.000E+01    8(   0,    0,    0)       9.710E-01  -5.665E-02  -2.323E-01
      0.000E+00   0.000E+00   1.000E+01    7(   0,    0,    0)       9.710E-01  -5.665E-02  -2.323E-01
      0.000E+00   0.000E+00   1.000E+01    1                   0    9.710E-01  -5.665E-02  -2.323E-01
   5  0.000E+00   0.000E+00   1.000E+01   14                          5.861E-01   1.496E-01  -7.963E-01  1.902E+00   1.000E+00   0.000E+00
```

```
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        5.861E-01  1.496E-01 -7.963E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        5.861E-01  1.496E-01 -7.963E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0  5.861E-01  1.496E-01 -7.963E-01
 6  0.000E+00  0.000E+00  1.000E+01  14                        -6.489E-02 -1.626E-01  9.845E-01  4.410E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -6.489E-02 -1.626E-01  9.845E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -6.489E-02 -1.626E-01  9.845E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -6.489E-02 -1.626E-01  9.845E-01
 7  0.000E+00  0.000E+00  1.000E+01  14                        -7.068E-02  3.263E-02 -9.970E-01  4.750E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -7.068E-02  3.263E-02 -9.970E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -7.068E-02  3.263E-02 -9.970E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -7.068E-02  3.263E-02 -9.970E-01
 8  0.000E+00  0.000E+00  1.000E+01  14                        -3.915E-01  4.664E-01 -7.932E-01  4.136E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -3.915E-01  4.664E-01 -7.932E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -3.915E-01  4.664E-01 -7.932E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -3.915E-01  4.664E-01 -7.932E-01
 9  0.000E+00  0.000E+00  1.000E+01  14                        -2.368E-01  9.215E-01 -3.079E-01  7.453E-02  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -2.368E-01  9.215E-01 -3.079E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -2.368E-01  9.215E-01 -3.079E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -2.368E-01  9.215E-01 -3.079E-01
10  0.000E+00  0.000E+00  1.000E+01  14                         1.946E-01 -3.204E-01  9.271E-01  3.128E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)         1.946E-01 -3.204E-01  9.271E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)         1.946E-01 -3.204E-01  9.271E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0  1.946E-01 -3.204E-01  9.271E-01
11  0.000E+00  0.000E+00  1.000E+01  14                        -6.698E-01 -7.177E-01 -1.905E-01  1.014E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -6.698E-01 -7.177E-01 -1.905E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -6.698E-01 -7.177E-01 -1.905E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -6.698E-01 -7.177E-01 -1.905E-01
12  0.000E+00  0.000E+00  1.000E+01  14                        -8.398E-01 -4.129E-01  3.524E-01  1.395E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -8.398E-01 -4.129E-01  3.524E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -8.398E-01 -4.129E-01  3.524E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -8.398E-01 -4.129E-01  3.524E-01
13  0.000E+00  0.000E+00  1.000E+01  14                        -1.714E-01 -8.572E-01  4.857E-01  7.748E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -1.714E-01 -8.572E-01  4.857E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -1.714E-01 -8.572E-01  4.857E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -1.714E-01 -8.572E-01  4.857E-01
14  0.000E+00  0.000E+00  1.000E+01  14                        -2.489E-01 -5.118E-01 -8.222E-01  1.101E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -2.489E-01 -5.118E-01 -8.222E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -2.489E-01 -5.118E-01 -8.222E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -2.489E-01 -5.118E-01 -8.222E-01
15  0.000E+00  0.000E+00  1.000E+01  14                        -2.959E-01  2.119E-01  9.314E-01  1.951E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -2.959E-01  2.119E-01  9.314E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -2.959E-01  2.119E-01  9.314E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -2.959E-01  2.119E-01  9.314E-01
16  0.000E+00  0.000E+00  1.000E+01  14                         1.395E-01 -9.829E-01  1.202E-01  2.186E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)         1.395E-01 -9.829E-01  1.202E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)         1.395E-01 -9.829E-01  1.202E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0  1.395E-01 -9.829E-01  1.202E-01
17  0.000E+00  0.000E+00  1.000E+01  14                         6.909E-01 -7.110E-01  1.307E-01  1.865E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)         6.909E-01 -7.110E-01  1.307E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)         6.909E-01 -7.110E-01  1.307E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0  6.909E-01 -7.110E-01  1.307E-01
18  0.000E+00  0.000E+00  1.000E+01  14                        -6.580E-01  5.320E-01 -5.329E-01  1.229E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -6.580E-01  5.320E-01 -5.329E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -6.580E-01  5.320E-01 -5.329E-01
    0.000E+00  0.000E+00  1.000E+01   1                     0 -6.580E-01  5.320E-01 -5.329E-01
19  0.000E+00  0.000E+00  1.000E+01  14                        -9.903E-01 -1.380E-01  1.353E-02  1.305E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)        -9.903E-01 -1.380E-01  1.353E-02
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)        -9.903E-01 -1.380E-01  1.353E-02
    0.000E+00  0.000E+00  1.000E+01   1                     0 -9.903E-01 -1.380E-01  1.353E-02
20  0.000E+00  0.000E+00  1.000E+01  14                         7.462E-01  4.859E-01 -4.551E-01  1.000E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   8(   0,   0,   0)         7.462E-01  4.859E-01 -4.551E-01
    0.000E+00  0.000E+00  1.000E+01   7(   0,   0,   0)         7.462E-01  4.859E-01 -4.551E-01
```

```
    0.000E+00  0.000E+00  1.000E+01    1                                    0  7.462E-01  4.859E-01 -4.551E-01
21  0.000E+00  0.000E+00  1.000E+01   14                                      -1.977E-01  9.797E-01  3.360E-02  3.990E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -1.977E-01  9.797E-01  3.360E-02
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -1.977E-01  9.797E-01  3.360E-02
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -1.977E-01  9.797E-01  3.360E-02
22  0.000E+00  0.000E+00  1.000E+01   14                                      -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -9.117E-01 -3.647E-01 -1.891E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -9.117E-01 -3.647E-01 -1.891E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -9.117E-01 -3.647E-01 -1.891E-01
23  0.000E+00  0.000E+00  1.000E+01   14                                      -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -4.287E-01  8.361E-01 -3.423E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -4.287E-01  8.361E-01 -3.423E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -4.287E-01  8.361E-01 -3.423E-01
24  0.000E+00  0.000E+00  1.000E+01   14                                       1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                      1.080E-01  3.412E-01 -9.338E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                      1.080E-01  3.412E-01 -9.338E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  1.080E-01  3.412E-01 -9.338E-01
25  0.000E+00  0.000E+00  1.000E+01   14                                      -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -9.111E-01 -9.012E-03 -4.122E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -9.111E-01 -9.012E-03 -4.122E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -9.111E-01 -9.012E-03 -4.122E-01
26  0.000E+00  0.000E+00  1.000E+01   14                                      -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -2.568E-01 -6.391E-01 -7.249E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -2.568E-01 -6.391E-01 -7.249E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -2.568E-01 -6.391E-01 -7.249E-01
27  0.000E+00  0.000E+00  1.000E+01   14                                      -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -2.912E-01  8.086E-01  5.113E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -2.912E-01  8.086E-01  5.113E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -2.912E-01  8.086E-01  5.113E-01
28  0.000E+00  0.000E+00  1.000E+01   14                                       1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                      1.472E-01 -9.514E-01  2.705E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                      1.472E-01 -9.514E-01  2.705E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  1.472E-01 -9.514E-01  2.705E-01
29  0.000E+00  0.000E+00  1.000E+01   14                                      -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -6.135E-01 -7.645E-01 -1.978E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -6.135E-01 -7.645E-01 -1.978E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -6.135E-01 -7.645E-01 -1.978E-01
30  0.000E+00  0.000E+00  1.000E+01   14                                      -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -5.702E-01  5.651E-01 -5.963E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -5.702E-01  5.651E-01 -5.963E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -5.702E-01  5.651E-01 -5.963E-01
31  0.000E+00  0.000E+00  1.000E+01   14                                      -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -6.607E-01  5.373E-01 -5.242E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -6.607E-01  5.373E-01 -5.242E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -6.607E-01  5.373E-01 -5.242E-01
32  0.000E+00  0.000E+00  1.000E+01   14                                      -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -9.742E-02 -3.639E-01 -9.263E-01
33  0.000E+00  0.000E+00  1.000E+01   14                                      -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -1.965E-01 -3.145E-01 -9.287E-01
34  0.000E+00  0.000E+00  1.000E+01   14                                       4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                      4.097E-01  8.465E-01 -3.399E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                      4.097E-01  8.465E-01 -3.399E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  4.097E-01  8.465E-01 -3.399E-01
35  0.000E+00  0.000E+00  1.000E+01   14                                      -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)                     -4.048E-02  8.831E-01  4.675E-01
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     -4.048E-02  8.831E-01  4.675E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -4.048E-02  8.831E-01  4.675E-01
36  0.000E+00  0.000E+00  1.000E+01   14                                       3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
```

```
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        3.371E-01 -9.269E-01 -1.652E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        3.371E-01 -9.269E-01 -1.652E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    3.371E-01 -9.269E-01 -1.652E-01
 37   0.000E+00  0.000E+00  1.000E+01   14                        -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -1.867E-01  9.756E-01 -1.155E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -1.867E-01  9.756E-01 -1.155E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -1.867E-01  9.756E-01 -1.155E-01
 38   0.000E+00  0.000E+00  1.000E+01   14                        -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -2.616E-01  2.336E-01 -9.365E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -2.616E-01  2.336E-01 -9.365E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -2.616E-01  2.336E-01 -9.365E-01
 39   0.000E+00  0.000E+00  1.000E+01   14                         9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        9.780E-01 -7.641E-02 -1.939E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        9.780E-01 -7.641E-02 -1.939E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    9.780E-01 -7.641E-02 -1.939E-01
 40   0.000E+00  0.000E+00  1.000E+01   14                         2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        2.580E-01 -7.076E-01  6.578E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        2.580E-01 -7.076E-01  6.578E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    2.580E-01 -7.076E-01  6.578E-01
 41   0.000E+00  0.000E+00  1.000E+01   14                        -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -3.212E-01 -7.678E-01 -5.543E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -3.212E-01 -7.678E-01 -5.543E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -3.212E-01 -7.678E-01 -5.543E-01
 42   0.000E+00  0.000E+00  1.000E+01   14                         5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        5.039E-01 -1.460E-01  8.513E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        5.039E-01 -1.460E-01  8.513E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    5.039E-01 -1.460E-01  8.513E-01
 43   0.000E+00  0.000E+00  1.000E+01   14                         6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        6.080E-01  5.487E-01  5.738E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        6.080E-01  5.487E-01  5.738E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    6.080E-01  5.487E-01  5.738E-01
 44   0.000E+00  0.000E+00  1.000E+01   14                        -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -2.932E-01  9.304E-01 -2.199E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -2.932E-01  9.304E-01 -2.199E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -2.932E-01  9.304E-01 -2.199E-01
 45   0.000E+00  0.000E+00  1.000E+01   14                        -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -8.475E-01 -3.993E-01 -3.497E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -8.475E-01 -3.993E-01 -3.497E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -8.475E-01 -3.993E-01 -3.497E-01
 46   0.000E+00  0.000E+00  1.000E+01   14                         1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        1.200E-01 -9.195E-01 -3.743E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        1.200E-01 -9.195E-01 -3.743E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    1.200E-01 -9.195E-01 -3.743E-01
 47   0.000E+00  0.000E+00  1.000E+01   14                         7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        7.085E-01  5.879E-01  3.904E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        7.085E-01  5.879E-01  3.904E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    7.085E-01  5.879E-01  3.904E-01
 48   0.000E+00  0.000E+00  1.000E+01   14                         4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        4.261E-01  9.046E-01  9.254E-03
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        4.261E-01  9.046E-01  9.254E-03
      0.000E+00  0.000E+00  1.000E+01    1                   0    4.261E-01  9.046E-01  9.254E-03
 49   0.000E+00  0.000E+00  1.000E+01   14                         5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        5.431E-01  4.270E-01 -7.230E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        5.431E-01  4.270E-01 -7.230E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0    5.431E-01  4.270E-01 -7.230E-01
 50   0.000E+00  0.000E+00  1.000E+01   14                        -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -1.053E-01 -9.805E-01  1.658E-01
      0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -1.053E-01 -9.805E-01  1.658E-01
      0.000E+00  0.000E+00  1.000E+01    1                   0 -1.053E-01 -9.805E-01  1.658E-01
lestimated keff results by cycle                                                                                  print table 175
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```
dump no.     2 on file c01220r      nps =      47910     coll =        2788344     ctm =    15.34     nrn =        62899660

 source distribution written to file c01220s         cycle =    20
 source distribution written to file c01220s         cycle =    21
 source distribution written to file c01220s         cycle =    22
 source distribution written to file c01220s         cycle =    23
 ********************************************************************************************************************************
dump no.     3 on file c01220r      nps =      91759     coll =        5242070     ctm =    31.41     nrn =       122536663

 source distribution written to file c01220s         cycle =    24
 source distribution written to file c01220s         cycle =    25
 source distribution written to file c01220s         cycle =    26
 source distribution written to file c01220s         cycle =    27
 source distribution written to file c01220s         cycle =    28
 source distribution written to file c01220s         cycle =    29
 source distribution written to file c01220s         cycle =    30
 source distribution written to file c01220s         cycle =    31
 source distribution written to file c01220s         cycle =    32
 source distribution written to file c01220s         cycle =    33
 ********************************************************************************************************************************
dump no.     4 on file c01220r      nps =     132198     coll =        7469128     ctm =    46.57     nrn =       177628736

 source distribution written to file c01220s         cycle =    34
 source distribution written to file c01220s         cycle =    35
 source distribution written to file c01220s         cycle =    36
 source distribution written to file c01220s         cycle =    37
 source distribution written to file c01220s         cycle =    38
 source distribution written to file c01220s         cycle =    39
 source distribution written to file c01220s         cycle =    40
 source distribution written to file c01220s         cycle =    41
 source distribution written to file c01220s         cycle =    42
 source distribution written to file c01220s         cycle =    43
 ********************************************************************************************************************************
dump no.     5 on file c01220r      nps =     172093     coll =        9657534     ctm =    61.68     nrn =       232100295
```

```
source distribution written to file c01220s         cycle =    44
source distribution written to file c01220s         cycle =    45
source distribution written to file c01220s         cycle =    46
source distribution written to file c01220s         cycle =    47
source distribution written to file c01220s         cycle =    48
source distribution written to file c01220s         cycle =    49
source distribution written to file c01220s         cycle =    50
source distribution written to file c01220s         cycle =    51
source distribution written to file c01220s         cycle =    52
source distribution written to file c01220s         cycle =    53
************************************************************************************************************************
dump no.     6 on file c01220r      nps =     212113     coll =       11872392     ctm =    76.98     nrn =      287246665

source distribution written to file c01220s         cycle =    54
source distribution written to file c01220s         cycle =    55
source distribution written to file c01220s         cycle =    56
source distribution written to file c01220s         cycle =    57
source distribution written to file c01220s         cycle =    58
source distribution written to file c01220s         cycle =    59
source distribution written to file c01220s         cycle =    60
source distribution written to file c01220s         cycle =    61
source distribution written to file c01220s         cycle =    62
source distribution written to file c01220s         cycle =    63
************************************************************************************************************************
dump no.     7 on file c01220r      nps =     252022     coll =       14074751     ctm =    92.17     nrn =      342000862

source distribution written to file c01220s         cycle =    64
source distribution written to file c01220s         cycle =    65
source distribution written to file c01220s         cycle =    66
source distribution written to file c01220s         cycle =    67
source distribution written to file c01220s         cycle =    68
source distribution written to file c01220s         cycle =    69
source distribution written to file c01220s         cycle =    70
```

```
source distribution written to file c01220s         cycle =    71
source distribution written to file c01220s         cycle =    72
source distribution written to file c01220s         cycle =    73
************************************************************************************************************************
dump no.    8 on file c01220r      nps =    292084     coll =       16296415     ctm =  107.44     nrn =       397193960

source distribution written to file c01220s         cycle =    74
source distribution written to file c01220s         cycle =    75
source distribution written to file c01220s         cycle =    76
source distribution written to file c01220s         cycle =    77
source distribution written to file c01220s         cycle =    78
source distribution written to file c01220s         cycle =    79
source distribution written to file c01220s         cycle =    80
source distribution written to file c01220s         cycle =    81
source distribution written to file c01220s         cycle =    82
source distribution written to file c01220s         cycle =    83
************************************************************************************************************************
dump no.    9 on file c01220r      nps =    332309     coll =       18500659     ctm =  122.85     nrn =       452334855

source distribution written to file c01220s         cycle =    84
source distribution written to file c01220s         cycle =    85
source distribution written to file c01220s         cycle =    86
source distribution written to file c01220s         cycle =    87
source distribution written to file c01220s         cycle =    88
source distribution written to file c01220s         cycle =    89
source distribution written to file c01220s         cycle =    90
source distribution written to file c01220s         cycle =    91
source distribution written to file c01220s         cycle =    92
source distribution written to file c01220s         cycle =    93
************************************************************************************************************************
dump no.   10 on file c01220r      nps =    372434     coll =       20715832     ctm =  138.28     nrn =       507667034

source distribution written to file c01220s         cycle =    94
source distribution written to file c01220s         cycle =    95
```

```
source distribution written to file c01220s         cycle =    96

source distribution written to file c01220s         cycle =    97

source distribution written to file c01220s         cycle =    98

source distribution written to file c01220s         cycle =    99

 estimator      cycle   100   ave of    80 cycles      combination          simple average     combined average      corr
k(collision)      1.000613       0.969906 0.0013     k(col/abs)          0.968978 0.0011     0.968784 0.0011    0.4582
k(absorption)     0.961029       0.968050 0.0012     k(abs/tk ln)        0.968954 0.0010     0.968660 0.0010    0.0898
k(trk length)     1.013374       0.969858 0.0016     k(tk ln/col)        0.969882 0.0013     0.969892 0.0013    0.5827
rem life(col)   2.8447E+03     3.0764E+03 0.0083     k(col/abs/tk ln)    0.969271 0.0011     0.968761 0.0010
rem life(abs)   2.7948E+03     3.0695E+03 0.0078     life(col/abs)     3.0729E+03 0.0080   3.0597E+03 0.0077    0.9851
source points generated   4132

source distribution written to file c01220s         cycle =   100

source distribution written to file c01220s         cycle =   101

source distribution written to file c01220s         cycle =   102

source distribution written to file c01220s         cycle =   103

*****************************************************************************************************************
dump no.   11 on file c01220r      nps =    412752     coll =       22916454     ctm =  153.65     nrn =      562660436

source distribution written to file c01220s         cycle =   104

source distribution written to file c01220s         cycle =   105

source distribution written to file c01220s         cycle =   106

source distribution written to file c01220s         cycle =   107

source distribution written to file c01220s         cycle =   108

source distribution written to file c01220s         cycle =   109

source distribution written to file c01220s         cycle =   110

source distribution written to file c01220s         cycle =   111

source distribution written to file c01220s         cycle =   112

source distribution written to file c01220s         cycle =   113

*****************************************************************************************************************
dump no.   12 on file c01220r      nps =    452661     coll =       25105148     ctm =  168.96     nrn =      617448485

source distribution written to file c01220s         cycle =   114

source distribution written to file c01220s         cycle =   115

 estimator      cycle   116   ave of    96 cycles      combination          simple average     combined average      corr
k(collision)      0.964548       0.970265 0.0012     k(col/abs)          0.969178 0.0009     0.968992 0.0009    0.4235
k(absorption)     0.962384       0.968091 0.0010     k(abs/tk ln)        0.969371 0.0009     0.968939 0.0009    0.0587
k(trk length)     0.975658       0.970651 0.0015     k(tk ln/col)        0.970458 0.0012     0.970361 0.0011    0.5643
rem life(col)   3.1330E+03     3.0557E+03 0.0074     k(col/abs/tk ln)    0.969669 0.0009     0.969078 0.0009
```

rem life(abs)	3.1215E+03	3.0496E+03	0.0069	life(col/abs)	3.0527E+03	0.0071	3.0416E+03	0.0068	0.9833

source points generated 3950

source distribution written to file c01220s cycle = 116

estimator	cycle 117	ave of 97 cycles		combination	simple average		combined average		corr
k(collision)	0.975771	0.970322	0.0011	k(col/abs)	0.969285	0.0009	0.969126	0.0009	0.4257
k(absorption)	0.983313	0.968248	0.0010	k(abs/tk ln)	0.969485	0.0009	0.969077	0.0009	0.0657
k(trk length)	0.977473	0.970721	0.0014	k(tk ln/col)	0.970522	0.0011	0.970421	0.0011	0.5654
rem life(col)	3.1638E+03	3.0569E+03	0.0073	k(col/abs/tk ln)	0.969764	0.0009	0.969217	0.0009	
rem life(abs)	3.1077E+03	3.0502E+03	0.0069	life(col/abs)	3.0535E+03	0.0071	3.0416E+03	0.0067	0.9831

source points generated 4019

source distribution written to file c01220s cycle = 117

estimator	cycle 118	ave of 98 cycles		combination	simple average		combined average		corr
k(collision)	0.966726	0.970286	0.0011	k(col/abs)	0.969300	0.0009	0.969152	0.0009	0.4224
k(absorption)	0.974731	0.968314	0.0010	k(abs/tk ln)	0.969540	0.0009	0.969138	0.0009	0.0677
k(trk length)	0.975128	0.970766	0.0014	k(tk ln/col)	0.970526	0.0011	0.970405	0.0011	0.5637
rem life(col)	2.7043E+03	3.0533E+03	0.0074	k(col/abs/tk ln)	0.969789	0.0009	0.969267	0.0009	
rem life(abs)	2.7163E+03	3.0468E+03	0.0069	life(col/abs)	3.0500E+03	0.0071	3.0382E+03	0.0068	0.9835

source points generated 4030

source distribution written to file c01220s cycle = 118

estimator	cycle 119	ave of 99 cycles		combination	simple average		combined average		corr
k(collision)	0.984104	0.970425	0.0011	k(col/abs)	0.969411	0.0009	0.969249	0.0009	0.4280
k(absorption)	0.976462	0.968396	0.0010	k(abs/tk ln)	0.969617	0.0009	0.969217	0.0009	0.0716
k(trk length)	0.977816	0.970837	0.0014	k(tk ln/col)	0.970631	0.0011	0.970530	0.0011	0.5650
rem life(col)	2.7614E+03	3.0503E+03	0.0074	k(col/abs/tk ln)	0.969886	0.0009	0.969349	0.0009	
rem life(abs)	2.7568E+03	3.0439E+03	0.0069	life(col/abs)	3.0471E+03	0.0071	3.0353E+03	0.0068	0.9838

source points generated 4066

source distribution written to file c01220s cycle = 119

estimator	cycle 120	ave of 100 cycles		combination	simple average		combined average		corr
k(collision)	0.973206	0.970453	0.0011	k(col/abs)	0.969383	0.0009	0.969219	0.0009	0.4242
k(absorption)	0.959989	0.968312	0.0010	k(abs/tk ln)	0.969626	0.0009	0.969199	0.0009	0.0648
k(trk length)	0.981073	0.970940	0.0014	k(tk ln/col)	0.970696	0.0011	0.970576	0.0011	0.5652
rem life(col)	2.7194E+03	3.0470E+03	0.0074	k(col/abs/tk ln)	0.969902	0.0009	0.969335	0.0009	
rem life(abs)	2.6720E+03	3.0401E+03	0.0069	life(col/abs)	3.0436E+03	0.0071	3.0317E+03	0.0069	0.9838

source points generated 3999

source distribution written to file c01220s cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

\+ 05/31/00 22:39:32

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water probid = 05/31/00 19:39:39

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	480808	9.9832E-01	2.0282E+00	escape	13764	2.0988E-02	1.1063E-02
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	8.2024E-02	7.3134E-05	weight cutoff	467825	8.1833E-02	8.7232E-05
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.

exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	5.2354E-08	downscattering	0	0.	1.8459E+00
				capture	0	5.8735E-01	5.7563E-02
(n,xn)	1559	2.4895E-03	1.8122E-03	loss to (n,xn)	778	1.2427E-03	1.0463E-02
fission	0	0.	0.	loss to fission	0	3.9142E-01	1.0503E-01
total	482367	1.0828E+00	2.0301E+00	total	482367	1.0828E+00	2.0301E+00

number of neutrons banked	781	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0032E+00	escape	1.8554E+02	tco	1.0000E+34
neutron collisions per source particle	5.5429E+01	capture	3.3706E+03	eco	0.0000E+00
total neutron collisions	26650495	capture or escape	3.3038E+03	wc1	-5.0000E-01
net multiplication	1.0012E+00 0.0001	any termination	3.8624E+03	wc2	-2.5000E-01

computer time so far in this run	179.88 minutes	maximum number ever in bank	2
computer time in mcrun	179.86 minutes	bank overflows to backup file	0
source particles per minute	2.6732E+03	field length	0
random numbers generated	656283951	most random numbers used was	12049 in history 461399

range of sampled source weights = 9.5306E-01 to 1.0785E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions • weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	1	19553811	481589	6447166	9.8280E+00	3.7466E-03	5.5053E-01	7.6383E-01	2.5379E+00
2	2	40193999	481143	2371201	3.4368E+00	3.3193E-03	5.3753E-01	7.6262E-01	2.9862E+00
3	3	44898436	481055	478	7.0184E-04	3.1971E-03	5.3463E-01	7.6252E-01	5.5158E+03
4	4	19514539	468505	9511411	1.4682E+01	8.6373E-04	5.8204E-01	8.2494E-01	1.5779E+00
5	5	22285166	468894	1526055	2.4472E+00	9.8751E-04	5.9878E-01	8.2564E-01	2.4610E+00
6	6	23402980	468853	304	4.7022E-04	1.0117E-03	6.0405E-01	8.2602E-01	5.1880E+03
7	7	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8	8	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	9	54804326	326210	5216	7.3271E-03	1.2840E-02	5.0486E-01	7.4025E-01	5.6314E+03
10	10	63153334	327828	3236895	4.4590E+00	1.3071E-02	5.0389E-01	7.4012E-01	3.1803E+00
11	11	66471139	327604	711	9.9460E-04	1.3072E-02	5.0418E-01	7.4017E-01	5.6311E+03
12	12	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	13	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	14	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	15	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
16	16	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
17	17	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
18	18	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
19	19	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	20	2614660	305321	432242	6.2469E-01	3.4669E-03	5.1840E-01	7.5778E-01	4.3505E+00
21	21	1327332	301625	3512	5.0409E-03	3.3349E-03	5.1891E-01	7.5766E-01	5.4754E+03
23	23	93840	57724	3115304	4.0861E+00	8.3750E-05	2.4623E-01	6.6344E-01	2.7613E+00
total		358313562	4496351	26650495	3.9578E+01				

1keff results for: WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water probid = 05/31/00 19:39:39

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79915 neutron histories and 100 active cycles with 400893 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 480808 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

---

the final estimated combined collision/absorption/track-length keff = 0.96934 with an estimated standard deviation of 0.00084

the estimated 68, 95, & 99 percent keff confidence intervals are 0.96849 to 0.97018, 0.96766 to 0.97101, and 0.96711 to 0.97156

the estimated collision/absorption neutron removal lifetime = 3.03E-05 seconds with an estimated standard deviation of 2.08E-07

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the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.97045	0.00109	0.96937 to 0.97154	0.96829 to 0.97262	0.96758 to 0.97332	
absorption	0.96831	0.00099	0.96732 to 0.96931	0.96633 to 0.97029	0.96568 to 0.97094	
track length	0.97094	0.00136	0.96958 to 0.97230	0.96823 to 0.97365	0.96734 to 0.97454	
col/absorp	0.96922	0.00089	0.96832 to 0.97011	0.96744 to 0.97100	0.96685 to 0.97158	0.4242
abs/trk len	0.96920	0.00084	0.96836 to 0.97004	0.96752 to 0.97088	0.96697 to 0.97143	0.0648
col/trk len	0.97058	0.00105	0.96952 to 0.97163	0.96848 to 0.97267	0.96780 to 0.97336	0.5652
col/abs/trk len	0.96934	0.00084	0.96849 to 0.97018	0.96766 to 0.97101	0.96711 to 0.97156	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.97075	0.00112	0.96963 to 0.97187	0.96853 to 0.97298	0.96780 to 0.97370
absorption	0.96859	0.00102	0.96757 to 0.96961	0.96655 to 0.97063	0.96589 to 0.97129
track length	0.97136	0.00141	0.96995 to 0.97277	0.96855 to 0.97417	0.96763 to 0.97509
col/abs/trk len	0.96963	0.00090	0.96873 to 0.97052	0.96784 to 0.97141	0.96726 to 0.97199

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	3.0317E-05	2.0841E-07	3.0108E-05 to 3.0526E-05	2.9902E-05 to 3.0732E-05	2.9766E-05 to 3.0868E-05
capture	3.0987E-05	2.0456E-07	3.0782E-05 to 3.1192E-05	3.0579E-05 to 3.1394E-05	3.0446E-05 to 3.1527E-05
fission	2.3220E-05	8.3020E-08	2.3137E-05 to 2.3303E-05	2.3054E-05 to 2.3385E-05	2.3000E-05 to 2.3439E-05
escape	1.7194E-06	2.3025E-07	1.4889E-06 to 1.9498E-06	1.2607E-06 to 2.1780E-06	1.1110E-06 to 2.3277E-06

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.9705 0.0011	0.9683 0.0010	0.9709 0.0014	95/95/95	0.96934 0.00084	0.96766-0.97101	0.96711-0.97156
2	50	0.9705 0.0011	0.9683 0.0011	0.9709 0.0014	95/95/95	0.96929 0.00089	0.96749-0.97109	0.96689-0.97169
4	25	0.9705 0.0009	0.9683 0.0011	0.9709 0.0013	95/95/95	0.96968 0.00083	0.96796-0.97141	0.96734-0.97203
5	20	0.9705 0.0009	0.9683 0.0010	0.9709 0.0013	95/95/95	0.96963 0.00094	0.96765-0.97161	0.96691-0.97235
10	10	0.9705 0.0010	0.9683 0.0011	0.9709 0.0013	95/95/95	0.96970 0.00112	0.96705-0.97235	0.96578-0.97362
20	5	0.9705 0.0006	0.9683 0.0010	0.9709 0.0015	95/95/95	0.96989 0.00083	0.96633-0.97345	0.96168-0.97810
25	4	0.9705 0.0009	0.9683 0.0008	0.9709 0.0022	95/95/no	0.96968 0.00011	0.96833-0.97103	0.96290-0.97646

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	1.00256	1.00009	1.00922									
2	4047	0.93939	0.94639	0.94159									
3	3709	0.93741	0.93297	0.93818									
4	3998	0.93777	0.94389	0.95411									
5	4053	0.93836	0.94597	0.94934									
6	3922	0.95560	0.95012	0.97431									
7	4088	0.95848	0.95683	0.94922									
8	3943	0.95895	0.96863	0.94024									
9	4095	0.95176	0.96069	0.96129									
10	3961	0.95117	0.96140	0.95714									
11	3960	0.98388	0.98855	0.97882									
12	4134	0.97227	0.96637	0.96041									
13	3955	0.98984	0.97268	0.99341									
14	3978	0.96951	0.95042	0.95631									
15	3956	0.95295	0.96594	0.96330									
16	3886	0.95580	0.96287	0.96083									
17	3999	0.96848	0.98569	0.96292									
18	4128	0.98477	0.96283	0.97318									
19	4081	0.98009	0.95635	0.99700									
20	4022	0.96832	0.97134	0.97352									
		begin active keff cycles											
21	3913	0.94319	0.96476	0.94768									
22	3912	0.94749	0.94712	0.94813	0.94534	0.00215	0.95594	0.00882	0.94790	0.00023			
23	4019	0.97840	0.96944	0.99694	0.95636	0.01109	0.96044	0.00680	0.96425	0.01635			
24	4197	0.97729	0.97256	0.98266	0.96159	0.00943	0.96347	0.00568	0.96885	0.01244	0.95614	0.01295	917
25	3922	0.96468	0.97002	0.96481	0.96221	0.00733	0.96478	0.00459	0.96804	0.00967	0.96099	0.00909	1507
26	4035	0.95984	0.97838	0.95811	0.96182	0.00600	0.96705	0.00438	0.96639	0.00807	0.96326	0.00863	1395
27	3975	0.98098	0.98389	0.98735	0.96455	0.00576	0.96945	0.00442	0.96938	0.00745	0.96535	0.00885	1140
28	4061	0.95475	0.96293	0.95575	0.96333	0.00514	0.96864	0.00391	0.96768	0.00667	0.96433	0.00764	1329
29	3878	0.96754	0.97253	0.99158	0.96380	0.00455	0.96907	0.00348	0.97033	0.00646	0.96563	0.00615	1836
30	4133	0.97743	0.96665	0.96744	0.96516	0.00430	0.96883	0.00312	0.97005	0.00578	0.96730	0.00409	3732
31	4126	0.95505	0.96164	0.95046	0.96424	0.00399	0.96817	0.00289	0.96826	0.00552	0.96665	0.00364	4259
32	3946	0.98475	0.97771	0.97235	0.96595	0.00403	0.96897	0.00276	0.96861	0.00505	0.96875	0.00326	4884
33	4166	0.98277	0.98374	0.97758	0.96724	0.00392	0.97010	0.00278	0.96930	0.00470	0.97017	0.00323	4606
34	3996	0.96487	0.96255	0.96480	0.96707	0.00364	0.96957	0.00263	0.96897	0.00436	0.96953	0.00301	4942
35	3859	0.97730	0.97834	0.98373	0.96776	0.00345	0.97015	0.00252	0.96996	0.00418	0.97008	0.00288	5058
36	4039	0.96477	0.96091	0.98894	0.96757	0.00324	0.96957	0.00243	0.97114	0.00409	0.96978	0.00281	4960
37	3996	0.96151	0.96591	0.94508	0.96721	0.00306	0.96936	0.00229	0.96961	0.00413	0.96936	0.00258	5524
38	3935	0.98264	0.97461	0.97939	0.96807	0.00301	0.96965	0.00218	0.97015	0.00393	0.96976	0.00239	6067
39	4033	0.98681	0.97055	0.96798	0.96906	0.00301	0.96970	0.00206	0.97004	0.00372	0.96974	0.00219	6861
40	4052	0.98241	0.97855	0.98085	0.96972	0.00293	0.97014	0.00200	0.97058	0.00357	0.97019	0.00212	6965
41	4004	0.95622	0.96949	0.94751	0.96908	0.00286	0.97011	0.00191	0.96948	0.00357	0.97016	0.00202	7328
42	3922	0.97094	0.97841	0.96947	0.96917	0.00273	0.97049	0.00186	0.96948	0.00341	0.97050	0.00197	7354
43	4059	0.97965	0.97275	0.97674	0.96962	0.00265	0.97058	0.00178	0.96980	0.00327	0.97060	0.00187	7788
44	4040	0.96273	0.95901	0.96432	0.96933	0.00255	0.97010	0.00177	0.96957	0.00314	0.97010	0.00185	7588
45	4008	0.96792	0.96752	0.95447	0.96928	0.00245	0.97000	0.00170	0.96896	0.00307	0.96997	0.00178	7882
46	3974	0.95847	0.96417	0.97939	0.96886	0.00239	0.96977	0.00165	0.96937	0.00298	0.96980	0.00172	8111
47	3911	0.96884	0.98906	0.96595	0.96886	0.00230	0.97049	0.00174	0.96924	0.00287	0.97026	0.00180	7157
48	4126	0.97726	0.97142	0.96450	0.96916	0.00224	0.97052	0.00168	0.96907	0.00277	0.97029	0.00172	7503
49	4004	0.97807	0.99542	0.95955	0.96947	0.00218	0.97138	0.00183	0.96874	0.00269	0.97067	0.00180	6608
50	3983	0.96945	0.96154	0.96112	0.96947	0.00211	0.97105	0.00180	0.96849	0.00261	0.97035	0.00176	6719
51	3953	0.95015	0.96706	0.95731	0.96884	0.00213	0.97092	0.00174	0.96813	0.00255	0.97018	0.00173	6731
52	3872	0.97626	0.97609	0.96405	0.96908	0.00208	0.97109	0.00170	0.96800	0.00247	0.97028	0.00168	6912
53	4149	0.96260	0.96592	0.96236	0.96888	0.00202	0.97093	0.00165	0.96783	0.00240	0.97012	0.00164	7036
54	3947	0.96452	0.95882	0.95044	0.96875	0.00197	0.97057	0.00164	0.96732	0.00239	0.96975	0.00163	6852

55	4056	0.98695	0.95826	0.97825	0.96927	0.00198	0.97022	0.00163	0.96763	0.00234	0.96960	0.00157	7211
56	4082	0.95589	0.96140	0.98987	0.96890	0.00196	0.96998	0.00161	0.96825	0.00236	0.96948	0.00151	7542
57	3839	0.96974	0.94584	0.98692	0.96892	0.00190	0.96932	0.00169	0.96875	0.00235	0.96912	0.00149	7564
58	4137	0.96665	0.96466	0.96547	0.96886	0.00185	0.96920	0.00165	0.96867	0.00229	0.96901	0.00145	7733
59	3914	0.98177	0.97865	0.98278	0.96919	0.00184	0.96944	0.00163	0.96903	0.00226	0.96930	0.00144	7638
60	4016	0.97307	0.99626	0.96951	0.96929	0.00179	0.97011	0.00172	0.96904	0.00220	0.96966	0.00147	7207
61	3912	0.96353	0.95867	0.96477	0.96915	0.00175	0.96983	0.00170	0.96894	0.00215	0.96945	0.00144	7260
62	3912	0.97315	0.96313	0.97629	0.96924	0.00171	0.96967	0.00167	0.96911	0.00210	0.96943	0.00141	7469
63	4094	0.96565	0.96434	0.96757	0.96916	0.00168	0.96955	0.00163	0.96907	0.00205	0.96934	0.00138	7621
64	3957	0.94940	0.96456	0.93247	0.96871	0.00170	0.96944	0.00160	0.96824	0.00217	0.96901	0.00140	7226
65	3901	0.96201	0.96476	0.97834	0.96856	0.00167	0.96933	0.00157	0.96847	0.00213	0.96897	0.00136	7404
66	4068	0.97603	0.95853	0.98945	0.96873	0.00164	0.96910	0.00155	0.96892	0.00214	0.96898	0.00133	7603
67	4140	0.98461	0.97144	0.96881	0.96906	0.00164	0.96915	0.00152	0.96892	0.00209	0.96908	0.00131	7736
68	3956	0.98058	0.97403	0.96984	0.96930	0.00162	0.96925	0.00149	0.96894	0.00205	0.96919	0.00128	7845
69	4006	0.97004	0.97076	0.96492	0.96932	0.00159	0.96928	0.00146	0.96886	0.00201	0.96919	0.00126	8014
70	4061	0.97339	0.96293	0.96119	0.96940	0.00156	0.96915	0.00144	0.96870	0.00197	0.96910	0.00123	8120
71	4006	0.96842	0.97762	0.95754	0.96938	0.00153	0.96932	0.00142	0.96849	0.00195	0.96914	0.00121	8268
72	3956	0.95071	0.95147	0.97211	0.96902	0.00154	0.96898	0.00143	0.96856	0.00191	0.96887	0.00121	8121
73	4011	0.98535	0.97269	0.97376	0.96933	0.00154	0.96905	0.00141	0.96865	0.00187	0.96898	0.00119	8190
74	4133	0.98733	0.97247	0.99424	0.96966	0.00155	0.96911	0.00138	0.96913	0.00190	0.96919	0.00119	8067
75	4058	0.96996	0.97441	0.96766	0.96967	0.00152	0.96921	0.00136	0.96910	0.00187	0.96924	0.00117	8212
76	3951	0.95427	0.94623	0.95992	0.96939	0.00152	0.96880	0.00140	0.96894	0.00184	0.96892	0.00120	7722
77	3967	0.96249	0.96805	0.95897	0.96927	0.00150	0.96878	0.00137	0.96876	0.00181	0.96884	0.00118	7839
78	4067	0.96419	0.97221	0.95255	0.96919	0.00147	0.96884	0.00135	0.96848	0.00181	0.96879	0.00116	7954
79	4007	0.97988	0.98076	0.95436	0.96937	0.00146	0.96904	0.00134	0.96824	0.00179	0.96885	0.00114	8025
80	4038	0.98862	0.97682	0.99778	0.96969	0.00147	0.96917	0.00133	0.96874	0.00183	0.96911	0.00115	7763
81	4061	0.96310	0.94768	0.96488	0.96958	0.00145	0.96882	0.00135	0.96867	0.00180	0.96889	0.00116	7516
82	3939	0.96838	0.95672	0.97105	0.96956	0.00143	0.96863	0.00134	0.96871	0.00177	0.96879	0.00115	7561
83	4004	0.96972	0.95717	0.96619	0.96956	0.00140	0.96844	0.00133	0.96867	0.00174	0.96869	0.00114	7575
84	4011	0.96273	0.95889	0.97444	0.96946	0.00139	0.96829	0.00132	0.96876	0.00172	0.96861	0.00112	7669
85	4005	0.95474	0.95428	0.97610	0.96923	0.00138	0.96808	0.00132	0.96887	0.00169	0.96848	0.00111	7714
86	3900	0.97647	0.96380	0.97964	0.96934	0.00137	0.96801	0.00130	0.96904	0.00168	0.96850	0.00109	7809
87	4101	0.97916	0.96222	0.96653	0.96949	0.00135	0.96793	0.00128	0.96900	0.00165	0.96847	0.00108	7867
88	3931	0.96034	0.96262	0.97188	0.96935	0.00134	0.96785	0.00127	0.96904	0.00163	0.96842	0.00106	7993
89	4006	0.98323	0.97497	0.97519	0.96955	0.00134	0.96795	0.00125	0.96913	0.00161	0.96852	0.00106	7994
90	4086	0.95138	0.96273	0.94685	0.96929	0.00134	0.96788	0.00124	0.96881	0.00161	0.96832	0.00105	7920
91	3969	0.97756	0.96610	0.97023	0.96941	0.00133	0.96785	0.00122	0.96883	0.00159	0.96832	0.00104	8000
92	4152	0.97675	0.97216	0.96855	0.96951	0.00131	0.96791	0.00120	0.96883	0.00157	0.96837	0.00103	8077
93	3964	0.96027	0.97899	0.96496	0.96938	0.00130	0.96806	0.00120	0.96878	0.00155	0.96844	0.00101	8237
94	3959	0.97288	0.96920	0.97078	0.96943	0.00128	0.96808	0.00118	0.96880	0.00153	0.96846	0.00100	8343
95	4115	0.98235	0.97202	0.96730	0.96960	0.00128	0.96813	0.00117	0.96878	0.00151	0.96850	0.00099	8404
96	4141	0.97857	0.98968	0.98535	0.96972	0.00127	0.96842	0.00118	0.96900	0.00150	0.96879	0.00100	8045
97	4018	0.95341	0.95513	0.96614	0.96951	0.00127	0.96824	0.00118	0.96896	0.00148	0.96864	0.00100	8009
98	3902	0.96825	0.96266	0.98840	0.96949	0.00125	0.96817	0.00117	0.96921	0.00149	0.96867	0.00099	8108
99	4110	0.97128	0.96553	0.97669	0.96952	0.00124	0.96814	0.00115	0.96931	0.00147	0.96868	0.00097	8202
100	4005	1.00061	0.96103	1.01337	0.96991	0.00128	0.96805	0.00114	0.96986	0.00155	0.96876	0.00098	8009
101	4132	0.98163	0.96496	0.97087	0.97005	0.00127	0.96801	0.00113	0.96987	0.00153	0.96876	0.00097	8064
102	3910	0.98198	0.96791	0.99176	0.97020	0.00127	0.96801	0.00112	0.97014	0.00154	0.96883	0.00096	8058
103	4026	0.98095	0.96587	0.98293	0.97033	0.00126	0.96798	0.00110	0.97029	0.00153	0.96886	0.00096	8104
104	4087	0.96694	0.97036	0.96303	0.97029	0.00124	0.96801	0.00109	0.97021	0.00151	0.96885	0.00094	8217
105	3887	0.96527	0.95856	0.97494	0.97023	0.00123	0.96790	0.00108	0.97026	0.00149	0.96880	0.00094	8266
106	3951	0.97632	0.96446	0.96499	0.97030	0.00122	0.96786	0.00107	0.97020	0.00148	0.96877	0.00093	8316
107	4071	0.96118	0.97489	0.95071	0.97019	0.00121	0.96794	0.00106	0.96998	0.00148	0.96874	0.00091	8464
108	3892	0.97746	0.98890	0.97228	0.97027	0.00120	0.96818	0.00108	0.97000	0.00146	0.96893	0.00092	8330
109	4087	0.97516	0.95535	0.98016	0.97033	0.00119	0.96804	0.00107	0.97012	0.00145	0.96890	0.00091	8354
110	3918	0.97503	0.98225	0.98395	0.97038	0.00117	0.96819	0.00107	0.97027	0.00144	0.96907	0.00091	8265

111	4049	0.95417	0.96900	0.96493	0.97020	0.00117	0.96820	0.00106	0.97021	0.00143	0.96902	0.00090	8398
112	3841	0.97033	0.96537	1.00605	0.97021	0.00116	0.96817	0.00105	0.97060	0.00146	0.96910	0.00089	8395
113	4126	0.98186	0.97513	0.97526	0.97033	0.00116	0.96825	0.00104	0.97065	0.00145	0.96918	0.00089	8409
114	4122	0.96938	0.96734	0.95947	0.97032	0.00114	0.96824	0.00103	0.97053	0.00144	0.96914	0.00088	8480
115	3914	0.97083	0.96004	0.97687	0.97033	0.00113	0.96815	0.00102	0.97060	0.00143	0.96911	0.00087	8529
116	4046	0.96455	0.96238	0.97566	0.97027	0.00112	0.96809	0.00101	0.97065	0.00141	0.96908	0.00086	8599
117	3950	0.97577	0.98331	0.97747	0.97032	0.00111	0.96825	0.00102	0.97072	0.00140	0.96922	0.00086	8545
118	4019	0.96673	0.97473	0.97513	0.97029	0.00110	0.96831	0.00101	0.97077	0.00138	0.96927	0.00085	8633
119	4030	0.98410	0.97646	0.97782	0.97043	0.00110	0.96840	0.00100	0.97084	0.00137	0.96935	0.00085	8609
120	4066	0.97321	0.95999	0.98107	0.97045	0.00109	0.96831	0.00099	0.97094	0.00136	0.96934	0.00084	8662

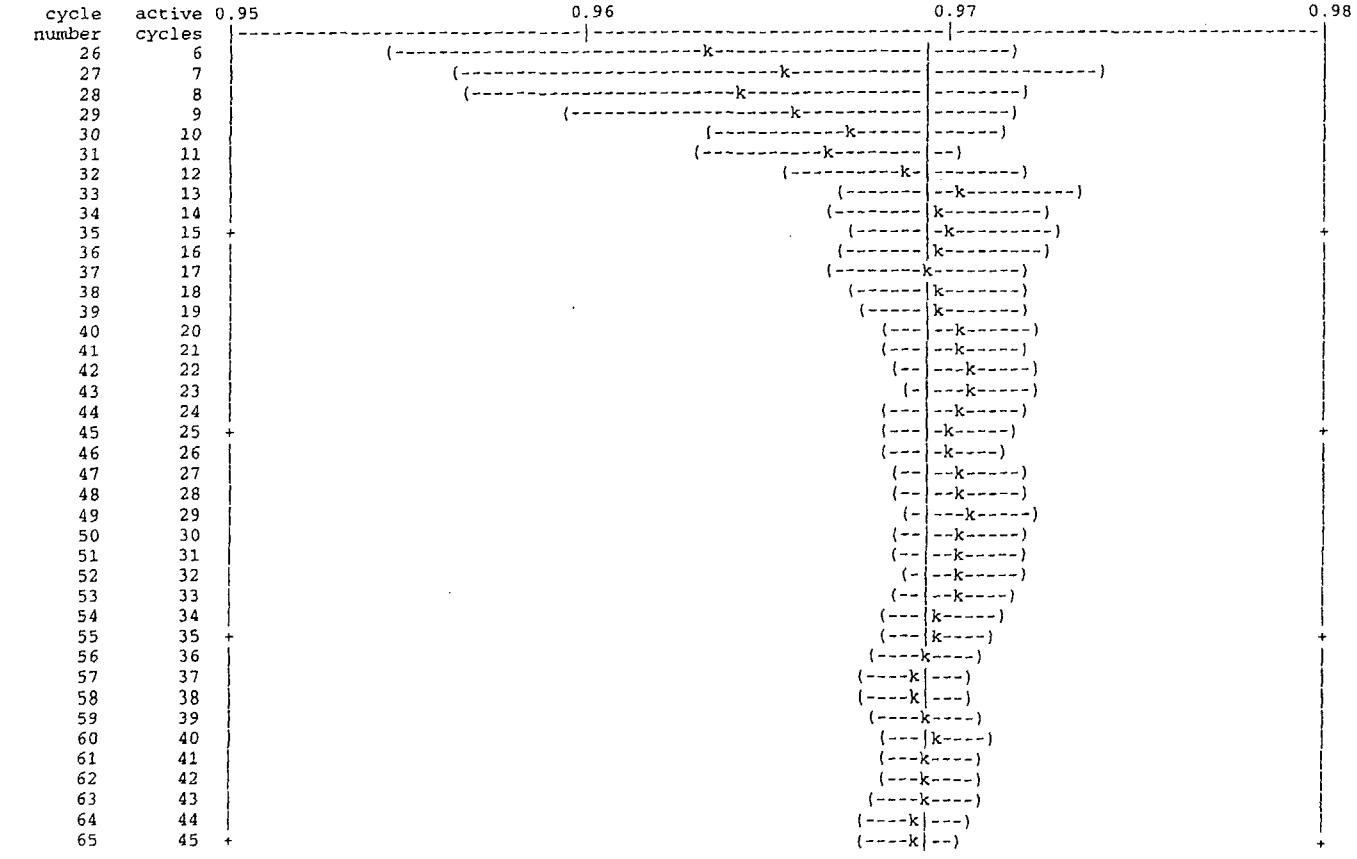
the largest active cycle keffs by estimator are:

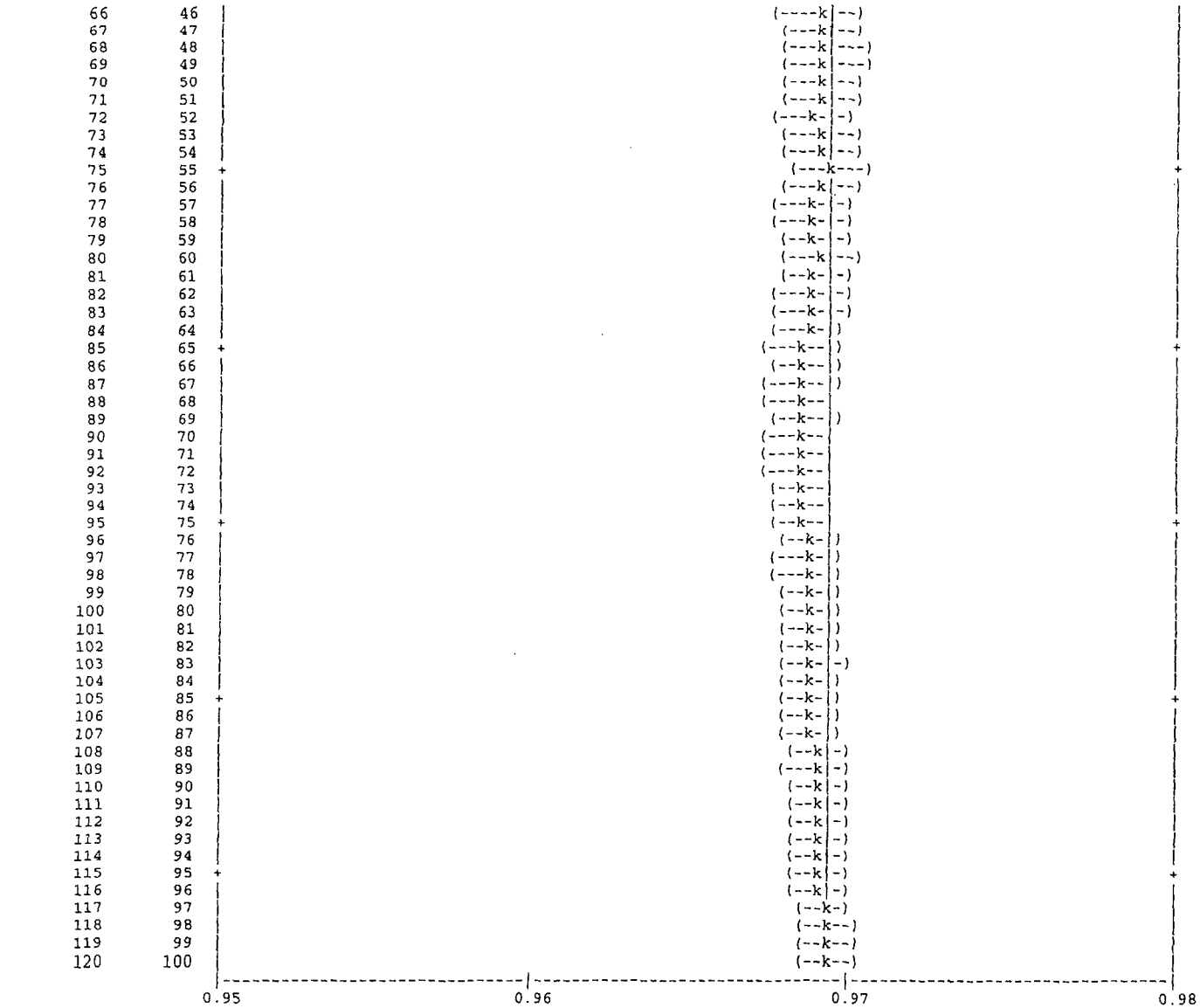
collision 1.00061 on cycle 100
absorption 0.99626 on cycle 60
track length 1.01337 on cycle 100

the smallest active cycle keffs by estimator are:

collision 0.94319 on cycle 21
absorption 0.94584 on cycle 57
track length 0.93247 on cycle 64

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.96934)





1individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
66	46												
67	47												
68	48												
69	49												
70	50												
71	51												
72	52												
73	53												
74	54												
75	55												
76	56												
77	57												
78	58												
79	59												
80	60												
81	61												
82	62												
83	63												
84	64												
85	65												
86	66												
87	67												
88	68												
89	69												
90	70												
91	71												
92	72												
93	73												
94	74												
95	75												
96	76												
97	77												
98	78												
99	79												
100	80												
101	81												
102	82												
103	83												
104	84												
105	85												
106	86												
107	87												
108	88												
109	89												
110	90												
111	91												
112	92												
113	93												
114	94												
115	95												
116	96												
117	97												
118	98												
119	99												
120	100												

0	120	480808	0.9692	0.0012	0.9673	0.0010	0.9699	0.0013	95/95/95	0.96824	0.00094	0.96637-0.97010	0.96576-0.97071
1	119	476808	0.9689	0.0011	0.9671	0.0010	0.9696	0.0013	95/95/95	0.96796	0.00089	0.96617-0.96974	0.96559-0.97032
2	118	472761	0.9692	0.0011	0.9672	0.0010	0.9698	0.0013	95/95/95	0.96818	0.00088	0.96643-0.96993	0.96586-0.97050
3	117	469052	0.9694	0.0011	0.9675	0.0010	0.9701	0.0013	95/95/95	0.96845	0.00084	0.96679-0.97012	0.96624-0.97066
4	116	465054	0.9697	0.0011	0.9677	0.0010	0.9702	0.0013	95/95/95	0.96865	0.00082	0.96702-0.97029	0.96649-0.97082
5	115	461001	0.9700	0.0010	0.9679	0.0009	0.9704	0.0013	95/95/95	0.96887	0.00080	0.96728-0.97047	0.96675-0.97100
6	114	457079	0.9701	0.0010	0.9681	0.0009	0.9704	0.0013	95/95/95	0.96897	0.00080	0.96737-0.97057	0.96685-0.97109
7	113	452991	0.9702	0.0010	0.9682	0.0009	0.9706	0.0013	95/95/95	0.96909	0.00080	0.96750-0.97069	0.96698-0.97121
8	112	449048	0.9703	0.0011	0.9682	0.0009	0.9708	0.0013	95/95/95	0.96920	0.00080	0.96760-0.97080	0.96707-0.97132
9	111	444953	0.9705	0.0010	0.9682	0.0010	0.9709	0.0013	95/95/95	0.96930	0.00081	0.96769-0.97091	0.96717-0.97143
10	110	440992	0.9706	0.0010	0.9683	0.0010	0.9710	0.0013	95/95/95	0.96941	0.00081	0.96780-0.97103	0.96728-0.97155
11	109	437032	0.9705	0.0010	0.9681	0.0010	0.9710	0.0013	95/95/95	0.96925	0.00080	0.96765-0.97085	0.96712-0.97137
12	108	432898	0.9705	0.0011	0.9681	0.0010	0.9711	0.0013	95/95/95	0.96928	0.00081	0.96766-0.97089	0.96714-0.97142
13	107	428943	0.9703	0.0011	0.9681	0.0010	0.9709	0.0013	95/95/95	0.96920	0.00081	0.96759-0.97081	0.96706-0.97134
14	106	424965	0.9703	0.0011	0.9683	0.0010	0.9710	0.0013	95/95/95	0.96930	0.00080	0.96770-0.97090	0.96718-0.97142
15	105	421009	0.9705	0.0011	0.9683	0.0010	0.9711	0.0013	95/95/95	0.96937	0.00081	0.96776-0.97099	0.96723-0.97151
16	104	417123	0.9706	0.0011	0.9683	0.0010	0.9712	0.0013	95/95/95	0.96946	0.00081	0.96784-0.97109	0.96731-0.97162
17	103	413124	0.9707	0.0011	0.9682	0.0010	0.9712	0.0013	95/95/95	0.96936	0.00082	0.96772-0.97100	0.96719-0.97154
18	102	408996	0.9705	0.0011	0.9682	0.0010	0.9712	0.0014	95/95/95	0.96937	0.00083	0.96771-0.97102	0.96718-0.97155
19	101	404915	0.9704	0.0011	0.9683	0.0010	0.9710	0.0013	95/95/95	0.96936	0.00083	0.96770-0.97102	0.96715-0.97156
20	100*	400893	0.9705	0.0011	0.9683	0.0010	0.9709	0.0014	95/95/95	0.96934	0.00084	0.96766-0.97101	0.96711-0.97156
22	98	393068	0.9710	0.0010	0.9686	0.0010	0.9714	0.0013	95/95/95	0.96975	0.00082	0.96812-0.97139	0.96759-0.97192
24	96	384852	0.9708	0.0011	0.9685	0.0010	0.9710	0.0013	95/95/95	0.96962	0.00083	0.96797-0.97126	0.96743-0.97180
26	94	376895	0.9710	0.0011	0.9684	0.0010	0.9712	0.0014	95/95/95	0.96964	0.00085	0.96795-0.97134	0.96739-0.97189
28	92	368859	0.9711	0.0011	0.9683	0.0010	0.9712	0.0014	95/95/95	0.96960	0.00085	0.96791-0.97129	0.96736-0.97184
30	90	360848	0.9710	0.0011	0.9683	0.0011	0.9710	0.0014	95/95/99	0.96951	0.00086	0.96779-0.97123	0.96723-0.97179
32	88	352776	0.9711	0.0011	0.9682	0.0011	0.9713	0.0014	95/95/99	0.96960	0.00087	0.96787-0.97132	0.96731-0.97189
34	86	344614	0.9710	0.0011	0.9681	0.0011	0.9713	0.0014	95/95/95	0.96951	0.00087	0.96778-0.97125	0.96721-0.97182
36	84	336716	0.9710	0.0011	0.9681	0.0011	0.9709	0.0014	95/95/99	0.96938	0.00088	0.96762-0.97114	0.96705-0.97171
38	82	328785	0.9710	0.0012	0.9680	0.0011	0.9711	0.0014	95/95/99	0.96944	0.00089	0.96767-0.97121	0.96709-0.97179
40	80	320700	0.9706	0.0012	0.9679	0.0011	0.9710	0.0015	95/95/99	0.96928	0.00090	0.96750-0.97107	0.96691-0.97165
42	78	312774	0.9708	0.0012	0.9677	0.0012	0.9714	0.0015	95/95/99	0.96936	0.00092	0.96753-0.97119	0.96693-0.97178
44	76	304675	0.9708	0.0012	0.9677	0.0012	0.9714	0.0015	95/95/99	0.96939	0.00093	0.96754-0.97124	0.96693-0.97185
46	74	296693	0.9710	0.0012	0.9678	0.0012	0.9715	0.0015	95/95/99	0.96950	0.00095	0.96760-0.97140	0.96698-0.97203
48	72	288656	0.9710	0.0012	0.9675	0.0012	0.9717	0.0016	95/95/99	0.96929	0.00098	0.96733-0.97124	0.96669-0.97188
50	70	280669	0.9709	0.0013	0.9671	0.0012	0.9720	0.0016	95/95/99	0.96907	0.00099	0.96708-0.97105	0.96643-0.97170
52	68	272844	0.9711	0.0013	0.9670	0.0012	0.9723	0.0016	95/95/99	0.96917	0.00103	0.96712-0.97122	0.96645-0.97189
54	66	264748	0.9713	0.0013	0.9671	0.0012	0.9728	0.0016	95/95/99	0.96946	0.00104	0.96738-0.97153	0.96670-0.97222
56	64	256610	0.9713	0.0013	0.9674	0.0013	0.9725	0.0016	95/95/99	0.96947	0.00106	0.96735-0.97160	0.96664-0.97230
58	62	248634	0.9714	0.0013	0.9678	0.0012	0.9723	0.0017	95/95/no	0.96959	0.00108	0.96743-0.97174	0.96671-0.97246
60	60	240704	0.9712	0.0014	0.9671	0.0012	0.9722	0.0017	95/95/no	0.96887	0.00107	0.96672-0.97102	0.96601-0.97173
62	58	232880	0.9713	0.0014	0.9673	0.0012	0.9723	0.0018	95/95/99	0.96902	0.00109	0.96683-0.97122	0.96610-0.97194
64	56	224829	0.9718	0.0014	0.9674	0.0013	0.9731	0.0017	95/95/99	0.96960	0.00111	0.96737-0.97182	0.96663-0.97256
66	54	216860	0.9719	0.0014	0.9676	0.0013	0.9727	0.0017	95/95/99	0.96962	0.00114	0.96732-0.97191	0.96655-0.97268
68	52	208764	0.9715	0.0015	0.9674	0.0013	0.9728	0.0018	95/95/99	0.96950	0.00118	0.96713-0.97187	0.96634-0.97266
70	50	200697	0.9715	0.0015	0.9675	0.0014	0.9732	0.0018	95/95/95	0.96963	0.00122	0.96717-0.97208	0.96635-0.97290
72	48	192735	0.9720	0.0015	0.9676	0.0014	0.9735	0.0019	95/95/95	0.96983	0.00125	0.96731-0.97236	0.96646-0.97320
74	46	184591	0.9714	0.0015	0.9674	0.0014	0.9731	0.0019	95/95/95	0.96960	0.00126	0.96706-0.97214	0.96620-0.97300
76	44	176582	0.9718	0.0015	0.9677	0.0014	0.9735	0.0020	95/95/95	0.96987	0.00123	0.96738-0.97236	0.96654-0.97321
78	42	168548	0.9722	0.0016	0.9676	0.0015	0.9743	0.0020	95/95/95	0.97021	0.00131	0.96756-0.97287	0.96666-0.97376
80	40	160503	0.9716	0.0016	0.9670	0.0015	0.9742	0.0019	95/95/99	0.96984	0.00133	0.96715-0.97253	0.96624-0.97344
82	38	152503	0.9719	0.0017	0.9678	0.0015	0.9746	0.0020	95/95/99	0.97023	0.00128	0.96762-0.97283	0.96674-0.97372
84	36	144488	0.9722	0.0017	0.9683	0.0015	0.9748	0.0021	95/95/95	0.97059	0.00129	0.96796-0.97322	0.96705-0.97413
86	34	136583	0.9726	0.0018	0.9689	0.0015	0.9746	0.0022	95/95/95	0.97084	0.00130	0.96818-0.97349	0.96727-0.97441
88	32	128551	0.9728	0.0018	0.9693	0.0016	0.9750	0.0024	95/95/95	0.97117	0.00135	0.96841-0.97392	0.96745-0.97488
90	30	120459	0.9732	0.0018	0.9693	0.0016	0.9759	0.0023	95/95/95	0.97169	0.00134	0.96893-0.97445	0.96796-0.97541
92	28	112338	0.9729	0.0019	0.9693	0.0018	0.9764	0.0025	95/95/95	0.97173	0.00145	0.96873-0.97472	0.96768-0.97578

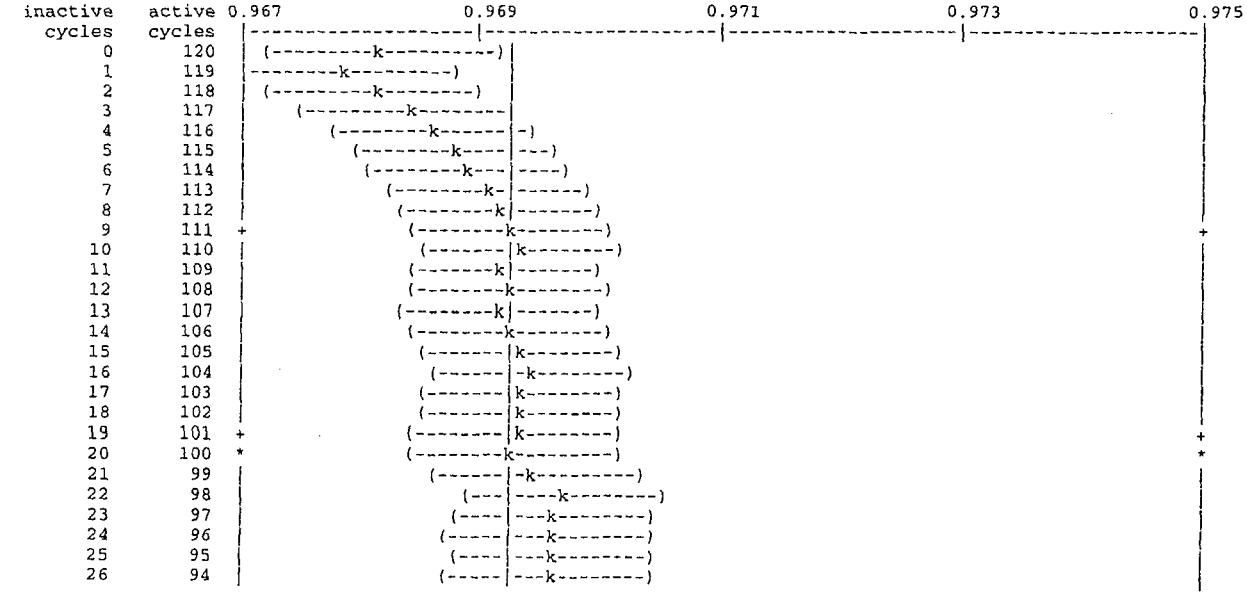
94	26	104415	0.9734	0.0020	0.9690	0.0019	0.9770	0.0026	95/95/95	0.97180	0.00160	0.96848-0.97512	0.96730-0.97631
96	24	96159	0.9728	0.0021	0.9680	0.0018	0.9771	0.0028	95/95/95	0.97088	0.00161	0.96752-0.97423	0.96631-0.97544
98	22	88239	0.9739	0.0021	0.9688	0.0018	0.9771	0.0030	95/95/95	0.97151	0.00154	0.96827-0.97474	0.96709-0.97593
100	20	80124	0.9726	0.0018	0.9694	0.0020	0.9753	0.0027	95/95/95	0.97175	0.00153	0.96853-0.97496	0.96733-0.97617
102	18	72082	0.9716	0.0018	0.9697	0.0022	0.9746	0.0028	95/95/95	0.97150	0.00162	0.96805-0.97495	0.96673-0.97627
104	16	63969	0.9713	0.0019	0.9699	0.0025	0.9748	0.0030	95/95/95	0.97160	0.00179	0.96772-0.97547	0.96619-0.97700
106	14	56131	0.9714	0.0021	0.9711	0.0027	0.9755	0.0034	95/95/95	0.97219	0.00201	0.96776-0.97661	0.96595-0.97842
108	12	48168	0.9718	0.0023	0.9693	0.0026	0.9778	0.0032	95/95/99	0.97232	0.00230	0.96711-0.97753	0.96484-0.97980
110	10	40163	0.9711	0.0027	0.9694	0.0025	0.9770	0.0038	95/95/99	0.97164	0.00242	0.96591-0.97738	0.96316-0.98013
112	8	32273	0.9733	0.0025	0.9699	0.0031	0.9748	0.0023	95/95/no	0.97335	0.00239	0.96721-0.97949	0.96371-0.98299
114	6	24025	0.9725	0.0029	0.9695	0.0041	0.9773	0.0009	95/95/95	0.97715	0.00116	0.97347-0.98083	0.97039-0.98391
116	4	16065	0.9750	0.0036	0.9736	0.0049	0.9779	0.0012	95/95/95	0.97740	0.00120	0.96221-0.99260	0.90130-1.05350
117	3	12115	0.9747	0.0051	0.9704	0.0052	0.9780	0.0017					
118	2	8096	0.9787	0.0054	0.9682	0.0082	0.9794	0.0016					

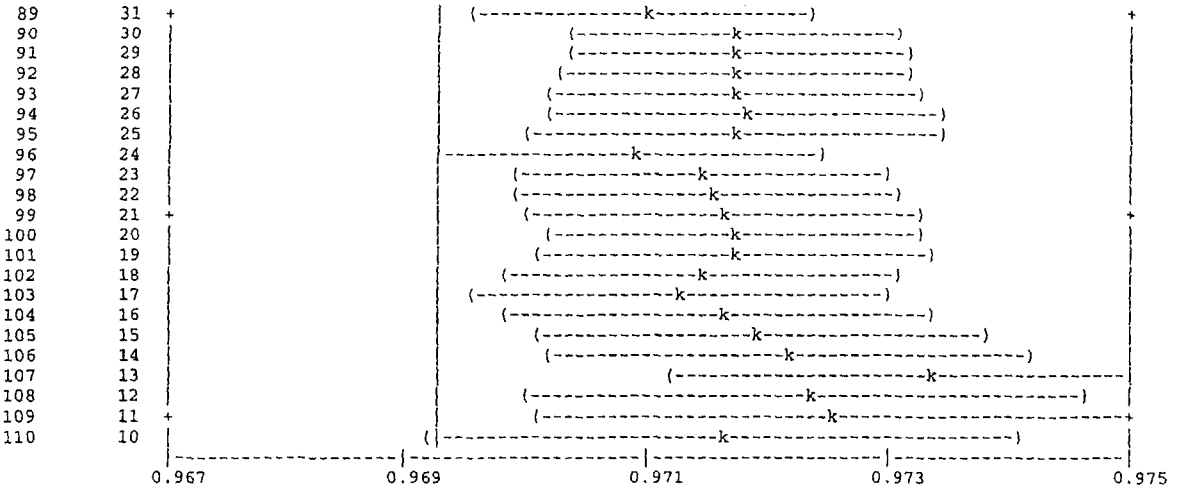
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 7 inactive cycles and 113 active cycles.

the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.96910	0.00123	0.96786 to 0.97034	0.96661 to 0.97158	0.96578 to 0.97241
second half	0.96963	0.00122	0.96840 to 0.97085	0.96717 to 0.97208	0.96635 to 0.97290
final result	0.96934	0.00084	0.96849 to 0.97018	0.96766 to 0.97101	0.96711 to 0.97156

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.96934)





dump no. 13 on file c01220r nps = 480808 coll = 26650495 ctm = 179.86 nrn = 656283951

1 warning message so far.

run terminated when 120 kcode cycles were done.

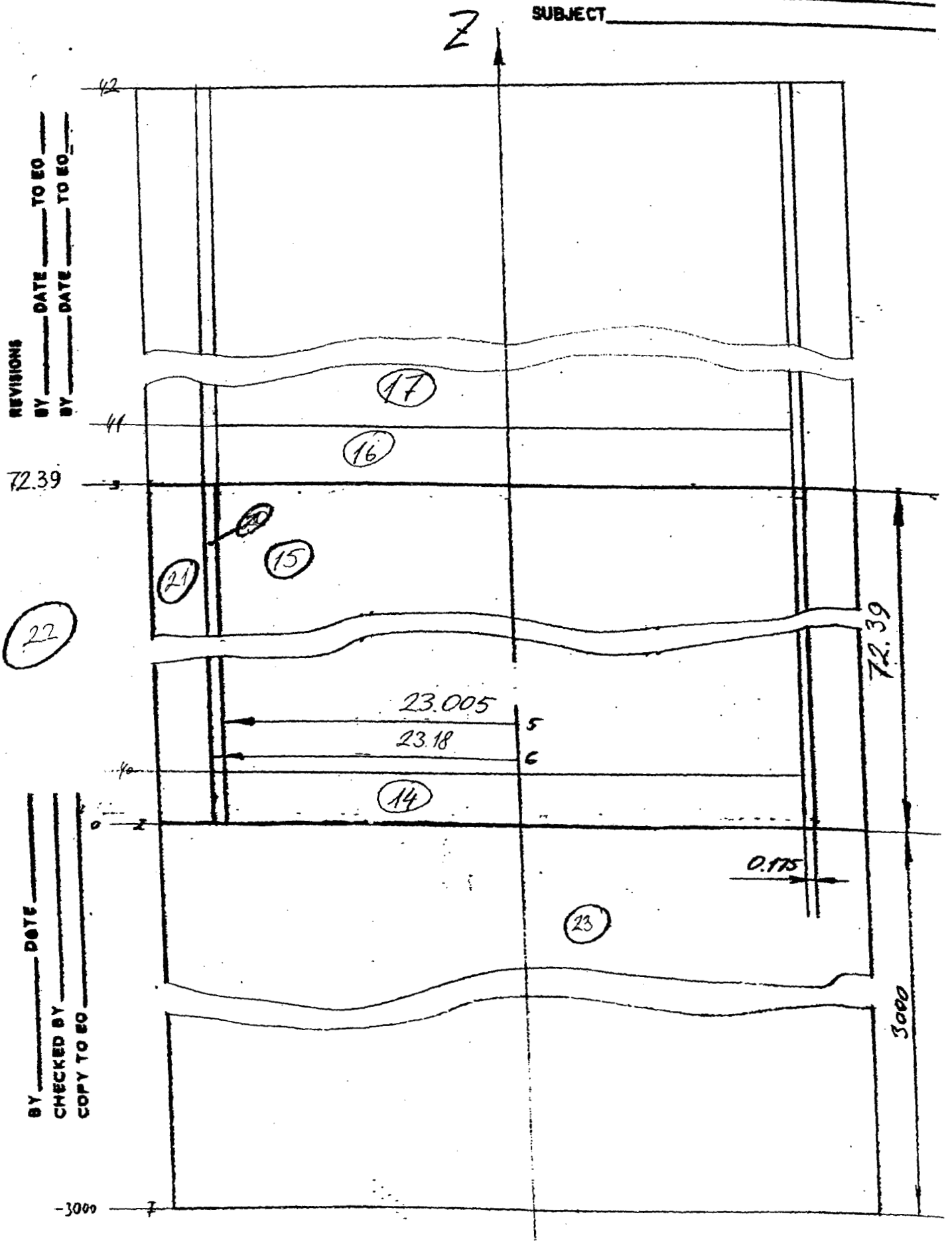
computer time = 179.88 minutes

mcnp version 4a 10/01/93 *05/31/00 22:39:32* *probid =* 05/31/00 19:39:39

Attachment 5: Case 2 with MCNP surface and cell numbers

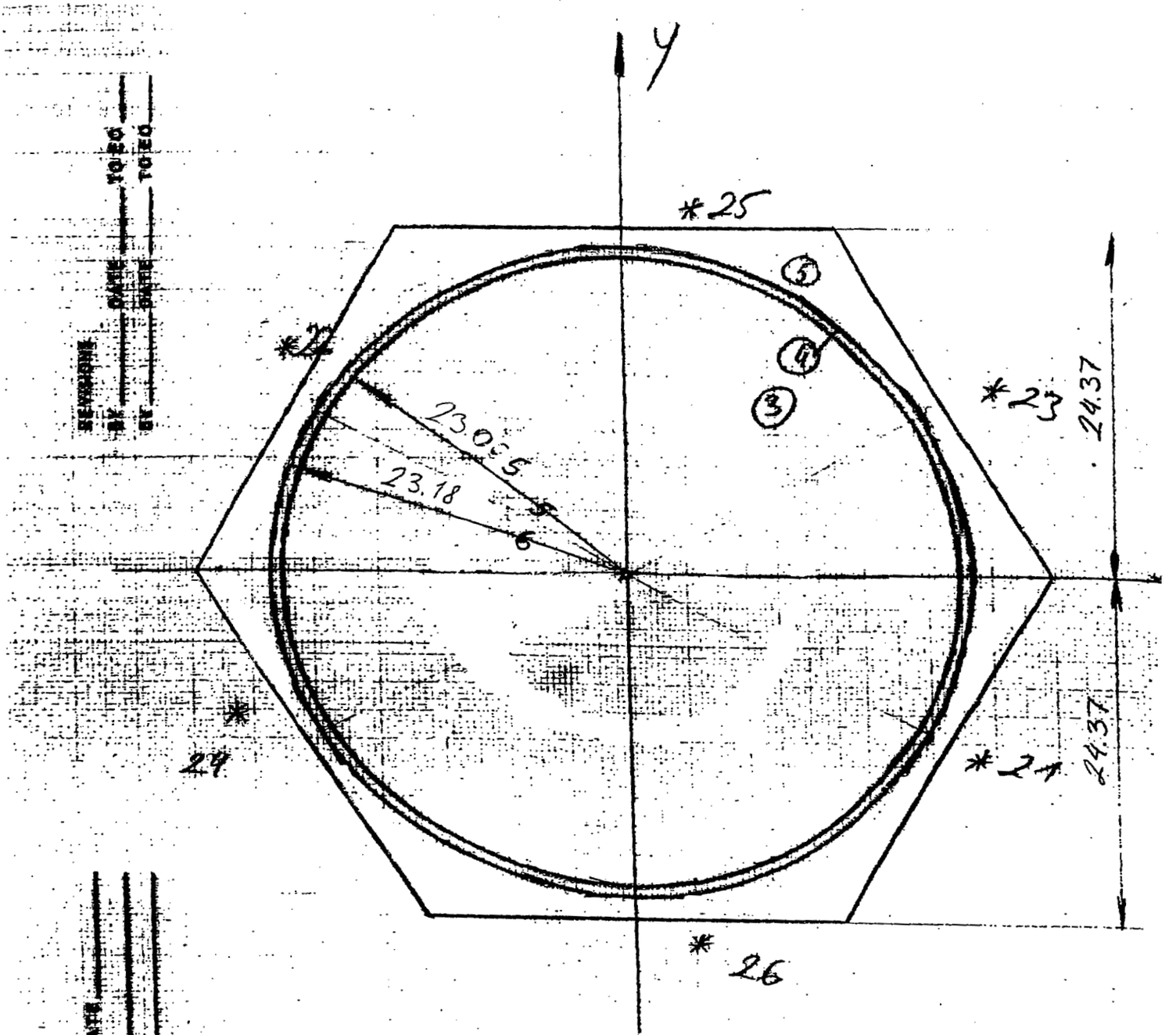
FILE _____
SUBJECT _____

REVISIONS
BY _____ DATE _____ TO EO ____
BY _____ DATE _____ TO EO ____
BY _____

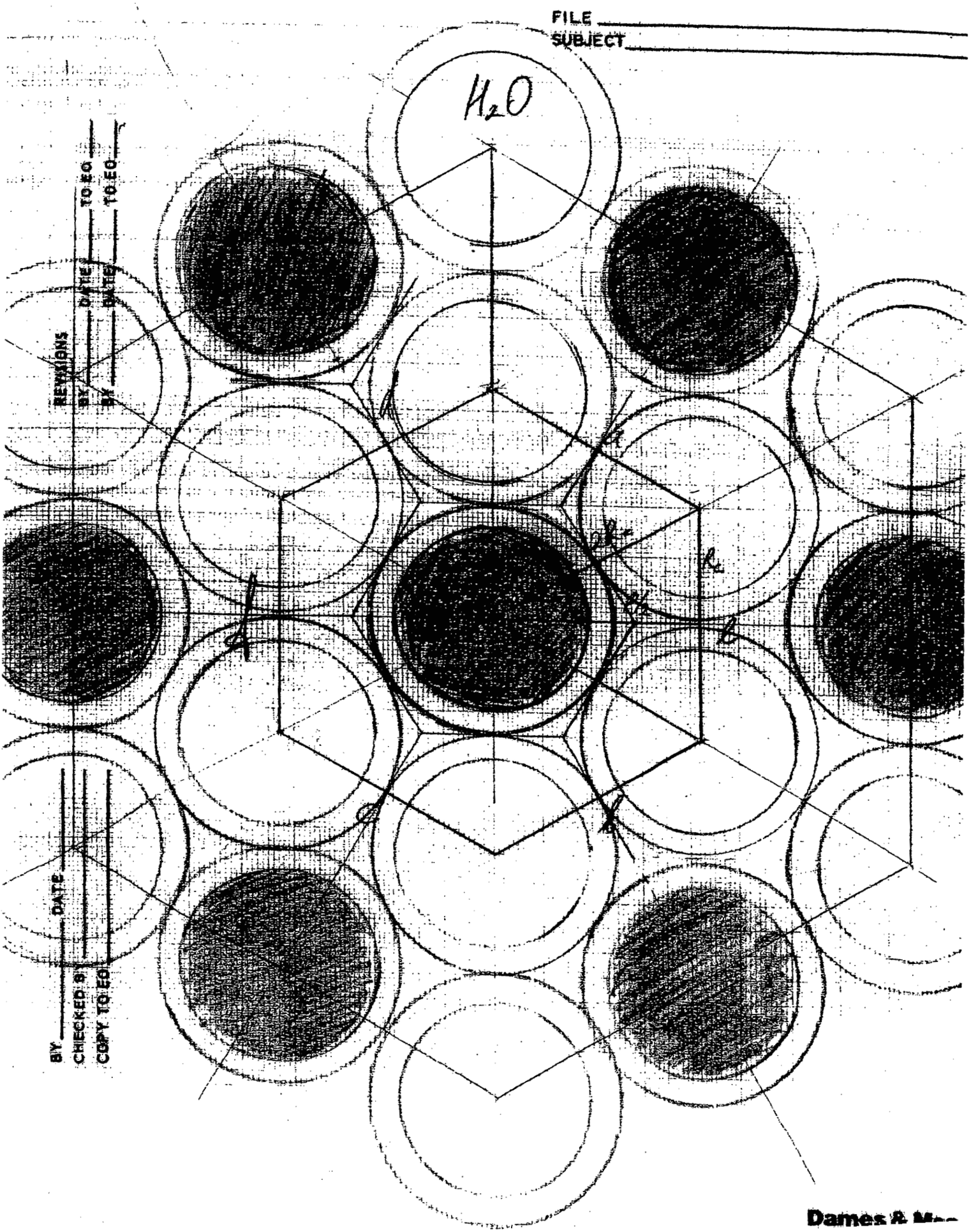


BY _____ DATE _____
CHECKED BY _____
COPY TO EO _____

FILE
SUBJECT



FILE
SUBJECT



Attachment 6: Case 2 MCNP input file

```
                                                        C07222
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
c ------------------------------------------------------------------------
c Universe 1. Fuel rod, clad and air outside the clad
c
1 61 -10.4  -17    u=1       imp:n=1 $ fuel rod
2 62 -7.92  -18 17 u=1       imp:n=1 $ SS-304 clad
3 64 -0.001293  18 u=1       imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 2. Water instead of the fuel, clad and air outside the clad
c
4 63 -1.0   -17    u=2       imp:n=1 $ water instead of fuel inside the clad
5 62 -7.92  -18 17 u=2       imp:n=1 $ SS-304 clad
6 64 -0.001293  18 u=2       imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 3. 1 fuel rod per 2 water rods hexagonal lattice arrangement
c
7  0        -11 12 -13 14 -15 16 u=3
                lat=2 fill= -1:1 -1:1 0:0
                1 2 2
                2 1 2
                2 2 1     imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 4. Water-fuel lattice filling the lower part of the drum
c
8 0    -35 36 -31 33 -34 32 u=4
                lat=2 fill=3 imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 5. Air instead of the fuel, clad and air outside the clad
c
9  64 -0.001293 -17 u=5       imp:n=1 $ air instead of fuel inside the clad
10 62 -7.92  -18 17 u=5       imp:n=1 $ SS-304 clad
11 64 -0.001293  18 u=5       imp:n=1 $ air outside the clad
c
c ------------------------------------------------------------------------
c Universe 6. 1 fuel rod per 2 air rods hexagonal lattice arrangement
c
12  0        -11 12 -13 14 -15 16 u=6
                lat=2 fill= -1:1 -1:1 0:0
                1 5 5
                5 1 5
                5 5 1     imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
c Universe 7. Air-fuel lattice filling the upper part drum
c
13 0    -35 36 -31 33 -34 32 u=7
                lat=2 fill=6 imp:n=1 $ Hexagonal lattice
c ------------------------------------------------------------------------
14  0  2 -40 -5  fill=4  imp:n=1 $ lower part of the 1st drum filled with
c                                  water-fuel lattice
15  0  40 -3 -5  fill=7  imp:n=1 $ upper part of the 1st drum filled with
c                                  air-fuel lattice
16  0  3 -41 -5  fill=4  imp:n=1 $ lower part of the 2nd drum filled with
c                                  water-fuel lattice
17  0  41 -42 -5 fill=7  imp:n=1 $ upper part of the 2nd drum filled with
c                                  air-fuel lattice
c
c outside the drum:
c
20  65  -7.82      5 -6 2 -42    imp:n=1 $ drum wall
21  64 -0.001293 -21 22 -23 24 -25 26 2 -42 6 imp:n=1 $  air ouside the drum
22  0        21 : -22 : 23 : -24 : 25 : -26 : -7 : 42 imp:n=0 $ Outside world
23  67 -2.35     -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
```

C07222

```
2  pz 0       $ 1st drum bottom plane
40 pz 10.9068 $ plane separating the lower and upper part of the 1st drum
c               (water level boundary corresponding to 0.07 volume fraction)
3  pz 72.39   $ 1st drum top plane
41 pz 83.2968 $ plane separating the lower and upper part of the 2nd drum
c               (water level boundary corresponding to 0.07 volume fraction)
42 pz 144.78  $ 2nd drum top plane
5  cz 23.005  $ internal wall of the drum
6  cz 23.180  $ external wall of the drum
7  pz -3000   $ concrete bottom plane
c
c 1st level lattice
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of lattice surfaces
c
c 2nd level lattice
c begin the lattice surfaces
31 p  1  1.73205  0  1.495798
32 p -1  1.73205  0 -1.495798
33 p  1  1.73205  0 -1.495798
34 p -1  1.73205  0  1.495798
35 px  0.747899
36 px -0.747899
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
c (simulates infinite array of the drums)
c begin the lattice surfaces
*21 p 0.8660254 -0.5 0  24.37
*22 p 0.8660254 -0.5 0 -24.37
*23 p 0.8660254  0.5 0  24.37
*24 p 0.8660254  0.5 0 -24.37
*25 py  24.37
*26 py -24.37
c end of lattice surfaces
c
C ------------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185844
      92235.50c -0.0435427
      92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
      24000.50c -0.19
      25055.50c -0.02
      26000.55c -0.68
      28000.50c -0.10
c Water (H, O)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64    6000.50c -0.000124
       7014.50c -0.755267
       8016.50c -0.231781
      18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65    6000.50c -0.005
      26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
```

```
                                                        C07222
c adjusted to sum to unity without minor trace elements)
m67     1001.50c -0.006
        8016.50c -0.5
       11023.50c -0.017
       13027.50c -0.048
       14000.50c -0.315
       19000.50c -0.019
       20000.50c -0.083
       26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 7: Case 2 MCNP output file

```
lmcnp     version 4a    ld=10/01/93                    06/02/00 02:05:17
*************************************************************************          probid =   06/02/00 02:05:17
name=c07222

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water
      C The drum height is 28 1/2 inches (72.39 cm)
      c drum wall thickness is 0.157 cm
      c
      C Cell cards
      C
      C ---------------------------------------------------------------------
      c inside the drum:
      c
      c ---------------------------------------------------------------------
      c Universe 1. Fuel rod, clad and air outside the clad
      c
      1 61 -10.4  -17    u=1       imp:n=1 $ fuel rod
      2 62 -7.92  -18 17 u=1       imp:n=1 $ SS-304 clad
      3 64 -0.001293  18 u=1       imp:n=1 $ air outside the clad
      c
      c ---------------------------------------------------------------------
      c Universe 2. Water instead of the fuel, clad and air outside the clad
      c
      4 63 -1.0   -17    u=2       imp:n=1 $ water instead of fuel inside the clad
      5 62 -7.92  -18 17 u=2       imp:n=1 $ SS-304 clad
      6 64 -0.001293  18 u=2       imp:n=1 $ air outside the clad
      c
      c ---------------------------------------------------------------------
      c Universe 3. 1 fuel rod per 2 water rods hexagonal lattice arrangement
      c
      7  0         -11 12 -13 14 -15 16 u=3
                        lat=2 fill= -1:1 -1:1 0:0
                        1 2 2
                        2 1 2
                        2 2 1     imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      c Universe 4. Water-fuel lattice filling the lower part of the drum
      c
      8 0    -35 36 -31 33 -34 32 u=4
                        lat=2 fill=3 imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      c Universe 5. Air instead of the fuel, clad and air outside the clad
      c
      9  64 -0.001293 -17 u=5       imp:n=1 $ air instead of fuel inside the clad
      10 62 -7.92  -18 17 u=5       imp:n=1 $ SS-304 clad
      11 64 -0.001293  18 u=5       imp:n=1 $ air outside the clad
      c
      c ---------------------------------------------------------------------
      c Universe 6. 1 fuel rod per 2 air rods hexagonal lattice arrangement
      c
      12  0         -11 12 -13 14 -15 16 u=6
                        lat=2 fill= -1:1 -1:1 0:0
                        1 5 5
                        5 1 5
                        5 5 1     imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      c Universe 7. Air-fuel lattice filling the upper part drum
      c
      13 0    -35 36 -31 33 -34 32 u=7
                        lat=2 fill=6 imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      14  0  2 -40 -5  fill=4  imp:n=1 $ lower part of the 1st drum filled with
```

```
c                                        water-fuel lattice
15  0  40 -3 -5  fill=7  imp:n=1 $ upper part of the 1st drum filled with
c                                        air-fuel lattice
16  0  3 -41 -5  fill=4  imp:n=1 $ lower part of the 2nd drum filled with
c                                        water-fuel lattice
17  0  41 -42 -5 fill=7  imp:n=1 $ upper part of the 2nd drum filled with
c                                        air-fuel lattice
c
c outside the drum:
c
20  65  -7.82       5 -6 2 -42    imp:n=1 $ drum wall
21  64 -0.001293 -21 22 -23 24 -25 26 2 -42 6 imp:n=1 $  air ouside the drum
22  0        21 : -22 : 23 : -24 : 25 : -26 : -7 : 42 imp:n=0 $ Outside world
23  67 -2.35      -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0        $ 1st drum bottom plane
40 pz 10.9068 $ plane separating the lower and upper part of the 1st drum
c                (water level boundary corresponding to 0.07 volume fraction)
3  pz 72.39    $ 1st drum top plane
41 pz 83.2968 $ plane separating the lower and upper part of the 2nd drum
c                (water level boundary corresponding to 0.07 volume fraction)
42 pz 144.78  $ 2nd drum top plane
5  cz 23.005  $ internal wall of the drum
6  cz 23.180  $ external wall of the drum
7  pz -3000   $ concrete bottom plane
c
c 1st level lattice
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of lattice surfaces
c
c 2nd level lattice
c begin the lattice surfaces
31 p  1  1.73205  0  1.495798
32 p -1  1.73205  0 -1.495798
33 p  1  1.73205  0 -1.495798
34 p -1  1.73205  0  1.495798
35 px  0.747899
36 px -0.747899
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
c (simulates infinite array of the drums)
c begin the lattice surfaces
*21 p 0.8660254 -0.5 0  24.37
*22 p 0.8660254 -0.5 0 -24.37
*23 p 0.8660254  0.5 0  24.37
*24 p 0.8660254  0.5 0 -24.37
*25 py  24.37
```

```
 121-       *26 py -24.37
 122-       c end of lattice surfaces
 123-       c
 124-       C ------------------------------------------------------------------------
 125-       c
 126-       c Note: next line must be completely blank
 127-
 128-       c Data cards
 129-       c
 130-       c Materials
 131-       c
 132-       c
 133-       c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
 134-       m61     8016.50c -0.1185844
 135-             92235.50c -0.0435427
 136-             92238.50c -0.8378729
 137-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
 138-       m62   14000.50c -0.01
 139-             24000.50c -0.19
 140-             25055.50c -0.02
 141-             26000.55c -0.68
 142-             28000.50c -0.10
 143-       c Water (H, O)
 144-       m63     1001.50c 0.66667
 145-              8016.50c 0.33333
 146-       mt63 lwtr.01t
 147-       c Air (C, N, O, Ar) composition from Attix p.523
 148-       m64     6000.50c -0.000124
 149-              7014.50c -0.755267
 150-              8016.50c -0.231781
 151-             18000.35c -0.012828
 152-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
 153-       m65     6000.50c -0.005
 154-             26000.55c -0.995
 155-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
 156-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
 157-       c adjusted to sum to unity without minor trace elements)
 158-       m67     1001.50c -0.006
 159-              8016.50c -0.5
 160-             11023.50c -0.017
 161-             13027.50c -0.048
 162-             14000.50c -0.315
 163-             19000.50c -0.019
 164-             20000.50c -0.083
 165-             26000.55c -0.012
 166-       c
 167-       mode n
 168-       print 40 60 80 100 110 126
 169-       kcode 4000 1. 20 120
 170-       ksrc  0 0 10
 171-
 total fission nubar data are being used.
1material composition                                                    print table 40

 material
  number     component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01666      92238,  0.31655
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
```

64	6000,	0.00015	7014,	0.78443	8016,	0.21075	18000,	0.00467
65	6000,	0.02283	26000,	0.97717				
67	1001,	0.11082	8016,	0.58191	11023,	0.01377	13027,	0.03312
	14000,	0.20878	19000,	0.00905	20000,	0.03855	26000,	0.00400

material number — component nuclide, mass fraction

61	8016,	0.11858	92235,	0.04354	92238,	0.83787		
62	14000,	0.01000	24000,	0.19000	25055,	0.02000	26000,	0.68000
	28000,	0.10000						
63	1001,	0.11192	8016,	0.88808				
64	6000,	0.00012	7014,	0.75527	8016,	0.23178	18000,	0.01283
65	6000,	0.00500	26000,	0.99500				
67	1001,	0.00600	8016,	0.50000	11023,	0.01700	13027,	0.04800
	14000,	0.31500	19000,	0.01900	20000,	0.08300	26000,	0.01200

1cells print table 60

	cell	mat	atom density	gram density	volume	mass	pieces	neutron importance
1	1	61	6.96366E-02	1.04000E+01	0.00000E+00	0.00000E+00	0	1.0000E+00
2	2	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
3	3	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
4	4	63s	1.00309E-01	1.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
5	5	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
6	6	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
7	7	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
8	8	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
9	9	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
10	10	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
11	11	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
12	12	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
13	13	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
14	14	0	0.00000E+00	0.00000E+00	1.81339E+04	0.00000E+00	1	1.0000E+00
15	15	0	0.00000E+00	0.00000E+00	1.02224E+05	0.00000E+00	1	1.0000E+00
16	16	0	0.00000E+00	0.00000E+00	1.81339E+04	0.00000E+00	1	1.0000E+00
17	17	0	0.00000E+00	0.00000E+00	1.02224E+05	0.00000E+00	1	1.0000E+00
18	20	65	8.58651E-02	7.82000E+00	3.67619E+03	2.87478E+04	1	1.0000E+00
19	21	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
20	22	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	0.0000E+00
21	23	67	7.60226E-02	2.35000E+00	6.17196E+06	1.45041E+07	0	1.0000E+00
total					6.41635E+06	1.45328E+07		

1cross-section tables print table 100

table	length			
tables from file critxs				
1001.50c	1153	njoy	(1301)	79/07/31.
6000.50c	16126	njoy	(1306)	79/07/31.
7014.50c	22772	njoy	(1275)	79/09/08.
8016.50c	23669	njoy	(1276)	05/14/81
11023.50c	36270	njoy	(1311)	79/06/21.
13027.50c	22891	njoy	(1313)	79/09/08.
14000.50c	48275	njoy	(1314)	79/06/21.
18000.35c	2182	endl85	(18)	11/01/85

```
 19000.50c    9766  njoy                                                          (  1150)      79/10/29.
 20000.50c   26104  njoy                                                          (  1320)      79/06/22.
 24000.50c   89104  njoy                                                          (  1324)      79/06/21.
 25055.50c   60097  njoy                                                          (  1325)      79/06/21.
 26000.55c   84136  njoy                                                          ( 260)       10/21/82
 28000.50c   82267  njoy                                                          (  1328)      79/06/21.
 92235.50c   44188  njoy                                    total nu              (  1395)      79/09/12.
 92238.50c   66440  njoy                                    total nu              (  1398)      79/09/13.
  lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                1001     0     010/22/85

 total      645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general            120974
     tallies                 0
     bank                14403
     cross sections     645633

     total              781010

 ********************************************************************************************************************
 dump no.    1 on file c07222r      nps =         0     coll =             0     ctm =    0.00     nrn =              0


 source distribution written to file c07222s         cycle =     0

         1 warning message so far.
1   starting mcrun.      field length =      0      cp0 =  0.02                                        print table 110

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water


 nps   x          y          z        cell lattice(i,j,k)  surface    u          v          w          energy     weight      time

  1  0.000E+00  0.000E+00  1.000E+01   14                              5.085E-01  4.733E-01  7.193E-01  2.209E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)           5.085E-01  4.733E-01  7.193E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)           5.085E-01  4.733E-01  7.193E-01
     0.000E+00  0.000E+00  1.000E+01    1                       0   5.085E-01  4.733E-01  7.193E-01
  2  0.000E+00  0.000E+00  1.000E+01   14                              8.952E-01 -4.447E-01 -2.944E-02  4.904E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)           8.952E-01 -4.447E-01 -2.944E-02
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)           8.952E-01 -4.447E-01 -2.944E-02
     0.000E+00  0.000E+00  1.000E+01    1                       0   8.952E-01 -4.447E-01 -2.944E-02
  3  0.000E+00  0.000E+00  1.000E+01   14                             -6.184E-01 -4.495E-01  6.446E-01  3.809E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)          -6.184E-01 -4.495E-01  6.446E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)          -6.184E-01 -4.495E-01  6.446E-01
     0.000E+00  0.000E+00  1.000E+01    1                       0  -6.184E-01 -4.495E-01  6.446E-01
  4  0.000E+00  0.000E+00  1.000E+01   14                              9.710E-01 -5.665E-02 -2.323E-01  1.331E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)           9.710E-01 -5.665E-02 -2.323E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)           9.710E-01 -5.665E-02 -2.323E-01
     0.000E+00  0.000E+00  1.000E+01    1                       0   9.710E-01 -5.665E-02 -2.323E-01
  5  0.000E+00  0.000E+00  1.000E+01   14                              5.861E-01  1.496E-01 -7.963E-01  1.902E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)           5.861E-01  1.496E-01 -7.963E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)           5.861E-01  1.496E-01 -7.963E-01
     0.000E+00  0.000E+00  1.000E+01    1                       0   5.861E-01  1.496E-01 -7.963E-01
  6  0.000E+00  0.000E+00  1.000E+01   14                             -6.489E-02 -1.626E-01  9.845E-01  4.410E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)          -6.489E-02 -1.626E-01  9.845E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)          -6.489E-02 -1.626E-01  9.845E-01
     0.000E+00  0.000E+00  1.000E+01    1                       0  -6.489E-02 -1.626E-01  9.845E-01
  7  0.000E+00  0.000E+00  1.000E+01   14                             -7.068E-02  3.263E-02 -9.970E-01  4.750E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)          -7.068E-02  3.263E-02 -9.970E-01
```

	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-7.068E-02	3.263E-02	-9.970E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -7.068E-02	3.263E-02	-9.970E-01				
8	0.000E+00	0.000E+00	1.000E+01	14				-3.915E-01	4.664E-01	-7.932E-01	4.136E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-3.915E-01	4.664E-01	-7.932E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-3.915E-01	4.664E-01	-7.932E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -3.915E-01	4.664E-01	-7.932E-01				
9	0.000E+00	0.000E+00	1.000E+01	14				-2.368E-01	9.215E-01	-3.079E-01	7.453E-02	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-2.368E-01	9.215E-01	-3.079E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-2.368E-01	9.215E-01	-3.079E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -2.368E-01	9.215E-01	-3.079E-01				
10	0.000E+00	0.000E+00	1.000E+01	14				1.946E-01	-3.204E-01	9.271E-01	3.128E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	1.946E-01	-3.204E-01	9.271E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	1.946E-01	-3.204E-01	9.271E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 1.946E-01	-3.204E-01	9.271E-01				
11	0.000E+00	0.000E+00	1.000E+01	14				-6.698E-01	-7.177E-01	-1.905E-01	1.014E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-6.698E-01	-7.177E-01	-1.905E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-6.698E-01	-7.177E-01	-1.905E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -6.698E-01	-7.177E-01	-1.905E-01				
12	0.000E+00	0.000E+00	1.000E+01	14				-8.398E-01	-4.129E-01	3.524E-01	1.395E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-8.398E-01	-4.129E-01	3.524E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-8.398E-01	-4.129E-01	3.524E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -8.398E-01	-4.129E-01	3.524E-01				
13	0.000E+00	0.000E+00	1.000E+01	14				-1.714E-01	-8.572E-01	4.857E-01	7.748E-01	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-1.714E-01	-8.572E-01	4.857E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-1.714E-01	-8.572E-01	4.857E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -1.714E-01	-8.572E-01	4.857E-01				
14	0.000E+00	0.000E+00	1.000E+01	14				-2.489E-01	-5.118E-01	-8.222E-01	1.101E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-2.489E-01	-5.118E-01	-8.222E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-2.489E-01	-5.118E-01	-8.222E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -2.489E-01	-5.118E-01	-8.222E-01				
15	0.000E+00	0.000E+00	1.000E+01	14				-2.959E-01	2.119E-01	9.314E-01	1.951E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-2.959E-01	2.119E-01	9.314E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-2.959E-01	2.119E-01	9.314E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -2.959E-01	2.119E-01	9.314E-01				
16	0.000E+00	0.000E+00	1.000E+01	14				1.395E-01	-9.829E-01	1.202E-01	2.186E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	1.395E-01	-9.829E-01	1.202E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	1.395E-01	-9.829E-01	1.202E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 1.395E-01	-9.829E-01	1.202E-01				
17	0.000E+00	0.000E+00	1.000E+01	14				6.909E-01	-7.110E-01	1.307E-01	1.865E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	6.909E-01	-7.110E-01	1.307E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	6.909E-01	-7.110E-01	1.307E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 6.909E-01	-7.110E-01	1.307E-01				
18	0.000E+00	0.000E+00	1.000E+01	14				-6.580E-01	5.320E-01	-5.329E-01	1.229E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-6.580E-01	5.320E-01	-5.329E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-6.580E-01	5.320E-01	-5.329E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -6.580E-01	5.320E-01	-5.329E-01				
19	0.000E+00	0.000E+00	1.000E+01	14				-9.903E-01	-1.380E-01	1.353E-02	1.305E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-9.903E-01	-1.380E-01	1.353E-02				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-9.903E-01	-1.380E-01	1.353E-02				
	0.000E+00	0.000E+00	1.000E+01	1				0 -9.903E-01	-1.380E-01	1.353E-02				
20	0.000E+00	0.000E+00	1.000E+01	14				7.462E-01	4.859E-01	-4.551E-01	1.000E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	7.462E-01	4.859E-01	-4.551E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	7.462E-01	4.859E-01	-4.551E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 7.462E-01	4.859E-01	-4.551E-01				
21	0.000E+00	0.000E+00	1.000E+01	14				-1.977E-01	9.797E-01	3.360E-02	3.990E+00	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-1.977E-01	9.797E-01	3.360E-02				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-1.977E-01	9.797E-01	3.360E-02				
	0.000E+00	0.000E+00	1.000E+01	1				0 -1.977E-01	9.797E-01	3.360E-02				
22	0.000E+00	0.000E+00	1.000E+01	14				-9.117E-01	-3.647E-01	-1.891E-01	2.665E-01	1.000E+00	0.000E+00	
	0.000E+00	0.000E+00	1.000E+01	8(	0,	0,	0)	-9.117E-01	-3.647E-01	-1.891E-01				
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)	-9.117E-01	-3.647E-01	-1.891E-01				
	0.000E+00	0.000E+00	1.000E+01	1				0 -9.117E-01	-3.647E-01	-1.891E-01				

```
23  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
24  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
25  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
26  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
27  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
28  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
29  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
30  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
31  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
32  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
33  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
34  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
35  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
36  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
37  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   7(  0,  0,  0)
    0.000E+00  0.000E+00  1.000E+01   1
38  0.000E+00  0.000E+00  1.000E+01  14
    0.000E+00  0.000E+00  1.000E+01   8(  0,  0,  0)
```

```
   -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
   -4.287E-01  8.361E-01 -3.423E-01
   -4.287E-01  8.361E-01 -3.423E-01
 0 -4.287E-01  8.361E-01 -3.423E-01
    1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
    1.080E-01  3.412E-01 -9.338E-01
    1.080E-01  3.412E-01 -9.338E-01
 0  1.080E-01  3.412E-01 -9.338E-01
   -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
   -9.111E-01 -9.012E-03 -4.122E-01
   -9.111E-01 -9.012E-03 -4.122E-01
 0 -9.111E-01 -9.012E-03 -4.122E-01
   -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
   -2.568E-01 -6.391E-01 -7.249E-01
   -2.568E-01 -6.391E-01 -7.249E-01
 0 -2.568E-01 -6.391E-01 -7.249E-01
   -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
   -2.912E-01  8.086E-01  5.113E-01
   -2.912E-01  8.086E-01  5.113E-01
 0 -2.912E-01  8.086E-01  5.113E-01
    1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
    1.472E-01 -9.514E-01  2.705E-01
    1.472E-01 -9.514E-01  2.705E-01
 0  1.472E-01 -9.514E-01  2.705E-01
   -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
   -6.135E-01 -7.645E-01 -1.978E-01
   -6.135E-01 -7.645E-01 -1.978E-01
 0 -6.135E-01 -7.645E-01 -1.978E-01
   -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
   -5.702E-01  5.651E-01 -5.963E-01
   -5.702E-01  5.651E-01 -5.963E-01
 0 -5.702E-01  5.651E-01 -5.963E-01
   -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
   -6.607E-01  5.373E-01 -5.242E-01
   -6.607E-01  5.373E-01 -5.242E-01
 0 -6.607E-01  5.373E-01 -5.242E-01
   -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
   -9.742E-02 -3.639E-01 -9.263E-01
   -9.742E-02 -3.639E-01 -9.263E-01
 0 -9.742E-02 -3.639E-01 -9.263E-01
   -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
   -1.965E-01 -3.145E-01 -9.287E-01
   -1.965E-01 -3.145E-01 -9.287E-01
 0 -1.965E-01 -3.145E-01 -9.287E-01
    4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    4.097E-01  8.465E-01 -3.399E-01
    4.097E-01  8.465E-01 -3.399E-01
 0  4.097E-01  8.465E-01 -3.399E-01
   -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
   -4.048E-02  8.831E-01  4.675E-01
   -4.048E-02  8.831E-01  4.675E-01
 0 -4.048E-02  8.831E-01  4.675E-01
    3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
    3.371E-01 -9.269E-01 -1.652E-01
    3.371E-01 -9.269E-01 -1.652E-01
 0  3.371E-01 -9.269E-01 -1.652E-01
   -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
   -1.867E-01  9.756E-01 -1.155E-01
   -1.867E-01  9.756E-01 -1.155E-01
 0 -1.867E-01  9.756E-01 -1.155E-01
   -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
   -2.616E-01  2.336E-01 -9.365E-01
```

```
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        -2.616E-01  2.336E-01 -9.365E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0 -2.616E-01  2.336E-01 -9.365E-01
39   0.000E+00  0.000E+00  1.000E+01   14                        9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        9.780E-01 -7.641E-02 -1.939E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        9.780E-01 -7.641E-02 -1.939E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  9.780E-01 -7.641E-02 -1.939E-01
40   0.000E+00  0.000E+00  1.000E+01   14                        2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        2.580E-01 -7.076E-01  6.578E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        2.580E-01 -7.076E-01  6.578E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  2.580E-01 -7.076E-01  6.578E-01
41   0.000E+00  0.000E+00  1.000E+01   14                       -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -3.212E-01 -7.678E-01 -5.543E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -3.212E-01 -7.678E-01 -5.543E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0 -3.212E-01 -7.678E-01 -5.543E-01
42   0.000E+00  0.000E+00  1.000E+01   14                        5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        5.039E-01 -1.460E-01  8.513E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        5.039E-01 -1.460E-01  8.513E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  5.039E-01 -1.460E-01  8.513E-01
43   0.000E+00  0.000E+00  1.000E+01   14                        6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        6.080E-01  5.487E-01  5.738E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        6.080E-01  5.487E-01  5.738E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  6.080E-01  5.487E-01  5.738E-01
44   0.000E+00  0.000E+00  1.000E+01   14                       -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -2.932E-01  9.304E-01 -2.199E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -2.932E-01  9.304E-01 -2.199E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0 -2.932E-01  9.304E-01 -2.199E-01
45   0.000E+00  0.000E+00  1.000E+01   14                       -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -8.475E-01 -3.993E-01 -3.497E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -8.475E-01 -3.993E-01 -3.497E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0 -8.475E-01 -3.993E-01 -3.497E-01
46   0.000E+00  0.000E+00  1.000E+01   14                        1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        1.200E-01 -9.195E-01 -3.743E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        1.200E-01 -9.195E-01 -3.743E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  1.200E-01 -9.195E-01 -3.743E-01
47   0.000E+00  0.000E+00  1.000E+01   14                        7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        7.085E-01  5.879E-01  3.904E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        7.085E-01  5.879E-01  3.904E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  7.085E-01  5.879E-01  3.904E-01
48   0.000E+00  0.000E+00  1.000E+01   14                        4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        4.261E-01  9.046E-01  9.254E-03
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        4.261E-01  9.046E-01  9.254E-03
     0.000E+00  0.000E+00  1.000E+01    1                     0  4.261E-01  9.046E-01  9.254E-03
49   0.000E+00  0.000E+00  1.000E+01   14                        5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)        5.431E-01  4.270E-01 -7.230E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)        5.431E-01  4.270E-01 -7.230E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0  5.431E-01  4.270E-01 -7.230E-01
50   0.000E+00  0.000E+00  1.000E+01   14                       -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    8(   0,   0,   0)       -1.053E-01 -9.805E-01  1.658E-01
     0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)       -1.053E-01 -9.805E-01  1.658E-01
     0.000E+00  0.000E+00  1.000E+01    1                     0 -1.053E-01 -9.805E-01  1.658E-01
 1estimated keff results by cycle                                                                                print table 175

 ************************************************************************************************************************
 dump no.     2 on file c07222r       nps =      39575      coll =        2520751      ctm =    15.26      nrn =        60229145

 source distribution written to file c07222s          cycle =     20

 ************************************************************************************************************************
 dump no.     3 on file c07222r       nps =      79533      coll =        4978673      ctm =    31.64      nrn =       121573741
```

```
 source distribution written to file c07222s         cycle =    21
 source distribution written to file c07222s         cycle =    22
 source distribution written to file c07222s         cycle =    23
 source distribution written to file c07222s         cycle =    24
 source distribution written to file c07222s         cycle =    25
 source distribution written to file c07222s         cycle =    26
 source distribution written to file c07222s         cycle =    27
 source distribution written to file c07222s         cycle =    28
 source distribution written to file c07222s         cycle =    29
 source distribution written to file c07222s         cycle =    30
 ********************************************************************************************************************
 dump no.     4 on file c07222r      nps =     119591     coll =        7419608     ctm =    48.27     nrn =      183092858

 source distribution written to file c07222s         cycle =    31
 source distribution written to file c07222s         cycle =    32
 source distribution written to file c07222s         cycle =    33
 source distribution written to file c07222s         cycle =    34
 source distribution written to file c07222s         cycle =    35
 source distribution written to file c07222s         cycle =    36
 source distribution written to file c07222s         cycle =    37
 source distribution written to file c07222s         cycle =    38
 source distribution written to file c07222s         cycle =    39
 ********************************************************************************************************************
 dump no.     5 on file c07222r      nps =     155639     coll =        9622944     ctm =    63.49     nrn =      238978820

 source distribution written to file c07222s         cycle =    40
 source distribution written to file c07222s         cycle =    41
 source distribution written to file c07222s         cycle =    42
 source distribution written to file c07222s         cycle =    43
 source distribution written to file c07222s         cycle =    44
 source distribution written to file c07222s         cycle =    45
 source distribution written to file c07222s         cycle =    46
 source distribution written to file c07222s         cycle =    47
```

```
source distribution written to file c07222s         cycle =    48
*****************************************************************************************************************
dump no.     6 on file c07222r      nps =     191606     coll =       11824839     ctm =   78.52     nrn =      294468046

source distribution written to file c07222s         cycle =    49
source distribution written to file c07222s         cycle =    50
source distribution written to file c07222s         cycle =    51
source distribution written to file c07222s         cycle =    52
source distribution written to file c07222s         cycle =    53
source distribution written to file c07222s         cycle =    54
source distribution written to file c07222s         cycle =    55
source distribution written to file c07222s         cycle =    56
source distribution written to file c07222s         cycle =    57
*****************************************************************************************************************
dump no.     7 on file c07222r      nps =     227751     coll =       14024844     ctm =   93.65     nrn =      350151553

source distribution written to file c07222s         cycle =    58
source distribution written to file c07222s         cycle =    59
source distribution written to file c07222s         cycle =    60
source distribution written to file c07222s         cycle =    61
source distribution written to file c07222s         cycle =    62
source distribution written to file c07222s         cycle =    63
source distribution written to file c07222s         cycle =    64
source distribution written to file c07222s         cycle =    65
source distribution written to file c07222s         cycle =    66
source distribution written to file c07222s         cycle =    67
*****************************************************************************************************************
dump no.     8 on file c07222r      nps =     267721     coll =       16444481     ctm =  110.42     nrn =      411604975

source distribution written to file c07222s         cycle =    68
source distribution written to file c07222s         cycle =    69
source distribution written to file c07222s         cycle =    70
source distribution written to file c07222s         cycle =    71
source distribution written to file c07222s         cycle =    72
```

```
source distribution written to file c07222s         cycle =    73
source distribution written to file c07222s         cycle =    74
source distribution written to file c07222s         cycle =    75
source distribution written to file c07222s         cycle =    76
*****************************************************************************************************************
dump no.    9 on file c07222r      nps =    303760     coll =       18635305     ctm =  125.54     nrn =       467102229

source distribution written to file c07222s         cycle =    77
source distribution written to file c07222s         cycle =    78
source distribution written to file c07222s         cycle =    79
source distribution written to file c07222s         cycle =    80
source distribution written to file c07222s         cycle =    81
source distribution written to file c07222s         cycle =    82
source distribution written to file c07222s         cycle =    83
source distribution written to file c07222s         cycle =    84
source distribution written to file c07222s         cycle =    85
*****************************************************************************************************************
dump no.   10 on file c07222r      nps =    339697     coll =       20814964     ctm =  140.63     nrn =       522469594

source distribution written to file c07222s         cycle =    86
source distribution written to file c07222s         cycle =    87
source distribution written to file c07222s         cycle =    88
source distribution written to file c07222s         cycle =    89
source distribution written to file c07222s         cycle =    90
source distribution written to file c07222s         cycle =    91
source distribution written to file c07222s         cycle =    92
source distribution written to file c07222s         cycle =    93
source distribution written to file c07222s         cycle =    94
*****************************************************************************************************************
dump no.   11 on file c07222r      nps =    375684     coll =       23010236     ctm =  155.76     nrn =       578097206

source distribution written to file c07222s         cycle =    95
source distribution written to file c07222s         cycle =    96
source distribution written to file c07222s         cycle =    97
```

```
source distribution written to file c07222s        cycle =    98

source distribution written to file c07222s        cycle =    99

 estimator      cycle   100   ave of    80 cycles      combination          simple average     combined average      corr
k(collision)       0.881541       0.880494 0.0014    k(col/abs)          0.880357 0.0013     0.880373 0.0013    0.5193
k(absorption)      0.907574       0.880221 0.0015    k(abs/tk ln)        0.880461 0.0012     0.880447 0.0012    0.2755
k(trk length)      0.873578       0.880702 0.0016    k(tk ln/col)        0.880598 0.0014     0.880563 0.0014    0.7123
rem life(col)   3.9384E+03     4.5565E+03 0.0078     k(col/abs/tk ln)    0.880472 0.0012     0.880442 0.0012
rem life(abs)   4.0065E+03     4.5509E+03 0.0075     life(col/abs)    4.5537E+03 0.0076   4.5471E+03 0.0075    0.9818
source points generated   3996

source distribution written to file c07222s        cycle =   100

source distribution written to file c07222s        cycle =   101

source distribution written to file c07222s        cycle =   102

source distribution written to file c07222s        cycle =   103

*****************************************************************************************************************
dump no.   12 on file c07222r      nps =    411900     coll =       25208745     ctm =  171.02     nrn =       634017575

source distribution written to file c07222s        cycle =   104

source distribution written to file c07222s        cycle =   105

source distribution written to file c07222s        cycle =   106

source distribution written to file c07222s        cycle =   107

source distribution written to file c07222s        cycle =   108

source distribution written to file c07222s        cycle =   109

source distribution written to file c07222s        cycle =   110

source distribution written to file c07222s        cycle =   111

source distribution written to file c07222s        cycle =   112

*****************************************************************************************************************
dump no.   13 on file c07222r      nps =    447789     coll =       27394057     ctm =  186.06     nrn =       689349472

source distribution written to file c07222s        cycle =   113

source distribution written to file c07222s        cycle =   114

source distribution written to file c07222s        cycle =   115

 estimator      cycle   116   ave of    96 cycles      combination          simple average     combined average      corr
k(collision)       0.884784       0.881194 0.0013    k(col/abs)          0.880766 0.0011     0.880762 0.0011    0.4656
k(absorption)      0.875945       0.880337 0.0013    k(abs/tk ln)        0.880819 0.0011     0.880739 0.0011    0.2263
k(trk length)      0.885654       0.881300 0.0015    k(tk ln/col)        0.881247 0.0013     0.881223 0.0013    0.7384
rem life(col)   4.5317E+03     4.5716E+03 0.0071     k(col/abs/tk ln)    0.880944 0.0011     0.880784 0.0011
rem life(abs)   4.5904E+03     4.5660E+03 0.0068     life(col/abs)    4.5688E+03 0.0069   4.5621E+03 0.0068    0.9807
source points generated   3943

source distribution written to file c07222s        cycle =   116
```

estimator	cycle 117	ave of 97 cycles		combination	simple average		combined average		corr
k(collision)	0.890922	0.881295	0.0013	k(col/abs)	0.880828	0.0011	0.880821	0.0011	0.4656
k(absorption)	0.882687	0.880361	0.0013	k(abs/tk ln)	0.880823	0.0011	0.880746	0.0011	0.2260
k(trk length)	0.879770	0.881284	0.0015	k(tk ln/col)	0.881289	0.0013	0.881292	0.0013	0.7344
rem life(col)	4.6783E+03	4.5727E+03	0.0070	k(col/abs/tk ln)	0.880980	0.0011	0.880808	0.0011	
rem life(abs)	4.6360E+03	4.5667E+03	0.0067	life(col/abs)	4.5697E+03	0.0068	4.5625E+03	0.0067	0.9807

source points generated 3991

source distribution written to file c07222s cycle = 117

estimator	cycle 118	ave of 98 cycles		combination	simple average		combined average		corr
k(collision)	0.882173	0.881304	0.0013	k(col/abs)	0.880814	0.0011	0.880807	0.0011	0.4650
k(absorption)	0.876770	0.880325	0.0013	k(abs/tk ln)	0.880828	0.0011	0.880745	0.0011	0.2245
k(trk length)	0.885878	0.881331	0.0014	k(tk ln/col)	0.881317	0.0013	0.881311	0.0013	0.7342
rem life(col)	5.0015E+03	4.5771E+03	0.0070	k(col/abs/tk ln)	0.880987	0.0011	0.880805	0.0011	
rem life(abs)	4.9765E+03	4.5709E+03	0.0067	life(col/abs)	4.5740E+03	0.0068	4.5664E+03	0.0067	0.9811

source points generated 3938

source distribution written to file c07222s cycle = 118

estimator	cycle 119	ave of 99 cycles		combination	simple average		combined average		corr
k(collision)	0.892839	0.881420	0.0013	k(col/abs)	0.880929	0.0011	0.880922	0.0011	0.4707
k(absorption)	0.891477	0.880437	0.0013	k(abs/tk ln)	0.881012	0.0011	0.880904	0.0011	0.2391
k(trk length)	0.906655	0.881587	0.0015	k(tk ln/col)	0.881504	0.0013	0.881462	0.0013	0.7363
rem life(col)	4.7986E+03	4.5793E+03	0.0070	k(col/abs/tk ln)	0.881148	0.0011	0.880958	0.0011	
rem life(abs)	4.7155E+03	4.5724E+03	0.0066	life(col/abs)	4.5759E+03	0.0068	4.5672E+03	0.0066	0.9809

source points generated 4073

source distribution written to file c07222s cycle = 119

estimator	cycle 120	ave of 100 cycles		combination	simple average		combined average		corr
k(collision)	0.857533	0.881181	0.0013	k(col/abs)	0.880686	0.0011	0.880680	0.0011	0.4950
k(absorption)	0.855774	0.880191	0.0013	k(abs/tk ln)	0.880805	0.0011	0.880699	0.0011	0.2599
k(trk length)	0.864747	0.881418	0.0015	k(tk ln/col)	0.881300	0.0013	0.881245	0.0013	0.7412
rem life(col)	4.8786E+03	4.5823E+03	0.0069	k(col/abs/tk ln)	0.880930	0.0011	0.880740	0.0011	
rem life(abs)	5.0015E+03	4.5767E+03	0.0066	life(col/abs)	4.5795E+03	0.0067	4.5734E+03	0.0066	0.9800

source points generated 3795

source distribution written to file c07222s cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

\+ 06/02/00 05:24:47

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water probid = 06/02/00 02:05:17

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	479855	1.0003E+00	2.0320E+00	escape	32550	4.9151E-02	2.4117E-02
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	8.9705E-02	1.2020E-04	weight cutoff	448054	8.9031E-02	9.5409E-05
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	6.3777E-08	downscattering	0	0.	1.8247E+00
				capture	0	5.9661E-01	6.4765E-02
(n,xn)	1496	2.3768E-03	1.7052E-03	loss to (n,xn)	747	1.1867E-03	9.8766E-03
fission	0	0.	0.	loss to fission	0	3.5640E-01	1.1031E-01

total	481351	1.0924E+00	2.0339E+00	total	481351	1.0924E+00	2.0339E+00

number of neutrons banked	749	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0031E+00	escape	1.6287E+02	tco	1.0000E+34
neutron collisions per source particle	6.1182E+01	capture	4.9632E+03	eco	0.0000E+00
total neutron collisions	29358347	capture or escape	4.7278E+03	wc1	-5.0000E-01
net multiplication	1.0012E+00 0.0001	any termination	5.6948E+03	wc2	-2.5000E-01

computer time so far in this run	199.49 minutes	maximum number ever in bank	2
computer time in mcrun	199.47 minutes	bank overflows to backup file	0
source particles per minute	2.4056E+03	field length	0
random numbers generated	738943658	most random numbers used was	11109 in history 37002

range of sampled source weights = 9.4451E-01 to 1.0638E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	1	21985490	480603	7204652	1.0864E+01	4.8004E-03	5.3577E-01	7.5373E-01	2.5356E+00
2	2	45320436	479722	2609663	3.7144E+00	4.2810E-03	5.2449E-01	7.5268E-01	3.0444E+00
3	3	50615174	479517	593	8.6311E-04	4.1244E-03	5.2187E-01	7.5266E-01	5.5408E+03
4	4	16615707	452079	8017542	1.2303E+01	8.8754E-04	5.7636E-01	8.1958E-01	1.5727E+00
5	5	18911068	452872	1290667	2.0560E+00	1.0149E-03	5.9255E-01	8.2022E-01	2.4694E+00
6	6	19843901	452847	271	4.2725E-04	1.0392E-03	5.9703E-01	8.2056E-01	5.1784E+03
7	7	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8	8	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	9	67185407	361057	6227	8.6972E-03	1.4235E-02	4.9928E-01	7.3614E-01	5.6266E+03
10	10	77445831	362601	3952773	5.4094E+00	1.4516E-02	4.9839E-01	7.3600E-01	3.1926E+00
11	11	81513705	362423	867	1.1895E-03	1.4526E-02	4.9900E-01	7.3610E-01	5.6280E+03
12	12	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	13	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	14	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	15	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
16	16	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
17	17	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
18	20	2940872	325036	468348	6.7015E-01	4.1937E-03	5.0586E-01	7.4936E-01	4.4824E+00
19	21	1506136	321547	3939	5.6702E-03	3.8113E-03	5.0629E-01	7.4943E-01	5.4939E+03
21	23	177258	108548	5802805	7.5844E+00	8.2494E-05	2.4252E-01	6.5980E-01	2.7532E+00
total		404060985	4638852	29358347	4.2618E+01				

1keff results for: WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air and water probid = 06/02/00 02:05:17

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79533 neutron histories and 100 active cycles with 400322 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 479855 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

---

the final estimated combined collision/absorption/track-length keff = 0.88074 with an estimated standard deviation of 0.00096

the estimated 68, 95, & 99 percent keff confidence intervals are 0.87978 to 0.88170, 0.87884 to 0.88264, and 0.87822 to 0.88327

the estimated collision/absorption neutron removal lifetime = 4.57E-05 seconds with an estimated standard deviation of 3.04E-07

---

the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.88118	0.00114	0.88004 to 0.88232	0.87892 to 0.88344	0.87818 to 0.88418	
absorption	0.88019	0.00113	0.87906 to 0.88132	0.87794 to 0.88244	0.87721 to 0.88317	
track length	0.88142	0.00128	0.88013 to 0.88270	0.87886 to 0.88398	0.87803 to 0.88481	
col/absorp	0.88068	0.00099	0.87969 to 0.88167	0.87871 to 0.88265	0.87807 to 0.88329	0.4950
abs/trk len	0.88070	0.00096	0.87974 to 0.88166	0.87879 to 0.88261	0.87817 to 0.88323	0.2599
col/trk len	0.88125	0.00112	0.88013 to 0.88236	0.87902 to 0.88347	0.87830 to 0.88419	0.7412
col/abs/trk len	0.88074	0.00096	0.87978 to 0.88170	0.87884 to 0.88264	0.87822 to 0.88327	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.88141	0.00115	0.88026 to 0.88256	0.87912 to 0.88369	0.87838 to 0.88444
absorption	0.88048	0.00115	0.87932 to 0.88163	0.87818 to 0.88277	0.87743 to 0.88352
track length	0.88167	0.00130	0.88037 to 0.88297	0.87909 to 0.88425	0.87825 to 0.88509
col/abs/trk len	0.88101	0.00098	0.88003 to 0.88200	0.87906 to 0.88297	0.87842 to 0.88361

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	4.5734E-05	3.0393E-07	4.5430E-05 to 4.6038E-05	4.5129E-05 to 4.6340E-05	4.4931E-05 to 4.6537E-05
capture	4.8055E-05	3.0813E-07	4.7747E-05 to 4.8364E-05	4.7441E-05 to 4.8669E-05	4.7241E-05 to 4.8869E-05
fission	2.7899E-05	1.2162E-07	2.7777E-05 to 2.8021E-05	2.7657E-05 to 2.8141E-05	2.7578E-05 to 2.8220E-05
escape	1.6687E-06	1.4922E-07	1.5193E-06 to 1.8180E-06	1.3714E-06 to 1.9659E-06	1.2744E-06 to 2.0629E-06

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.8812 0.0011	0.8802 0.0011	0.8814 0.0013	95/95/95	0.88074 0.00096	0.87884-0.88264	0.87822-0.88327
2	50	0.8812 0.0011	0.8802 0.0011	0.8814 0.0013	95/95/95	0.88070 0.00093	0.87883-0.88257	0.87820-0.88320
4	25	0.8812 0.0011	0.8802 0.0012	0.8814 0.0013	95/95/95	0.88074 0.00104	0.87859-0.88289	0.87782-0.88367
5	20	0.8812 0.0011	0.8802 0.0011	0.8814 0.0011	99/95/95	0.88075 0.00085	0.87896-0.88254	0.87829-0.88321
10	10	0.8812 0.0010	0.8802 0.0012	0.8814 0.0009	95/95/95	0.88102 0.00091	0.87887-0.88317	0.87783-0.88420
20	5	0.8812 0.0009	0.8802 0.0013	0.8814 0.0012	95/95/95	0.88096 0.00092	0.87702-0.88490	0.87187-0.89004
25	4	0.8812 0.0013	0.8802 0.0011	0.8814 0.0010	95/95/99	0.88071 0.00048	0.87455-0.88687	0.84986-0.91156

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll) st dev	k(abs) st dev	k(track) st dev	average k(c/a/t) k(c/a/t) st dev	fom
1	4000	0.92919	0.90940	0.92885					
2	3760	0.88064	0.89413	0.87917					
3	3802	0.88287	0.88386	0.85469					
4	4068	0.88265	0.88198	0.89854					

5	3956	0.89155	0.88591	0.87869								
6	4024	0.88398	0.88639	0.87294								
7	4051	0.88948	0.88683	0.87910								
8	4010	0.88027	0.87611	0.88084								
9	3964	0.87579	0.86630	0.86650								
10	3940	0.88736	0.89631	0.88858								
11	4069	0.90789	0.88674	0.90502								
12	4099	0.88029	0.87449	0.88369								
13	3876	0.88110	0.87694	0.88288								
14	3997	0.84916	0.87445	0.85096								
15	3863	0.87526	0.88854	0.86935								
16	4122	0.88200	0.88206	0.88351								
17	4043	0.87121	0.88746	0.87749								
18	3922	0.90244	0.89127	0.90195								
19	4136	0.87521	0.86454	0.88562								
20	3831	0.86650	0.87169	0.87338								
		begin active keff cycles										
21	3894	0.87526	0.89119	0.88216								
22	4076	0.89786	0.89830	0.89636	0.88656	0.01130	0.89474	0.00355	0.88926	0.00710		
23	4045	0.87364	0.87734	0.87551	0.88225	0.00782	0.88894	0.00615	0.88467	0.00615		
24	3868	0.90333	0.89904	0.88708	0.88752	0.00764	0.89147	0.00503	0.88527	0.00439	0.88700	0.01253 763
25	4178	0.87885	0.88803	0.87225	0.88579	0.00616	0.89078	0.00396	0.88267	0.00428	0.88949	0.00895 1194
26	3959	0.88770	0.89729	0.88147	0.88611	0.00504	0.89187	0.00341	0.88247	0.00350	0.88872	0.00735 1475
27	3995	0.89063	0.90906	0.88686	0.88675	0.00431	0.89432	0.00379	0.88310	0.00303	0.88529	0.00678 1475
28	4015	0.87686	0.87516	0.87162	0.88552	0.00393	0.89193	0.00406	0.88166	0.00299	0.88123	0.00627 1495
29	4025	0.87971	0.89158	0.88403	0.88487	0.00353	0.89189	0.00358	0.88193	0.00265	0.88170	0.00550 1719
30	4003	0.87546	0.86633	0.86752	0.88393	0.00329	0.88933	0.00410	0.88048	0.00277	0.87826	0.00484 1980
31	4013	0.88534	0.88028	0.90204	0.88406	0.00298	0.88851	0.00380	0.88244	0.00318	0.88376	0.00357 3337
32	4118	0.89993	0.88001	0.88374	0.88538	0.00303	0.88780	0.00354	0.88255	0.00291	0.88454	0.00317 3871
33	4004	0.87157	0.88132	0.87626	0.88432	0.00298	0.88730	0.00329	0.88207	0.00272	0.88382	0.00301 3953
34	3851	0.86392	0.87946	0.84817	0.88286	0.00312	0.88674	0.00310	0.87965	0.00349	0.88411	0.00340 2879
35	3949	0.89515	0.89119	0.87923	0.88368	0.00302	0.88704	0.00290	0.87962	0.00325	0.88438	0.00326 2922
36	4174	0.87491	0.86219	0.87273	0.88313	0.00288	0.88548	0.00313	0.87919	0.00307	0.88278	0.00313 2953
37	3824	0.85230	0.88572	0.84264	0.88132	0.00325	0.88550	0.00294	0.87704	0.00360	0.88304	0.00327 2549
38	3947	0.88316	0.86724	0.87419	0.88142	0.00307	0.88448	0.00295	0.87688	0.00340	0.88235	0.00314 2620
39	4168	0.88140	0.87832	0.89187	0.88142	0.00290	0.88416	0.00281	0.87767	0.00331	0.88225	0.00281 3097
40	3999	0.88825	0.88849	0.89276	0.88176	0.00277	0.88438	0.00267	0.87842	0.00323	0.88272	0.00264 3334
41	3896	0.87789	0.89041	0.87266	0.88158	0.00265	0.88466	0.00256	0.87815	0.00308	0.88276	0.00254 3434
42	3992	0.86018	0.86249	0.87395	0.88060	0.00270	0.88366	0.00264	0.87796	0.00294	0.88138	0.00252 3314
43	3910	0.87724	0.86761	0.89918	0.88046	0.00259	0.88296	0.00262	0.87888	0.00296	0.88121	0.00231 3779
44	4075	0.87627	0.86852	0.87958	0.88028	0.00248	0.88236	0.00258	0.87891	0.00284	0.88082	0.00221 3936
45	3982	0.88363	0.88258	0.86839	0.88042	0.00239	0.88237	0.00247	0.87849	0.00275	0.88074	0.00214 4060
46	4042	0.87506	0.87945	0.87858	0.88021	0.00230	0.88225	0.00238	0.87849	0.00264	0.88064	0.00205 4244
47	4069	0.88601	0.87279	0.89196	0.88043	0.00223	0.88190	0.00231	0.87899	0.00259	0.88068	0.00195 4524
48	4002	0.88953	0.89933	0.90097	0.88075	0.00217	0.88253	0.00231	0.87978	0.00262	0.88130	0.00197 4256
49	4021	0.87764	0.87494	0.88267	0.88064	0.00210	0.88226	0.00225	0.87988	0.00253	0.88116	0.00190 4429
50	3920	0.88173	0.87631	0.89213	0.88068	0.00202	0.88207	0.00218	0.88029	0.00248	0.88119	0.00183 4640
51	4033	0.88696	0.88153	0.89053	0.88088	0.00197	0.88205	0.00211	0.88062	0.00242	0.88134	0.00176 4805
52	4087	0.87648	0.90705	0.88398	0.88075	0.00191	0.88283	0.00219	0.88072	0.00234	0.88154	0.00175 4733
53	3934	0.86918	0.86605	0.87221	0.88040	0.00189	0.88232	0.00218	0.88046	0.00229	0.88112	0.00174 4640
54	4028	0.85634	0.86108	0.88248	0.87969	0.00196	0.88170	0.00221	0.88052	0.00222	0.88073	0.00176 4397
55	3922	0.85978	0.87687	0.86336	0.87912	0.00199	0.88156	0.00215	0.88003	0.00221	0.88046	0.00176 4262
56	4026	0.89105	0.88904	0.88802	0.87945	0.00196	0.88177	0.00210	0.88025	0.00216	0.88072	0.00173 4320
57	4174	0.87651	0.87155	0.89240	0.87937	0.00191	0.88149	0.00206	0.88058	0.00213	0.88070	0.00168 4437
58	4004	0.87630	0.87893	0.87535	0.87929	0.00186	0.88142	0.00200	0.88044	0.00207	0.88061	0.00164 4549
59	3992	0.89752	0.87612	0.89782	0.87976	0.00187	0.88129	0.00196	0.88089	0.00207	0.88086	0.00159 4685
60	4082	0.89456	0.88363	0.89697	0.88013	0.00186	0.88135	0.00191	0.88129	0.00206	0.88112	0.00157 4721

61	3932	0.88735	0.88110	0.88757	0.88030	0.00182	0.88134	0.00186	0.88144	0.00201	0.88121	0.00153	4853
62	4008	0.88807	0.88180	0.88591	0.88049	0.00179	0.88135	0.00182	0.88155	0.00196	0.88129	0.00149	4990
63	4035	0.87849	0.87982	0.88099	0.88044	0.00175	0.88131	0.00177	0.88154	0.00192	0.88126	0.00145	5110
64	3901	0.88494	0.88980	0.89381	0.88054	0.00171	0.88151	0.00174	0.88182	0.00189	0.88144	0.00144	5096
65	4053	0.85736	0.85674	0.86492	0.88003	0.00175	0.88096	0.00179	0.88144	0.00189	0.88100	0.00149	4610
66	3845	0.88217	0.89684	0.87855	0.88008	0.00171	0.88130	0.00178	0.88138	0.00185	0.88114	0.00147	4664
67	4118	0.86826	0.87210	0.86480	0.87982	0.00169	0.88111	0.00176	0.88103	0.00184	0.88086	0.00146	4601
68	3889	0.87359	0.85390	0.87500	0.87969	0.00166	0.88054	0.00181	0.88090	0.00181	0.88049	0.00146	4494
69	4027	0.87411	0.87314	0.87636	0.87958	0.00163	0.88039	0.00178	0.88081	0.00177	0.88037	0.00144	4556
70	4074	0.85998	0.85719	0.86584	0.87919	0.00165	0.87992	0.00181	0.88051	0.00176	0.88000	0.00147	4295
71	4003	0.89060	0.88407	0.86711	0.87941	0.00163	0.88001	0.00177	0.88025	0.00175	0.87997	0.00143	4450
72	4089	0.89505	0.87708	0.89535	0.87971	0.00163	0.87995	0.00174	0.88054	0.00174	0.88013	0.00141	4497
73	3962	0.87899	0.88490	0.88773	0.87970	0.00159	0.88004	0.00171	0.88067	0.00171	0.88021	0.00138	4556
74	3932	0.88959	0.88375	0.89370	0.87988	0.00158	0.88011	0.00168	0.88091	0.00170	0.88036	0.00137	4582
75	4090	0.87821	0.86981	0.88125	0.87985	0.00155	0.87992	0.00166	0.88092	0.00167	0.88028	0.00134	4648
76	3973	0.88940	0.88007	0.88669	0.88002	0.00153	0.87993	0.00163	0.88102	0.00164	0.88036	0.00132	4728
77	3995	0.88636	0.87117	0.88391	0.88013	0.00151	0.87977	0.00161	0.88107	0.00161	0.88034	0.00130	4815
78	3921	0.87897	0.86855	0.87119	0.88011	0.00148	0.87958	0.00159	0.88090	0.00159	0.88018	0.00128	4842
79	3910	0.88895	0.89638	0.89201	0.88026	0.00146	0.87986	0.00159	0.88109	0.00158	0.88040	0.00128	4786
80	4099	0.87629	0.88045	0.86630	0.88020	0.00144	0.87987	0.00156	0.88084	0.00157	0.88029	0.00126	4855
81	3918	0.86843	0.87283	0.87326	0.88000	0.00143	0.87976	0.00154	0.88072	0.00155	0.88016	0.00125	4872
82	3989	0.88776	0.89068	0.88127	0.88013	0.00141	0.87994	0.00152	0.88073	0.00152	0.88027	0.00123	4930
83	4108	0.86720	0.87126	0.86459	0.87992	0.00140	0.87980	0.00151	0.88047	0.00152	0.88007	0.00123	4880
84	3887	0.89681	0.88646	0.88552	0.88019	0.00141	0.87990	0.00149	0.88055	0.00150	0.88020	0.00121	4912
85	4110	0.90410	0.88972	0.88878	0.88056	0.00143	0.88005	0.00147	0.88068	0.00148	0.88038	0.00121	4878
86	4062	0.88911	0.88293	0.90372	0.88069	0.00142	0.88010	0.00145	0.88103	0.00150	0.88055	0.00120	4835
87	3845	0.88537	0.89077	0.87798	0.88076	0.00140	0.88026	0.00144	0.88098	0.00148	0.88062	0.00119	4908
88	3990	0.89187	0.89044	0.89637	0.88092	0.00139	0.88041	0.00142	0.88121	0.00147	0.88080	0.00118	4864
89	3973	0.86177	0.87600	0.85520	0.88064	0.00139	0.88034	0.00140	0.88083	0.00150	0.88057	0.00118	4780
90	3909	0.87663	0.87004	0.87875	0.88058	0.00137	0.88019	0.00139	0.88080	0.00148	0.88048	0.00117	4818
91	4056	0.89132	0.88047	0.90104	0.88074	0.00136	0.88020	0.00137	0.88109	0.00149	0.88059	0.00116	4821
92	4072	0.87880	0.85803	0.88555	0.88071	0.00134	0.87989	0.00139	0.88115	0.00147	0.88048	0.00116	4807
93	3967	0.89623	0.89287	0.89730	0.88092	0.00134	0.88007	0.00138	0.88137	0.00146	0.88068	0.00116	4727
94	4113	0.87804	0.86756	0.88683	0.88088	0.00133	0.87990	0.00137	0.88144	0.00144	0.88063	0.00115	4762
95	3906	0.86837	0.87228	0.86455	0.88072	0.00132	0.87980	0.00136	0.88122	0.00144	0.88046	0.00114	4740
96	3954	0.88455	0.88630	0.88572	0.88077	0.00130	0.87988	0.00134	0.88128	0.00142	0.88053	0.00113	4790
97	4103	0.86332	0.88115	0.86255	0.88054	0.00130	0.87990	0.00132	0.88103	0.00143	0.88040	0.00112	4814
98	3912	0.88016	0.87108	0.86866	0.88053	0.00129	0.87979	0.00131	0.88088	0.00142	0.88029	0.00111	4832
99	4073	0.87633	0.88674	0.87423	0.88048	0.00127	0.87987	0.00130	0.88079	0.00140	0.88029	0.00109	4905
100	4010	0.88154	0.90757	0.87358	0.88049	0.00126	0.88022	0.00133	0.88070	0.00139	0.88044	0.00108	4910
101	3996	0.86833	0.87580	0.85726	0.88034	0.00125	0.88017	0.00131	0.88041	0.00140	0.88028	0.00108	4874
102	4043	0.89952	0.89713	0.88478	0.88058	0.00126	0.88037	0.00131	0.88047	0.00138	0.88044	0.00108	4823
103	4219	0.89065	0.87565	0.89281	0.88070	0.00125	0.88032	0.00130	0.88061	0.00138	0.88049	0.00107	4868
104	3971	0.87174	0.88958	0.87665	0.88059	0.00124	0.88043	0.00129	0.88057	0.00136	0.88051	0.00106	4933
105	3861	0.89096	0.87337	0.89395	0.88071	0.00123	0.88034	0.00127	0.88072	0.00135	0.88054	0.00104	4984
106	4128	0.89375	0.87982	0.89313	0.88087	0.00122	0.88034	0.00126	0.88087	0.00134	0.88062	0.00104	5013
107	3934	0.87564	0.88479	0.87396	0.88081	0.00121	0.88039	0.00125	0.88079	0.00133	0.88060	0.00102	5076
108	3945	0.89149	0.86802	0.89767	0.88093	0.00120	0.88025	0.00124	0.88098	0.00133	0.88062	0.00101	5124
109	4087	0.89108	0.88131	0.89622	0.88104	0.00119	0.88026	0.00123	0.88115	0.00133	0.88070	0.00100	5142
110	4007	0.87305	0.87626	0.86987	0.88095	0.00118	0.88022	0.00121	0.88103	0.00132	0.88062	0.00100	5169
111	3876	0.88948	0.88232	0.89552	0.88105	0.00118	0.88024	0.00120	0.88119	0.00131	0.88069	0.00099	5191
112	4080	0.87184	0.88297	0.85523	0.88095	0.00117	0.88027	0.00119	0.88090	0.00133	0.88059	0.00098	5207
113	3974	0.88864	0.88633	0.89457	0.88103	0.00116	0.88033	0.00118	0.88105	0.00132	0.88069	0.00098	5217
114	4053	0.87246	0.88378	0.88024	0.88094	0.00115	0.88037	0.00116	0.88104	0.00131	0.88069	0.00096	5281
115	3859	0.90172	0.88166	0.90115	0.88116	0.00116	0.88038	0.00115	0.88125	0.00131	0.88079	0.00096	5256
116	4235	0.88478	0.87594	0.88565	0.88119	0.00115	0.88034	0.00114	0.88130	0.00130	0.88078	0.00095	5304
117	3943	0.89092	0.88269	0.87977	0.88129	0.00114	0.88036	0.00113	0.88128	0.00129	0.88081	0.00094	5353

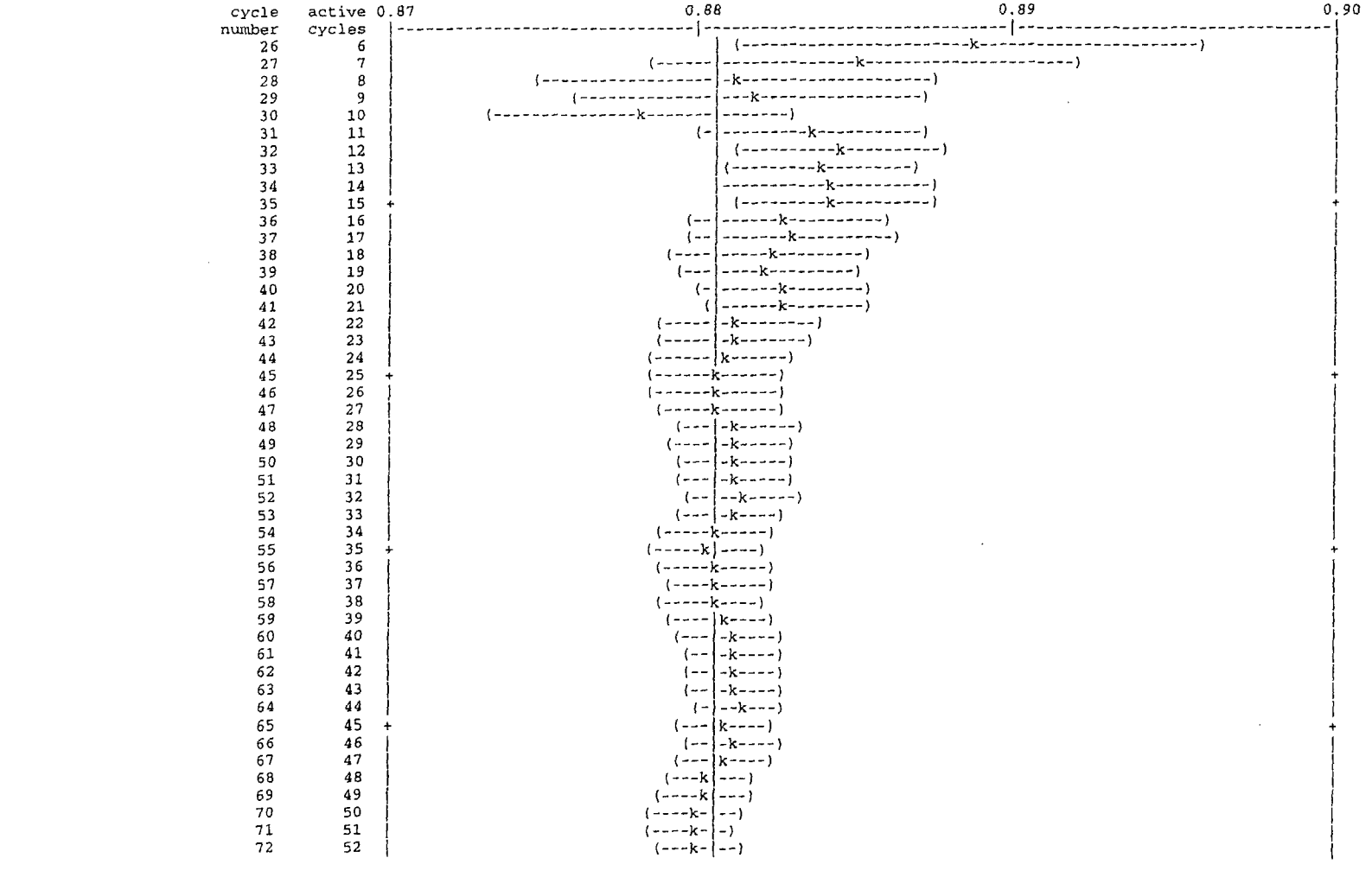
118	3991	0.88217	0.87677	0.88588	0.88130	0.00113	0.88032	0.00112	0.88133	0.00127	0.88080	0.00093	5407
119	3938	0.89284	0.89148	0.90666	0.88142	0.00112	0.88044	0.00111	0.88159	0.00129	0.88096	0.00094	5310
120	4073	0.85753	0.85577	0.86475	0.88118	0.00114	0.88019	0.00113	0.88142	0.00128	0.88074	0.00096	5061

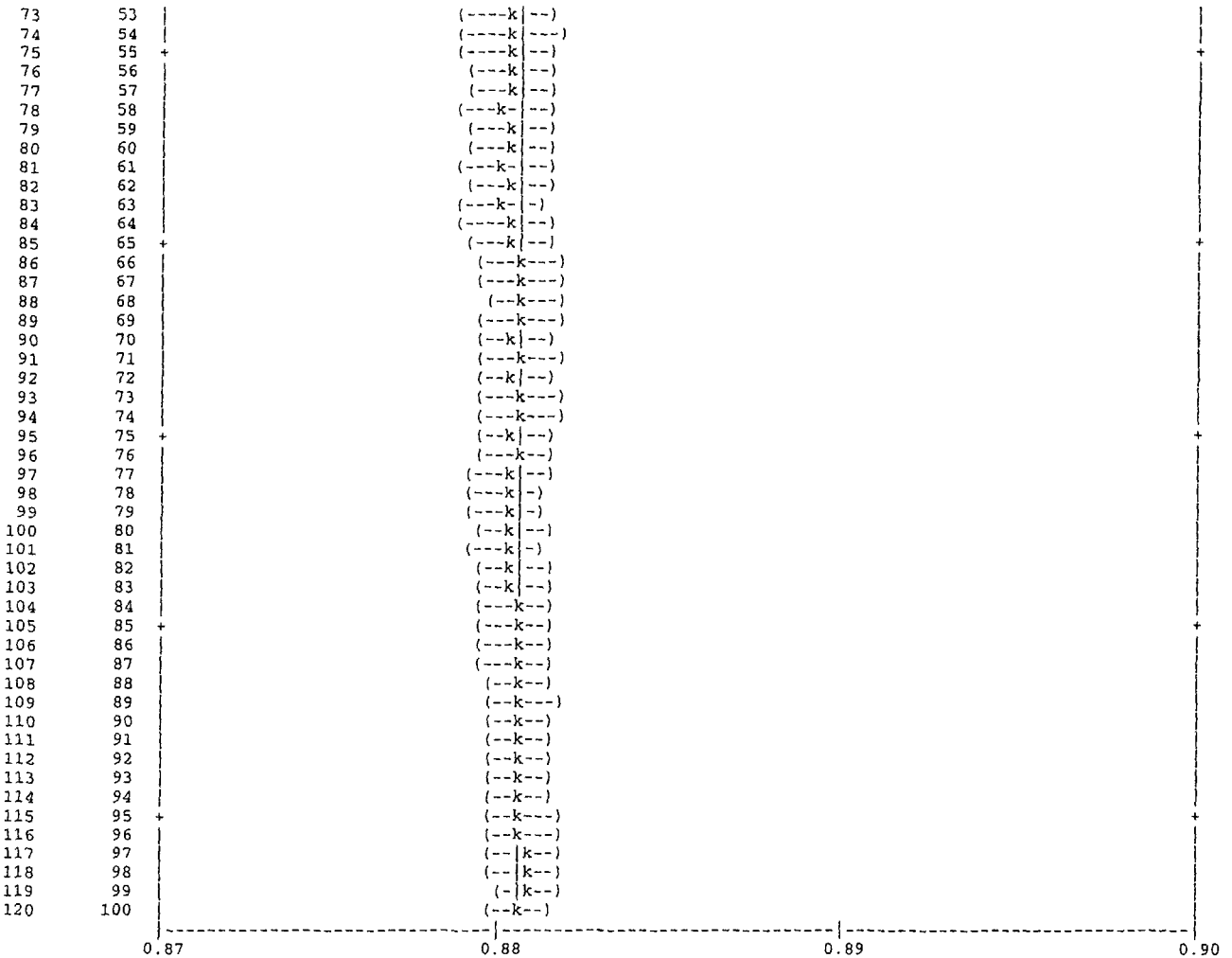
the largest active cycle keffs by estimator are:

collision 0.90410 on cycle 85
absorption 0.90906 on cycle 27
track length 0.90666 on cycle 119

the smallest active cycle keffs by estimator are:

collision 0.85230 on cycle 37
absorption 0.85390 on cycle 68
track length 0.84264 on cycle 37





1individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	479855	0.8816	0.0011	0.8807	0.0010	0.8815	0.0012	99/95/95	0.88104	0.00091	0.87923-0.88285	0.87864-0.88344
1	119	475855	0.8812	0.0011	0.8805	0.0010	0.8811	0.0012	95/95/95	0.88077	0.00086	0.87906-0.88249	0.87850-0.88304
2	118	472095	0.8812	0.0011	0.8803	0.0010	0.8811	0.0012	95/95/95	0.88071	0.00087	0.87898-0.88243	0.87842-0.88300
3	117	468293	0.8812	0.0011	0.8803	0.0010	0.8814	0.0012	95/95/95	0.88076	0.00087	0.87902-0.88250	0.87845-0.88306
4	116	464225	0.8812	0.0011	0.8803	0.0010	0.8812	0.0012	95/95/95	0.88070	0.00088	0.87895-0.88245	0.87838-0.88302
5	115	460269	0.8811	0.0011	0.8803	0.0010	0.8812	0.0012	95/95/95	0.88067	0.00089	0.87891-0.88244	0.87833-0.88301
6	114	456245	0.8811	0.0011	0.8802	0.0010	0.8813	0.0012	95/95/95	0.88066	0.00089	0.87888-0.88244	0.87830-0.88302

7	113	452194	0.8810	0.0011	0.8801	0.0010	0.8813	0.0012	95/95/95	0.88062	0.00090	0.87883-0.88242	0.87824-0.88301
8	112	448184	0.8810	0.0011	0.8802	0.0011	0.8813	0.0012	95/95/95	0.88065	0.00091	0.87884-0.88246	0.87825-0.88305
9	111	444220	0.8811	0.0011	0.8803	0.0011	0.8815	0.0012	95/95/95	0.88077	0.00091	0.87895-0.88258	0.87836-0.88317
10	110	440280	0.8810	0.0011	0.8802	0.0011	0.8814	0.0012	95/95/95	0.88065	0.00091	0.87884-0.88246	0.87824-0.88306
11	109	436211	0.8807	0.0011	0.8801	0.0011	0.8812	0.0012	95/95/95	0.88053	0.00091	0.87872-0.88234	0.87813-0.88293
12	108	432112	0.8808	0.0011	0.8801	0.0011	0.8812	0.0012	95/95/95	0.88055	0.00092	0.87873-0.88238	0.87813-0.88297
13	107	428236	0.8807	0.0011	0.8802	0.0011	0.8812	0.0013	95/95/95	0.88056	0.00093	0.87872-0.88241	0.87812-0.88301
14	106	424239	0.8810	0.0011	0.8802	0.0011	0.8814	0.0012	95/95/95	0.88074	0.00092	0.87891-0.88258	0.87831-0.88318
15	105	420376	0.8811	0.0011	0.8802	0.0011	0.8816	0.0012	95/95/95	0.88075	0.00093	0.87889-0.88260	0.87829-0.88321
16	104	416254	0.8811	0.0011	0.8801	0.0011	0.8815	0.0013	95/95/95	0.88073	0.00094	0.87886-0.88260	0.87825-0.88321
17	103	412211	0.8812	0.0011	0.8801	0.0011	0.8816	0.0013	95/95/95	0.88072	0.00095	0.87883-0.88261	0.87821-0.88323
18	102	408289	0.8810	0.0011	0.8800	0.0011	0.8814	0.0013	95/95/95	0.88058	0.00095	0.87869-0.88246	0.87808-0.88308
19	101	404153	0.8810	0.0011	0.8801	0.0011	0.8813	0.0013	95/95/95	0.88064	0.00095	0.87875-0.88254	0.87813-0.88316
20	100*	400322	0.8812	0.0011	0.8802	0.0011	0.8814	0.0013	95/95/95	0.88074	0.00096	0.87884-0.88264	0.87822-0.88327
22	98	392352	0.8811	0.0011	0.8799	0.0011	0.8813	0.0013	95/95/95	0.88051	0.00096	0.87860-0.88242	0.87797-0.88304
24	96	384439	0.8809	0.0011	0.8797	0.0011	0.8813	0.0013	95/95/95	0.88039	0.00096	0.87847-0.88231	0.87784-0.88293
26	94	376302	0.8809	0.0012	0.8794	0.0011	0.8814	0.0014	95/95/95	0.88024	0.00098	0.87829-0.88219	0.87765-0.88283
28	92	368292	0.8808	0.0012	0.8792	0.0011	0.8814	0.0014	95/95/95	0.88004	0.00098	0.87809-0.88199	0.87745-0.88262
30	90	360264	0.8809	0.0012	0.8792	0.0011	0.8815	0.0014	95/95/95	0.88007	0.00099	0.87810-0.88204	0.87745-0.88268
32	88	352133	0.8806	0.0012	0.8792	0.0012	0.8813	0.0014	95/95/95	0.87996	0.00100	0.87796-0.88196	0.87730-0.88261
34	86	344278	0.8809	0.0012	0.8791	0.0012	0.8817	0.0014	95/95/95	0.88017	0.00102	0.87813-0.88221	0.87746-0.88287
36	84	336155	0.8808	0.0012	0.8792	0.0012	0.8818	0.0014	95/95/95	0.88019	0.00103	0.87814-0.88225	0.87746-0.88292
38	82	328384	0.8811	0.0012	0.8792	0.0012	0.8824	0.0014	95/95/95	0.88055	0.00105	0.87845-0.88264	0.87777-0.88332
40	80	320217	0.8810	0.0012	0.8791	0.0012	0.8822	0.0014	95/95/95	0.88040	0.00107	0.87828-0.88253	0.87759-0.88322
42	78	312329	0.8813	0.0012	0.8792	0.0012	0.8824	0.0014	95/95/95	0.88053	0.00108	0.87838-0.88268	0.87768-0.88338
44	76	304344	0.8815	0.0013	0.8795	0.0012	0.8822	0.0014	95/95/95	0.88063	0.00110	0.87845-0.88281	0.87773-0.88353
46	74	296320	0.8815	0.0013	0.8795	0.0013	0.8824	0.0015	95/95/95	0.88069	0.00113	0.87844-0.88295	0.87770-0.88368
48	72	288249	0.8813	0.0013	0.8793	0.0013	0.8821	0.0015	95/95/95	0.88043	0.00113	0.87818-0.88268	0.87744-0.88342
50	70	280308	0.8814	0.0014	0.8794	0.0013	0.8819	0.0015	95/95/95	0.88044	0.00116	0.87813-0.88276	0.87737-0.88351
52	68	272188	0.8814	0.0014	0.8789	0.0013	0.8817	0.0015	95/95/95	0.87999	0.00117	0.87765-0.88233	0.87688-0.88310
54	66	264226	0.8820	0.0014	0.8794	0.0013	0.8819	0.0016	95/95/95	0.88039	0.00118	0.87803-0.88274	0.87725-0.88352
56	64	256278	0.8822	0.0014	0.8793	0.0013	0.8821	0.0016	95/95/95	0.88047	0.00121	0.87806-0.88289	0.87726-0.88369
58	62	248100	0.8823	0.0014	0.8794	0.0013	0.8820	0.0016	95/95/95	0.88058	0.00125	0.87808-0.88308	0.87725-0.88390
60	60	240026	0.8819	0.0014	0.8794	0.0014	0.8815	0.0017	95/95/95	0.88042	0.00127	0.87788-0.88296	0.87704-0.88380
62	58	232086	0.8817	0.0015	0.8794	0.0014	0.8813	0.0017	95/95/95	0.88031	0.00131	0.87769-0.88292	0.87682-0.88379
64	56	224150	0.8817	0.0015	0.8792	0.0015	0.8811	0.0018	95/95/99	0.88009	0.00135	0.87739-0.88280	0.87649-0.88370
66	54	216252	0.8821	0.0015	0.8792	0.0014	0.8815	0.0018	95/95/95	0.88031	0.00134	0.87763-0.88299	0.87674-0.88389
68	52	208245	0.8826	0.0015	0.8799	0.0014	0.8819	0.0018	95/95/95	0.88075	0.00131	0.87811-0.88338	0.87723-0.88426
70	50	200144	0.8832	0.0015	0.8805	0.0014	0.8823	0.0019	95/95/95	0.88137	0.00128	0.87880-0.88394	0.87794-0.88480
72	48	192052	0.8828	0.0016	0.8805	0.0014	0.8824	0.0019	95/95/95	0.88131	0.00131	0.87867-0.88396	0.87778-0.88485
74	46	184158	0.8827	0.0016	0.8803	0.0015	0.8820	0.0020	95/95/95	0.88112	0.00137	0.87835-0.88389	0.87741-0.88482
76	44	176095	0.8827	0.0017	0.8805	0.0015	0.8819	0.0021	95/95/95	0.88124	0.00142	0.87837-0.88410	0.87741-0.88507
78	42	168179	0.8827	0.0018	0.8810	0.0016	0.8821	0.0021	95/95/95	0.88150	0.00144	0.87858-0.88442	0.87759-0.88541
80	40	160170	0.8827	0.0018	0.8807	0.0016	0.8823	0.0022	95/95/95	0.88123	0.00148	0.87823-0.88422	0.87722-0.88524
82	38	152263	0.8829	0.0019	0.8806	0.0016	0.8825	0.0023	95/95/95	0.88131	0.00153	0.87820-0.88443	0.87714-0.88549
84	36	144268	0.8829	0.0019	0.8807	0.0017	0.8830	0.0024	95/95/95	0.88154	0.00156	0.87836-0.88473	0.87727-0.88582
86	34	136096	0.8821	0.0019	0.8804	0.0018	0.8822	0.0024	95/95/95	0.88112	0.00160	0.87787-0.88438	0.87674-0.88550
88	32	128261	0.8817	0.0020	0.8797	0.0018	0.8819	0.0025	95/95/95	0.88057	0.00165	0.87719-0.88395	0.87602-0.88512
90	30	120379	0.8826	0.0020	0.8802	0.0019	0.8829	0.0026	95/95/95	0.88127	0.00170	0.87778-0.88477	0.87656-0.88599
92	28	112251	0.8824	0.0021	0.8810	0.0019	0.8821	0.0027	95/95/95	0.88148	0.00173	0.87793-0.88503	0.87667-0.88629
94	26	104171	0.8820	0.0022	0.8810	0.0019	0.8813	0.0028	95/95/95	0.88133	0.00175	0.87771-0.88496	0.87641-0.88626
96	24	96311	0.8825	0.0024	0.8812	0.0021	0.8819	0.0029	95/95/95	0.88160	0.00183	0.87778-0.88541	0.87640-0.88679
98	22	88296	0.8835	0.0024	0.8816	0.0022	0.8833	0.0030	95/95/95	0.88234	0.00192	0.87831-0.88637	0.87683-0.88785
100	20	80213	0.8839	0.0026	0.8801	0.0020	0.8843	0.0032	95/95/95	0.88108	0.00204	0.87677-0.88539	0.87516-0.88700
102	18	72174	0.8839	0.0026	0.8794	0.0019	0.8858	0.0032	95/95/95	0.88071	0.00207	0.87629-0.88513	0.87460-0.88681
104	16	63984	0.8843	0.0028	0.8790	0.0021	0.8859	0.0036	95/99/95	0.88025	0.00240	0.87506-0.88545	0.87301-0.88750

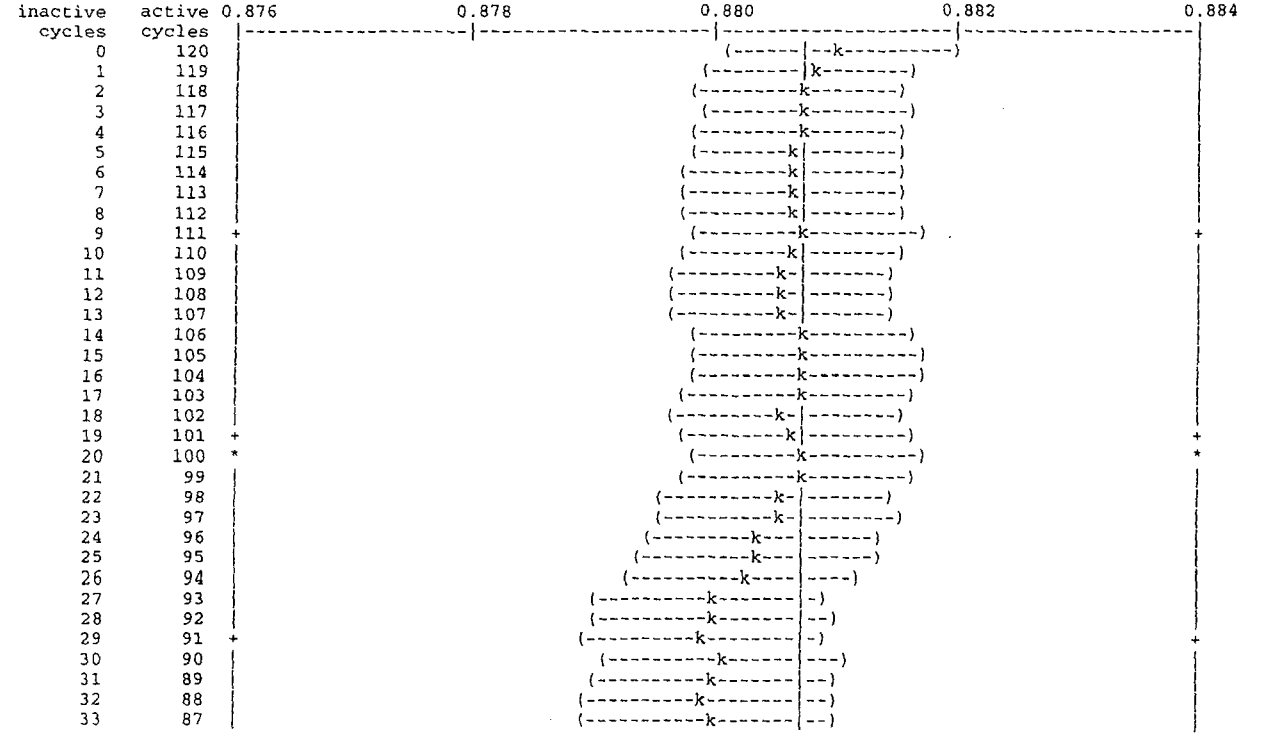
106	14	55995	0.8831	0.0031	0.8793	0.0023	0.8848	0.0040	95/99/95	0.88021	0.00264	0.87441-0.88602	0.87202-0.88840
108	12	48116	0.8830	0.0035	0.8798	0.0025	0.8846	0.0045	95/no/95	0.87991	0.00301	0.87310-0.88673	0.87013-0.88970
110	10	40022	0.8832	0.0040	0.8800	0.0030	0.8849	0.0050	95/99/95	0.88031	0.00369	0.87159-0.88903	0.86740-0.89321
112	8	32066	0.8839	0.0048	0.8793	0.0038	0.8873	0.0047	95/95/95	0.87930	0.00664	0.86224-0.89637	0.85254-0.90607
114	6	24039	0.8850	0.0062	0.8774	0.0049	0.8873	0.0062	95/95/95	0.87338	0.01173	0.83604-0.91071	0.80487-0.94188
116	4	15945	0.8809	0.0081	0.8767	0.0076	0.8843	0.0087	95/95/95	0.83324	0.05910	0.08204-1.58444	0.00000-4.59576
117	3	12002	0.8775	0.0105	0.8747	0.0104	0.8858	0.0121					
118	2	8011	0.8752	0.0177	0.8736	0.0179	0.8857	0.0210					

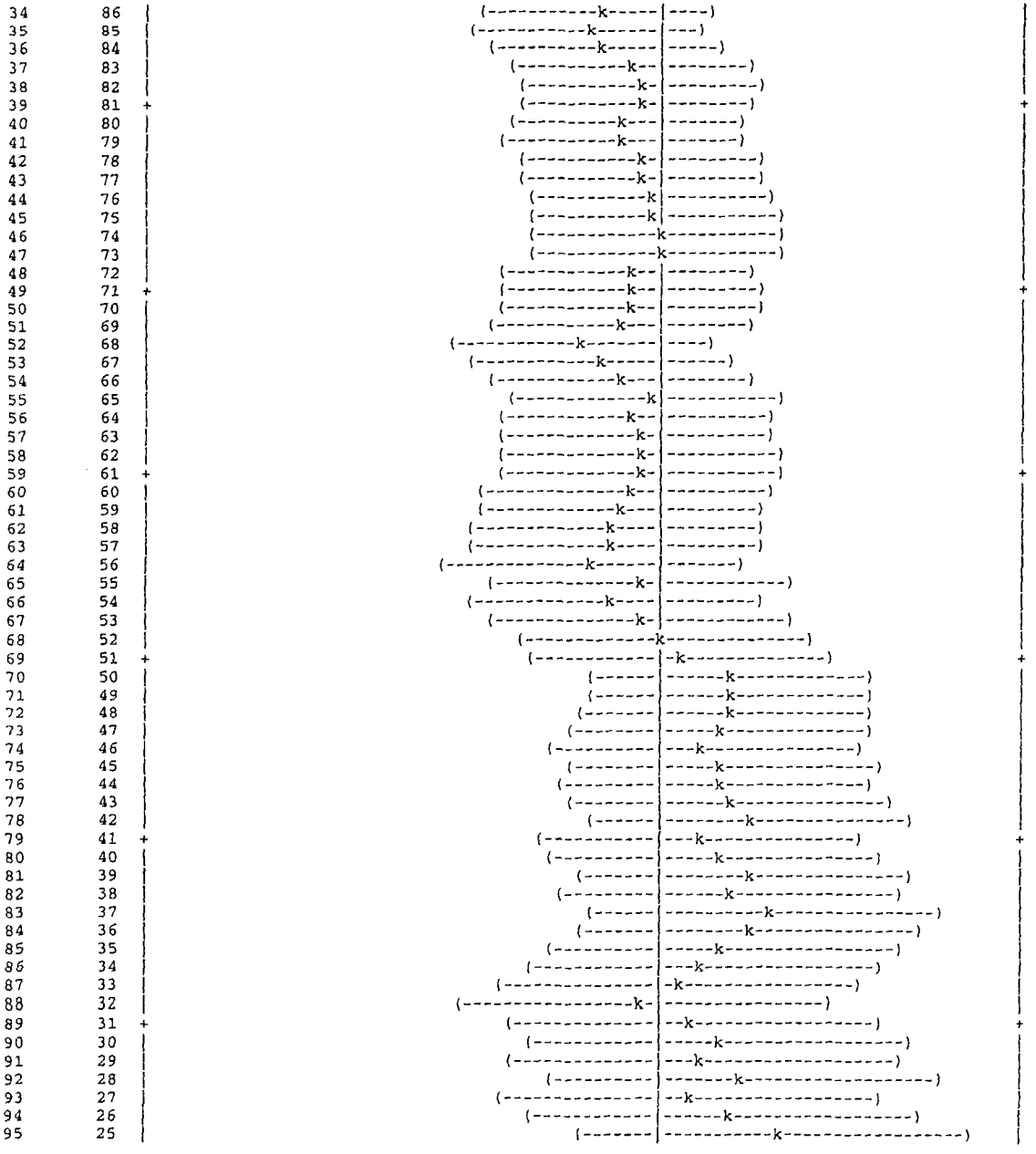
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 1 inactive cycles and 119 active cycles.

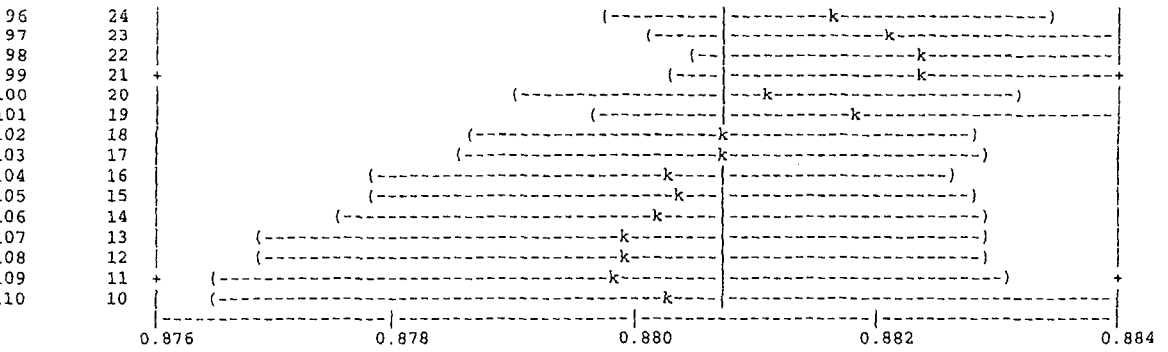
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.88000	0.00147	0.87852 to 0.88148	0.87705 to 0.88295	0.87606 to 0.88394
second half	0.88137	0.00128	0.88008 to 0.88265	0.87880 to 0.88394	0.87794 to 0.88480
final result	0.88074	0.00096	0.87978 to 0.88170	0.87884 to 0.88264	0.87822 to 0.88327

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
lplot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.88074)







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dump no. 14 on file c07222r nps = 479855 coll = 29358347 ctm = 199.47 nrn = 738943658

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 199.49 minutes

mcnp version 4a 10/01/93 06/02/00 05:24:47 probid = 06/02/00 02:05:17

Attachment 8: Derivation of the height of the water filling the empty clad

FILE
SUBJECT

REVISIONS
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Water fraction of total volume of the drum assuming the full height of the empty clad is filled with wa

$$f_{H_2O} = \frac{S_{H_2O}}{S_{hex}}$$

S_{H_2O} = cross section area of water in hexagonal element

S_{hex} = total cross section area of hexagonal element

$$S_{H_2O} = 2\pi R_f^2 \qquad S_{hex} = 3(2R_c)^2 \sin\frac{\pi}{3} = 12 R_c^2 \sin\frac{\pi}{3}$$

$$f_{H_2O} = \frac{2\pi R_f^2}{12 R_c^2 \sin\frac{\pi}{3}}$$

$$f_{H_2O} = \frac{\pi R_f^2}{6 R_c^2 \sin\frac{\pi}{3}}$$

$R_f = 0.3785$ cm

$R_c = 0.4318$ cm

$f_{H_2O} = 0.4646$ for empty clad completely filled with wat

If the clad is partially filled with water:

$$f_{H_2O} = 0.4646\, f_h \qquad f_h = \frac{f_{H_2O}}{0.4646}$$

Height filled with water

$$h_{H_2O} = f_h h_{drum} = \frac{f_{H_2O}\, h}{0.4646}$$

BY DATE
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A DAMES & MOORE GROUP COMPANY

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Suite 202
Orchard Park, NY 14127
716 675 7130 Tel
716 675 7137 Fax

Calculation Cover Page

Job No: **30822-244-023 /7150** Calculation No: **BUF-2000-066/Rev. 1** Date: **June 6, 2000**

Problem Statement & Calculation Objectives:

Determine the neutron multiplication factors for 30 gallon drum arrays with 206 rods of 5% enriched uranium dioxide (UO_2) fuel arranged in the hexagonal lattice in each drum. 206 rods of 5% enriched uranium dioxide (UO_2) fuel contain 1/3 of the estimated fissile mass in the GPC and PMC combined. The 30 gallon drums are 72.39 cm (28 1/2 inches) high and arranged in the infinite hexagonal array. Drum walls are made 0.175 cm carbon steel and the drums stand on a concrete floor. The drums are filled with water inside, and the air fills the outside of the drums. There was no moderation or reflection outside the drum except concrete floor.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993

Attachments:

Attachment 1: 30 gallon drum dimensions
Attachment 2: The model cross section with MCNP surface and cell numbers
Attachment 3: The model longitudinal section with MCNP surface and cell numbers
Attachment 4: MCNP input file
Attachment 5: MCNP output file
Attachment 6: Fuel region radius derivation

Prepared by:

Signature Igor V. Chichkov — Date 06/06/00

Checked by:

Signature Joseph C. Wolniewicz — Date 06/22/00

Analysis

Assumptions

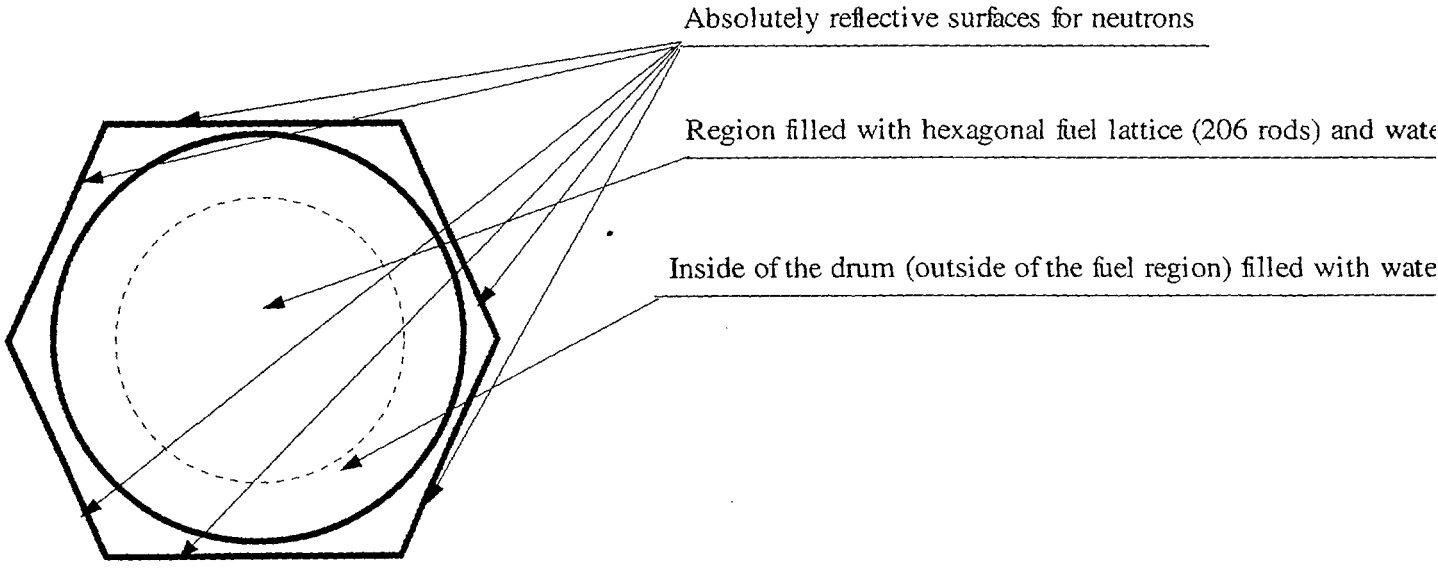
The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is fresh (not irradiated) with 5% enrichment
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel rods are arranged in a hexagonal array
- The drum array is infinite in horizontal direction and is 3 drum high ($\infty \times \infty \times 3$)
- The drum and fuel element heights are 72.39 cm (28 1/2 inches)
- The drums are arranged in the infinite hexagonal array without any gap between two adjacent drums
- The space between the fuel pins is filled with water
- Air fills outside of the drums
- Drum walls are made of 0.175 cm carbon steel
- The drums stand on a concrete floor
- The thickness of the concrete floor is 30 m
- Drum lid & bottom are ignored

MCNP Model

Neutron multiplication factors were calculated with MCNP4A code. To model the infinite hexagonal array of drums without any gap between two adjacent drums, one drum filled with fuel elements was surrounded by a hexagon prism. The hexagon prism sides surrounding the drum were set up having absolutely reflective surfaces for neutrons to simulate the infinite array. Figure 1 illustrates the MCNP model. The cylinder representing the drum does not touch the hexagon to account for the rings around the cylindrical drums. The rings were not modeled.

Figure 1. Top view of the MCNP geometry set up.



Example of MCNP input file is presented in Attachments 4, and MCNP output file is in Attachments 5. Th calculations of neutron multiplication factor were performed for several different water to pin ratios in the fuel region. The drum array was infinite in both horizontal directions and was 3 drums high (∞ x ∞ x 3).

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for air (Attix F.H., 1986). Table 2 and 3 show the element weig fractions for stainless steel 304 used in the fuel clad and the carbon steel used in the drum walls, respective (Harmon C. D., II et al., 1993). Table 4 shows the element composition of concrete (Harmon C. D., II et a 1993). The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 5. Molar mass of uranium dioxide (UO_2) can be determined from equation (1).

$$M_{UO_2} = A_U + 2A_{O-16} = f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16} \qquad (1)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)
$A_{U\text{-}235}$ = uranium-235 molar mass (g/mole)
$A_{U\text{-}238}$ = uranium-238 molar mass (g/mole)
$A_{O\text{-}16}$ = oxygen-16 molar mass (g/mole)
f = uranium-235 enrichment

Then the weight fractions for uranium-235 ($w_{U\text{-}235}$), uranium-238 ($w_{U\text{-}238}$), and oxygen-16 ($w_{O\text{-}16}$) are:

$$w_{U-235} = \frac{f\,A_{U-235}}{M_{UO_2}} = \frac{f\,A_{U-235}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2\,A_{O-16}} \qquad (2)$$

$$w_{U-238} = \frac{(1-f)\,A_{U-238}}{M_{UO_2}} = \frac{(1-f)\,A_{U-238}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2\,A_{O-16}} \qquad (3)$$

$$w_{O-16} = \frac{2\,A_{O-16}}{M_{UO_2}} = \frac{2\,A_{O-16}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2\,A_{O-16}} \qquad (4)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012828

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02

Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Carbon Steel Composition

Element	Weight Fraction
Iron (Fe)	0.995
Carbon (C)	0.005

Table 4. Concrete composition

Element	Weight Fraction
Hydrogen (H)	0.006
Oxygen (O)	0.500
Sodium (Na)	0.017
Aluminum (Al)	0.048
Silicon (Si)	0.315
Potassium (K)	0.019
Calcium (Ca)	0.083
Iron (Fe)	0.012

Table 5. Fuel Composition

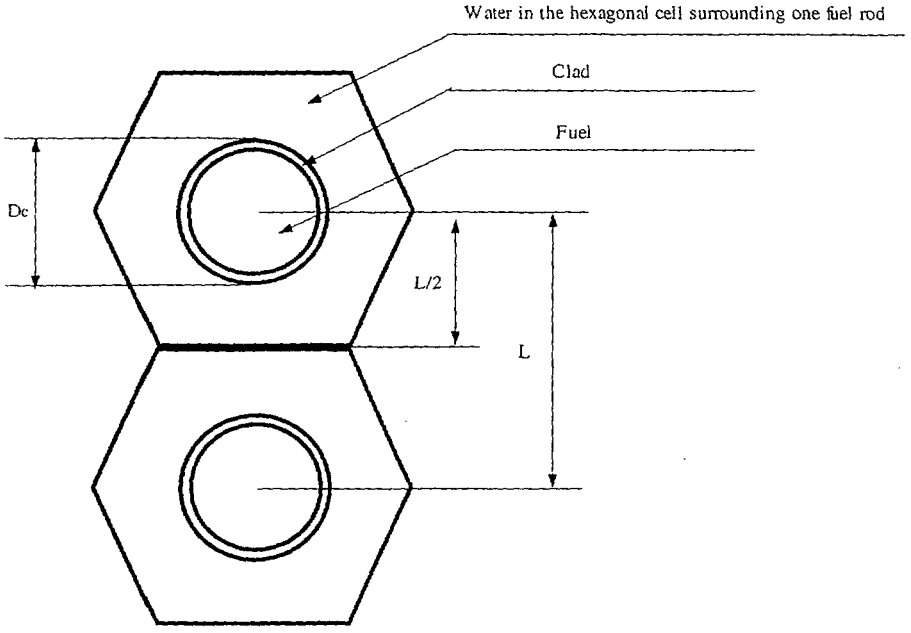
Element	Weight Fraction
Uranium-235 (^{235}U)	0.0435427
Uranium-238 (^{238}U)	0.8378729
Oxygen (O)	0.1185844

Water to Pin Ratio and Half-distance Between Two Adjacent Rods

To find the optimum moderation configuration the calculations for fuel rod arrangements with different wa to pin ratio were performed. However, the parameter, which is needed to be entered to the MCNP input de

is the half-distance between two adjacent rods. Figure 2 shows the horizontal cross-section of two adjacent fuel rods with water surrounding each rod. This figure shows also the dimension used for the following equations.

Figure 2. Horizontal cross-section of two adjacent fuel rods with water surrounding each rod.



Water to pin ratio can be determined as:

$$w/p = \frac{S_w}{S_p} = \frac{6(L/2)^2 \tan(30^\circ) - \pi D_c^2/4}{\pi D_c^2/4} = \frac{24(L/2)^2 \tan(30^\circ)}{\pi D_c^2} - 1 \qquad (5)$$

Where:

S_w = cross-section area of the water in the hexagonal cell surrounding a pin;

S_p = cross-section area of the pin;

D_c = clad diameter;

$L/2$ = half-distance between two adjacent pins (fuel rods).

Thus, the half-distance between two adjacent pins can be calculated from equation (6) and Table 6 presents the half-distance values corresponding to some water to pin ratios.

$$L/2 = \sqrt{\frac{(w/p+1)\pi D_c^2}{24\tan(30^o)}} \qquad (6)$$

Table 6. Half-distance values (L/2) corresponding to some water to pin ratios (w/p)

w/p	0.1	1	2	3	4	5	6	7	8.2
L/2, cm	0.4318	0.58154	0.71223	0.82242	0.91949	1.00725	1.08796	1.16307	1.24832

The minimum w/p value 0.1 corresponds to the case when all fuel pins are packed in the smallest possible lattice, touching each other. The maximum w/p value 12.8 corresponds to the case when the lattice has the greatest possible pitch, i.e. the fuel fills all drum and the fuel region radius is equal to the radius of the drum. The Attachment 6 has the derivation of the fuel region radius as a function of w/p. The numerical values for radii of the studied fuel regions can be found in Table 7.

Table 7. Radii of the fuel regions R_f.

w/p	0.1	1	2	3	4	5	6	7	12.8
R_f, cm	6.500	8.7646	10.734	12.395	13.858	15.181	16.397	17.529	23.005

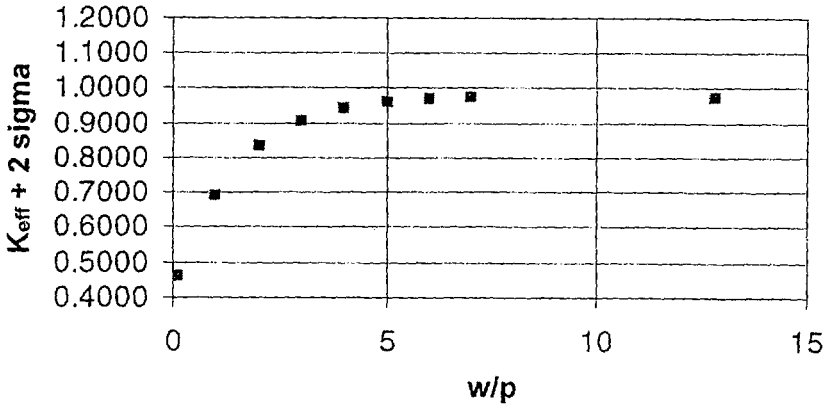
Results

The k_∞ values were calculated for several water to pin ratios (w/p) using MCNP 4A code. Table 8 shows these calculated neutron multiplication factors and Figures 3 plots the calculated $k_\infty + 2\sigma$ values.

Table 8. MCNP calculated neutron multiplication factors k_∞ with their standard deviations σ.

w/p	k_∞	σ	$k_\infty + 2\sigma$
0.1	0.4598	0.0010	0.4618
1	0.6905	0.0012	0.6930
2	0.8338	0.0013	0.8364
3	0.9056	0.0013	0.9082
4	0.9421	0.0012	0.9445
5	0.9594	0.0014	0.9622
6	0.9667	0.0012	0.9690
7	0.9733	0.0012	0.9756
12.8	0.9750	0.0008	0.9765

Figure 3. $k_\infty + 2\sigma$ values.



The criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq k_a - \Delta k_b - \sigma_b \qquad (7)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

σ = standard deviation of predicted k_∞

$k_a = 0.95$ = established allowable limiting neutron multiplication factor

Δk_b = calculation method bias

σ_b = bias uncertainty

For this case, calculation method bias together with bias uncertainty ($\Delta k_b + \sigma_b$) is equal to 0.02. Thus the criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq 0.93 \qquad (8)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

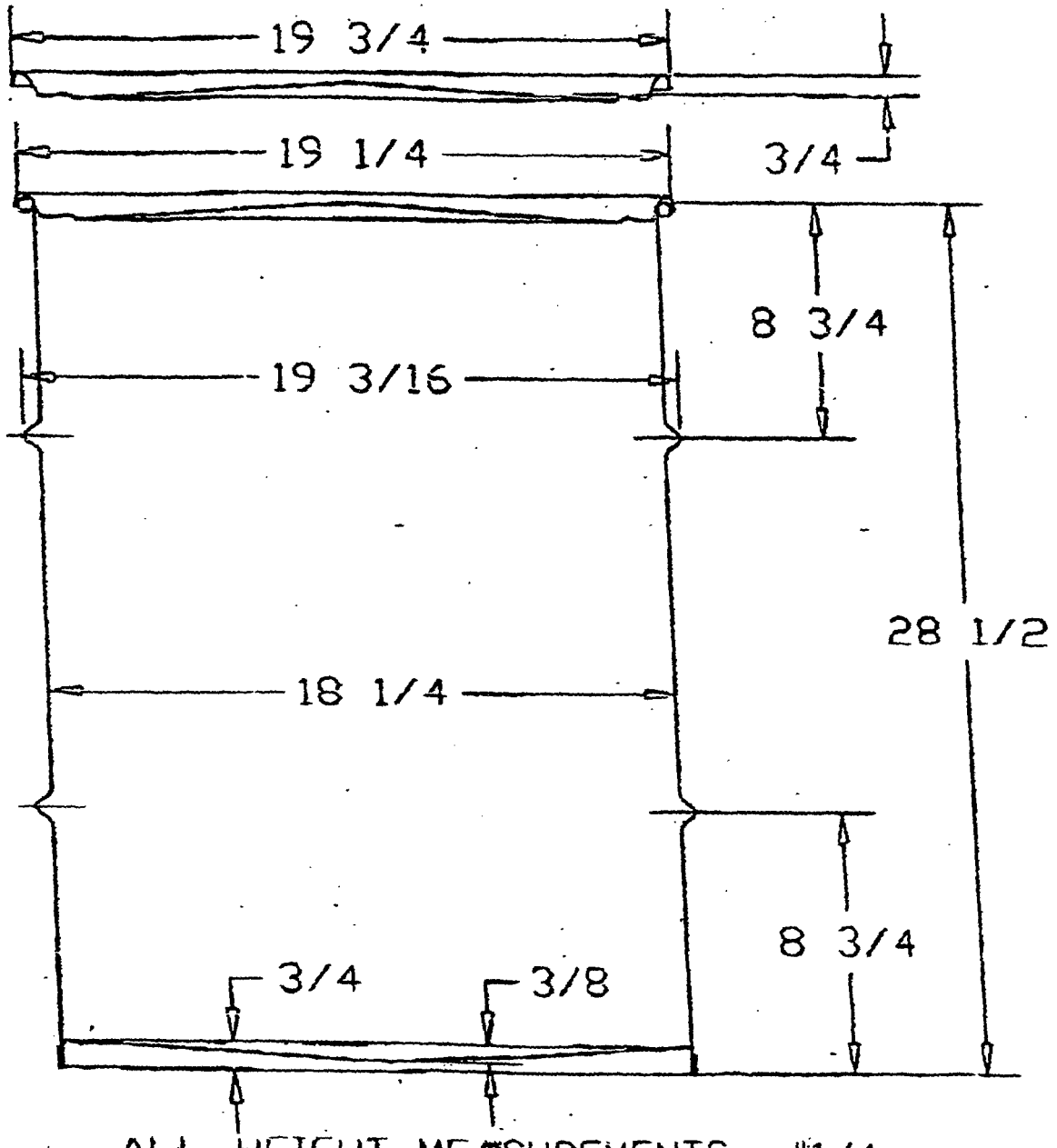
σ = standard deviation of predicted k_∞

As it can be seen from the data in Table 8, and Figure 3 the system is sub-critical but the criterion 8 is not met for most of the water to pin ratios.

Attachment 1: 30 gallon drum dimensions

COPY

30 GAL 1.5/1.2/1.2mm OPEN HEAD DRU
UN 1A2/Y1.5/150

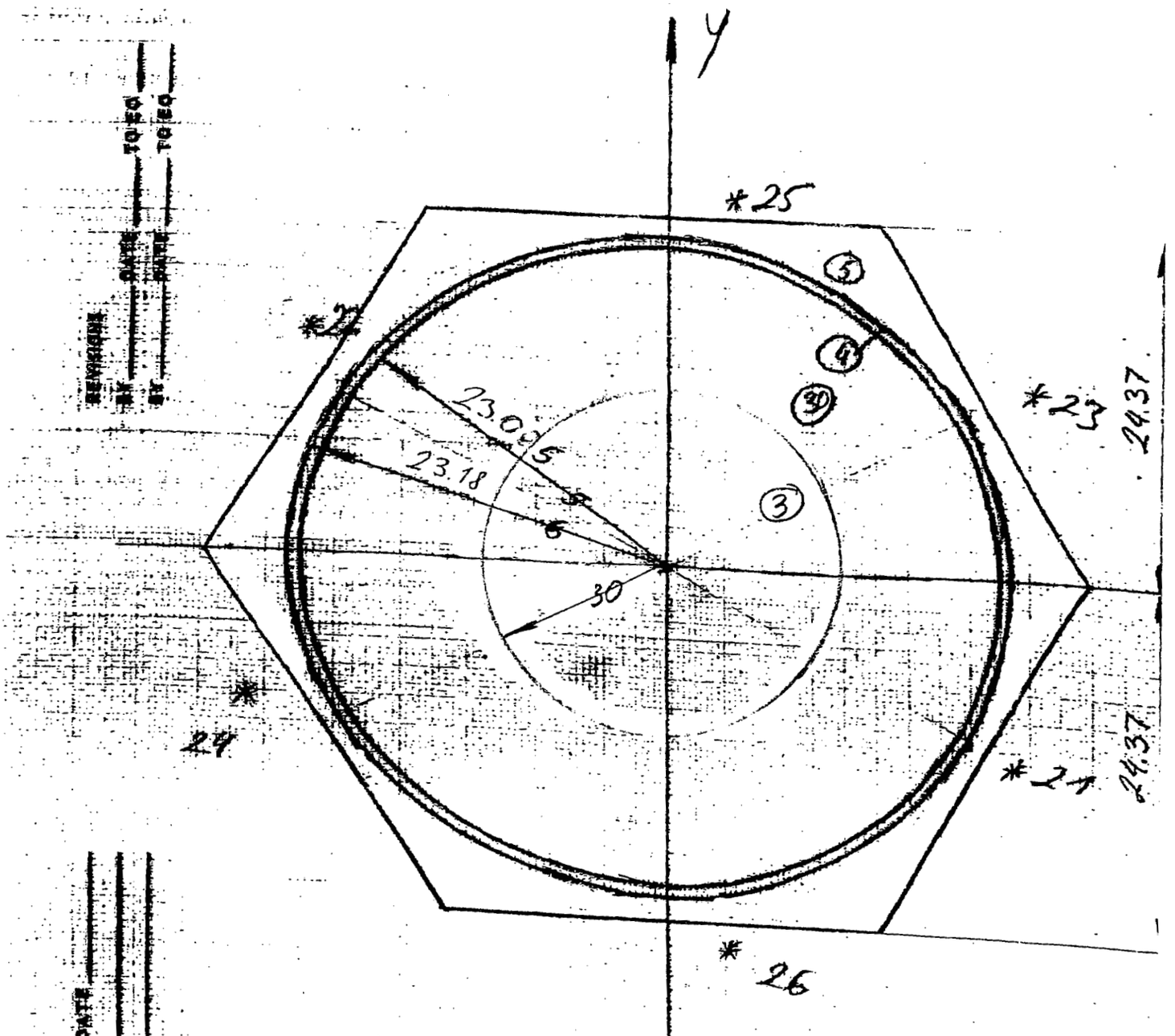


ALL HEIGHT MEASUREMENTS ±1/4
ALL OTHERS ±1/8
PRODUCT#:ST3004 , DATE:1/23/95

SKOLNIK INDUSTRIES,INC

Attachment 2: The model cross section with MCNP surface and cell numbers

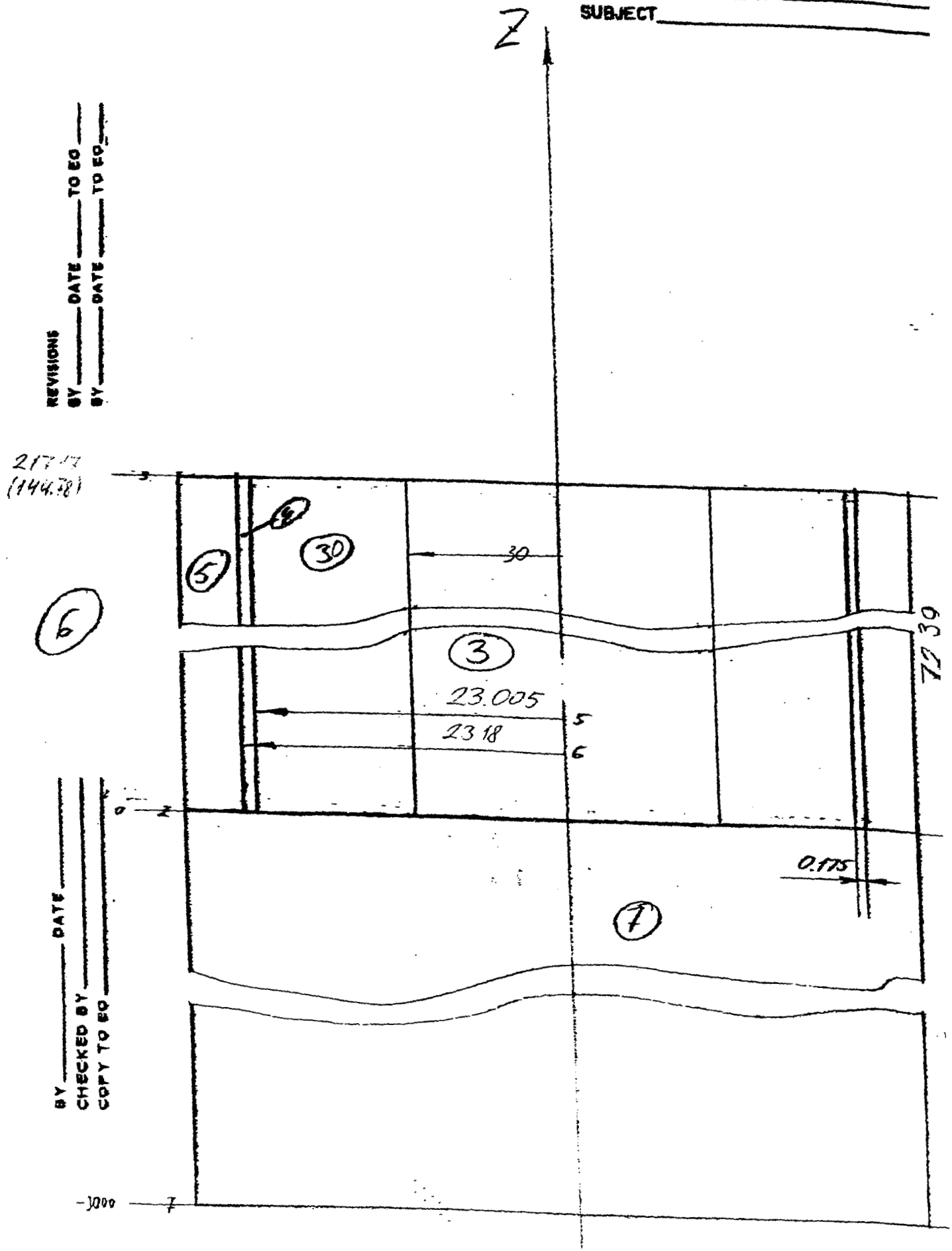
FILE
SUBJECT



Attachment 3: The model longitudinal section with MCNP surface and cell numbers

FILE _____
SUBJECT _____

REVISIONS
BY _____ DATE _____ TO ED _____
BY _____ DATE _____ TO ED _____



BY _____ DATE _____
CHECKED BY _____
COPY TO ED _____

Attachment 4: MCNP input file

```
                                                    C10242
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
11  0         -11 12 -13 14 -15 16 u=1
                  lat=2 fill=2 imp:n=1 $ Hexagonal lattice
12 61 -10.4   -17     u=2        imp:n=1 $ fuel rod
13 62  -7.92 -18 17 u=2        imp:n=1 $ SS-304 clad
14 63 -1.0   18 u=2        imp:n=1 $ water in the lattice cell
c
3  0  2 -3 -30  fill=1  imp:n=1 $ region filled with fuel lattice
30 63 -1.0 2 -3 30 -5   imp:n=1 $ water outside the fuel region
c
c outside the drum:
c
4  65  -7.82       5 -6 2 -3     imp:n=1 $ drum wall
5  64 -0.001293 -21 22 -23 24 -25 26 2 -3 6 imp:n=1 $ air ouside the drum
6  0         21 : -22 : 23 : -24 : 25 : -26 : -7 : 3 imp:n=0 $ Outside world
7  67 -2.35      -21 22 -23 24 -25 26 -2 7    imp:n=1 $  concrete floor
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0        $ drum bottom plane
3  pz 217.17   $ drum top plane
5  cz 23.005   $ internal wall of the drum
6  cz 23.180   $ external wall of the drum
7  pz -3000    $ concrete bottom plane
30 cz 8.764583 $ fuel region boundary
c
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.581537
12 p 0.8660254 -0.5 0 -0.581537
13 p 0.8660254  0.5 0  0.581537
14 p 0.8660254  0.5 0 -0.581537
15 py  0.581537
16 py -0.581537
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c hexagonal cell with reflecting surfaces outside the drum
c (simulates infinite array of the drums)
c begin the lattice surfaces
*21 p 0.8660254 -0.5 0  24.37
*22 p 0.8660254 -0.5 0 -24.37
*23 p 0.8660254  0.5 0  24.37
*24 p 0.8660254  0.5 0 -24.37
*25 py  24.37
*26 py -24.37
c end of lattice surfaces
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
```

C10242

```
      28000.50c -0.10
c Water (H, O)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64    6000.50c -0.000124
       7014.50c -0.755267
       8016.50c -0.231781
      18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65    6000.50c -0.005
      26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67    1001.50c -0.006
       8016.50c -0.5
      11023.50c -0.017
      13027.50c -0.048
      14000.50c -0.315
      19000.50c -0.019
      20000.50c -0.083
      26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 5: MCNP output file

```
1mcnp     version 4a     ld=10/01/93                    06/06/00 11:07:39
 ***********************************************************************          probid =   06/06/00 11:07:39
 name=c10242

     1-       WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
     2-       C The drum height is 28 1/2 inches (72.39 cm)
     3-       c drum wall thickness is 0.157 cm
     4-       c
     5-       C Cell cards
     6-       C
     7-       C ---------------------------------------------------------------------
     8-       c inside the drum:
     9-       c
    10-       11  0         -11 12 -13 14 -15 16 u=1
    11-                         lat=2 fill=2 imp:n=1 $ Hexagonal lattice
    12-       12 61 -10.4  -17     u=2        imp:n=1 $ fuel rod
    13-       13 62  -7.92 -18 17 u=2        imp:n=1 $ SS-304 clad
    14-       14 63 -1.0  18 u=2        imp:n=1 $ water in the lattice cell
    15-       c
    16-       3  0  2 -3 -30  fill=1  imp:n=1 $ region filled with fuel lattice
    17-       30 63 -1.0 2 -3 30 -5   imp:n=1 $ water outside the fuel region
    18-       c
    19-       c outside the drum:
    20-       c
    21-       4  65  -7.82       5 -6 2 -3     imp:n=1 $ drum wall
    22-       5  64 -0.001293 -21 22 -23 24 -25 26 2 -3 6 imp:n=1 $ air ouside the drum
    23-       6  0         21 : -22 : 23 : -24 : 25 : -26 : -7 : 3 imp:n=0 $ Outside world
    24-       7  67 -2.35      -21 22 -23 24 -25 26 -2 7   imp:n=1 $  concrete floor
    25-       C ---------------------------------------------------------------------
    26-       c
    27-       c Note: next line must be completely blank
    28-
    29-       c Surface cards
    30-       C ---------------------------------------------------------------------
    31-       2  pz 0        $ drum bottom plane
    32-       3  pz 217.17  $ drum top plane
    33-       5  cz 23.005  $ internal wall of the drum
    34-       6  cz 23.180  $ external wall of the drum
    35-       7  pz -3000   $ concrete bottom plane
    36-       30 cz 8.764583 $ fuel region boundary
    37-       c
    38-       c begin the lattice surfaces
    39-       11 p 0.8660254 -0.5 0  0.581537
    40-       12 p 0.8660254 -0.5 0 -0.581537
    41-       13 p 0.8660254  0.5 0  0.581537
    42-       14 p 0.8660254  0.5 0 -0.581537
    43-       15 py  0.581537
    44-       16 py -0.581537
    45-       c end of lattice surfaces
    46-       c
    47-       17 cz 0.3785 $ fuel wall cylinder
    48-       18 cz 0.4318 $ clad outer wall cylinder
    49-       c
    50-       c hexagonal cell with reflecting surfaces outside the drum
    51-       c (simulates infinite array of the drums)
    52-       c begin the lattice surfaces
    53-       *21 p 0.8660254 -0.5 0  24.37
    54-       *22 p 0.8660254 -0.5 0 -24.37
```

```
 55-       *23 p 0.8660254  0.5 0  24.37
 56-       *24 p 0.8660254  0.5 0 -24.37
 57-       *25 py  24.37
 58-       *26 py -24.37
 59-       c end of lattice surfaces
 60-       c
 61-       C ------------------------------------------------------------------------
 62-       c
 63-       c Note: next line must be completely blank
 64-
 65-       c Data cards
 66-       c
 67-       c Materials
 68-       c
 69-       c
 70-       c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
 71-       m61     8016.50c -0.1185844
 72-             92235.50c -0.0435427
 73-             92238.50c -0.8378729
 74-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
 75-       m62    14000.50c -0.01
 76-              24000.50c -0.19
 77-              25055.50c -0.02
 78-              26000.55c -0.68
 79-              28000.50c -0.10
 80-       c Water (H, O)
 81-       m63     1001.50c 0.66667
 82-               8016.50c 0.33333
 83-       mt63 lwtr.01t
 84-       c Air (C, N, O, Ar) composition from Attix p.523
 85-       m64     6000.50c -0.000124
 86-               7014.50c -0.755267
 87-               8016.50c -0.231781
 88-              18000.35c -0.012828
 89-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
 90-       m65     6000.50c -0.005
 91-              26000.55c -0.995
 92-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
 93-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
 94-       c adjusted to sum to unity without minor trace elements)
 95-       m67     1001.50c -0.006
 96-               8016.50c -0.5
 97-              11023.50c -0.017
 98-              13027.50c -0.048
 99-              14000.50c -0.315
100-              19000.50c -0.019
101-              20000.50c -0.083
102-              26000.55c -0.012
103-       c
104-       mode n
105-       print 40 60 80 100 110 126
106-       kcode 4000 1. 20 120
107-       ksrc  0 0 10
108-
 total fission nubar data are being used.
1material composition                                          print table 40

 material
```

```
 number     component nuclide, atom fraction

   61            8016,  0.66678      92235,  0.01666      92238,  0.31655
   62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                28000,  0.09334
   63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
   64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
   65            6000,  0.02283      26000,  0.97717
   67            1001,  0.11082       8016,  0.58191      11023,  0.01377      13027,  0.03312
                14000,  0.20878      19000,  0.00905      20000,  0.03855      26000,  0.00400
```

```
 material
  number     component nuclide, mass fraction

   61            8016,  0.11858      92235,  0.04354      92238,  0.83787
   62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                28000,  0.10000
   63            1001,  0.11192       8016,  0.88808
   64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
   65            6000,  0.00500      26000,  0.99500
   67            1001,  0.00600       8016,  0.50000      11023,  0.01700      13027,  0.04800
                14000,  0.31500      19000,  0.01900      20000,  0.08300      26000,  0.01200
lcells                                                                                  print table 60

                        atom         gram                                      neutron
        cell  mat      density      density      volume        mass      pieces importance

     1    11    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     2    12   61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     3    13   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     4    14  63s 1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     5     3    0  0.00000E+00 0.00000E+00 5.24098E+04 0.00000E+00      1  1.0000E+00
     6    30  63s 1.00309E-01 1.00000E+00 3.08663E+05 3.08663E+05      1  1.0000E+00
     7     4   65  8.58651E-02 7.82000E+00 5.51428E+03 4.31217E+04      1  1.0000E+00
     8     5   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
     9     6    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  0.0000E+00
    10     7   67  7.60226E-02 2.35000E+00 6.17196E+06 1.45041E+07      0  1.0000E+00

 total                                     6.53854E+06 1.48559E+07
lcross-section tables                                                                   print table 100

     table    length

                        tables from file critxs

   1001.50c     1153  njoy                                                    ( 1301)      79/07/31.
   6000.50c    16126  njoy                                                    ( 1306)      79/07/31.
   7014.50c    22772  njoy                                                    ( 1275)      79/09/08.
   8016.50c    23669  njoy                                                     ( 1276)     05/14/81
  11023.50c    36270  njoy                                                    ( 1311)      79/06/21.
  13027.50c    22891  njoy                                                    ( 1313)      79/09/08.
  14000.50c    48275  njoy                                                    ( 1314)      79/06/21.
  18000.35c     2182       end185                                             ( 18)        11/01/85
```

```
 19000.50c    9766  njoy                                                                  (  1150)      79/10/29.
 20000.50c   26104  njoy                                                                  (  1320)      79/06/22.
 24000.50c   89104  njoy                                                                  (  1324)      79/06/21.
 25055.50c   60097  njoy                                                                  (  1325)      79/06/21.
 26000.55c   84136  njoy                                                                  ( 260)       10/21/82
 28000.50c   82267  njoy                                                                  (  1328)      79/06/21.
 92235.50c   44188  njoy                                                  total nu        (  1395)      79/09/12.
 92238.50c   66440  njoy                                                  total nu        (  1398)      79/09/13.
  lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                      1001     0     010/22/85

 total      645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general            114334
     tallies                 0
     bank                12403
     cross sections     645633

     total              772370

*****************************************************************************************************************
 dump no.    1 on file c10242r      nps =         0     coll =              0     ctm =    0.00     nrn =              0

 source distribution written to file c10242s         cycle =     0

          1 warning message so far.
1   starting mcrun.      field length =      0      cp0 =  0.02                                    print table 110

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air

 nps   x          y          z        cell lattice(i,j,k)  surface    u          v          w        energy     weight      time

  1  0.000E+00  0.000E+00  1.000E+01    3                          5.085E-01  4.733E-01  7.193E-01  2.209E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)        5.085E-01  4.733E-01  7.193E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0  5.085E-01  4.733E-01  7.193E-01
  2  0.000E+00  0.000E+00  1.000E+01    3                          8.952E-01 -4.447E-01 -2.944E-02  4.904E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)        8.952E-01 -4.447E-01 -2.944E-02
     0.000E+00  0.000E+00  1.000E+01   12                      0  8.952E-01 -4.447E-01 -2.944E-02
  3  0.000E+00  0.000E+00  1.000E+01    3                         -6.184E-01 -4.495E-01  6.446E-01  3.809E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)       -6.184E-01 -4.495E-01  6.446E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0 -6.184E-01 -4.495E-01  6.446E-01
  4  0.000E+00  0.000E+00  1.000E+01    3                          9.710E-01 -5.665E-02 -2.323E-01  1.331E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)        9.710E-01 -5.665E-02 -2.323E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0  9.710E-01 -5.665E-02 -2.323E-01
  5  0.000E+00  0.000E+00  1.000E+01    3                          5.861E-01  1.496E-01 -7.963E-01  1.902E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)        5.861E-01  1.496E-01 -7.963E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0  5.861E-01  1.496E-01 -7.963E-01
  6  0.000E+00  0.000E+00  1.000E+01    3                         -6.489E-02 -1.626E-01  9.845E-01  4.410E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)       -6.489E-02 -1.626E-01  9.845E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0 -6.489E-02 -1.626E-01  9.845E-01
  7  0.000E+00  0.000E+00  1.000E+01    3                         -7.068E-02  3.263E-02 -9.970E-01  4.750E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,    0,    0)       -7.068E-02  3.263E-02 -9.970E-01
     0.000E+00  0.000E+00  1.000E+01   12                      0 -7.068E-02  3.263E-02 -9.970E-01
  8  0.000E+00  0.000E+00  1.000E+01    3                         -3.915E-01  4.664E-01 -7.932E-01  4.136E+00  1.000E+00  0.000E+00
```

```
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -3.915E-01  4.664E-01 -7.932E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -3.915E-01  4.664E-01 -7.932E-01
  9   0.000E+00  0.000E+00  1.000E+01   3                     -2.368E-01  9.215E-01 -3.079E-01  7.453E-02  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -2.368E-01  9.215E-01 -3.079E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -2.368E-01  9.215E-01 -3.079E-01
 10   0.000E+00  0.000E+00  1.000E+01   3                      1.946E-01 -3.204E-01  9.271E-01  3.128E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.946E-01 -3.204E-01  9.271E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0  1.946E-01 -3.204E-01  9.271E-01
 11   0.000E+00  0.000E+00  1.000E+01   3                     -6.698E-01 -7.177E-01 -1.905E-01  1.014E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -6.698E-01 -7.177E-01 -1.905E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -6.698E-01 -7.177E-01 -1.905E-01
 12   0.000E+00  0.000E+00  1.000E+01   3                     -8.398E-01 -4.129E-01  3.524E-01  1.395E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -8.398E-01 -4.129E-01  3.524E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -8.398E-01 -4.129E-01  3.524E-01
 13   0.000E+00  0.000E+00  1.000E+01   3                     -1.714E-01 -8.572E-01  4.857E-01  7.748E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -1.714E-01 -8.572E-01  4.857E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -1.714E-01 -8.572E-01  4.857E-01
 14   0.000E+00  0.000E+00  1.000E+01   3                     -2.489E-01 -5.118E-01 -8.222E-01  1.101E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.489E-01 -5.118E-01 -8.222E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -2.489E-01 -5.118E-01 -8.222E-01
 15   0.000E+00  0.000E+00  1.000E+01   3                     -2.959E-01  2.119E-01  9.314E-01  1.951E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.959E-01  2.119E-01  9.314E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -2.959E-01  2.119E-01  9.314E-01
 16   0.000E+00  0.000E+00  1.000E+01   3                      1.395E-01 -9.829E-01  1.202E-01  2.186E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.395E-01 -9.829E-01  1.202E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0  1.395E-01 -9.829E-01  1.202E-01
 17   0.000E+00  0.000E+00  1.000E+01   3                      6.909E-01 -7.110E-01  1.307E-01  1.865E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      6.909E-01 -7.110E-01  1.307E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0  6.909E-01 -7.110E-01  1.307E-01
 18   0.000E+00  0.000E+00  1.000E+01   3                     -6.580E-01  5.320E-01 -5.329E-01  1.229E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -6.580E-01  5.320E-01 -5.329E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -6.580E-01  5.320E-01 -5.329E-01
 19   0.000E+00  0.000E+00  1.000E+01   3                     -9.903E-01 -1.380E-01  1.353E-02  1.305E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.903E-01 -1.380E-01  1.353E-02
      0.000E+00  0.000E+00  1.000E+01  12                   0 -9.903E-01 -1.380E-01  1.353E-02
 20   0.000E+00  0.000E+00  1.000E+01   3                      7.462E-01  4.859E-01 -4.551E-01  1.000E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      7.462E-01  4.859E-01 -4.551E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0  7.462E-01  4.859E-01 -4.551E-01
 21   0.000E+00  0.000E+00  1.000E+01   3                     -1.977E-01  9.797E-01  3.360E-02  3.990E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -1.977E-01  9.797E-01  3.360E-02
      0.000E+00  0.000E+00  1.000E+01  12                   0 -1.977E-01  9.797E-01  3.360E-02
 22   0.000E+00  0.000E+00  1.000E+01   3                     -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.117E-01 -3.647E-01 -1.891E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -9.117E-01 -3.647E-01 -1.891E-01
 23   0.000E+00  0.000E+00  1.000E+01   3                     -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -4.287E-01  8.361E-01 -3.423E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -4.287E-01  8.361E-01 -3.423E-01
 24   0.000E+00  0.000E+00  1.000E+01   3                      1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.080E-01  3.412E-01 -9.338E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0  1.080E-01  3.412E-01 -9.338E-01
 25   0.000E+00  0.000E+00  1.000E+01   3                     -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.111E-01 -9.012E-03 -4.122E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -9.111E-01 -9.012E-03 -4.122E-01
 26   0.000E+00  0.000E+00  1.000E+01   3                     -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.568E-01 -6.391E-01 -7.249E-01
      0.000E+00  0.000E+00  1.000E+01  12                   0 -2.568E-01 -6.391E-01 -7.249E-01
 27   0.000E+00  0.000E+00  1.000E+01   3                     -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
      0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.912E-01  8.086E-01  5.113E-01
```

```
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -2.912E-01  8.086E-01  5.113E-01
28  0.000E+00   0.000E+00   1.000E+01    3                                      1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     1.472E-01 -9.514E-01  2.705E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  1.472E-01 -9.514E-01  2.705E-01
29  0.000E+00   0.000E+00   1.000E+01    3                                     -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -6.135E-01 -7.645E-01 -1.978E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -6.135E-01 -7.645E-01 -1.978E-01
30  0.000E+00   0.000E+00   1.000E+01    3                                     -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -5.702E-01  5.651E-01 -5.963E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -5.702E-01  5.651E-01 -5.963E-01
31  0.000E+00   0.000E+00   1.000E+01    3                                     -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -6.607E-01  5.373E-01 -5.242E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -6.607E-01  5.373E-01 -5.242E-01
32  0.000E+00   0.000E+00   1.000E+01    3                                     -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -9.742E-02 -3.639E-01 -9.263E-01
33  0.000E+00   0.000E+00   1.000E+01    3                                     -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -1.965E-01 -3.145E-01 -9.287E-01
34  0.000E+00   0.000E+00   1.000E+01    3                                      4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     4.097E-01  8.465E-01 -3.399E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  4.097E-01  8.465E-01 -3.399E-01
35  0.000E+00   0.000E+00   1.000E+01    3                                     -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -4.048E-02  8.831E-01  4.675E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -4.048E-02  8.831E-01  4.675E-01
36  0.000E+00   0.000E+00   1.000E+01    3                                      3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     3.371E-01 -9.269E-01 -1.652E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  3.371E-01 -9.269E-01 -1.652E-01
37  0.000E+00   0.000E+00   1.000E+01    3                                     -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -1.867E-01  9.756E-01 -1.155E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -1.867E-01  9.756E-01 -1.155E-01
38  0.000E+00   0.000E+00   1.000E+01    3                                     -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -2.616E-01  2.336E-01 -9.365E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -2.616E-01  2.336E-01 -9.365E-01
39  0.000E+00   0.000E+00   1.000E+01    3                                      9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     9.780E-01 -7.641E-02 -1.939E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  9.780E-01 -7.641E-02 -1.939E-01
40  0.000E+00   0.000E+00   1.000E+01    3                                      2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     2.580E-01 -7.076E-01  6.578E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  2.580E-01 -7.076E-01  6.578E-01
41  0.000E+00   0.000E+00   1.000E+01    3                                     -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -3.212E-01 -7.678E-01 -5.543E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -3.212E-01 -7.678E-01 -5.543E-01
42  0.000E+00   0.000E+00   1.000E+01    3                                      5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     5.039E-01 -1.460E-01  8.513E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  5.039E-01 -1.460E-01  8.513E-01
43  0.000E+00   0.000E+00   1.000E+01    3                                      6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     6.080E-01  5.487E-01  5.738E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  6.080E-01  5.487E-01  5.738E-01
44  0.000E+00   0.000E+00   1.000E+01    3                                     -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -2.932E-01  9.304E-01 -2.199E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -2.932E-01  9.304E-01 -2.199E-01
45  0.000E+00   0.000E+00   1.000E+01    3                                     -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                    -8.475E-01 -3.993E-01 -3.497E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0 -8.475E-01 -3.993E-01 -3.497E-01
46  0.000E+00   0.000E+00   1.000E+01    3                                      1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
    0.000E+00   0.000E+00   1.000E+01   11(   0,   0,   0)                     1.200E-01 -9.195E-01 -3.743E-01
    0.000E+00   0.000E+00   1.000E+01   12                                    0  1.200E-01 -9.195E-01 -3.743E-01
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 47  0.000E+00  0.000E+00  1.000E+01    3                          7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)         7.085E-01  5.879E-01  3.904E-01
     0.000E+00  0.000E+00  1.000E+01   12                     0   7.085E-01  5.879E-01  3.904E-01
 48  0.000E+00  0.000E+00  1.000E+01    3                          4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)         4.261E-01  9.046E-01  9.254E-03
     0.000E+00  0.000E+00  1.000E+01   12                     0   4.261E-01  9.046E-01  9.254E-03
 49  0.000E+00  0.000E+00  1.000E+01    3                          5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)         5.431E-01  4.270E-01 -7.230E-01
     0.000E+00  0.000E+00  1.000E+01   12                     0   5.431E-01  4.270E-01 -7.230E-01
 50  0.000E+00  0.000E+00  1.000E+01    3                         -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)        -1.053E-01 -9.805E-01  1.658E-01
     0.000E+00  0.000E+00  1.000E+01   12                     0  -1.053E-01 -9.805E-01  1.658E-01
1estimated keff results by cycle                                                              print table 175

 source distribution written to file c10242s         cycle =    20

 source distribution written to file c10242s         cycle =    24

 source distribution written to file c10242s         cycle =    28

 source distribution written to file c10242s         cycle =    32

 source distribution written to file c10242s         cycle =    36

 source distribution written to file c10242s         cycle =    40

 source distribution written to file c10242s         cycle =    44

 ************************************************************************************************************************
 dump no.    2 on file c10242r      nps =    182725     coll =      34099801     ctm =   15.01     nrn =      283502233

 source distribution written to file c10242s         cycle =    48

 source distribution written to file c10242s         cycle =    52

 source distribution written to file c10242s         cycle =    56

 source distribution written to file c10242s         cycle =    60

 source distribution written to file c10242s         cycle =    64

 source distribution written to file c10242s         cycle =    68

 source distribution written to file c10242s         cycle =    72

 source distribution written to file c10242s         cycle =    76

 source distribution written to file c10242s         cycle =    80

 source distribution written to file c10242s         cycle =    84

 source distribution written to file c10242s         cycle =    88

 source distribution written to file c10242s         cycle =    92

 ************************************************************************************************************************
 dump no.    3 on file c10242r      nps =    370548     coll =      69595804     ctm =   30.31     nrn =      572414095
```

source distribution written to file c10242s cycle = 96

estimator	cycle 100	ave of 80 cycles	combination	simple average	combined average	corr
k(collision)	0.681757	0.689731 0.0023	k(col/abs)	0.689442 0.0020	0.689306 0.0020	0.7334
k(absorption)	0.679947	0.689153 0.0020	k(abs/tk ln)	0.689278 0.0021	0.689205 0.0020	0.5786
k(trk length)	0.694799	0.689403 0.0027	k(tk ln/col)	0.689567 0.0024	0.689668 0.0023	0.7884
rem life(col)	1.1742E+04	1.1565E+04 0.0033	k(col/abs/tk ln)	0.689429 0.0021	0.689265 0.0020	
rem life(abs)	1.1760E+04	1.1559E+04 0.0033	life(col/abs)	1.1562E+04 0.0033	1.1560E+04 0.0033	0.9916

source points generated 3981

source distribution written to file c10242s cycle = 100

source distribution written to file c10242s cycle = 104

source distribution written to file c10242s cycle = 108

source distribution written to file c10242s cycle = 112

source distribution written to file c10242s cycle = 115

estimator	cycle 116	ave of 96 cycles	combination	simple average	combined average	corr
k(collision)	0.686509	0.690527 0.0021	k(col/abs)	0.690330 0.0018	0.690244 0.0018	0.7431
k(absorption)	0.695756	0.690134 0.0018	k(abs/tk ln)	0.690363 0.0019	0.690215 0.0018	0.5830
k(trk length)	0.696801	0.690593 0.0025	k(tk ln/col)	0.690560 0.0021	0.690537 0.0021	0.7553
rem life(col)	1.1575E+04	1.1547E+04 0.0031	k(col/abs/tk ln)	0.690418 0.0019	0.690255 0.0018	
rem life(abs)	1.1591E+04	1.1543E+04 0.0031	life(col/abs)	1.1545E+04 0.0031	1.1543E+04 0.0031	0.9927

source points generated 3924

estimator	cycle 117	ave of 97 cycles	combination	simple average	combined average	corr
k(collision)	0.702393	0.690649 0.0021	k(col/abs)	0.690498 0.0018	0.690437 0.0018	0.7444
k(absorption)	0.710731	0.690346 0.0019	k(abs/tk ln)	0.690483 0.0019	0.690399 0.0018	0.5774
k(trk length)	0.693102	0.690619 0.0024	k(tk ln/col)	0.690634 0.0021	0.690644 0.0020	0.7537
rem life(col)	1.1507E+04	1.1546E+04 0.0031	k(col/abs/tk ln)	0.690538 0.0019	0.690437 0.0018	
rem life(abs)	1.1472E+04	1.1543E+04 0.0031	life(col/abs)	1.1544E+04 0.0031	1.1543E+04 0.0031	0.9926

source points generated 4077

estimator	cycle 118	ave of 98 cycles	combination	simple average	combined average	corr
k(collision)	0.680462	0.690545 0.0020	k(col/abs)	0.690450 0.0018	0.690411 0.0018	0.7419
k(absorption)	0.691137	0.690354 0.0018	k(abs/tk ln)	0.690355 0.0019	0.690354 0.0018	0.5693
k(trk length)	0.664757	0.690355 0.0025	k(tk ln/col)	0.690450 0.0021	0.690517 0.0020	0.7540
rem life(col)	1.1593E+04	1.1547E+04 0.0031	k(col/abs/tk ln)	0.690418 0.0019	0.690393 0.0018	
rem life(abs)	1.1660E+04	1.1544E+04 0.0030	life(col/abs)	1.1545E+04 0.0030	1.1544E+04 0.0031	0.9924

source points generated 3833

estimator	cycle 119	ave of 99 cycles	combination	simple average	combined average	corr
k(collision)	0.682399	0.690463 0.0020	k(col/abs)	0.690389 0.0018	0.690359 0.0018	0.7420
k(absorption)	0.686518	0.690316 0.0018	k(abs/tk ln)	0.690292 0.0019	0.690307 0.0018	0.5699
k(trk length)	0.681798	0.690268 0.0024	k(tk ln/col)	0.690366 0.0021	0.690434 0.0020	0.7547
rem life(col)	1.0908E+04	1.1540E+04 0.0031	k(col/abs/tk ln)	0.690349 0.0019	0.690340 0.0018	
rem life(abs)	1.0862E+04	1.1537E+04 0.0031	life(col/abs)	1.1539E+04 0.0031	1.1538E+04 0.0031	0.9926

source points generated 4024

source distribution written to file c10242s cycle = 119

estimator	cycle 120	ave of 100 cycles	combination	simple average	combined average	corr
k(collision)	0.692461	0.690483 0.0020	k(col/abs)	0.690525 0.0018	0.690539 0.0018	0.7301

k(absorption)	0.715448	0.690567	0.0018	k(abs/tk ln)	0.690412	0.0019	0.690501 0.0018 0.5571
k(trk length)	0.689060	0.690256	0.0024	k(tk ln/col)	0.690370	0.0021	0.690449 0.0020 0.7545
rem life(col)	1.1285E+04	1.1538E+04	0.0031	k(col/abs/tk ln)	0.690435	0.0018	0.690513 0.0018
rem life(abs)	1.1289E+04	1.1534E+04	0.0030	life(col/abs)	1.1536E+04	0.0030	1.1535E+04 0.0031 0.9926

source points generated 4084

source distribution written to file c10242s cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

06/06/00 11:46:50

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 06/06/00 11:07:39

0

neutron creation	tracks	weight (per source	energy particle)	neutron loss	tracks	weight (per source	energy particle)
source	478563	1.0030E+00	2.0301E+00	escape	276	3.7647E-04	2.6190E-04
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	1.3864E-01	5.8366E-06	weight cutoff	478791	1.3829E-01	7.3317E-06
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	5.7514E-07	downscattering	0	0.	1.9364E+00
				capture	0	7.2347E-01	2.9053E-02
(n,xn)	1008	1.6903E-03	1.2288E-03	loss to (n,xn)	504	8.4514E-04	7.0436E-03
fission	0	0.	0.	loss to fission	0	2.8036E-01	5.8638E-02
total	479571	1.1433E+00	2.0314E+00	total	479571	1.1433E+00	2.0314E+00

number of neutrons banked	504	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0021E+00	escape	2.1082E+04	tco	1.0000E+34
neutron collisions per source particle	1.8814E+02	capture	1.1738E+04	eco	0.0000E+00
total neutron collisions	90034698	capture or escape	1.1741E+04	wc1	-5.0000E-01
net multiplication	1.0008E+00 0.0001	any termination	1.4708E+04	wc2	-2.5000E-01

computer time so far in this run	39.18 minutes	maximum number ever in bank	1
computer time in mcrun	39.17 minutes	bank overflows to backup file	0
source particles per minute	1.2218E+04	field length	0
random numbers generated	738338100	most random numbers used was	14312 in history 125732

range of sampled source weights = 9.4162E-01 to 1.2555E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	12	4737294	479066	1547720	2.7297E+00	1.6074E-03	8.9099E-01	8.9637E-01	2.6771E+00
3	13	9143441	472727	606999	1.0638E+00	1.3429E-03	8.4566E-01	8.9184E-01	2.6636E+00
4	14	12319894	468753	4890886	8.1735E+00	1.1616E-03	8.1850E-01	8.9005E-01	1.9043E+00
5	3	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	30	841745	383615	81542742	8.9668E+01	4.9134E-05	2.5387E-01	5.8905E-01	8.1629E-01
7	4	551866	69063	195007	1.9391E-01	5.5095E-05	3.0295E-01	5.1779E-01	1.5788E+00
8	5	275831	66583	1287	1.2669E-03	5.6721E-05	3.1474E-01	5.1982E-01	3.1726E+03

10	7	45140	21019	1250057	1.4931E+00	6.0179E-05	2.3819E-01	6.0252E-01	2.6879E+00
total		27915211	1960826	90034698	1.0332E+02				

1keff results for: WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 06/06/00 11:07:39

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 78526 neutron histories and 100 active cycles with 400037 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 478563 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

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the final estimated combined collision/absorption/track-length keff = 0.69051 with an estimated standard deviation of 0.00123

the estimated 68, 95, & 99 percent keff confidence intervals are 0.68928 to 0.69174, 0.68807 to 0.69296, and 0.68727 to 0.69376

the estimated collision/absorption neutron removal lifetime = 1.15E-04 seconds with an estimated standard deviation of 3.54E-07

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the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.69048	0.00138	0.68910 to 0.69187	0.68773 to 0.69324	0.68683 to 0.69414	
absorption	0.69057	0.00127	0.68930 to 0.69183	0.68805 to 0.69309	0.68722 to 0.69391	
track length	0.69026	0.00166	0.68859 to 0.69192	0.68695 to 0.69357	0.68587 to 0.69464	
col/absorp	0.69054	0.00123	0.68931 to 0.69177	0.68809 to 0.69299	0.68729 to 0.69378	0.7301
abs/trk len	0.69050	0.00124	0.68926 to 0.69174	0.68804 to 0.69296	0.68724 to 0.69376	0.5571
col/trk len	0.69045	0.00138	0.68907 to 0.69183	0.68770 to 0.69320	0.68680 to 0.69410	0.7545
col/abs/trk len	0.69051	0.00123	0.68928 to 0.69174	0.68807 to 0.69296	0.68727 to 0.69376	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.69084	0.00142	0.68942 to 0.69226	0.68802 to 0.69366	0.68710 to 0.69458
absorption	0.69090	0.00130	0.68960 to 0.69220	0.68832 to 0.69348	0.68747 to 0.69433
track length	0.69073	0.00171	0.68902 to 0.69244	0.68732 to 0.69414	0.68621 to 0.69525
col/abs/trk len	0.69087	0.00127	0.68960 to 0.69214	0.68835 to 0.69340	0.68752 to 0.69422

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	1.1535E-04	3.5418E-07	1.1500E-04 to 1.1571E-04	1.1465E-04 to 1.1606E-04	1.1442E-04 to 1.1629E-04
capture	1.1518E-04	3.2408E-07	1.1486E-04 to 1.1551E-04	1.1454E-04 to 1.1583E-04	1.1433E-04 to 1.1604E-04
fission	4.4063E-05	1.5645E-07	4.3906E-05 to 4.4219E-05	4.3751E-05 to 4.4374E-05	4.3649E-05 to 4.4476E-05
escape	3.1287E-04	4.2805E-05	2.7002E-04 to 3.5572E-04	2.2760E-04 to 3.9814E-04	1.9978E-04 to 4.2596E-04

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.6905 0.0014	0.6906 0.0013	0.6903 0.0017	95/95/95	0.69051 0.00123	0.68807-0.69296	0.68727-0.69376
2	50	0.6905 0.0014	0.6906 0.0013	0.6903 0.0016	95/95/95	0.69048 0.00129	0.68789-0.69307	0.68703-0.69394
4	25	0.6905 0.0016	0.6906 0.0016	0.6903 0.0019	95/95/95	0.69052 0.00159	0.68722-0.69382	0.68603-0.69500
5	20	0.6905 0.0017	0.6906 0.0014	0.6903 0.0020	95/95/95	0.69054 0.00150	0.68736-0.69371	0.68618-0.69490
10	10	0.6905 0.0020	0.6906 0.0017	0.6903 0.0021	95/95/95	0.69059 0.00195	0.68598-0.69521	0.68376-0.69742
20	5	0.6905 0.0023	0.6906 0.0024	0.6903 0.0027	95/95/no	0.69071 0.00309	0.67740-0.70401	0.66002-0.72139
25	4	0.6905 0.0016	0.6906 0.0020	0.6903 0.0028	95/95/95	0.69061 0.00186	0.66696-0.71427	0.57213-0.80910

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll) st dev	k(abs) st dev	k(track) st dev	average k(c/a/t) k(c/a/t) st dev	fom
1	4000	0.80942	0.81315	0.81309					
2	3250	0.65362	0.66308	0.66747					
3	3186	0.62685	0.64511	0.63074					
4	3872	0.63524	0.63517	0.63464					
5	4074	0.66045	0.65498	0.65060					
6	4184	0.68365	0.68371	0.66959					
7	4120	0.65320	0.65121	0.65104					
8	3780	0.64394	0.64563	0.63685					
9	3945	0.68283	0.67388	0.67042					
10	4155	0.64516	0.67307	0.64214					
11	3727	0.66379	0.67397	0.67629					
12	4133	0.65554	0.65974	0.65327					
13	3901	0.68145	0.67503	0.70203					
14	4198	0.67077	0.67320	0.67594					
15	3985	0.70268	0.69887	0.70374					
16	4206	0.67882	0.66679	0.67215					
17	3871	0.67388	0.66171	0.66765					
18	3956	0.70217	0.70707	0.69834					
19	4214	0.66051	0.67153	0.65895					
20	3769	0.68773	0.67120	0.68773					
		begin active keff cycles							
21	4149	0.67637	0.67516	0.67015					
22	3905	0.68806	0.67471	0.68287	0.68222 0.00585	0.67493 0.00023	0.67651 0.00636		
23	4051	0.67731	0.68476	0.64984	0.68058 0.00375	0.67821 0.00328	0.66762 0.00962		
24	3930	0.68557	0.68480	0.69563	0.68183 0.00293	0.67986 0.00284	0.67462 0.00976	0.68187 0.00393	22807
25	3998	0.66343	0.66534	0.66296	0.67815 0.00432	0.67695 0.00364	0.67229 0.00791	0.67661 0.00582	8197
26	3848	0.69624	0.68781	0.68572	0.68116 0.00464	0.67876 0.00348	0.67453 0.00684	0.67702 0.00552	7652
27	4183	0.66104	0.67727	0.66322	0.67829 0.00486	0.67855 0.00295	0.67291 0.00600	0.67753 0.00385	13479
28	3784	0.68388	0.68373	0.69280	0.67899 0.00427	0.67920 0.00264	0.67540 0.00576	0.67887 0.00323	16877
29	4118	0.69562	0.68531	0.68507	0.68083 0.00420	0.67988 0.00242	0.67647 0.00519	0.67924 0.00293	18212
30	4089	0.69463	0.68712	0.69729	0.68221 0.00400	0.68060 0.00228	0.67856 0.00509	0.68003 0.00269	19367
31	3929	0.65764	0.66604	0.66431	0.67998 0.00425	0.67928 0.00245	0.67726 0.00478	0.67863 0.00258	19126
32	3805	0.66622	0.67403	0.65856	0.67883 0.00405	0.67884 0.00228	0.67570 0.00464	0.67839 0.00238	20674

33	4015	0.69722	0.68332	0.70095	0.68025	0.00398	0.67918	0.00213	0.67764	0.00469	0.67845	0.00216	23193
34	4216	0.70116	0.71072	0.68652	0.68174	0.00398	0.68144	0.00299	0.67828	0.00438	0.68008	0.00322	9657
35	4058	0.67090	0.68421	0.66064	0.68102	0.00377	0.68162	0.00279	0.67710	0.00425	0.68015	0.00303	10210
36	3748	0.70831	0.69625	0.70041	0.68272	0.00392	0.68254	0.00277	0.67856	0.00423	0.68071	0.00298	9927
37	4248	0.67390	0.68848	0.68124	0.68220	0.00372	0.68289	0.00262	0.67872	0.00398	0.68175	0.00283	10351
38	3830	0.67946	0.66017	0.66964	0.68205	0.00351	0.68162	0.00278	0.67821	0.00378	0.68071	0.00308	8265
39	3996	0.69731	0.68218	0.70191	0.68286	0.00342	0.68165	0.00263	0.67946	0.00379	0.68103	0.00289	8902
40	4134	0.67721	0.68771	0.68224	0.68257	0.00325	0.68196	0.00251	0.67960	0.00360	0.68145	0.00271	9645
41	3899	0.69335	0.69494	0.69120	0.68309	0.00314	0.68257	0.00247	0.68015	0.00347	0.68208	0.00266	9560
42	4079	0.69896	0.68515	0.67564	0.68381	0.00308	0.68269	0.00235	0.67995	0.00331	0.68209	0.00258	9640
43	4068	0.68648	0.69290	0.69006	0.68392	0.00294	0.68313	0.00229	0.68039	0.00320	0.68267	0.00249	9962
44	3946	0.70303	0.69330	0.69517	0.68472	0.00293	0.68356	0.00224	0.68100	0.00312	0.68304	0.00245	9835
45	4069	0.71407	0.71816	0.71081	0.68589	0.00304	0.68494	0.00255	0.68220	0.00322	0.68443	0.00279	7301
46	4104	0.70263	0.70583	0.68747	0.68654	0.00299	0.68575	0.00258	0.68240	0.00310	0.68477	0.00282	6890
47	3951	0.70216	0.68938	0.71688	0.68712	0.00294	0.68588	0.00249	0.68368	0.00325	0.68546	0.00268	7381
48	4043	0.70218	0.68491	0.69993	0.68765	0.00288	0.68585	0.00240	0.68426	0.00318	0.68553	0.00260	7575
49	3958	0.69691	0.69728	0.69706	0.68797	0.00280	0.68624	0.00235	0.68470	0.00310	0.68600	0.00253	7692
50	3983	0.70867	0.68218	0.70810	0.68866	0.00279	0.68611	0.00227	0.68548	0.00310	0.68603	0.00247	7824
51	4054	0.67249	0.69365	0.67653	0.68814	0.00275	0.68635	0.00221	0.68519	0.00301	0.68623	0.00234	8420
52	3780	0.68821	0.68113	0.67342	0.68814	0.00266	0.68619	0.00215	0.68482	0.00294	0.68613	0.00230	8456
53	4103	0.67521	0.68340	0.66904	0.68775	0.00261	0.68610	0.00208	0.68434	0.00289	0.68596	0.00224	8655
54	3924	0.69304	0.69813	0.69193	0.68791	0.00254	0.68645	0.00205	0.68457	0.00281	0.68633	0.00219	8761
55	4026	0.68251	0.68805	0.70244	0.68775	0.00247	0.68650	0.00199	0.68508	0.00277	0.68648	0.00207	9539
56	3932	0.70129	0.69695	0.68888	0.68813	0.00243	0.68679	0.00196	0.68518	0.00270	0.68667	0.00205	9498
57	4122	0.68395	0.68142	0.67820	0.68802	0.00236	0.68665	0.00191	0.68499	0.00263	0.68654	0.00200	9648
58	3878	0.68902	0.70455	0.71155	0.68804	0.00230	0.68712	0.00192	0.68569	0.00266	0.68727	0.00195	9917
59	4071	0.69899	0.69083	0.71387	0.68832	0.00226	0.68721	0.00187	0.68641	0.00269	0.68747	0.00190	10274
60	4017	0.68427	0.68166	0.69261	0.68822	0.00220	0.68707	0.00183	0.68657	0.00262	0.68732	0.00184	10570
61	3949	0.70050	0.70219	0.69958	0.68852	0.00217	0.68744	0.00182	0.68689	0.00258	0.68769	0.00183	10446
62	4099	0.69703	0.69037	0.71492	0.68872	0.00213	0.68751	0.00178	0.68755	0.00260	0.68782	0.00179	10757
63	4041	0.71287	0.70807	0.70858	0.68928	0.00215	0.68799	0.00180	0.68804	0.00259	0.68828	0.00182	10119
64	4092	0.68145	0.66911	0.69165	0.68911	0.00211	0.68756	0.00181	0.68813	0.00253	0.68794	0.00182	9912
65	3817	0.68202	0.68816	0.70885	0.68895	0.00207	0.68757	0.00177	0.68859	0.00251	0.68794	0.00177	10260
66	4024	0.71970	0.70619	0.70973	0.68962	0.00213	0.68798	0.00178	0.68905	0.00250	0.68832	0.00180	9705
67	4206	0.68754	0.69405	0.69271	0.68957	0.00209	0.68811	0.00174	0.68912	0.00245	0.68843	0.00176	9941
68	3809	0.67342	0.68269	0.66645	0.68924	0.00207	0.68799	0.00171	0.68865	0.00244	0.68824	0.00172	10101
69	3900	0.67551	0.68636	0.67866	0.68896	0.00205	0.68796	0.00168	0.68845	0.00240	0.68814	0.00169	10354
70	4065	0.69426	0.68697	0.70584	0.68906	0.00201	0.68794	0.00164	0.68880	0.00238	0.68817	0.00165	10565
71	4113	0.70799	0.70277	0.71053	0.68943	0.00200	0.68823	0.00164	0.68922	0.00237	0.68847	0.00165	10377
72	4067	0.68168	0.68286	0.69243	0.68929	0.00197	0.68813	0.00161	0.68928	0.00233	0.68836	0.00162	10551
73	3807	0.66897	0.67008	0.66833	0.68890	0.00197	0.68779	0.00161	0.68889	0.00232	0.68801	0.00163	10249
74	3934	0.67578	0.67335	0.68094	0.68866	0.00195	0.68752	0.00161	0.68874	0.00228	0.68776	0.00162	10167
75	4039	0.67175	0.69435	0.66373	0.68835	0.00194	0.68765	0.00158	0.68829	0.00228	0.68779	0.00158	10457
76	4034	0.68064	0.67870	0.68457	0.68821	0.00191	0.68749	0.00156	0.68822	0.00224	0.68764	0.00156	10550
77	4011	0.69125	0.70045	0.70450	0.68827	0.00187	0.68771	0.00155	0.68850	0.00222	0.68785	0.00155	10570
78	4047	0.67130	0.67404	0.68195	0.68797	0.00186	0.68748	0.00154	0.68839	0.00218	0.68762	0.00154	10491
79	3885	0.68357	0.70340	0.67574	0.68790	0.00183	0.68775	0.00154	0.68818	0.00216	0.68781	0.00152	10583
80	4071	0.70837	0.70396	0.69519	0.68824	0.00183	0.68802	0.00154	0.68829	0.00212	0.68808	0.00152	10453
81	4164	0.69903	0.69956	0.70321	0.68842	0.00181	0.68821	0.00152	0.68854	0.00210	0.68827	0.00151	10454
82	3944	0.68569	0.68879	0.68406	0.68837	0.00178	0.68822	0.00150	0.68847	0.00207	0.68827	0.00148	10640
83	3905	0.69690	0.68620	0.69181	0.68851	0.00176	0.68818	0.00147	0.68852	0.00204	0.68827	0.00146	10818
84	3987	0.69219	0.68888	0.68986	0.68857	0.00173	0.68819	0.00145	0.68854	0.00201	0.68828	0.00143	10996
85	3989	0.71708	0.69910	0.72412	0.68901	0.00176	0.68836	0.00144	0.68909	0.00205	0.68850	0.00143	10829

86	4091	0.68332	0.68126	0.68052	0.68892	0.00174	0.68825	0.00142	0.68896	0.00202	0.68840	0.00142	10932
87	3815	0.71193	0.70151	0.70024	0.68926	0.00175	0.68845	0.00141	0.68913	0.00200	0.68859	0.00141	10850
88	4191	0.70099	0.69798	0.68292	0.68943	0.00173	0.68859	0.00140	0.68904	0.00197	0.68870	0.00140	10932
89	3961	0.68418	0.69215	0.67010	0.68936	0.00170	0.68864	0.00138	0.68876	0.00196	0.68870	0.00138	11103
90	3889	0.71317	0.71246	0.70668	0.68970	0.00171	0.68898	0.00140	0.68902	0.00195	0.68901	0.00140	10634
91	4188	0.69395	0.69841	0.68773	0.68976	0.00169	0.68912	0.00139	0.68900	0.00192	0.68912	0.00138	10725
92	3927	0.68034	0.66741	0.68317	0.68963	0.00167	0.68882	0.00140	0.68892	0.00190	0.68888	0.00139	10472
93	3920	0.68463	0.68302	0.67676	0.68956	0.00165	0.68874	0.00138	0.68875	0.00188	0.68879	0.00137	10555
94	4035	0.72672	0.72339	0.73815	0.69006	0.00170	0.68920	0.00144	0.68942	0.00197	0.68932	0.00144	9407
95	4241	0.70393	0.71597	0.69876	0.69025	0.00169	0.68956	0.00147	0.68954	0.00195	0.68965	0.00146	9114
96	3832	0.68505	0.69887	0.68970	0.69018	0.00167	0.68968	0.00145	0.68955	0.00192	0.68974	0.00144	9242
97	3921	0.67963	0.67496	0.68225	0.69004	0.00165	0.68949	0.00145	0.68945	0.00190	0.68957	0.00143	9225
98	3999	0.68674	0.68634	0.69326	0.69000	0.00163	0.68945	0.00143	0.68950	0.00187	0.68954	0.00141	9353
99	4052	0.67680	0.67500	0.67649	0.68983	0.00162	0.68927	0.00142	0.68933	0.00186	0.68936	0.00141	9310
100	3973	0.68176	0.67995	0.69480	0.68973	0.00160	0.68915	0.00141	0.68940	0.00184	0.68927	0.00139	9399
101	3981	0.68673	0.69121	0.68872	0.68969	0.00158	0.68918	0.00139	0.68939	0.00181	0.68928	0.00137	9531
102	4019	0.71867	0.72431	0.73477	0.69005	0.00160	0.68961	0.00144	0.68995	0.00187	0.68973	0.00142	8775
103	4180	0.70839	0.70350	0.69456	0.69027	0.00160	0.68977	0.00143	0.69000	0.00185	0.68989	0.00142	8749
104	3992	0.68398	0.69244	0.69454	0.69019	0.00158	0.68981	0.00142	0.69006	0.00183	0.68991	0.00140	8871
105	3823	0.69531	0.68400	0.69960	0.69025	0.00157	0.68974	0.00140	0.69017	0.00181	0.68988	0.00138	8969
106	4050	0.70259	0.69160	0.69757	0.69040	0.00155	0.68976	0.00139	0.69026	0.00179	0.68993	0.00137	9051
107	4026	0.68530	0.69674	0.65755	0.69034	0.00154	0.68984	0.00137	0.68988	0.00181	0.68994	0.00135	9161
108	3881	0.68683	0.69034	0.68876	0.69030	0.00152	0.68985	0.00136	0.68987	0.00179	0.68993	0.00134	9279
109	4031	0.68078	0.67839	0.68326	0.69019	0.00151	0.68972	0.00135	0.68979	0.00177	0.68981	0.00133	9304
110	3985	0.67986	0.68677	0.71327	0.69008	0.00149	0.68968	0.00133	0.69005	0.00177	0.68980	0.00131	9428
111	3979	0.69359	0.68936	0.67174	0.69012	0.00148	0.68968	0.00132	0.68985	0.00176	0.68978	0.00130	9525
112	4066	0.70200	0.70902	0.70926	0.69024	0.00147	0.68989	0.00132	0.69006	0.00176	0.68998	0.00130	9425
113	4081	0.68680	0.68863	0.70166	0.69021	0.00145	0.68988	0.00131	0.69019	0.00174	0.68998	0.00128	9528
114	3958	0.70622	0.69707	0.70403	0.69038	0.00145	0.68995	0.00129	0.69034	0.00173	0.69008	0.00127	9565
115	4102	0.70852	0.70150	0.70861	0.69057	0.00144	0.69007	0.00129	0.69053	0.00172	0.69021	0.00127	9541
116	3950	0.68651	0.69576	0.69680	0.69053	0.00143	0.69013	0.00127	0.69059	0.00171	0.69025	0.00125	9645
117	3924	0.70239	0.71073	0.69310	0.69065	0.00142	0.69035	0.00128	0.69062	0.00169	0.69044	0.00125	9568
118	4077	0.68046	0.69114	0.66476	0.69055	0.00141	0.69035	0.00127	0.69035	0.00169	0.69039	0.00124	9658
119	3833	0.68240	0.68652	0.68180	0.69046	0.00140	0.69032	0.00125	0.69027	0.00168	0.69034	0.00123	9745
120	4024	0.69246	0.71545	0.68906	0.69048	0.00138	0.69057	0.00127	0.69026	0.00166	0.69051	0.00123	9654

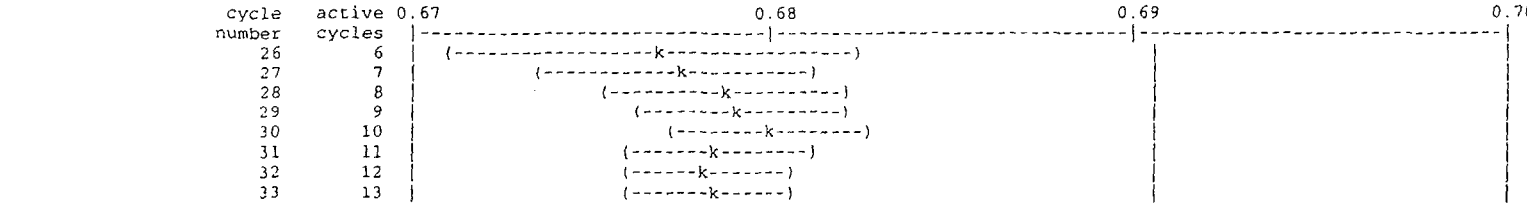
the largest active cycle keffs by estimator are:

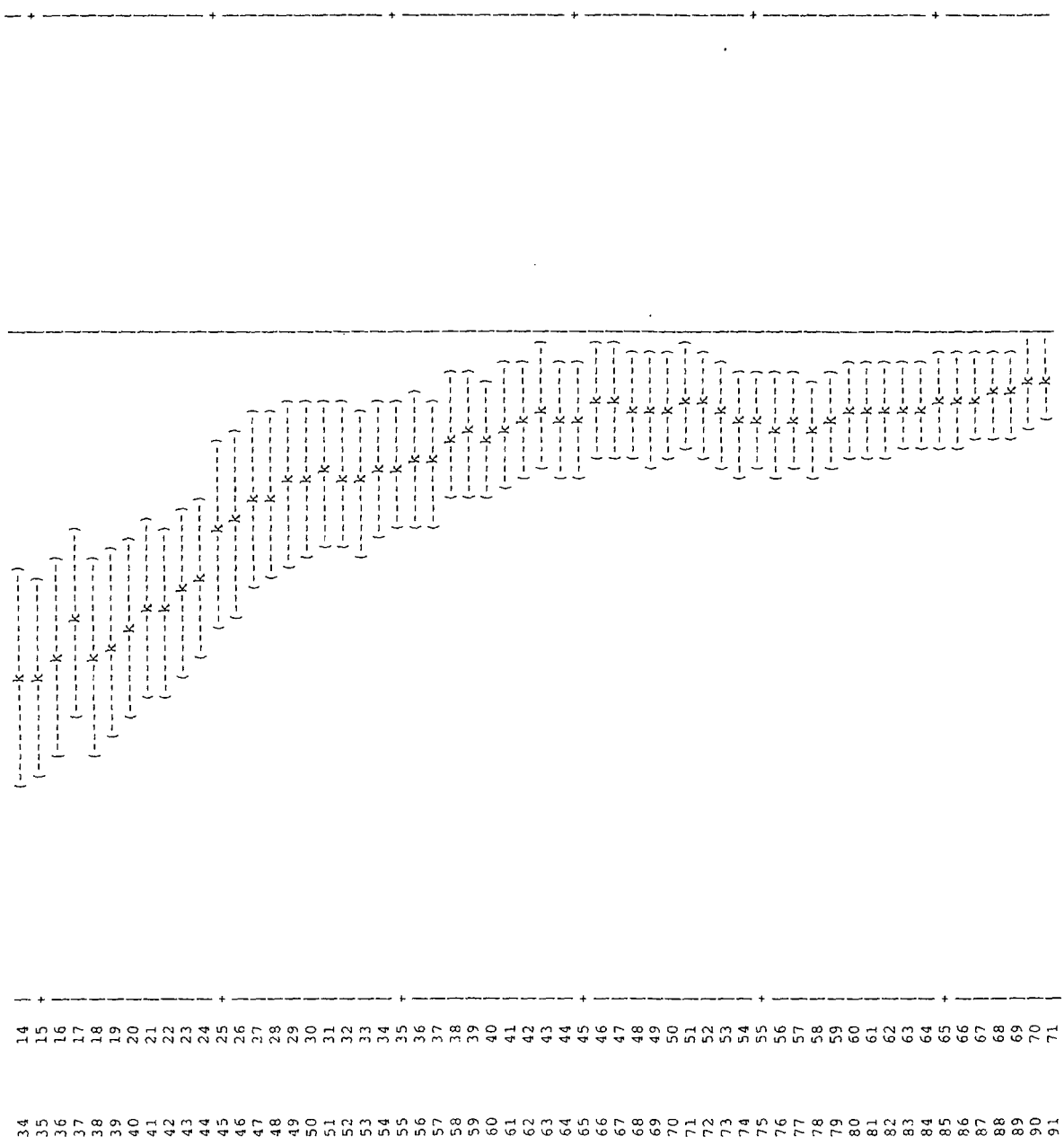
collision 0.72672 on cycle 94
absorption 0.72431 on cycle 102
track length 0.73815 on cycle 94

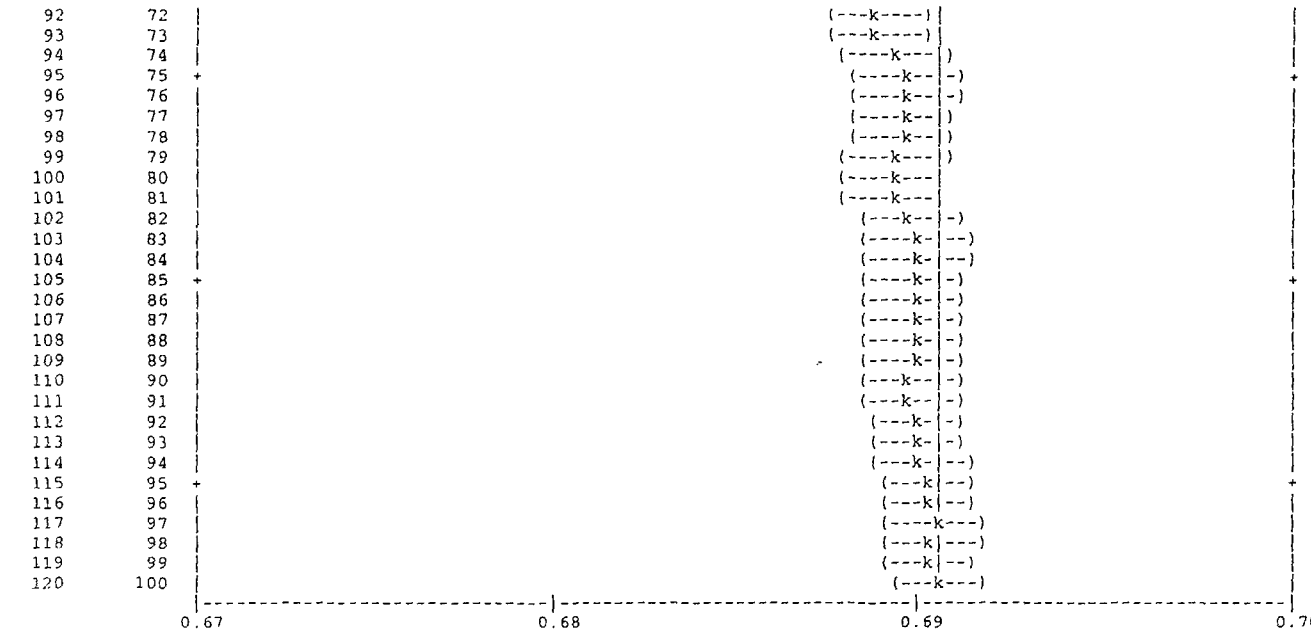
the smallest active cycle keffs by estimator are:

collision 0.65764 on cycle 31
absorption 0.66017 on cycle 38
track length 0.64984 on cycle 23

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.69051)







lindividual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	478563	0.6877	0.0019	0.6880	0.0018	0.6874	0.0021	no/no/no	0.68787	0.00179	0.68430-0.69143	0.68314-0.69259
1	119	474563	0.6866	0.0016	0.6869	0.0015	0.6863	0.0018	99/95/95	0.68682	0.00146	0.68392-0.68972	0.68297-0.69066
2	118	471313	0.6869	0.0016	0.6871	0.0015	0.6865	0.0018	99/95/95	0.68704	0.00145	0.68414-0.68993	0.68320-0.69087
3	117	468127	0.6874	0.0015	0.6875	0.0014	0.6870	0.0018	95/95/95	0.68743	0.00141	0.68463-0.69024	0.68372-0.69115
4	116	464255	0.6879	0.0015	0.6879	0.0014	0.6874	0.0017	95/95/95	0.68789	0.00134	0.68521-0.69056	0.68434-0.69143
5	115	460181	0.6881	0.0015	0.6882	0.0013	0.6878	0.0017	95/95/95	0.68815	0.00132	0.68552-0.69079	0.68465-0.69165
6	114	455997	0.6882	0.0015	0.6882	0.0014	0.6879	0.0017	95/95/95	0.68820	0.00133	0.68554-0.69086	0.68467-0.69172
7	113	451877	0.6885	0.0015	0.6886	0.0013	0.6882	0.0017	95/95/95	0.68852	0.00131	0.68592-0.69112	0.68507-0.69197
8	112	448097	0.6889	0.0014	0.6890	0.0013	0.6887	0.0016	95/95/95	0.68891	0.00125	0.68641-0.69141	0.68559-0.69222
9	111	444152	0.6889	0.0014	0.6891	0.0013	0.6889	0.0017	95/95/95	0.68903	0.00126	0.68652-0.69154	0.68570-0.69236
10	110	439997	0.6893	0.0014	0.6892	0.0013	0.6893	0.0016	95/95/95	0.68926	0.00125	0.68678-0.69175	0.68596-0.69256
11	109	436270	0.6896	0.0014	0.6894	0.0013	0.6894	0.0016	95/95/95	0.68943	0.00125	0.68694-0.69192	0.68613-0.69273
12	108	432137	0.6899	0.0013	0.6896	0.0013	0.6897	0.0016	95/95/95	0.68972	0.00123	0.68728-0.69217	0.68648-0.69296
13	107	428236	0.6900	0.0014	0.6898	0.0013	0.6896	0.0016	95/95/95	0.68982	0.00123	0.68736-0.69228	0.68656-0.69308
14	106	424038	0.6901	0.0014	0.6899	0.0013	0.6898	0.0016	95/95/95	0.68998	0.00124	0.68752-0.69244	0.68672-0.69325
15	105	420053	0.6900	0.0014	0.6899	0.0013	0.6896	0.0016	95/95/95	0.68988	0.00124	0.68741-0.69236	0.68660-0.69317
16	104	415847	0.6901	0.0014	0.6901	0.0013	0.6898	0.0016	95/95/95	0.69006	0.00124	0.68759-0.69253	0.68678-0.69334
17	103	411976	0.6903	0.0014	0.6904	0.0013	0.6900	0.0016	95/95/95	0.69030	0.00123	0.68785-0.69275	0.68705-0.69354
18	102	408020	0.6902	0.0014	0.6902	0.0013	0.6899	0.0017	95/95/95	0.69016	0.00123	0.68770-0.69261	0.68690-0.69341
19	101	403806	0.6905	0.0014	0.6904	0.0013	0.6902	0.0016	95/95/95	0.69038	0.00122	0.68794-0.69282	0.68715-0.69361
20	100*	400037	0.6905	0.0014	0.6906	0.0013	0.6903	0.0017	95/95/95	0.69051	0.00123	0.68807-0.69296	0.68727-0.69376

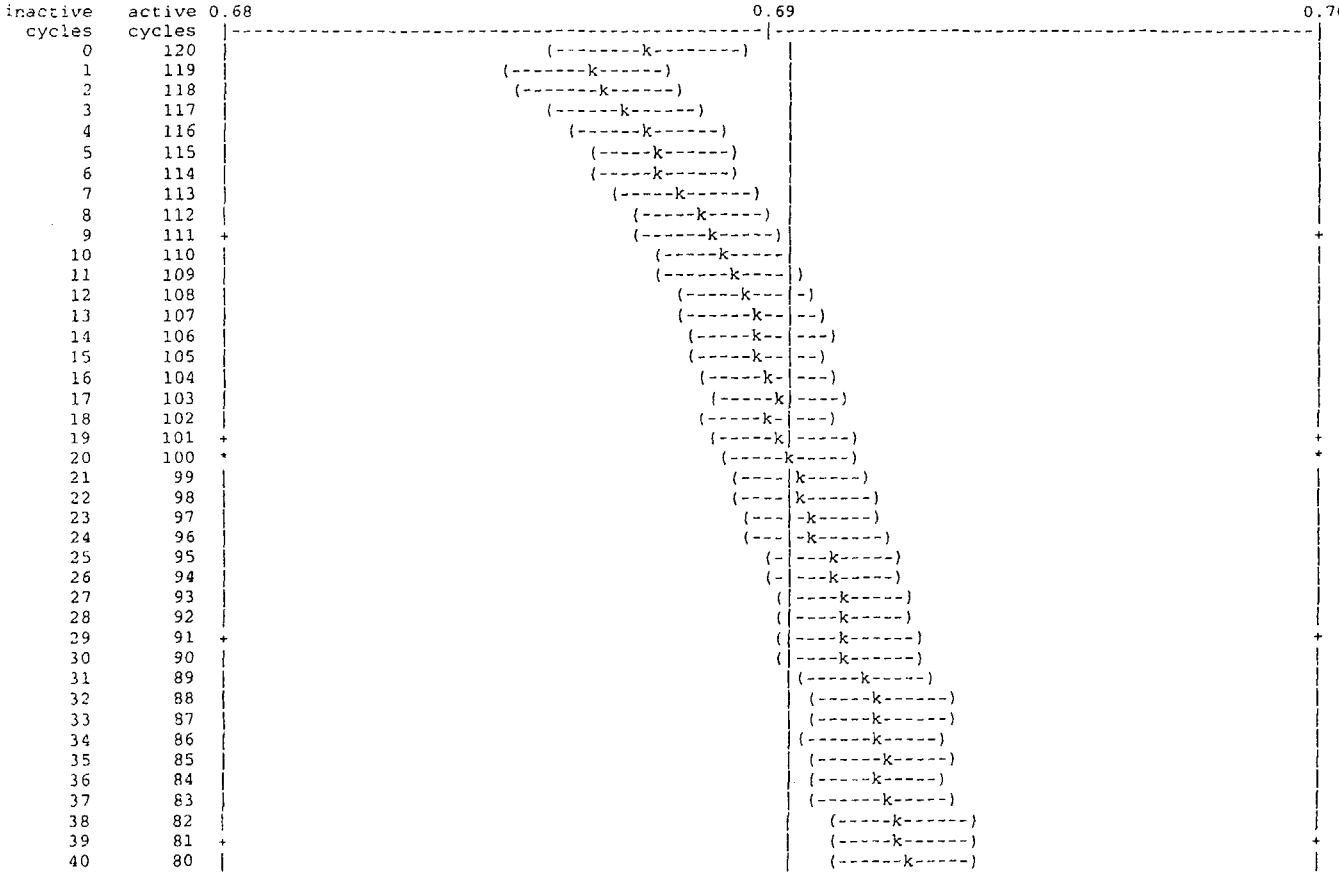
22	98	391983	0.6907	0.0014	0.6909	0.0013	0.6905	0.0017	95/95/95	0.69080	0.00124	0.68833-0.69326	0.68753-0.69406
24	96	384002	0.6908	0.0014	0.6910	0.0013	0.6909	0.0017	95/95/95	0.69097	0.00126	0.68846-0.69347	0.68765-0.69428
26	94	376156	0.6911	0.0014	0.6913	0.0013	0.6913	0.0017	95/95/95	0.69127	0.00125	0.68877-0.69376	0.68796-0.69457
28	92	368189	0.6915	0.0014	0.6916	0.0013	0.6915	0.0017	95/95/95	0.69154	0.00126	0.68903-0.69404	0.68822-0.69486
30	90	359982	0.6914	0.0014	0.6917	0.0013	0.6916	0.0017	95/95/95	0.69160	0.00129	0.68904-0.69416	0.68820-0.69499
32	88	352248	0.6921	0.0014	0.6922	0.0013	0.6922	0.0017	95/95/95	0.69215	0.00125	0.68967-0.69464	0.68886-0.69545
34	86	344017	0.6919	0.0014	0.6921	0.0013	0.6922	0.0017	95/95/95	0.69203	0.00127	0.68951-0.69456	0.68868-0.69539
36	84	336211	0.6920	0.0014	0.6921	0.0014	0.6925	0.0017	95/95/95	0.69211	0.00128	0.68955-0.69467	0.68872-0.69550
38	82	328133	0.6923	0.0014	0.6925	0.0013	0.6929	0.0017	95/95/95	0.69254	0.00127	0.69001-0.69508	0.68918-0.69591
40	80	320003	0.6925	0.0015	0.6927	0.0014	0.6929	0.0018	95/95/95	0.69269	0.00130	0.69010-0.69528	0.68926-0.69612
42	78	312025	0.6924	0.0015	0.6928	0.0014	0.6932	0.0018	95/95/95	0.69276	0.00133	0.69010-0.69542	0.68924-0.69629
44	76	304011	0.6923	0.0015	0.6928	0.0014	0.6932	0.0018	95/95/95	0.69274	0.00137	0.69001-0.69547	0.68912-0.69637
46	74	295838	0.6919	0.0015	0.6923	0.0014	0.6930	0.0019	95/95/95	0.69227	0.00136	0.68955-0.69500	0.68866-0.69589
48	72	287844	0.6916	0.0016	0.6924	0.0014	0.6926	0.0019	95/95/95	0.69224	0.00140	0.68944-0.69504	0.68852-0.69596
50	70	279903	0.6913	0.0016	0.6925	0.0015	0.6923	0.0019	95/95/95	0.69218	0.00145	0.68928-0.69508	0.68833-0.69603
52	68	272069	0.6916	0.0016	0.6926	0.0015	0.6928	0.0020	95/95/95	0.69243	0.00148	0.68947-0.69540	0.68850-0.69637
54	66	264042	0.6918	0.0016	0.6927	0.0015	0.6932	0.0020	95/95/95	0.69258	0.00151	0.68955-0.69560	0.68856-0.69660
56	64	256084	0.6918	0.0017	0.6927	0.0016	0.6931	0.0020	95/95/95	0.69254	0.00156	0.68943-0.69566	0.68840-0.69669
58	62	248084	0.6920	0.0017	0.6927	0.0016	0.6931	0.0021	95/95/95	0.69264	0.00158	0.68947-0.69581	0.68842-0.69686
60	60	239996	0.6920	0.0018	0.6929	0.0017	0.6927	0.0021	95/95/95	0.69271	0.00163	0.68944-0.69597	0.68837-0.69705
62	58	231948	0.6918	0.0018	0.6928	0.0017	0.6922	0.0021	95/95/95	0.69250	0.00168	0.68913-0.69586	0.68802-0.69698
64	56	223815	0.6916	0.0018	0.6929	0.0017	0.6919	0.0022	95/95/95	0.69253	0.00169	0.68914-0.69593	0.68801-0.69705
66	54	215974	0.6912	0.0018	0.6928	0.0017	0.6913	0.0022	95/95/95	0.69216	0.00173	0.68868-0.69563	0.68753-0.69679
68	52	207959	0.6916	0.0019	0.6929	0.0018	0.6917	0.0023	95/95/95	0.69239	0.00177	0.68884-0.69595	0.68766-0.69713
70	50	199994	0.6919	0.0019	0.6932	0.0019	0.6917	0.0023	99/95/95	0.69258	0.00183	0.68891-0.69626	0.68768-0.69748
72	48	191814	0.6918	0.0019	0.6932	0.0019	0.6913	0.0024	99/95/95	0.69247	0.00188	0.68868-0.69625	0.68742-0.69752
74	46	184073	0.6926	0.0019	0.6941	0.0019	0.6920	0.0024	99/95/95	0.69339	0.00185	0.68966-0.69711	0.68841-0.69837
76	44	176000	0.6934	0.0019	0.6945	0.0019	0.6928	0.0024	99/95/95	0.69386	0.00188	0.69007-0.69765	0.68878-0.69894
78	42	167942	0.6939	0.0020	0.6948	0.0020	0.6928	0.0025	no/95/95	0.69429	0.00190	0.69044-0.69815	0.68914-0.69945
80	40	159986	0.6938	0.0020	0.6944	0.0020	0.6932	0.0026	no/95/95	0.69406	0.00197	0.69007-0.69805	0.68872-0.69941
82	38	151878	0.6939	0.0021	0.6944	0.0021	0.6932	0.0027	no/95/95	0.69410	0.00206	0.68991-0.69828	0.68848-0.69971
84	36	143986	0.6939	0.0022	0.6948	0.0022	0.6933	0.0029	no/95/95	0.69427	0.00218	0.68983-0.69871	0.68830-0.70024
86	34	135906	0.6935	0.0022	0.6951	0.0023	0.6928	0.0029	no/95/95	0.69399	0.00226	0.68938-0.69861	0.68778-0.70021
88	32	127900	0.6927	0.0023	0.6948	0.0025	0.6929	0.0031	no/95/95	0.69325	0.00238	0.68838-0.69813	0.68668-0.69983
90	30	120050	0.6923	0.0023	0.6943	0.0026	0.6931	0.0031	no/95/95	0.69276	0.00243	0.68777-0.69775	0.68602-0.69949
92	28	111935	0.6927	0.0024	0.6951	0.0026	0.6937	0.0033	no/95/95	0.69352	0.00258	0.68822-0.69883	0.68634-0.70070
94	26	103980	0.6917	0.0022	0.6944	0.0025	0.6926	0.0031	99/95/95	0.69251	0.00238	0.68759-0.69743	0.68583-0.69919
96	24	95907	0.6914	0.0023	0.6934	0.0025	0.6925	0.0033	99/95/95	0.69217	0.00244	0.68710-0.69724	0.68527-0.69907
98	22	87987	0.6922	0.0025	0.6945	0.0026	0.6929	0.0036	95/95/95	0.69318	0.00258	0.68777-0.69858	0.68579-0.70056
100	20	79962	0.6935	0.0025	0.6962	0.0026	0.6937	0.0039	95/95/95	0.69483	0.00261	0.68932-0.70034	0.68726-0.70240
102	18	71962	0.6925	0.0024	0.6949	0.0023	0.6917	0.0036	99/95/95	0.69364	0.00223	0.68890-0.69839	0.68708-0.70020
104	16	63790	0.6920	0.0024	0.6946	0.0026	0.6913	0.0040	95/95/95	0.69310	0.00240	0.68790-0.69829	0.68585-0.70034
106	14	55917	0.6910	0.0027	0.6955	0.0028	0.6903	0.0046	95/ 95/95	0.69291	0.00305	0.68620-0.69961	0.68344-0.70237
108	12	48010	0.6918	0.0031	0.6959	0.0033	0.6931	0.0045	95/95/95	0.69361	0.00340	0.68591-0.70130	0.68256-0.70466
110	10	39994	0.6941	0.0032	0.6985	0.0032	0.6921	0.0048	95/95/95	0.69633	0.00364	0.68772-0.70495	0.68358-0.70908
112	8	31949	0.6932	0.0039	0.6983	0.0037	0.6925	0.0050	95/95/95	0.69622	0.00430	0.68516-0.70728	0.67887-0.71357
114	6	23910	0.6921	0.0046	0.7002	0.0046	0.6890	0.0061	95/95/95	0.69615	0.00732	0.67284-0.71946	0.65338-0.73893
116	4	15858	0.6894	0.0051	0.7010	0.0071	0.6822	0.0063	95/95/95	0.68701	0.02000	0.43275-0.94127	0.00000-1.96052
117	3	11934	0.6851	0.0037	0.6977	0.0090	0.6785	0.0072					
118	2	7857	0.6874	0.0050	0.7010	0.0145	0.6854	0.0036					

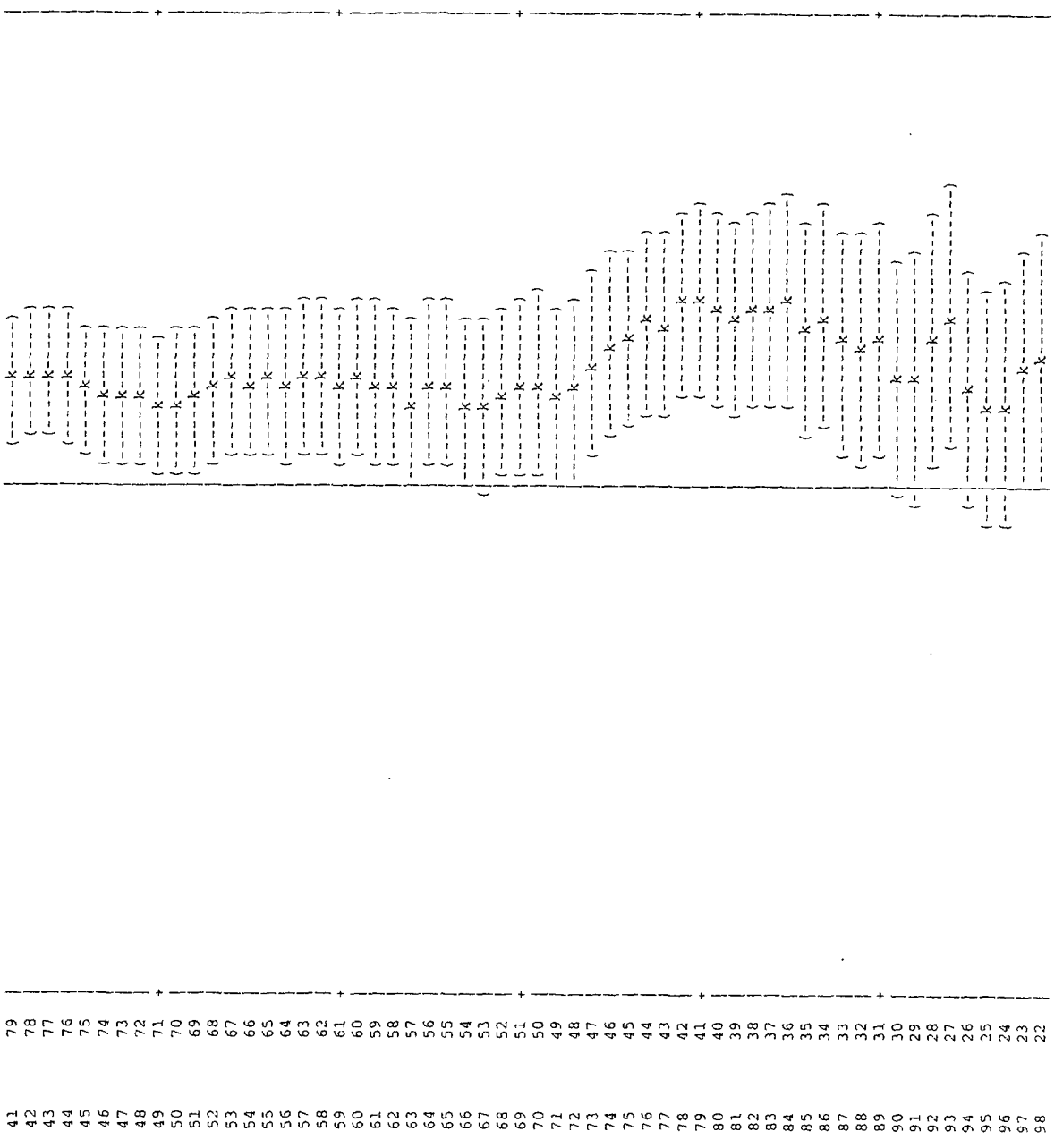
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 19 inactive cycles and 101 active cycles.

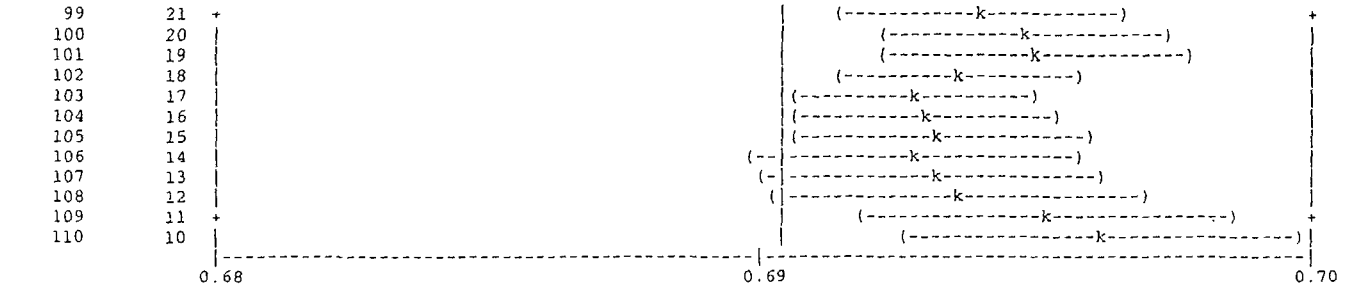
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.68817	0.00165	0.68650 to 0.68983	0.68484 to 0.69149	0.68373 to 0.69260
second half	0.69258	0.00183	0.69074 to 0.69442	0.68891 to 0.69626	0.68768 to 0.69748
final result	0.69051	0.00123	0.68928 to 0.69174	0.68807 to 0.69296	0.68727 to 0.69376

the first and second half values of k(collision/absorption/track length) appear to be the same at the 95 percent confidence level.
)plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.69051)







dump no. 4 on file c10242r nps = 478563 coll = 90034698 ctm = 39.17 nrn = 738338100

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 39.18 minutes

mcnp version 4a 10/01/93 06/06/00 11:46:50 probid = 06/06/00 11:07:39

Attachment 6: Fuel region radius derivation

Fuel region radius for 206 fuel rods in 30 gal drum

Total cross-section area of all fuel pins:

$$\sum S_{pin} = 206\, S_{pin} = 206\,\pi R_c^2$$

Total cross-section area of water in fuel region:

$$\sum S_w = S_{fuel\ region} - \sum S_{pin} = \pi R_f^2 - 206\pi R_c^2 = \pi(R_{in}^2 - 20$$

Water to pin ratio:

$$w/p = \frac{\sum S_w}{\sum S_p} = \frac{\pi(R_f^2 - 206R_c^2)}{206\pi R_c^2} = \frac{R_f^2}{206R_c^2} - 1$$

$$w/p = \frac{R_f^2}{206R_c^2} - 1$$

$$w/p + 1 = \frac{R_f^2}{206R_c^2}$$

$$206R_c^2(w/p + 1) = R_f^2$$

Then, the fuel region radius is:

$$R_f = R_c\sqrt{206(w/p + 1)}$$

URS

Calculation Cover Page

3065 Southwestern Boulevard
Suite 202
Orchard Park, NY 14127
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716 675 7137 Fax

Job No: **30822-244-023 /7150** Calculation No: **BUF-2000-067/Rev. 1** Date: **March 27, 2001**

Revision Basis:
Revised to extend analysis for two drum systems containing 5w/o fuel

Problem Statement & Calculation Objectives:

Determine the neutron multiplication factors for one and two 30 gallon drums filled with fuel pins arranged in the hexagonal lattice. The fuel inside the drum is completely flooded with water. There is no water outside the drums. Drum walls are made of 0.175 cm carbon steel and the drums stand on a concrete floor.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993

Attachments:

Attachment 1: 30 gallon drum dimensions
Attachment 2: Case 1 with MCNP surface and cell numbers
Attachment 3: Case 1 MCNP input file
Attachment 4: Case 1 MCNP output file
Attachment 5: Case 2 with MCNP surface and cell numbers
Attachment 6: Case 2 MCNP input file
Attachment 7: Case 2 MCNP output file

Prepared by:

Signature Igor V. Chichkov — Date 03/27/01

Checked by:

Signature Kevin Roberts — Date 03/29/01

Analysis

Assumptions

The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is unirradiated and may be enriched to 5 w/o, 4 w/o, or 3.327 w/o
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel pins are arranged in a hexagonal array and fill the 30 gallon drum
- Water density is 1 g/cm^3
- The drum and fuel element heights are 72.39 cm (28 1/12 inches)
- The space between the fuel pins is filled with water
- The air fills outside the drum
- Air density is 0.001293 g/cm^3
- Drum walls are made of 0.175 cm carbon steel.
- The drums stand on a concrete floor
- The thickness of the concrete floor is 30 m
- The drum diameter is 46.36 cm and the drum height is 72.39 cm

MCNP Model

Neutron multiplication factors were calculated with MCNP4A code. Two different cases were studied:

- **Case 1.** Two drums stand together touching each other
- **Case 2.** One drum standing alone

Attachments 2 and 5 have the drawings of the models used for case1 and 2 respectively. Examples of MCNP input and output files for both cases can be found in the Attachments.

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for air (Attix F.H., 1986). Table 2 and 3 show the element weight fractions for stainless steel 304 used in the fuel clad and the carbon steel used in the drum walls (Harmon C. D., II et al., 1993), respectively . Table 4 shows the element composition of concrete (Harmon C. D., II et al., 1993). The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 5. Molar mass of uranium dioxide (UO_2) can be determined from equation (1).

$$M_{UO_2} = A_U + 2A_{O-16} = f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16} \qquad (1)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)

A_{U-235} = uranium-235 molar mass (g/mole)

A_{U-238} = uranium-238 molar mass (g/mole)

A_{O-16} = oxygen-16 molar mass (g/mole)

f = uranium-235 enrichment

Then the weight fractions for uranium-235 (w_{U-235}), uranium-238 (w_{U-238}), and oxygen-16 (w_{O-16}) are:

$$w_{U-235} = \frac{f\,A_{U-235}}{M_{UO_2}} = \frac{f\,A_{U-235}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (2)$$

$$w_{U-238} = \frac{(1-f)\,A_{U-238}}{M_{UO_2}} = \frac{(1-f)\,A_{U-238}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (3)$$

$$w_{O-16} = \frac{2A_{O-16}}{M_{UO_2}} = \frac{2A_{O-16}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (4)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012828

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02
Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Carbon Steel Composition

Element	Weight Fraction
Iron (Fe)	0.995
Carbon (C)	0.005

Table 4. Concrete composition

Element	Weight Fraction
Hydrogen (H)	0.006
Oxygen (O)	0.500
Sodium (Na)	0.017
Aluminum (Al)	0.048
Silicon (Si)	0.315

Potassium (K)	0.019
Calcium (Ca)	0.083
Iron (Fe)	0.012

Table 5. Fuel Composition

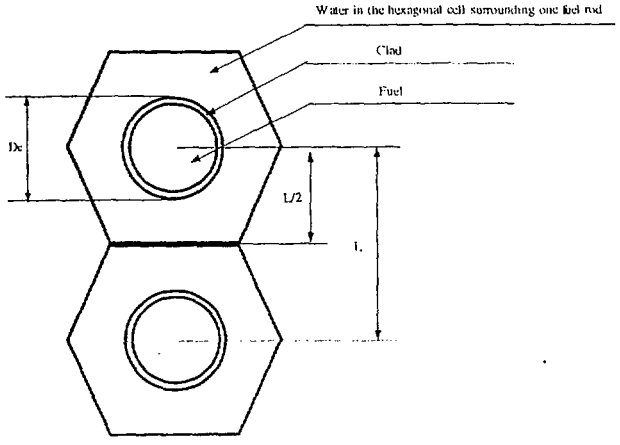
Element	Weight Fraction		
	5 w/o fuel	4 w/o fuel	3.327 w/o fuel
Uranium-235 (^{235}U)	0.0435427	0.0348303	0.0289679
Uranium-238 (^{238}U)	0.8378729	0.8465985	0.8524697
Oxygen (O)	0.1185844	0.1185712	0.1185623

Based on the previous Dames & Moore estimate, 97.5% of the fuel processed at West Valley had an effective enrichment of equal to or less than 3.327%.

Water to Pin Ratio and Half-distance Between Two Adjacent Rods

To find the optimum moderation configuration, calculations for fuel rod arrangements with different water-to- pin ratios were performed. The parameter, which is entered in the MCNP input deck is the half-distance between two adjacent rods. Figure 1 shows the horizontal cross-section of two adjacent fuel rods with water surrounding each rod. This figure shows also the dimension used for the following equations.

Figure 1. Horizontal cross-section of two adjacent fuel rods with water surrounding each rod.



Water to pin ratio can be determined as:

$$w/p = \frac{S_w}{S_p} = \frac{6(L/2)^2 \tan(30^\circ) - \pi D_c^2/4}{\pi D_c^2/4} = \frac{24(L/2)^2 \tan(30^\circ)}{\pi D_c^2} - 1 \qquad (5)$$

Where:

S_w = cross-section area of the water in the hexagonal cell surrounding a pin;

S_p = cross-section area of the pin;

D_c = clad diameter;

$L/2$ = half-distance between two adjacent pins (fuel rods).

Thus, the half-distance between two adjacent pins can be calculated from equation (6) and Table 6 presents the half-distance values corresponding to some water to pin ratios.

$$L/2 = \sqrt{\frac{(w/p+1)\pi D_c^2}{24\tan(30^\circ)}} \qquad (6)$$

Table 6.Half-distance values (L/2) corresponding to given water to pin ratios (w/p)

w/p	0.102658	1	2	3	4	5	6	7	8	9
L/2, cm	0.4318	0.58154	0.71223	0.82242	0.91949	1.00725	1.08796	1.16307	1.23363	1.30036

The water to pin ratio (w/p) equal to 0.102658 in Table 6 corresponds to the maximum densely packed fuel when the half-distance L/2 in the hexagonal fuel array is the same as the outside fuel clad radius R_c or $D_c/2$.

Results

The k_{eff} values were calculated for both models (one and two drums) and all enrichments (5%, 4% and 3.327%) using MCNP 4A code. Tables 7, 8 and 9 show the neutron multiplication factors for 5%, 4% and 3.327% enrichments, respectively. Figures 2, 3, and 4 plot the calculated $k_{eff} + 2\sigma$ values for 5%, 4% and 3.327% enrichments, respectively.

Table 7. MCNP calculated neutron multiplication factors k_{eff} with their standard deviations σ for 5% enriched fuel

	one 30 gallon drum			two 30 gallon drums		
w/p	k_{eff}	σ	$k_{eff} + 2\sigma$	k_{eff}	σ	$k_{eff} + 2\sigma$
0.1	0.5269	0.0008	0.5285	0.5612	0.0007	0.5627
1	0.9512	0.0013	0.9537	0.9903	0.0013	0.9928
2	1.0436	0.0012	1.0460	1.0769	0.0012	1.0792
3	1.0499	0.0012	1.0523	1.0849	0.0011	1.0872
4	1.0363	0.0012	1.0387	1.0669	0.0011	1.0690
5	-	-	-	1.0369	0.001	1.0390
6	-	-	-	1.0042	0.001	1.0061
7	-	-	-	0.9718	0.001	0.9739
8	-	-	-	0.9406	0.001	0.9426
9	-	-	-	0.9078	0.0009	0.9096

Table 8. MCNP calculated neutron multiplication factors k_{eff} with their standard deviations σ for 4% enriched fuel

	one 30 gallon drum			two 30 gallon drums		
w/p	k_{eff}	σ	$k_{eff} + 2\sigma$	k_{eff}	σ	$k_{eff} + 2\sigma$
0.1	0.4842	0.0009	0.4859	0.5180	0.0008	0.5196
1	0.9089	0.0013	0.9115	0.9446	0.0013	0.9472
2	0.9910	0.0012	0.9934	1.0245	0.0011	1.0268
3	0.9961	0.0012	0.9984	1.0237	0.0011	1.0260
4	0.9743	0.0010	0.9763	1.0031	0.0011	1.0053

Table 8. MCNP calculated neutron multiplication factors k_{eff} with their standard deviations σ for 3.327% enriched fuel

	one 30 gallon drum			two 30 gallon drums		
w/p	k_{eff}	σ	$k_{eff} + 2\sigma$	k_{eff}	σ	$k_{eff} + 2\sigma$
0.1	0.4544	0.0007	0.4557	0.4849	0.0007	0.4863
1	0.8685	0.0012	0.8708	0.9042	0.0011	0.9063
2	0.9452	0.0012	0.9476	0.975	0.0011	0.9772
3	0.9456	0.001	0.9476	0.9703	0.001	0.9722
4	0.9204	0.0011	0.9226	0.9475	0.001	0.9494

URS

Sheet No. 8/9
Calc. No. BUF-2000-067
Rev. No. 1

Job No 30822-244-023 /7150 Job: HEC Support Activities By IVC Date 03/27/01
Client WVNS Subject: drums with damp fuel Chk'd. KR Date 3/27/01

Figure 2. $k_\infty + 2\sigma$ values for 5% enriched fuel

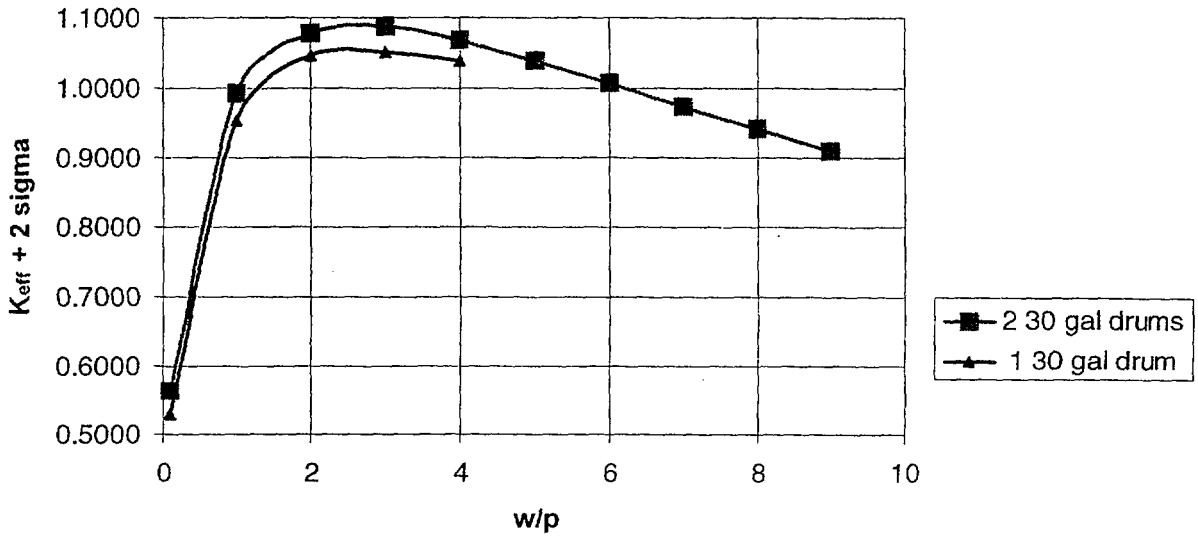


Figure 3. $k_\infty + 2\sigma$ values 4% enriched fuel

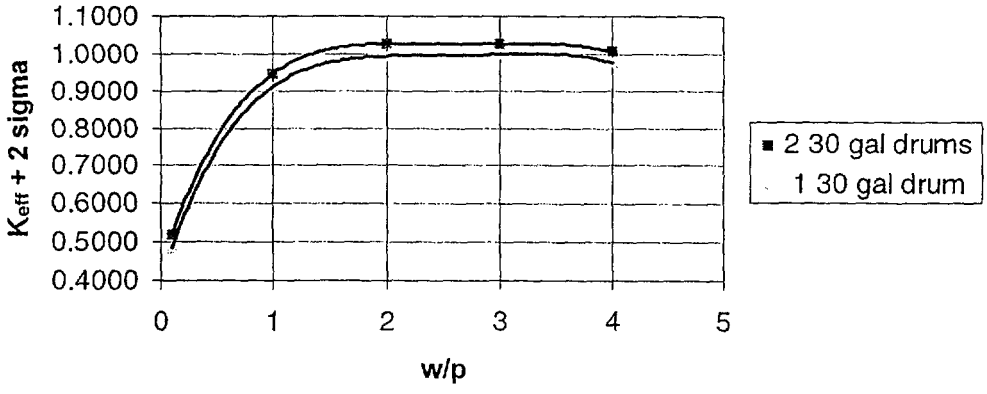
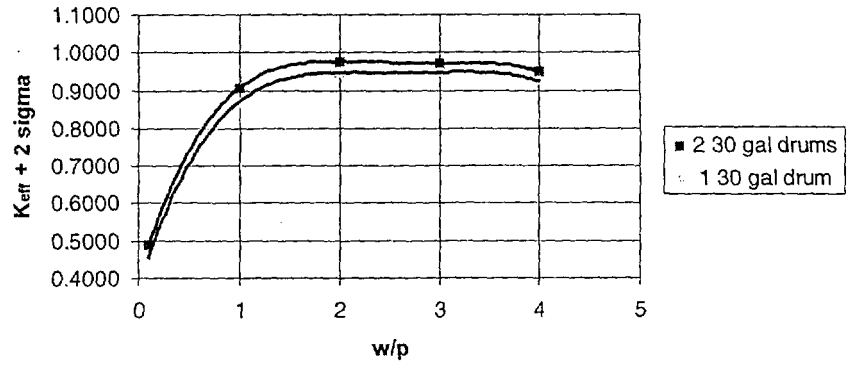


Figure 4. $k_\infty + 2\sigma$ values 3.327% enriched fuel



The criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq k_a - \Delta k_b - \sigma_b \qquad (7)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

σ = standard deviation of predicted k_∞

$k_a = 0.95$ = established allowable limiting neutron multiplication factor

Δk_b = calculation method bias

σ_b = bias uncertainty

For this case, calculation method bias together with bias uncertainty ($\Delta k_b + \sigma_b$) is equal to 0.02. Thus the criterion for the safe geometry is:

$$k_\infty + 2\sigma \leq 0.93 \qquad (8)$$

Where:

k_∞= neutron multiplication factor predicted by MCNP

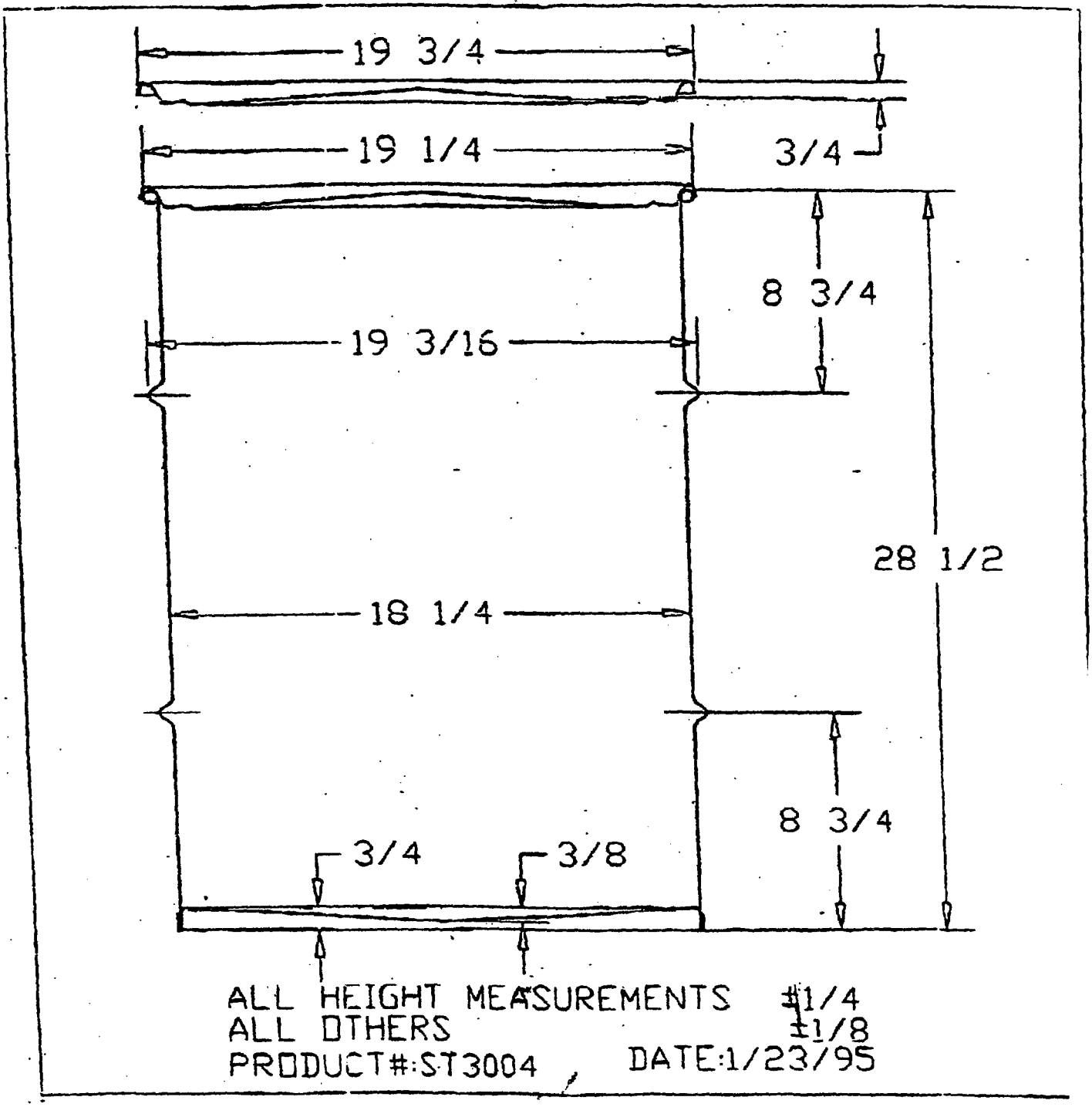
σ = standard deviation of predicted k_∞

As it can be seen from the data in Tables 7, 8 and 9, and Figures 2, 3 and 4 the criterion 8 is not met though one drum with 4% enriched fuel and both cases with 3.327% enriched fuel appear to be sub-critical.

Attachment 1: 30 gallon drum dimensions

COPY

30 GAL 1.5/1.2/1.2mm OPEN HEAD DRUM
UN 1A2/Y1.5/150

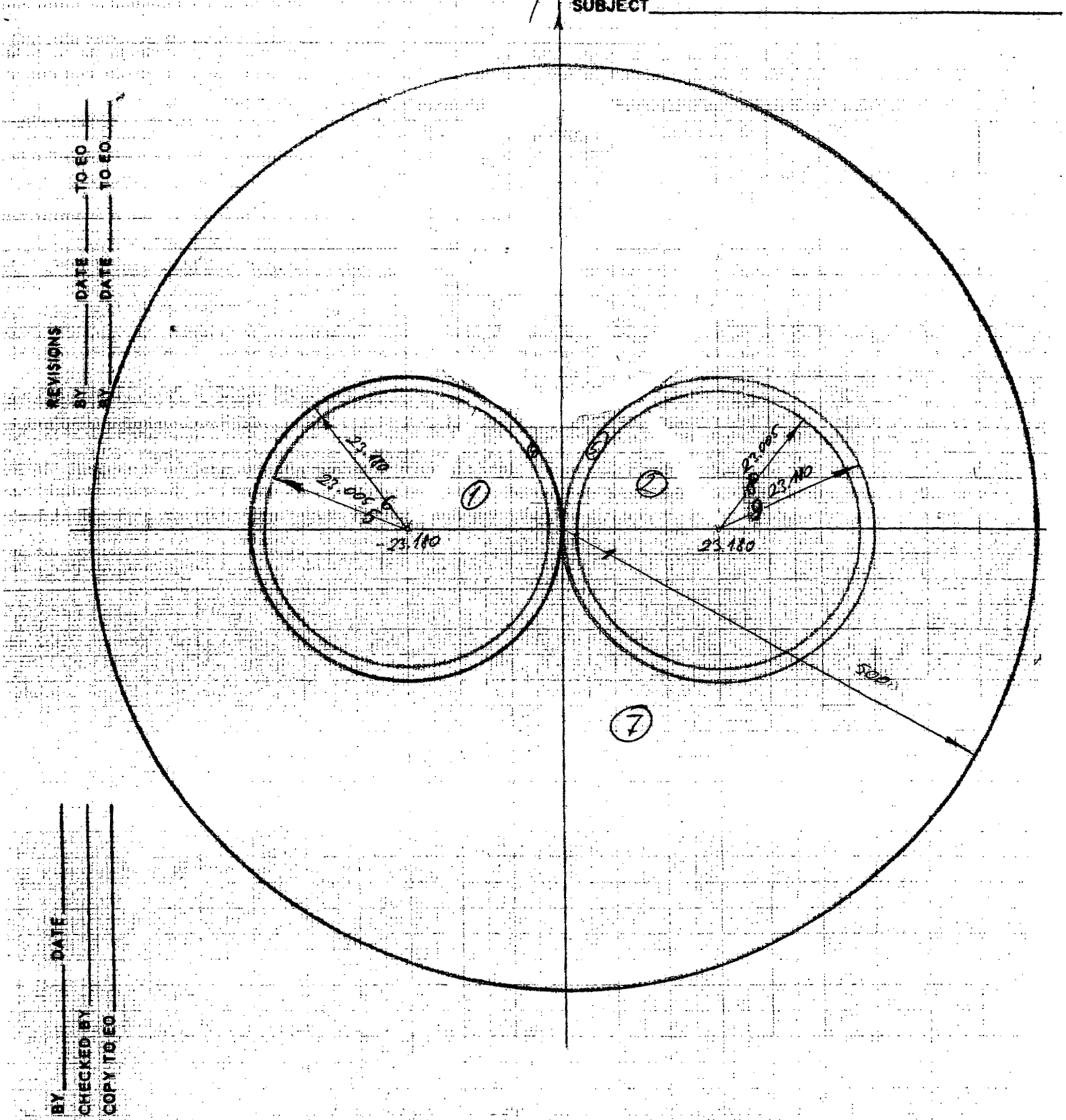


ALL HEIGHT MEASUREMENTS ±1/4
ALL OTHERS ±1/8
PRODUCT#:ST3004 DATE:1/23/95

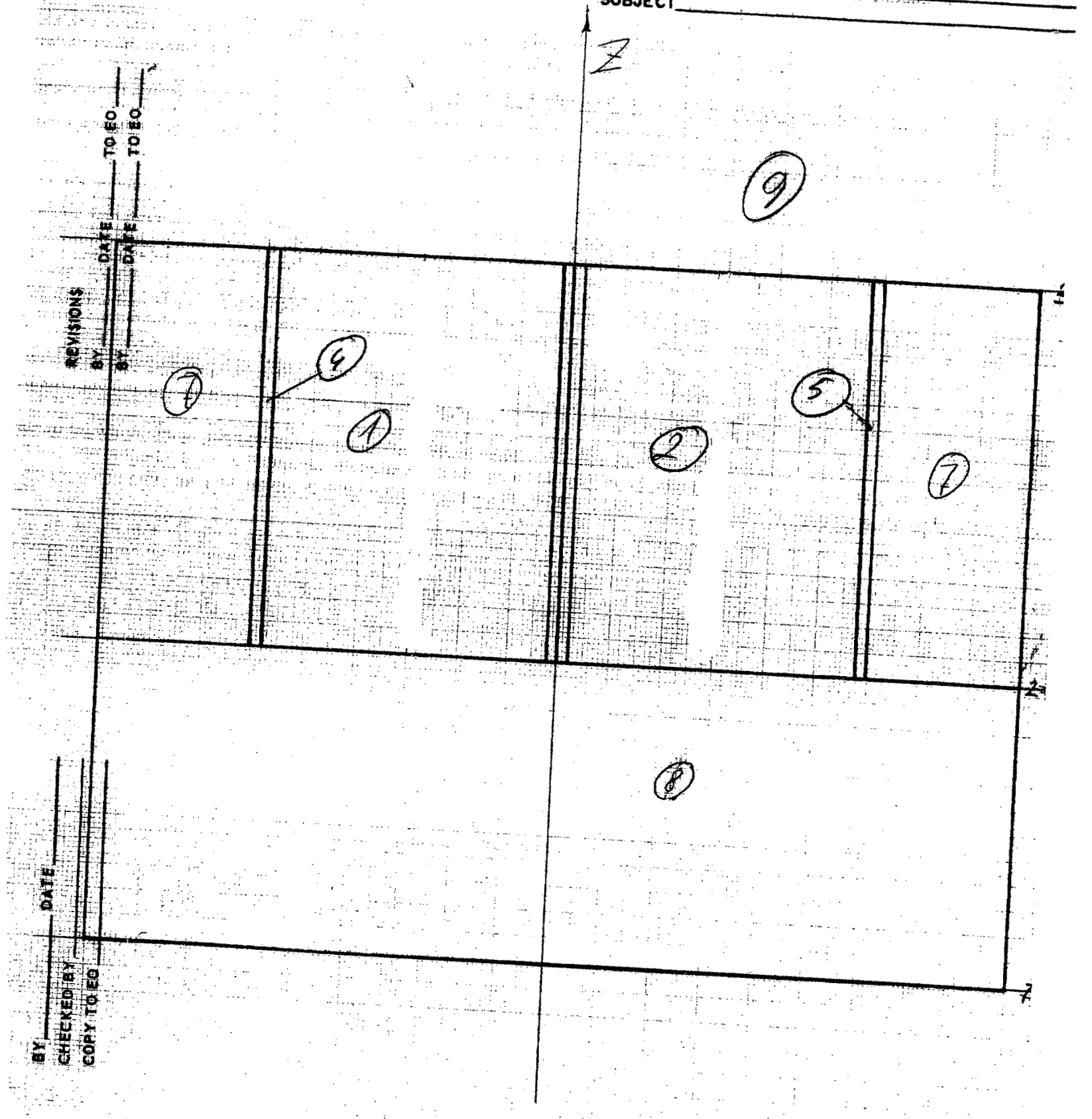
SKOLNIK INDUSTRIES,INC

Attachment 2: Case 1 with MCNP surface and cell numbers

FILE
SUBJECT



FILE
SUBJECT



Attachment 3: Case 1 MCNP input file

10253

```
WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c Drum filling universe:
c
11  0        -11 12 -13 14 -15 16 u=1
                 lat=2 fill=2 imp:n=1 $ Hexagonal lattice
12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
14 63 -1.0   18 u=2           imp:n=1 $ water in the lattice cell
c ------------------------------------------------------------------------
c
1  0  2 -3 -5  fill=1  imp:n=1 $ 1st drum filled with fuel lattice
2  0  2 -3 -8  fill=1  imp:n=1 $ 2nd drum filled with fuel lattice
c
4  65  -7.82       5 -6 2 -3    imp:n=1 $ 1st drum wall
5  65  -7.82       8 -9 2 -3    imp:n=1 $ 2nd drum wall
c
7  64 -0.001293  -1 6 9  2 -3   imp:n=1 $ air ouside the drums
8  67 -2.35      -1  -2 7       imp:n=1 $  concrete floor
9  0              1 : -7 : 3    imp:n=0 $ Outside world
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
1  cz 500      $ system cylinder
2  pz 0        $ drum bottom plane
3  pz 72.39    $ drum top plane
5  c/z -23.181 0 23.005  $ internal wall of the 1st drum
6  c/z -23.181 0 23.180  $ external wall of the 1st drum
7  pz -3000    $ concrete bottom plane
8  c/z 23.181 0 23.005  $ internal wall of the 2nd drum
9  c/z 23.181 0 23.180  $ external wall of the 2nd drum
c
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.581537
12 p 0.8660254 -0.5 0 -0.581537
13 p 0.8660254  0.5 0  0.581537
14 p 0.8660254  0.5 0 -0.581537
15 py  0.581537
16 py -0.581537
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 4% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185712
      92235.50c -0.0348303
      92238.50c -0.8465985
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
      24000.50c -0.19
      25055.50c -0.02
      26000.55c -0.68
      28000.50c -0.10
c Water (H, O)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64    6000.50c -0.000124
```

```
       7014.50c -0.755267
       8016.50c -0.231781
      18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65    6000.50c -0.005
      26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67    1001.50c -0.006
       8016.50c -0.5
      11023.50c -0.017
      13027.50c -0.048
      14000.50c -0.315
      19000.50c -0.019
      20000.50c -0.083
      26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 4: Case 1 MCNP output file

```
lmcnp     version 4a    ld=10/01/93                    06/07/00 16:29:57
*************************************************************************          probid =   06/07/00 16:29:57
 name=10253

      WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside
      C The drum height is 28 1/2 inches (72.39 cm)
      c drum wall thickness is 0.157 cm
      c
      C Cell cards
      C
      C ---------------------------------------------------------------------
      c Drum filling universe:
      c
      11  0         -11 12 -13 14 -15 16 u=1
                        lat=2 fill=2 imp:n=1 $ Hexagonal lattice
      12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
      13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
      14 63 -1.0  18 u=2            imp:n=1 $ water in the lattice cell
      c ---------------------------------------------------------------------
      c
      1  0  2 -3 -5  fill=1  imp:n=1 $ 1st drum filled with fuel lattice
      2  0  2 -3 -8  fill=1  imp:n=1 $ 2nd drum filled with fuel lattice
      c
      4  65  -7.82      5 -6 2 -3    imp:n=1 $ 1st drum wall
      5  65  -7.82      8 -9 2 -3    imp:n=1 $ 2nd drum wall
      c
      7  64 -0.001293  -1 6 9  2 -3   imp:n=1 $ air ouside the drums
      8  67 -2.35      -1  -2 7       imp:n=1 $  concrete floor
      9  0              1 : -7 : 3    imp:n=0 $ Outside world
      C ---------------------------------------------------------------------
      c
      c Note: next line must be completely blank

      c Surface cards
      C ---------------------------------------------------------------------
      1  cz 500     $ system cylinder
      2  pz 0       $ drum bottom plane
      3  pz 72.39   $ drum top plane
      5  c/z -23.181 0 23.005  $ internal wall of the 1st drum
      6  c/z -23.181 0 23.180  $ external wall of the 1st drum
      7  pz -3000   $ concrete bottom plane
      8  c/z 23.181 0 23.005  $ internal wall of the 2nd drum
      9  c/z 23.181 0 23.180  $ external wall of the 2nd drum
      c
      c begin the lattice surfaces
      11 p 0.8660254 -0.5 0  0.581537
      12 p 0.8660254 -0.5 0 -0.581537
      13 p 0.8660254  0.5 0  0.581537
      14 p 0.8660254  0.5 0 -0.581537
      15 py  0.581537
      16 py -0.581537
      c end of lattice surfaces
      c
      17 cz 0.3785 $ fuel wall cylinder
      18 cz 0.4318 $ clad outer wall cylinder
      c
      c
      C ---------------------------------------------------------------------
```

```
   55-       c
   56-       c Note: next line must be completely blank
   57-
   58-       c Data cards
   59-       c
   60-       c Materials
   61-       c
   62-       c
   63-       c Fresh Yankee fuel 4% enrichment (O-16, U-235, U-238)
   64-       m61     8016.50c -0.1185712
   65-             92235.50c -0.0348303
   66-             92238.50c -0.8465985
   67-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
   68-       m62   14000.50c -0.01
   69-             24000.50c -0.19
   70-             25055.50c -0.02
   71-             26000.55c -0.68
   72-             28000.50c -0.10
   73-       c Water (H, O)
   74-       m63     1001.50c 0.66667
   75-             8016.50c 0.33333
   76-       mt63 lwtr.01t
   77-       c Air (C, N, O, Ar) composition from Attix p.523
   78-       m64     6000.50c -0.000124
   79-             7014.50c -0.755267
   80-             8016.50c -0.231781
   81-            18000.35c -0.012828
   82-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
   83-       m65     6000.50c -0.005
   84-            26000.55c -0.995
   85-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
   86-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
   87-       c adjusted to sum to unity without minor trace elements)
   88-       m67     1001.50c -0.006
   89-             8016.50c -0.5
   90-            11023.50c -0.017
   91-            13027.50c -0.048
   92-            14000.50c -0.315
   93-            19000.50c -0.019
   94-            20000.50c -0.083
   95-            26000.55c -0.012
   96-       c
   97-       mode n
   98-       print 40 60 80 100 110 126
   99-       kcode 4000 1. 20 120
  100-       ksrc  0 0 10
  101-
 total fission nubar data are being used.
1material composition                                                    print table 40

 material
  number      component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01333      92238,  0.31989
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
```

```
    64          6000,  0.00015      7014,  0.78443      8016,  0.21075      18000,  0.00467
    65          6000,  0.02283     26000,  0.97717
    67          1001,  0.11082      8016,  0.58191     11023,  0.01377      13027,  0.03312
               14000,  0.20878     19000,  0.00905     20000,  0.03855      26000,  0.00400
```

```
 material
  number      component nuclide, mass fraction

    61          8016,  0.11857     92235,  0.03483     92238,  0.84660
    62         14000,  0.01000     24000,  0.19000     25055,  0.02000      26000,  0.68000
               28000,  0.10000
    63          1001,  0.11192      8016,  0.88808
    64          6000,  0.00012      7014,  0.75527      8016,  0.23178      18000,  0.01283
    65          6000,  0.00500     26000,  0.99500
    67          1001,  0.00600      8016,  0.50000     11023,  0.01700      13027,  0.04800
               14000,  0.31500     19000,  0.01900     20000,  0.08300      26000,  0.01200
1cells                                                                      print table 60

                        atom        gram                                        neutron
       cell  mat      density     density      volume        mass        pieces importance

    1    11    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    2    12   61  6.96288E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
    3    13   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    4    14  63s 1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    5     1    0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00      1  1.0000E+00
    6     2    0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00      1  1.0000E+00
    7     4   65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04      1  1.0000E+00
    8     5   65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04      1  1.0000E+00
    9     7   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
   10     8   67  7.60226E-02 2.35000E+00 2.35619E+09 5.53706E+09      1  1.0000E+00
   11     9    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  0.0000E+00

 total                                    2.35644E+09 5.53709E+09
1cross-section tables                                                       print table 100

     table    length

                        tables from file critxs

  1001.50c    1153  njoy                                                ( 1301)      79/07/31.
  6000.50c   16126  njoy                                                ( 1306)      79/07/31.
  7014.50c   22772  njoy                                                ( 1275)      79/09/08.
  8016.50c   23669  njoy                                                ( 1276)     05/14/81
 11023.50c   36270  njoy                                                ( 1311)      79/06/21.
 13027.50c   22891  njoy                                                ( 1313)      79/09/08.
 14000.50c   48275  njoy                                                ( 1314)      79/06/21.
 18000.35c    2182       endl85                                          ( 18)       11/01/85
 19000.50c    9766  njoy                                                ( 1150)      79/10/29.
 20000.50c   26104  njoy                                                ( 1320)      79/06/22.
 24000.50c   89104  njoy                                                ( 1324)      79/06/21.
 25055.50c   60097  njoy                                                ( 1325)      79/06/21.
 26000.55c   84136  njoy                                                ( 260)      10/21/82
 28000.50c   82267  njoy                                                ( 1328)      79/06/21.
```

```
 92235.50c   44188  njoy                                                  total nu              (  1395)      79/09/12.
 92238.50c   66440  njoy                                                  total nu              (  1398)      79/09/13.
  lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                          1001     0     010/22/85

 total       645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general              114712
     tallies                   0
     bank                  12403
     cross sections       645633

     total                772748

 ********************************************************************************************************************
 dump no.     1 on file 10253r       nps =          0     coll =              0     ctm =     0.00     nrn =               0


 source distribution written to file 10253s          cycle =      0

          1 warning message so far.
1    starting mcrun.       field length =       0      cp0 =  0.02                                        print table 110

      WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside

 nps    x           y           z        cell lattice(i,j,k)  surface    u           v           w         energy     weight      time

   1  0.000E+00   0.000E+00   1.000E+01     7                      0   5.085E-01   4.733E-01   7.193E-01  2.209E+00  1.000E+00  0.000E+00
   2  0.000E+00   0.000E+00   1.000E+01     7                      0   8.952E-01  -4.447E-01  -2.944E-02  4.904E+00  1.000E+00  0.000E+00
   3  0.000E+00   0.000E+00   1.000E+01     7                      0  -6.184E-01  -4.495E-01   6.446E-01  3.809E-01  1.000E+00  0.000E+00
   4  0.000E+00   0.000E+00   1.000E+01     7                      0   9.710E-01  -5.665E-02  -2.323E-01  1.331E+00  1.000E+00  0.000E+00
   5  0.000E+00   0.000E+00   1.000E+01     7                      0   5.861E-01   1.496E-01  -7.963E-01  1.902E+00  1.000E+00  0.000E+00
   6  0.000E+00   0.000E+00   1.000E+01     7                      0  -6.489E-02  -1.626E-01   9.845E-01  4.410E-01  1.000E+00  0.000E+00
   7  0.000E+00   0.000E+00   1.000E+01     7                      0  -7.068E-02   3.263E-02  -9.970E-01  4.750E-01  1.000E+00  0.000E+00
   8  0.000E+00   0.000E+00   1.000E+01     7                      0  -3.915E-01   4.664E-01  -7.932E-01  4.136E+00  1.000E+00  0.000E+00
   9  0.000E+00   0.000E+00   1.000E+01     7                      0  -2.368E-01   9.215E-01  -3.079E-01  7.453E-02  1.000E+00  0.000E+00
  10  0.000E+00   0.000E+00   1.000E+01     7                      0   1.946E-01  -3.204E-01   9.271E-01  3.128E+00  1.000E+00  0.000E+00
  11  0.000E+00   0.000E+00   1.000E+01     7                      0  -6.698E-01  -7.177E-01  -1.905E-01  1.014E+00  1.000E+00  0.000E+00
  12  0.000E+00   0.000E+00   1.000E+01     7                      0  -8.398E-01  -4.129E-01   3.524E-01  1.395E+00  1.000E+00  0.000E+00
  13  0.000E+00   0.000E+00   1.000E+01     7                      0  -1.714E-01  -8.572E-01   4.857E-01  7.748E-01  1.000E+00  0.000E+00
  14  0.000E+00   0.000E+00   1.000E+01     7                      0  -2.489E-01  -5.118E-01  -8.222E-01  1.101E+00  1.000E+00  0.000E+00
  15  0.000E+00   0.000E+00   1.000E+01     7                      0  -2.959E-01   2.119E-01   9.314E-01  1.951E+00  1.000E+00  0.000E+00
  16  0.000E+00   0.000E+00   1.000E+01     7                      0   1.395E-01  -9.829E-01   1.202E-01  2.186E+00  1.000E+00  0.000E+00
  17  0.000E+00   0.000E+00   1.000E+01     7                      0   6.909E-01  -7.110E-01   1.307E-01  1.865E+00  1.000E+00  0.000E+00
  18  0.000E+00   0.000E+00   1.000E+01     7                      0  -6.580E-01   5.320E-01  -5.329E-01  1.229E+00  1.000E+00  0.000E+00
  19  0.000E+00   0.000E+00   1.000E+01     7                      0  -9.903E-01  -1.380E-01   1.353E-02  1.305E+00  1.000E+00  0.000E+00
  20  0.000E+00   0.000E+00   1.000E+01     7                      0   7.462E-01   4.859E-01  -4.551E-01  1.000E+00  1.000E+00  0.000E+00
  21  0.000E+00   0.000E+00   1.000E+01     7                      0  -1.977E-01   9.797E-01   3.360E-02  3.990E+00  1.000E+00  0.000E+00
  22  0.000E+00   0.000E+00   1.000E+01     7                      0  -9.117E-01  -3.647E-01  -1.891E-01  2.665E-01  1.000E+00  0.000E+00
  23  0.000E+00   0.000E+00   1.000E+01     7                      0  -4.287E-01   8.361E-01  -3.423E-01  1.156E+00  1.000E+00  0.000E+00
  24  0.000E+00   0.000E+00   1.000E+01     7                      0   1.080E-01   3.412E-01  -9.338E-01  2.669E+00  1.000E+00  0.000E+00
  25  0.000E+00   0.000E+00   1.000E+01     7                      0  -9.111E-01  -9.012E-03  -4.122E-01  2.185E+00  1.000E+00  0.000E+00
  26  0.000E+00   0.000E+00   1.000E+01     7                      0  -2.568E-01  -6.391E-01  -7.249E-01  4.225E+00  1.000E+00  0.000E+00
  27  0.000E+00   0.000E+00   1.000E+01     7                      0  -2.912E-01   8.086E-01   5.113E-01  1.079E+00  1.000E+00  0.000E+00
  28  0.000E+00   0.000E+00   1.000E+01     7                      0   1.472E-01  -9.514E-01   2.705E-01  3.461E+00  1.000E+00  0.000E+00
```

```
 29  0.000E+00  0.000E+00  1.000E+01    7                    0 -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
 30  0.000E+00  0.000E+00  1.000E+01    7                    0 -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
 31  0.000E+00  0.000E+00  1.000E+01    7                    0 -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
 32  0.000E+00  0.000E+00  1.000E+01    7                    0 -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
 33  0.000E+00  0.000E+00  1.000E+01    7                    0 -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
 34  0.000E+00  0.000E+00  1.000E+01    7                    0  4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
 35  0.000E+00  0.000E+00  1.000E+01    7                    0 -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
 36  0.000E+00  0.000E+00  1.000E+01    7                    0  3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
 37  0.000E+00  0.000E+00  1.000E+01    7                    0 -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
 38  0.000E+00  0.000E+00  1.000E+01    7                    0 -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
 39  0.000E+00  0.000E+00  1.000E+01    7                    0  9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
 40  0.000E+00  0.000E+00  1.000E+01    7                    0  2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
 41  0.000E+00  0.000E+00  1.000E+01    7                    0 -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
 42  0.000E+00  0.000E+00  1.000E+01    7                    0  5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
 43  0.000E+00  0.000E+00  1.000E+01    7                    0  6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
 44  0.000E+00  0.000E+00  1.000E+01    7                    0 -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
 45  0.000E+00  0.000E+00  1.000E+01    7                    0 -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
 46  0.000E+00  0.000E+00  1.000E+01    7                    0  1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
 47  0.000E+00  0.000E+00  1.000E+01    7                    0  7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
 48  0.000E+00  0.000E+00  1.000E+01    7                    0  4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
 49  0.000E+00  0.000E+00  1.000E+01    7                    0  5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
 50  0.000E+00  0.000E+00  1.000E+01    7                    0 -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
lestimated keff results by cycle                                                                    print table 175

 source distribution written to file 10253s          cycle =    20

 source distribution written to file 10253s          cycle =    25

 source distribution written to file 10253s          cycle =    30

 source distribution written to file 10253s          cycle =    35

 source distribution written to file 10253s          cycle =    40

 source distribution written to file 10253s          cycle =    45

 source distribution written to file 10253s          cycle =    50

 source distribution written to file 10253s          cycle =    55

 source distribution written to file 10253s          cycle =    60

 source distribution written to file 10253s          cycle =    65

 ************************************************************************************************************************
 dump no.     2 on file 10253r        nps =     264057     coll =        8967687     ctm =    15.07     nrn =      139111012


 source distribution written to file 10253s          cycle =    70

 source distribution written to file 10253s          cycle =    75

 source distribution written to file 10253s          cycle =    80

 source distribution written to file 10253s          cycle =    85

 source distribution written to file 10253s          cycle =    90
```

source distribution written to file 10253s cycle = 95

estimator	cycle 100	ave of 80 cycles	combination	simple average	combined average	corr
k(collision)	0.940637	0.944241 0.0017	k(col/abs)	0.944279 0.0016	0.944279 0.0016	0.6856
k(absorption)	0.943162	0.944317 0.0017	k(abs/tk ln)	0.944216 0.0015	0.944230 0.0016	0.4579
k(trk length)	0.939228	0.944114 0.0019	k(tk ln/col)	0.944177 0.0017	0.944196 0.0017	0.7250
rem life(col)	3.8571E+03	3.7465E+03 0.0073	k(col/abs/tk ln)	0.944224 0.0015	0.944235 0.0016	
rem life(abs)	3.8517E+03	3.7488E+03 0.0070	life(col/abs)	3.7477E+03 0.0071	3.7503E+03 0.0070	0.9845

source points generated 4042

source distribution written to file 10253s cycle = 100

source distribution written to file 10253s cycle = 105

source distribution written to file 10253s cycle = 110

source distribution written to file 10253s cycle = 115

estimator	cycle 116	ave of 96 cycles	combination	simple average	combined average	corr
k(collision)	0.947860	0.944911 0.0016	k(col/abs)	0.944616 0.0014	0.944595 0.0014	0.6742
k(absorption)	0.934496	0.944321 0.0016	k(abs/tk ln)	0.944650 0.0014	0.944560 0.0014	0.4685
k(trk length)	0.935425	0.944978 0.0018	k(tk ln/col)	0.944945 0.0016	0.944928 0.0016	0.7522
rem life(col)	3.7942E+03	3.7292E+03 0.0065	k(col/abs/tk ln)	0.944737 0.0014	0.944614 0.0014	
rem life(abs)	3.7796E+03	3.7306E+03 0.0063	life(col/abs)	3.7299E+03 0.0064	3.7313E+03 0.0063	0.9840

source points generated 3969

estimator	cycle 117	ave of 97 cycles	combination	simple average	combined average	corr
k(collision)	0.956671	0.945032 0.0016	k(col/abs)	0.944775 0.0014	0.944762 0.0014	0.6768
k(absorption)	0.963528	0.944519 0.0016	k(abs/tk ln)	0.944703 0.0014	0.944657 0.0014	0.4563
k(trk length)	0.936136	0.944887 0.0018	k(tk ln/col)	0.944960 0.0016	0.944993 0.0016	0.7442
rem life(col)	3.5482E+03	3.7274E+03 0.0065	k(col/abs/tk ln)	0.944813 0.0014	0.944723 0.0014	
rem life(abs)	3.5204E+03	3.7285E+03 0.0063	life(col/abs)	3.7279E+03 0.0064	3.7290E+03 0.0063	0.9840

source points generated 4002

estimator	cycle 118	ave of 98 cycles	combination	simple average	combined average	corr
k(collision)	0.940149	0.944982 0.0016	k(col/abs)	0.944698 0.0014	0.944685 0.0014	0.6771
k(absorption)	0.934215	0.944413 0.0015	k(abs/tk ln)	0.944548 0.0014	0.944513 0.0014	0.4605
k(trk length)	0.924848	0.944683 0.0018	k(tk ln/col)	0.944833 0.0016	0.944905 0.0015	0.7424
rem life(col)	3.8217E+03	3.7283E+03 0.0064	k(col/abs/tk ln)	0.944693 0.0014	0.944610 0.0014	
rem life(abs)	3.8135E+03	3.7293E+03 0.0062	life(col/abs)	3.7288E+03 0.0063	3.7298E+03 0.0062	0.9840

source points generated 3880

estimator	cycle 119	ave of 99 cycles	combination	simple average	combined average	corr
k(collision)	0.930308	0.944834 0.0016	k(col/abs)	0.944617 0.0014	0.944603 0.0014	0.6746
k(absorption)	0.942989	0.944399 0.0015	k(abs/tk ln)	0.944541 0.0014	0.944504 0.0014	0.4605
k(trk length)	0.944673	0.944683 0.0018	k(tk ln/col)	0.944758 0.0015	0.944793 0.0015	0.7386
rem life(col)	4.0637E+03	3.7317E+03 0.0064	k(col/abs/tk ln)	0.944639 0.0014	0.944567 0.0014	
rem life(abs)	4.0014E+03	3.7321E+03 0.0062	life(col/abs)	3.7319E+03 0.0063	3.7323E+03 0.0062	0.9840

source points generated 3978

estimator	cycle 120	ave of 100 cycles	combination	simple average	combined average	corr
k(collision)	0.944201	0.944828 0.0015	k(col/abs)	0.944623 0.0014	0.944611 0.0014	0.6745
k(absorption)	0.946396	0.944419 0.0015	k(abs/tk ln)	0.944595 0.0014	0.944548 0.0014	0.4605
k(trk length)	0.953435	0.944770 0.0017	k(tk ln/col)	0.944799 0.0015	0.944812 0.0015	0.7373
rem life(col)	3.5605E+03	3.7300E+03 0.0064	k(col/abs/tk ln)	0.944672 0.0014	0.944599 0.0014	
rem life(abs)	3.5998E+03	3.7307E+03 0.0061	life(col/abs)	3.7304E+03 0.0062	3.7312E+03 0.0061	0.9840

source points generated 4093

source distribution written to file 10253s cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

06/07/00 16:57:20

+ WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside probid = 06/07/00 16:29:57

0

neutron creation	tracks	weight (per source particle)	energy	neutron loss	tracks	weight (per source particle)	energy
source	479938	1.0001E+00	2.0280E+00	escape	113122	2.0642E-01	1.7679E-01
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	4.5204E-02	4.0265E-05	weight cutoff	367592	4.5146E-02	1.6126E-05
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	4.7286E-08	downscattering	0	0.	1.7146E+00
				capture	0	4.1219E-01	3.8657E-02
(n,xn)	1548	2.5037E-03	1.8597E-03	loss to (n,xn)	772	1.2486E-03	1.0480E-02
fission	0	0.	0.	loss to fission	0	3.8283E-01	8.9362E-02
total	481486	1.0478E+00	2.0299E+00	total	481486	1.0478E+00	2.0299E+00

number of neutrons banked	776	average lifetime, shakes		cutoffs
neutron tracks per source particle	1.0032E+00	escape	6.5705E+03	tco 1.0000E+34
neutron collisions per source particle	3.3618E+01	capture	3.1746E+03	eco 0.0000E+00
total neutron collisions	16134352	capture or escape	3.8745E+03	wc1 -5.0000E-01
net multiplication	1.0013E+00 0.0001	any termination	4.3618E+03	wc2 -2.5000E-01

computer time so far in this run	27.38 minutes	maximum number ever in bank	2
computer time in mcrun	27.37 minutes	bank overflows to backup file	0
source particles per minute	1.7538E+04	field length	0
random numbers generated	250232612	most random numbers used was	12109 in history 370136

range of sampled source weights = 9.2614E-01 to 1.0920E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions • weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	12	8356906	480564	2791743	4.8919E+00	1.5352E-03	7.7791E-01	8.7838E-01	2.6306E+00
3	13	16897479	479297	1161180	2.0103E+00	1.3469E-03	7.4892E-01	8.7637E-01	2.5615E+00
4	14	22434377	479079	9014091	1.5118E+01	1.1971E-03	7.3018E-01	8.7635E-01	1.7865E+00
5	1	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	2	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7	4	126023	90389	23697	4.0878E-02	2.0666E-03	8.8906E-01	8.8784E-01	3.5270E+00
8	5	130568	94382	24453	4.2255E-02	2.0620E-03	8.8347E-01	8.8750E-01	3.5151E+00
9	7	230383	144745	6061	1.0453E-02	1.7543E-03	9.1074E-01	8.8331E-01	6.2488E+03
10	8	94730	77642	3113127	4.2302E+00	1.1597E-04	3.2915E-01	6.8734E-01	2.9017E+00
total		48270466	1846098	16134352	2.6344E+01				

1keff results for: WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside probid = 06/07/00 16:29:57

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79823 neutron histories and 100 active cycles with 400115 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 479938 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

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the final estimated combined collision/absorption/track-length keff = 0.94460 with an estimated standard deviation of 0.00130

the estimated 68, 95, & 99 percent keff confidence intervals are 0.94330 to 0.94590, 0.94201 to 0.94719, and 0.94117 to 0.94803

the estimated collision/absorption neutron removal lifetime = 3.73E-05 seconds with an estimated standard deviation of 2.29E-07

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the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.94483	0.00145	0.94337 to 0.94628	0.94193 to 0.94773	0.94098 to 0.94867	
absorption	0.94442	0.00143	0.94299 to 0.94585	0.94158 to 0.94726	0.94065 to 0.94819	
track length	0.94477	0.00165	0.94312 to 0.94642	0.94149 to 0.94805	0.94041 to 0.94913	
col/absorp	0.94461	0.00133	0.94328 to 0.94594	0.94197 to 0.94725	0.94111 to 0.94811	0.6745
abs/trk len	0.94455	0.00130	0.94324 to 0.94585	0.94195 to 0.94715	0.94110 to 0.94799	0.4605
col/trk len	0.94481	0.00143	0.94338 to 0.94624	0.94196 to 0.94766	0.94104 to 0.94859	0.7373
col/abs/trk len	0.94460	0.00130	0.94330 to 0.94590	0.94201 to 0.94719	0.94117 to 0.94803	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.94525	0.00150	0.94374 to 0.94675	0.94226 to 0.94823	0.94128 to 0.94921
absorption	0.94474	0.00145	0.94329 to 0.94619	0.94186 to 0.94762	0.94091 to 0.94856
track length	0.94529	0.00171	0.94358 to 0.94701	0.94188 to 0.94871	0.94077 to 0.94982
col/abs/trk len	0.94498	0.00135	0.94363 to 0.94632	0.94230 to 0.94766	0.94142 to 0.94853

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	3.7312E-05	2.2882E-07	3.7083E-05 to 3.7541E-05	3.6856E-05 to 3.7768E-05	3.6707E-05 to 3.7916E-05
capture	3.0298E-05	2.2605E-07	3.0071E-05 to 3.0524E-05	2.9847E-05 to 3.0748E-05	2.9700E-05 to 3.0895E-05
fission	1.6982E-05	5.5966E-08	1.6926E-05 to 1.7038E-05	1.6870E-05 to 1.7093E-05	1.6834E-05 to 1.7130E-05

escape 6.3758E-05 6.0255E-07 6.3154E-05 to 6.4361E-05 6.2557E-05 to 6.4958E-05 6.2166E-05 to 6.5350E-05

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col) st dev	k(abs) st dev	k(trk) st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t) st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.9448 0.0015	0.9444 0.0014	0.9448 0.0016	95/95/95	0.94460 0.00130	0.94201-0.94719	0.94117-0.94803
2	50	0.9448 0.0013	0.9444 0.0013	0.9448 0.0016	95/95/95	0.94462 0.00119	0.94222-0.94702	0.94141-0.94782
4	25	0.9448 0.0013	0.9444 0.0014	0.9448 0.0015	95/95/99	0.94466 0.00126	0.94205-0.94728	0.94111-0.94822
5	20	0.9448 0.0012	0.9444 0.0013	0.9448 0.0015	95/95/95	0.94466 0.00126	0.94200-0.94732	0.94101-0.94831
10	10	0.9448 0.0012	0.9444 0.0013	0.9448 0.0013	95/95/95	0.94467 0.00122	0.94178-0.94755	0.94040-0.94894
20	5	0.9448 0.0014	0.9444 0.0015	0.9448 0.0019	95/95/95	0.94501 0.00177	0.93739-0.95263	0.92743-0.96259
25	4	0.9448 0.0017	0.9444 0.0018	0.9448 0.0014	95/95/95	0.94443 0.00235	0.91454-0.97433	0.79471-1.09416

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll) st dev	k(abs) st dev	k(track) st dev	average k(c/a/t) k(c/a/t) st dev	fom
1	4000	0.92018	0.90561	0.91812					
2	3663	0.90982	0.90622	0.92375					
3	3901	0.92952	0.91404	0.92148					
4	4160	0.92869	0.93307	0.93513					
5	3999	0.90947	0.93027	0.90266					
6	3975	0.94145	0.92231	0.94579					
7	4112	0.91214	0.91664	0.92057					
8	3871	0.93508	0.96572	0.92667					
9	4095	0.95234	0.95346	0.93934					
10	4058	0.92532	0.94327	0.92870					
11	3915	0.96075	0.96056	0.95162					
12	4104	0.93173	0.92924	0.92301					
13	3875	0.94191	0.93120	0.94157					
14	4124	0.93591	0.94347	0.93214					
15	4015	0.93484	0.94916	0.92607					
16	3987	0.96131	0.97064	0.96418					
17	4088	0.94880	0.94500	0.94542					
18	3954	0.96055	0.93922	0.96906					
19	4103	0.91967	0.93435	0.89922					
20	3824	0.94304	0.94694	0.92161					
		begin active keff cycles							
21	4113	0.94172	0.95714	0.93071					
22	3964	0.94408	0.94352	0.96638	0.94290 0.00118	0.95033 0.00681	0.94855 0.01783		
23	4011	0.90696	0.91577	0.92542	0.93092 0.01200	0.93881 0.01217	0.94084 0.01286		
24	3900	0.98705	0.97092	0.98241	0.94495 0.01640	0.94684 0.01177	0.95123 0.01381	0.95510 0.00961	10946
25	4319	0.95537	0.95268	0.96518	0.94704 0.01287	0.94800 0.00919	0.95402 0.01105	0.95611 0.00653	18712
26	3865	0.93323	0.92977	0.93326	0.94474 0.01076	0.94497 0.00810	0.95056 0.00967	0.95004 0.00828	9657
27	3897	0.98086	0.96494	0.97548	0.94990 0.01045	0.94782 0.00741	0.95412 0.00891	0.94985 0.00654	13254
28	4228	0.90501	0.90561	0.92548	0.94429 0.01065	0.94254 0.00831	0.95054 0.00851	0.94848 0.00711	9775
29	3678	0.92279	0.93067	0.91922	0.94190 0.00969	0.94122 0.00745	0.94706 0.00827	0.94590 0.00615	11661
30	4048	0.95027	0.94713	0.95332	0.94274 0.00871	0.94181 0.00669	0.94769 0.00742	0.94606 0.00543	13441
31	4143	0.96427	0.96280	0.95106	0.94469 0.00812	0.94372 0.00634	0.94799 0.00672	0.94631 0.00461	16935
32	4059	0.93033	0.91959	0.94416	0.94350 0.00751	0.94171 0.00613	0.94767 0.00614	0.94539 0.00473	14672
33	3812	0.94657	0.93688	0.94156	0.94373 0.00691	0.94134 0.00565	0.94720 0.00567	0.94378 0.00470	13763
34	4127	0.95380	0.96063	0.94145	0.94445 0.00644	0.94272 0.00541	0.94679 0.00527	0.94452 0.00416	16269
35	4028	0.94260	0.94702	0.96029	0.94433 0.00599	0.94301 0.00504	0.94769 0.00499	0.94579 0.00427	14436
36	4039	0.95649	0.95575	0.97269	0.94509 0.00566	0.94380 0.00478	0.94925 0.00492	0.94686 0.00442	12668
37	4119	0.96106	0.94929	0.95781	0.94603 0.00540	0.94413 0.00451	0.94976 0.00465	0.94660 0.00417	13379

38	3983	0.93150	0.93295	0.93460	0.94522	0.00515	0.94350	0.00429	0.94892	0.00446	0.94595	0.00397	13971
39	3858	0.94580	0.92646	0.93726	0.94525	0.00487	0.94261	0.00416	0.94830	0.00426	0.94473	0.00420	11789
40	4027	0.92955	0.93527	0.92216	0.94446	0.00469	0.94224	0.00396	0.94700	0.00425	0.94366	0.00395	12661
41	3931	0.93993	0.95647	0.94313	0.94425	0.00447	0.94292	0.00383	0.94681	0.00405	0.94470	0.00375	13367
42	4090	0.94203	0.93664	0.94196	0.94415	0.00426	0.94263	0.00366	0.94659	0.00387	0.94435	0.00360	13846
43	3929	0.93820	0.94131	0.95480	0.94389	0.00408	0.94258	0.00350	0.94695	0.00371	0.94460	0.00349	14129
44	3991	0.92843	0.93803	0.94454	0.94325	0.00396	0.94239	0.00336	0.94685	0.00355	0.94470	0.00336	14571
45	3969	0.96811	0.96337	0.95301	0.94424	0.00392	0.94322	0.00333	0.94709	0.00342	0.94523	0.00319	15583
46	4108	0.94780	0.94998	0.95288	0.94438	0.00377	0.94348	0.00321	0.94732	0.00329	0.94553	0.00308	15975
47	3908	0.94280	0.94442	0.94850	0.94432	0.00363	0.94352	0.00309	0.94736	0.00317	0.94563	0.00297	16544
48	3973	0.93783	0.94242	0.94161	0.94409	0.00351	0.94348	0.00297	0.94716	0.00306	0.94559	0.00285	17251
49	3978	0.95010	0.95972	0.94910	0.94429	0.00339	0.94404	0.00292	0.94722	0.00295	0.94611	0.00277	17695
50	4001	0.96291	0.97120	0.96907	0.94491	0.00333	0.94495	0.00297	0.94795	0.00294	0.94702	0.00286	16099
51	4138	0.95649	0.97077	0.97306	0.94529	0.00324	0.94578	0.00299	0.94876	0.00296	0.94767	0.00298	14332
52	3999	0.92688	0.92739	0.92969	0.94471	0.00319	0.94520	0.00295	0.94816	0.00293	0.94707	0.00295	14103
53	3832	0.92587	0.93926	0.91462	0.94414	0.00315	0.94502	0.00286	0.94715	0.00301	0.94630	0.00289	14305
54	4085	0.93292	0.94255	0.92847	0.94381	0.00307	0.94495	0.00278	0.94660	0.00298	0.94603	0.00281	14689
55	4031	0.98239	0.94339	0.97374	0.94491	0.00318	0.94491	0.00270	0.94737	0.00299	0.94611	0.00270	15432
56	4199	0.94239	0.94222	0.92892	0.94484	0.00309	0.94483	0.00262	0.94686	0.00295	0.94574	0.00261	15975
57	3800	0.96437	0.94403	0.97998	0.94537	0.00305	0.94481	0.00255	0.94776	0.00301	0.94589	0.00257	16040
58	4055	0.94908	0.96958	0.93994	0.94547	0.00297	0.94546	0.00257	0.94755	0.00293	0.94642	0.00252	16321
59	3906	0.96559	0.97181	0.96415	0.94599	0.00294	0.94614	0.00259	0.94798	0.00289	0.94705	0.00252	15839
60	4042	0.95718	0.94456	0.93759	0.94626	0.00288	0.94610	0.00253	0.94772	0.00283	0.94679	0.00245	16401
61	4038	0.93743	0.93678	0.93241	0.94605	0.00282	0.94587	0.00247	0.94734	0.00278	0.94648	0.00240	16615
62	3887	0.95474	0.93294	0.94480	0.94626	0.00276	0.94556	0.00243	0.94728	0.00272	0.94621	0.00236	16817
63	4150	0.95891	0.94173	0.94973	0.94655	0.00271	0.94547	0.00238	0.94734	0.00265	0.94615	0.00230	17175
64	3977	0.94290	0.94230	0.93649	0.94647	0.00265	0.94540	0.00232	0.94709	0.00260	0.94600	0.00225	17564
65	3914	0.95370	0.97674	0.93214	0.94663	0.00259	0.94610	0.00238	0.94676	0.00257	0.94636	0.00221	17888
66	4085	0.93012	0.94039	0.93044	0.94627	0.00256	0.94597	0.00233	0.94641	0.00254	0.94614	0.00217	18149
67	3851	0.94296	0.95023	0.95234	0.94620	0.00251	0.94606	0.00228	0.94653	0.00249	0.94626	0.00212	18511
68	4074	0.95000	0.95530	0.93271	0.94628	0.00246	0.94626	0.00224	0.94624	0.00245	0.94625	0.00208	18946
69	4007	0.94375	0.94731	0.95567	0.94623	0.00241	0.94628	0.00219	0.94644	0.00241	0.94635	0.00204	19309
70	3974	0.96506	0.95824	0.95338	0.94660	0.00239	0.94652	0.00216	0.94658	0.00236	0.94654	0.00200	19577
71	4111	0.94637	0.93139	0.93812	0.94660	0.00234	0.94622	0.00214	0.94641	0.00232	0.94628	0.00198	19591
72	3957	0.93884	0.92468	0.94405	0.94645	0.00230	0.94581	0.00214	0.94636	0.00228	0.94604	0.00196	19593
73	3980	0.93779	0.93336	0.95239	0.94629	0.00226	0.94557	0.00211	0.94648	0.00224	0.94596	0.00193	19941
74	3996	0.93574	0.95070	0.92702	0.94609	0.00223	0.94567	0.00207	0.94612	0.00222	0.94585	0.00189	20335
75	3948	0.95832	0.95655	0.96862	0.94631	0.00220	0.94586	0.00205	0.94653	0.00222	0.94614	0.00188	20214
76	4054	0.94276	0.93602	0.95795	0.94625	0.00216	0.94569	0.00202	0.94673	0.00219	0.94613	0.00185	20549
77	3995	0.92232	0.92836	0.90980	0.94583	0.00216	0.94538	0.00200	0.94608	0.00225	0.94565	0.00187	19736
78	3922	0.94284	0.95308	0.95599	0.94578	0.00212	0.94552	0.00197	0.94625	0.00221	0.94580	0.00184	19977
79	4158	0.93862	0.94597	0.93026	0.94566	0.00209	0.94553	0.00194	0.94598	0.00219	0.94570	0.00181	20289
80	3955	0.94131	0.93883	0.94787	0.94558	0.00206	0.94541	0.00191	0.94601	0.00216	0.94564	0.00178	20610
81	4011	0.94673	0.96285	0.93770	0.94560	0.00202	0.94570	0.00190	0.94588	0.00213	0.94577	0.00175	20884
82	3997	0.94253	0.93932	0.96151	0.94555	0.00199	0.94560	0.00187	0.94613	0.00211	0.94580	0.00173	21194
83	3949	0.94704	0.95634	0.93395	0.94558	0.00196	0.94577	0.00185	0.94594	0.00208	0.94583	0.00170	21582
84	4026	0.94825	0.94742	0.94205	0.94562	0.00193	0.94579	0.00182	0.94588	0.00205	0.94582	0.00167	21949
85	4019	0.93320	0.94455	0.92451	0.94543	0.00191	0.94577	0.00179	0.94555	0.00204	0.94568	0.00165	22134
86	3917	0.95162	0.95430	0.94819	0.94552	0.00188	0.94590	0.00177	0.94559	0.00201	0.94578	0.00163	22418
87	4073	0.93792	0.94819	0.92512	0.94541	0.00186	0.94594	0.00174	0.94528	0.00201	0.94569	0.00161	22662
88	3933	0.93171	0.91938	0.93975	0.94521	0.00184	0.94555	0.00176	0.94520	0.00198	0.94540	0.00160	22368
89	3968	0.92631	0.92959	0.92052	0.94493	0.00184	0.94532	0.00175	0.94484	0.00198	0.94513	0.00161	21990
90	3911	0.92640	0.93004	0.92718	0.94467	0.00183	0.94510	0.00174	0.94459	0.00197	0.94490	0.00160	21828

91	4032	0.93766	0.95372	0.96637	0.94457 0.00180	0.94522 0.00172	0.94490 0.00197	0.94505 0.00159	21830
92	3996	0.93838	0.92076	0.93323	0.94448 0.00178	0.94488 0.00173	0.94474 0.00195	0.94478 0.00159	21617
93	4026	0.94250	0.95353	0.94951	0.94446 0.00176	0.94500 0.00171	0.94480 0.00192	0.94485 0.00157	21839
94	4017	0.95624	0.94915	0.94397	0.94462 0.00174	0.94505 0.00169	0.94479 0.00189	0.94491 0.00154	22161
95	4123	0.94753	0.92647	0.93623	0.94465 0.00172	0.94481 0.00168	0.94468 0.00187	0.94474 0.00153	22241
96	4044	0.94846	0.94598	0.93404	0.94470 0.00170	0.94482 0.00166	0.94454 0.00185	0.94471 0.00151	22537
97	4012	0.92854	0.90751	0.94217	0.94449 0.00169	0.94434 0.00171	0.94450 0.00183	0.94442 0.00152	22000
98	3822	0.92605	0.94681	0.92408	0.94426 0.00168	0.94437 0.00169	0.94424 0.00182	0.94431 0.00150	22164
99	3979	0.94649	0.94151	0.93893	0.94429 0.00166	0.94433 0.00167	0.94418 0.00180	0.94427 0.00148	22448
100	4086	0.94064	0.94316	0.93923	0.94424 0.00164	0.94432 0.00165	0.94411 0.00178	0.94424 0.00147	22722
101	4042	0.95457	0.95373	0.95168	0.94437 0.00162	0.94443 0.00163	0.94421 0.00176	0.94435 0.00145	22879
102	4036	0.93563	0.95342	0.94043	0.94426 0.00161	0.94454 0.00161	0.94416 0.00174	0.94436 0.00143	23158
103	3984	0.95894	0.94565	0.95039	0.94444 0.00160	0.94456 0.00159	0.94424 0.00172	0.94443 0.00142	23416
104	4114	0.96772	0.97241	0.97671	0.94472 0.00160	0.94489 0.00161	0.94462 0.00174	0.94477 0.00144	22376
105	4034	0.95250	0.93422	0.97225	0.94481 0.00159	0.94476 0.00160	0.94495 0.00175	0.94483 0.00143	22617
106	4019	0.95445	0.94911	0.94924	0.94492 0.00157	0.94481 0.00158	0.94500 0.00173	0.94489 0.00141	22850
107	3978	0.94805	0.93883	0.94875	0.94496 0.00155	0.94474 0.00156	0.94504 0.00171	0.94488 0.00139	23120
108	4035	0.93612	0.93320	0.94112	0.94486 0.00154	0.94461 0.00155	0.94500 0.00169	0.94478 0.00138	23268
109	3998	0.91408	0.93524	0.91036	0.94451 0.00156	0.94451 0.00153	0.94461 0.00172	0.94454 0.00139	22838
110	3903	0.94336	0.94216	0.94084	0.94450 0.00154	0.94448 0.00152	0.94457 0.00170	0.94451 0.00137	23101
111	4179	0.95668	0.94529	0.95635	0.94463 0.00153	0.94449 0.00150	0.94469 0.00169	0.94458 0.00136	23292
112	3972	0.92991	0.93789	0.93378	0.94447 0.00152	0.94442 0.00149	0.94458 0.00167	0.94448 0.00135	23426
113	3867	0.96003	0.95553	0.94504	0.94464 0.00152	0.94454 0.00147	0.94458 0.00165	0.94457 0.00134	23585
114	4071	0.97355	0.96015	0.99767	0.94495 0.00153	0.94470 0.00147	0.94515 0.00173	0.94486 0.00136	22616
115	4097	0.93874	0.91803	0.93881	0.94488 0.00152	0.94442 0.00148	0.94508 0.00171	0.94469 0.00136	22393
116	3800	0.94786	0.93450	0.93543	0.94491 0.00150	0.94432 0.00147	0.94498 0.00170	0.94461 0.00134	22558
117	3969	0.95667	0.96353	0.93614	0.94503 0.00149	0.94452 0.00147	0.94489 0.00168	0.94472 0.00133	22672
118	4002	0.94015	0.93421	0.92485	0.94498 0.00148	0.94441 0.00146	0.94468 0.00168	0.94461 0.00133	22699
119	3880	0.93031	0.94299	0.94467	0.94483 0.00147	0.94440 0.00144	0.94468 0.00166	0.94457 0.00131	22956
120	3978	0.94420	0.94640	0.95344	0.94483 0.00145	0.94442 0.00143	0.94477 0.00165	0.94460 0.00130	23192

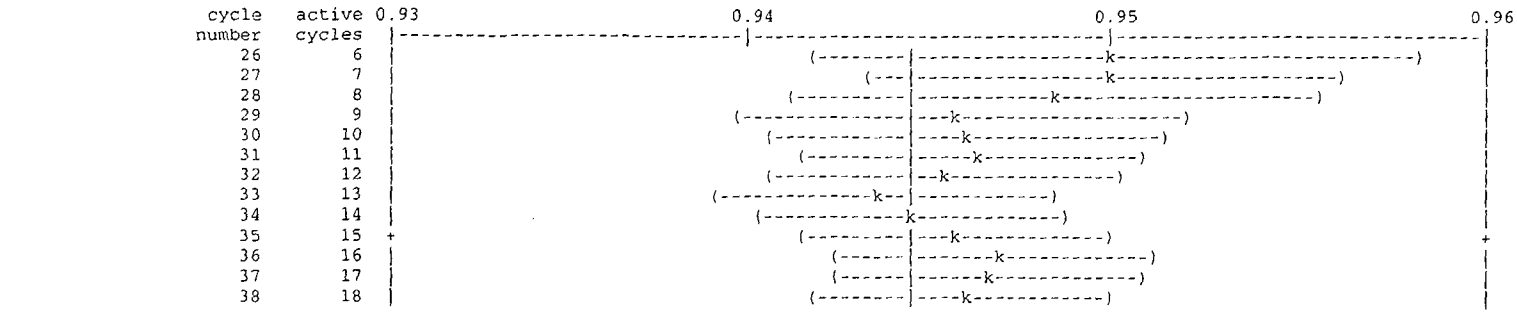
the largest active cycle keffs by estimator are:

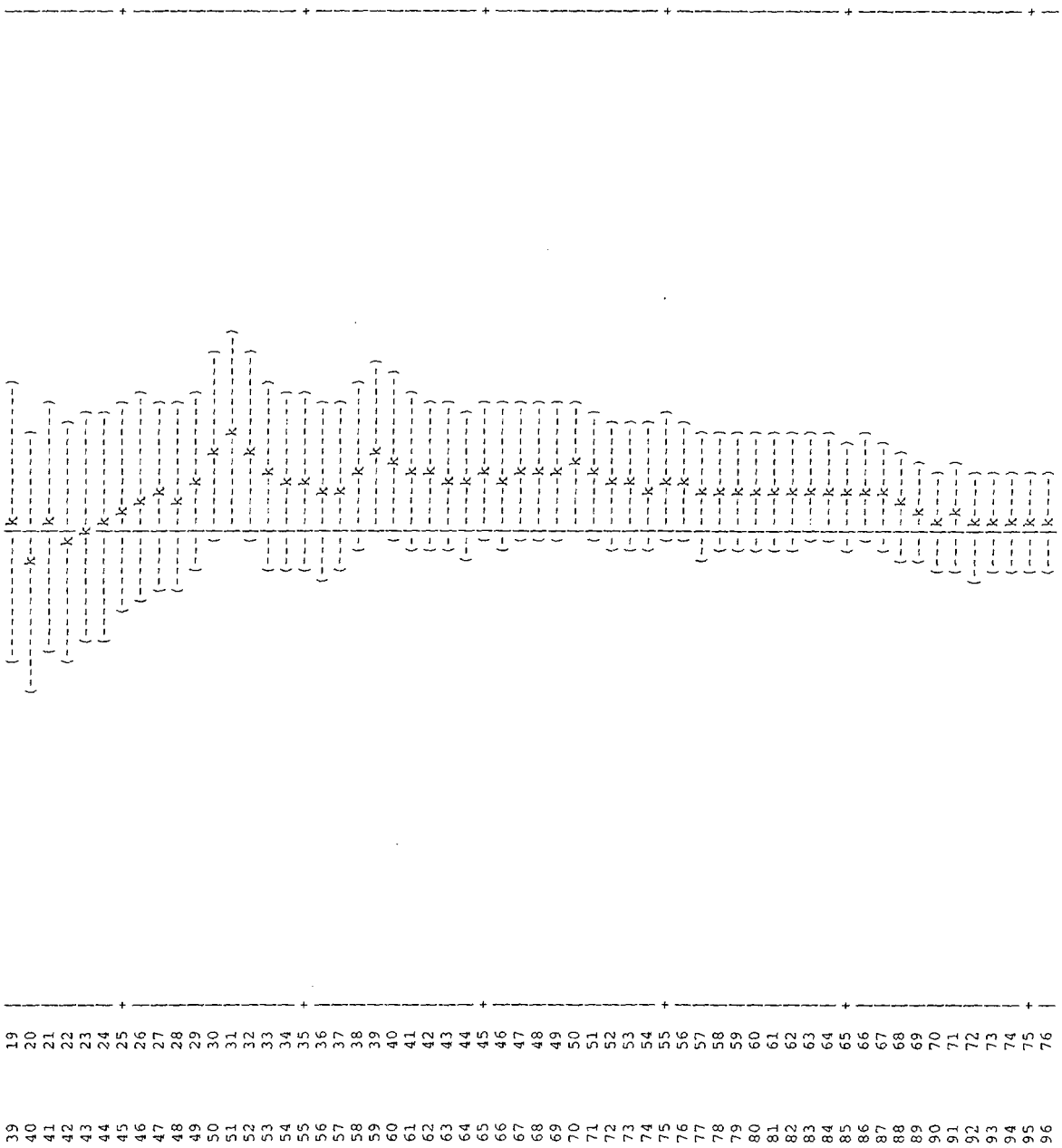
collision 0.98705 on cycle 24
absorption 0.97674 on cycle 65
track length 0.99767 on cycle 114

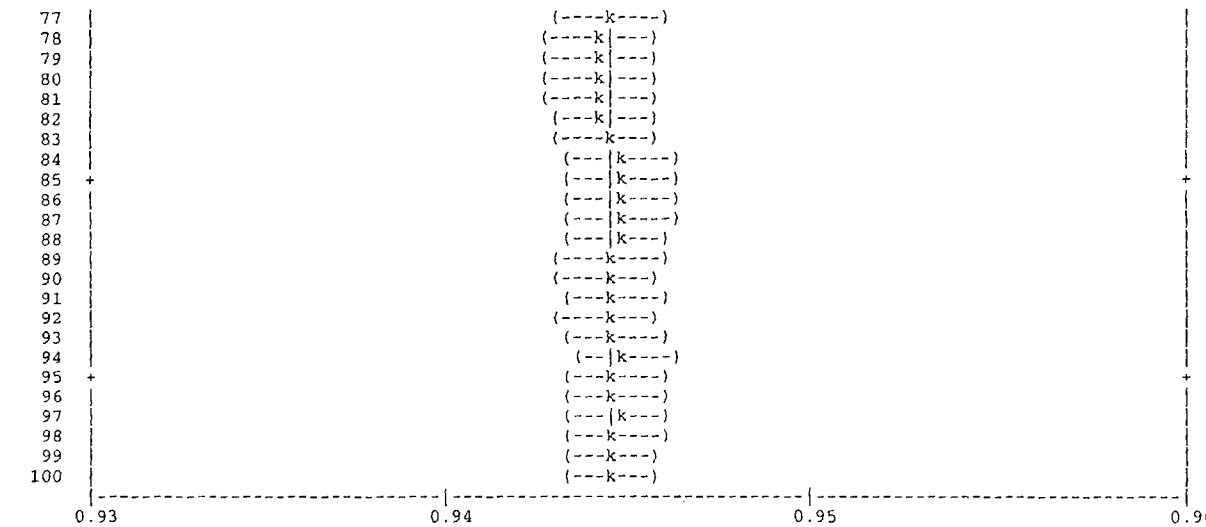
the smallest active cycle keffs by estimator are:

collision 0.90501 on cycle 28
absorption 0.90561 on cycle 28
track length 0.90980 on cycle 77

lplot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.94460)







lindividual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	479938	0.9432	0.0014	0.9432	0.0014	0.9426	0.0016	95/95/95	0.94305	0.00126	0.94053-0.94557	0.93971-0.94639
1	119	475938	0.9434	0.0014	0.9435	0.0014	0.9428	0.0016	95/95/95	0.94331	0.00125	0.94083-0.94579	0.94002-0.94660
2	118	472275	0.9437	0.0014	0.9438	0.0013	0.9430	0.0016	95/95/95	0.94360	0.00123	0.94116-0.94605	0.94036-0.94685
3	117	468374	0.9438	0.0014	0.9441	0.0013	0.9432	0.0016	95/95/95	0.94381	0.00122	0.94138-0.94624	0.94059-0.94703
4	116	464214	0.9439	0.0014	0.9442	0.0013	0.9432	0.0016	95/95/95	0.94391	0.00123	0.94147-0.94635	0.94067-0.94715
5	115	460215	0.9442	0.0014	0.9443	0.0013	0.9436	0.0016	95/95/95	0.94411	0.00122	0.94169-0.94654	0.94090-0.94733
6	114	456240	0.9443	0.0014	0.9445	0.0013	0.9436	0.0016	95/95/95	0.94422	0.00122	0.94178-0.94666	0.94099-0.94745
7	113	452128	0.9445	0.0014	0.9447	0.0013	0.9438	0.0016	95/95/95	0.94448	0.00121	0.94207-0.94689	0.94128-0.94767
8	112	448257	0.9446	0.0014	0.9445	0.0013	0.9439	0.0016	95/95/95	0.94443	0.00122	0.94200-0.94686	0.94121-0.94765
9	111	444162	0.9446	0.0014	0.9445	0.0013	0.9440	0.0016	95/95/95	0.94438	0.00123	0.94194-0.94683	0.94114-0.94763
10	110	440104	0.9447	0.0014	0.9445	0.0013	0.9441	0.0016	95/95/95	0.94446	0.00124	0.94200-0.94693	0.94119-0.94773
11	109	436189	0.9446	0.0014	0.9443	0.0013	0.9440	0.0016	95/95/95	0.94434	0.00124	0.94186-0.94681	0.94106-0.94762
12	108	432085	0.9447	0.0014	0.9445	0.0014	0.9442	0.0016	95/95/95	0.94448	0.00124	0.94200-0.94695	0.94119-0.94776
13	107	428210	0.9447	0.0014	0.9446	0.0014	0.9442	0.0017	95/95/95	0.94455	0.00125	0.94206-0.94705	0.94125-0.94786
14	106	424086	0.9448	0.0014	0.9446	0.0014	0.9444	0.0017	95/95/95	0.94460	0.00126	0.94209-0.94712	0.94127-0.94794
15	105	420071	0.9449	0.0014	0.9446	0.0014	0.9445	0.0017	95/95/95	0.94464	0.00128	0.94210-0.94718	0.94127-0.94801
16	104	416084	0.9448	0.0014	0.9443	0.0014	0.9443	0.0017	95/95/95	0.94442	0.00127	0.94189-0.94694	0.94106-0.94777
17	103	411996	0.9447	0.0014	0.9443	0.0014	0.9443	0.0017	95/95/95	0.94440	0.00128	0.94185-0.94695	0.94102-0.94779
18	102	408042	0.9446	0.0014	0.9443	0.0014	0.9441	0.0017	95/95/95	0.94434	0.00129	0.94177-0.94692	0.94093-0.94776
19	101	403939	0.9448	0.0014	0.9444	0.0014	0.9445	0.0016	95/95/95	0.94455	0.00129	0.94199-0.94711	0.94115-0.94795
20	100*	400115	0.9448	0.0015	0.9444	0.0014	0.9448	0.0016	95/95/95	0.94460	0.00130	0.94201-0.94719	0.94117-0.94803
22	98	392038	0.9449	0.0015	0.9443	0.0014	0.9447	0.0017	95/95/95	0.94452	0.00133	0.94188-0.94716	0.94102-0.94802
24	96	384127	0.9448	0.0014	0.9443	0.0014	0.9445	0.0016	95/95/95	0.94452	0.00127	0.94199-0.94705	0.94116-0.94788
26	94	375943	0.9448	0.0014	0.9444	0.0014	0.9444	0.0017	95/95/95	0.94453	0.00128	0.94197-0.94709	0.94114-0.94792
28	92	367818	0.9449	0.0013	0.9446	0.0014	0.9443	0.0016	95/95/95	0.94466	0.00121	0.94225-0.94708	0.94146-0.94787

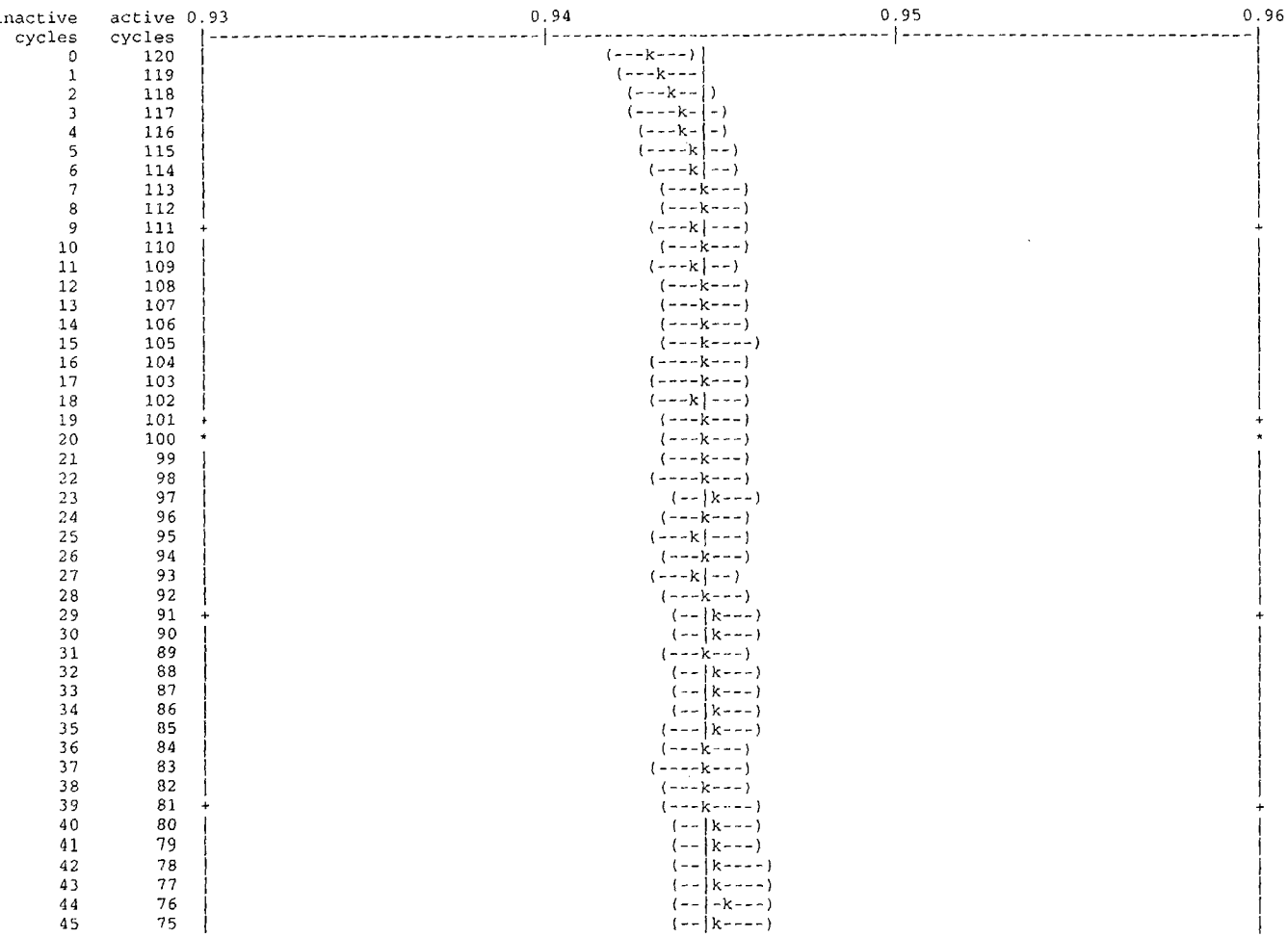
30	90	360092	0.9451	0.0013	0.9447	0.0014	0.9444	0.0017	95/95/95	0.94482	0.00122	0.94239-0.94725	0.94160-0.94805
32	88	351890	0.9450	0.0013	0.9448	0.0014	0.9444	0.0017	95/95/95	0.94485	0.00122	0.94242-0.94727	0.94163-0.94806
34	86	343951	0.9449	0.0014	0.9447	0.0014	0.9444	0.0017	95/95/95	0.94476	0.00124	0.94230-0.94723	0.94149-0.94803
36	84	335884	0.9448	0.0014	0.9445	0.0014	0.9439	0.0017	95/95/95	0.94457	0.00126	0.94206-0.94708	0.94124-0.94790
38	82	327782	0.9447	0.0014	0.9446	0.0015	0.9439	0.0018	95/95/95	0.94459	0.00127	0.94205-0.94713	0.94122-0.94796
40	80	319897	0.9449	0.0014	0.9450	0.0015	0.9442	0.0018	95/95/95	0.94485	0.00129	0.94228-0.94742	0.94144-0.94826
42	78	311876	0.9450	0.0014	0.9449	0.0015	0.9443	0.0018	95/95/95	0.94488	0.00132	0.94225-0.94751	0.94139-0.94837
44	76	303956	0.9453	0.0015	0.9451	0.0016	0.9441	0.0019	95/95/95	0.94509	0.00135	0.94239-0.94779	0.94151-0.94867
46	74	295879	0.9450	0.0015	0.9447	0.0016	0.9439	0.0019	95/95/95	0.94480	0.00136	0.94209-0.94752	0.94120-0.94840
48	72	287998	0.9451	0.0015	0.9448	0.0016	0.9438	0.0020	95/95/95	0.94488	0.00140	0.94209-0.94768	0.94117-0.94859
50	70	280019	0.9448	0.0015	0.9442	0.0016	0.9434	0.0020	95/95/95	0.94440	0.00140	0.94160-0.94719	0.94069-0.94811
52	68	271882	0.9449	0.0015	0.9440	0.0016	0.9432	0.0020	95/95/95	0.94427	0.00139	0.94149-0.94705	0.94058-0.94796
54	66	263965	0.9454	0.0016	0.9441	0.0016	0.9438	0.0020	95/95/99	0.94459	0.00141	0.94177-0.94741	0.94084-0.94834
56	64	255735	0.9448	0.0015	0.9442	0.0017	0.9436	0.0020	95/95/99	0.94443	0.00141	0.94162-0.94725	0.94069-0.94817
58	62	247880	0.9444	0.0015	0.9438	0.0017	0.9431	0.0019	95/95/99	0.94400	0.00142	0.94115-0.94684	0.94021-0.94778
60	60	239932	0.9439	0.0015	0.9433	0.0017	0.9428	0.0020	95/95/99	0.94352	0.00140	0.94070-0.94633	0.93977-0.94726
62	58	232007	0.9438	0.0015	0.9436	0.0017	0.9430	0.0020	95/95/99	0.94361	0.00144	0.94071-0.94650	0.93975-0.94746
64	56	223880	0.9435	0.0016	0.9436	0.0018	0.9429	0.0021	95/95/99	0.94350	0.00149	0.94052-0.94649	0.93953-0.94748
66	54	215881	0.9436	0.0016	0.9431	0.0017	0.9434	0.0022	95/95/95	0.94339	0.00150	0.94037-0.94640	0.93937-0.94740
68	52	207956	0.9435	0.0016	0.9427	0.0018	0.9434	0.0022	95/95/95	0.94318	0.00155	0.94006-0.94630	0.93902-0.94734
70	50	199975	0.9431	0.0017	0.9423	0.0018	0.9430	0.0023	95/95/95	0.94277	0.00157	0.93962-0.94592	0.93856-0.94698
72	48	191907	0.9431	0.0017	0.9429	0.0019	0.9430	0.0024	95/95/95	0.94301	0.00162	0.93975-0.94627	0.93865-0.94736
74	46	183931	0.9433	0.0018	0.9430	0.0019	0.9432	0.0025	95/95/95	0.94318	0.00168	0.93979-0.94658	0.93864-0.94772
76	44	175929	0.9430	0.0018	0.9428	0.0020	0.9423	0.0025	95/95/95	0.94290	0.00173	0.93941-0.94640	0.93823-0.94758
78	42	168012	0.9435	0.0019	0.9429	0.0020	0.9427	0.0025	95/95/99	0.94320	0.00175	0.93966-0.94675	0.93845-0.94795
80	40	159899	0.9437	0.0019	0.9429	0.0021	0.9429	0.0026	95/95/99	0.94332	0.00184	0.93959-0.94706	0.93832-0.94833
82	38	151891	0.9436	0.0020	0.9425	0.0022	0.9426	0.0026	95/95/99	0.94308	0.00194	0.93915-0.94701	0.93781-0.94835
84	36	143916	0.9434	0.0022	0.9420	0.0023	0.9428	0.0028	95/95/99	0.94276	0.00203	0.93862-0.94689	0.93720-0.94831
86	34	135980	0.9435	0.0022	0.9415	0.0024	0.9432	0.0029	95/95/99	0.94262	0.00214	0.93826-0.94698	0.93675-0.94849
88	32	127974	0.9440	0.0023	0.9420	0.0024	0.9439	0.0030	95/95/95	0.94307	0.00221	0.93855-0.94760	0.93697-0.94917
90	30	120095	0.9452	0.0024	0.9428	0.0025	0.9452	0.0031	95/95/99	0.94418	0.00224	0.93958-0.94878	0.93797-0.95039
92	28	112067	0.9457	0.0025	0.9432	0.0025	0.9449	0.0032	95/95/99	0.94444	0.00236	0.93958-0.94930	0.93786-0.95101
94	26	104024	0.9454	0.0027	0.9426	0.0027	0.9447	0.0034	95/95/99	0.94400	0.00254	0.93874-0.94925	0.93687-0.95113
96	24	95857	0.9452	0.0029	0.9431	0.0028	0.9455	0.0036	95/95/99	0.94412	0.00270	0.93851-0.94974	0.93648-0.95177
98	22	88023	0.9468	0.0029	0.9446	0.0026	0.9466	0.0038	95/95/99	0.94537	0.00260	0.93992-0.95083	0.93792-0.95282
100	20	79958	0.9472	0.0032	0.9448	0.0028	0.9474	0.0042	95/95/95	0.94562	0.00288	0.93955-0.95170	0.93727-0.95397
102	18	71880	0.9474	0.0034	0.9439	0.0030	0.9475	0.0047	95/95/95	0.94497	0.00328	0.93799-0.95196	0.93531-0.95464
104	16	63782	0.9454	0.0035	0.9420	0.0029	0.9455	0.0049	95/95/95	0.94273	0.00313	0.93597-0.94949	0.93331-0.95216
106	14	55729	0.9443	0.0040	0.9420	0.0032	0.9434	0.0052	95/95/99	0.94247	0.00348	0.93482-0.95013	0.93167-0.95327
108	12	47716	0.9446	0.0046	0.9430	0.0036	0.9431	0.0061	95/95/95	0.94337	0.00402	0.93428-0.95246	0.93031-0.95643
110	10	39815	0.9478	0.0044	0.9439	0.0043	0.9466	0.0064	95/95/99	0.94573	0.00486	0.93423-0.95723	0.92871-0.96275
112	8	31664	0.9489	0.0049	0.9444	0.0054	0.9470	0.0078	95/95/99	0.94755	0.00609	0.93188-0.96321	0.92298-0.97212
114	6	23726	0.9430	0.0036	0.9399	0.0062	0.9389	0.0039	95/95/95	0.94131	0.00326	0.93093-0.95169	0.92227-0.96036
116	4	15829	0.9428	0.0055	0.9468	0.0061	0.9398	0.0061	95/95/95	0.93996	0.00806	0.83755-1.04238	0.42700-1.45292
117	3	11860	0.9382	0.0041	0.9412	0.0036	0.9410	0.0085					
118	2	7858	0.9373	0.0069	0.9447	0.0017	0.9491	0.0044					

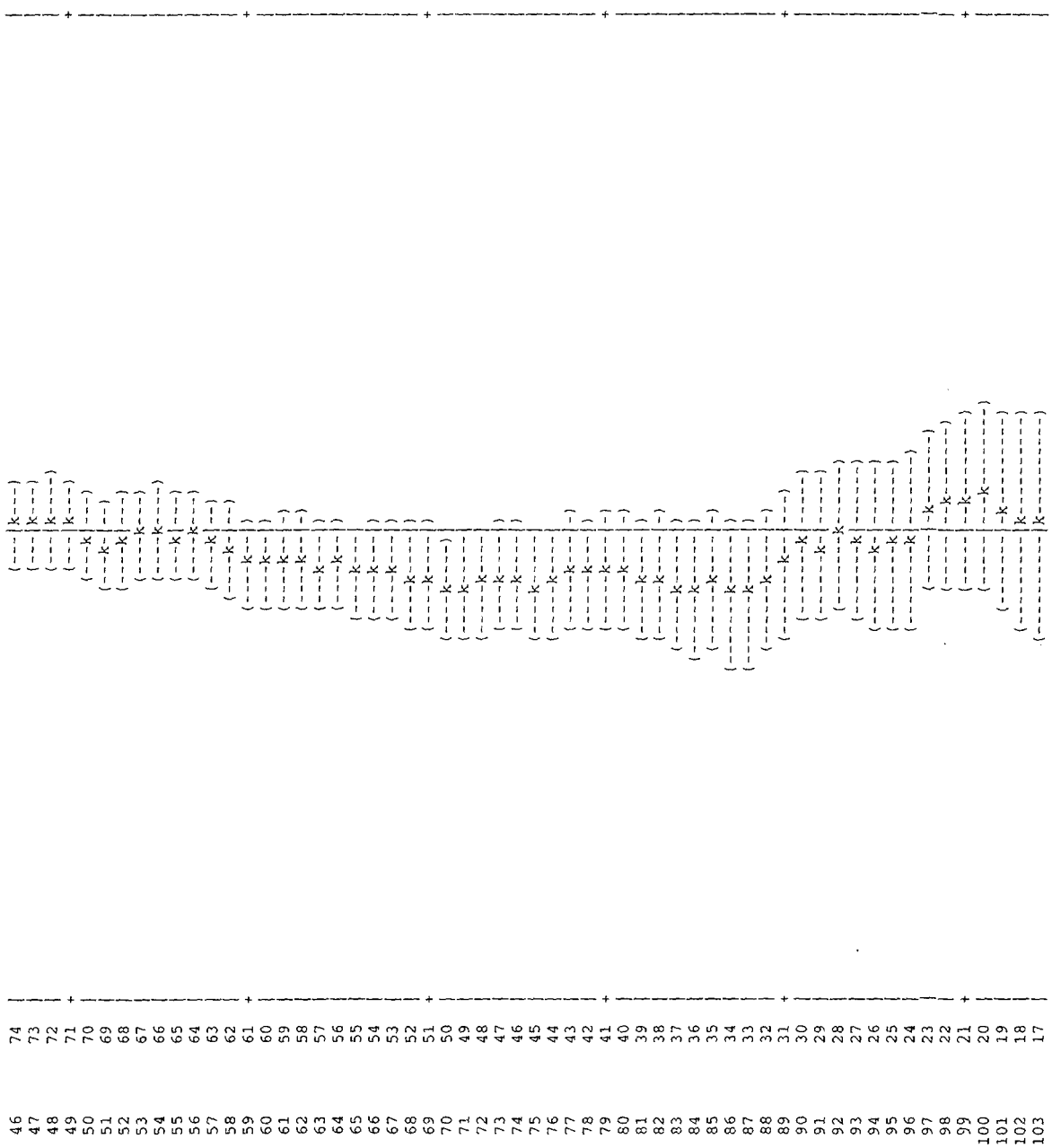
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 29 inactive cycles and 91 active cycles.

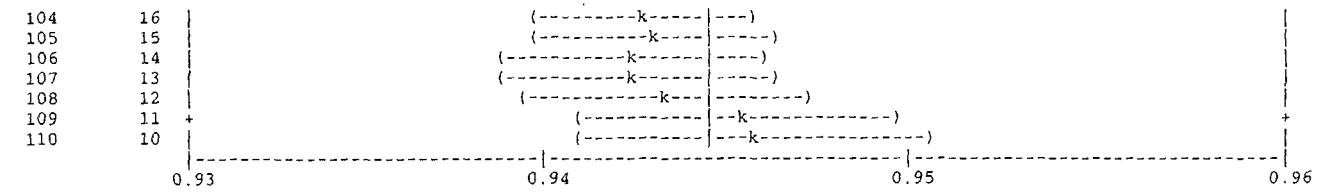
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.94654	0.00200	0.94452 to 0.94855	0.94251 to 0.95056	0.94116 to 0.95191
second half	0.94277	0.00157	0.94119 to 0.94435	0.93962 to 0.94592	0.93856 to 0.94698
final result	0.94460	0.00130	0.94330 to 0.94590	0.94201 to 0.94719	0.94117 to 0.94803

the first and second half values of k(collision/absorption/track length) appear to be the same at the 95 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.94460)







dump no. 3 on file 10253r nps = 479938 coll = 16134352 ctm = 27.37 nrn = 250232612

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 27.38 minutes

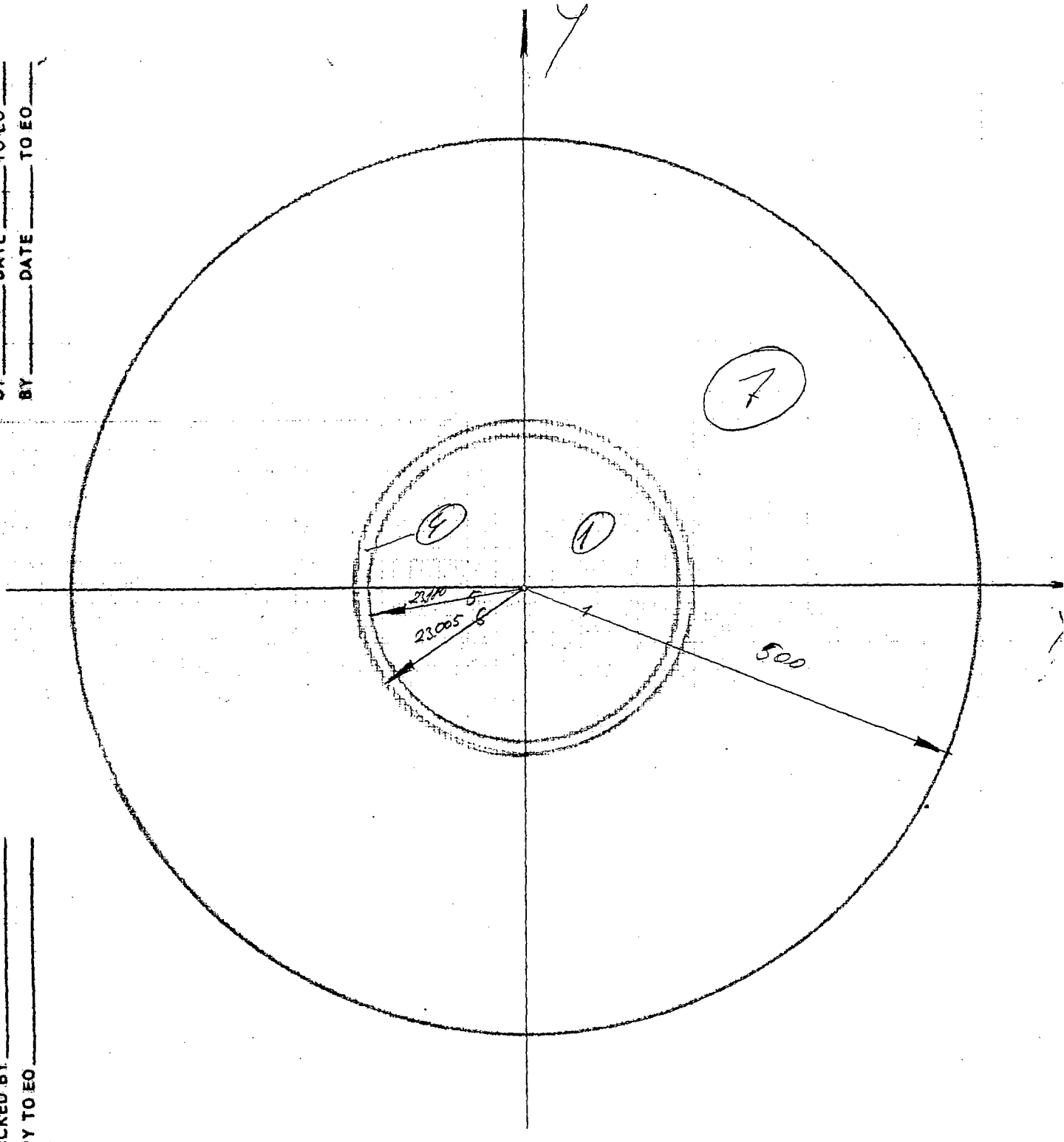
mcnp version 4a 10/01/93 06/07/00 16:57:20 probid = 06/07/00 16:29:57

Attachment 5: Case 2 with MCNP surface and cell numbers

FILE _____

SUBJECT _____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____

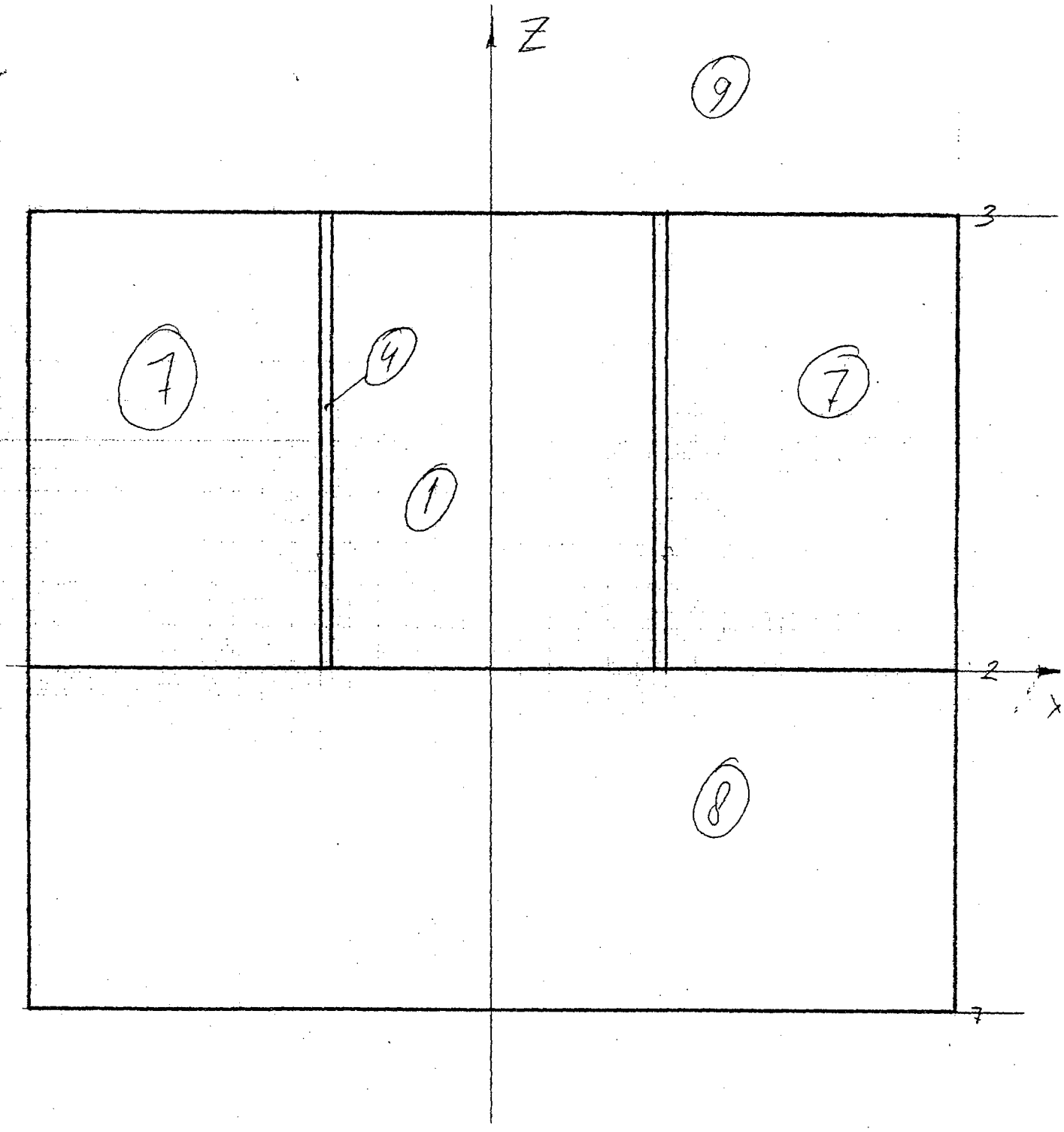


BY _____ DATE _____
CHECKED BY _____
COPY TO EO _____

FILE _____

SUBJECT _____

REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____



BY _____ DATE _____
CHECKED BY _____
COPY TO EO _____

Attachment 6: Case 2 MCNP input file

```
                                                    10254
WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c
C Cell cards
C
C ------------------------------------------------------------------------
c Drum filling universe:
c
11  0        -11 12 -13 14 -15 16 u=1
                 lat=2 fill=2 imp:n=1 $ Hexagonal lattice
12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
14 63 -1.0  18 u=2            imp:n=1 $ water in the lattice cell
c ------------------------------------------------------------------------
c
1  0  2 -3 -5  fill=1  imp:n=1 $ 1st drum filled with fuel lattice
c
4  65  -7.82      5 -6 2 -3    imp:n=1 $ 1st drum wall
c
7  64 -0.001293  -1 6   2 -3    imp:n=1 $ air ouside the drums
8  67 -2.35      -1  -2 7       imp:n=1 $  concrete floor
9  0              1 : -7 : 3    imp:n=0 $ Outside world
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
1  cz 500     $ system cylinder
2  pz 0       $ drum bottom plane
3  pz 72.39   $ drum top plane
5  cz 23.005  $ internal wall of the 1st drum
6  cz 23.180  $ external wall of the 1st drum
7  pz -3000   $ concrete bottom plane
c
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.581537
12 p 0.8660254 -0.5 0 -0.581537
13 p 0.8660254  0.5 0  0.581537
14 p 0.8660254  0.5 0 -0.581537
15 py  0.581537
16 py -0.581537
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 4% enrichment (O-16, U-235, U-238)
m61    8016.50c -0.1185712
      92235.50c -0.0348303
      92238.50c -0.8465985
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62   14000.50c -0.01
      24000.50c -0.19
      25055.50c -0.02
      26000.55c -0.68
      28000.50c -0.10
c Water (H, O)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64    6000.50c -0.000124
       7014.50c -0.755267
       8016.50c -0.231781
      18000.35c -0.012828
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
```

10254

```
m65    6000.50c -0.005
      26000.55c -0.995
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67    1001.50c -0.006
       8016.50c -0.5
      11023.50c -0.017
      13027.50c -0.048
      14000.50c -0.315
      19000.50c -0.019
      20000.50c -0.083
      26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 7: Case 2 MCNP output file

```
1mcnp     version 4a    ld=10/01/93                    06/07/00 19:03:31
*************************************************************************          probid =   06/07/00 19:03:31
 name=10254

      WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside
      C The drum height is 28 1/2 inches (72.39 cm)
      c drum wall thickness is 0.157 cm
      c
      C Cell cards
      C
      C ---------------------------------------------------------------------
      c Drum filling universe:
      c
      11  0         -11 12 -13 14 -15 16 u=1
                         lat=2 fill=2 imp:n=1 $ Hexagonal lattice
      12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
      13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
      14 63 -1.0  18 u=2            imp:n=1 $ water in the lattice cell
      c ---------------------------------------------------------------------
      c
      1  0  2 -3 -5  fill=1  imp:n=1 $ 1st drum filled with fuel lattice
      c
      4  65  -7.82      5 -6 2 -3    imp:n=1 $ 1st drum wall
      c
      7  64 -0.001293  -1 6   2 -3    imp:n=1 $ air ouside the drums
      8  67 -2.35      -1  -2 7       imp:n=1 $  concrete floor
      9  0              1 : -7 : 3    imp:n=0 $ Outside world
      C ---------------------------------------------------------------------
      c
      c Note: next line must be completely blank

      c Surface cards
      C ---------------------------------------------------------------------
      1  cz 500      $ system cylinder
      2  pz 0        $ drum bottom plane
      3  pz 72.39    $ drum top plane
      5  cz 23.005   $ internal wall of the 1st drum
      6  cz 23.180   $ external wall of the 1st drum
      7  pz -3000    $ concrete bottom plane
      c
      c begin the lattice surfaces
      11 p 0.8660254 -0.5 0  0.581537
      12 p 0.8660254 -0.5 0 -0.581537
      13 p 0.8660254  0.5 0  0.581537
      14 p 0.8660254  0.5 0 -0.581537
      15 py  0.581537
      16 py -0.581537
      c end of lattice surfaces
      c
      17 cz 0.3785 $ fuel wall cylinder
      18 cz 0.4318 $ clad outer wall cylinder
      c
      c
      C ---------------------------------------------------------------------
      c
      c Note: next line must be completely blank

      c Data cards
```

```
 55-       c
 56-       c Materials
 57-       c
 58-       c
 59-       c Fresh Yankee fuel 4% enrichment (O-16, U-235, U-238)
 60-       m61     8016.50c -0.1185712
 61-             92235.50c -0.0348303
 62-             92238.50c -0.8465985
 63-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
 64-       m62   14000.50c -0.01
 65-             24000.50c -0.19
 66-             25055.50c -0.02
 67-             26000.55c -0.68
 68-             28000.50c -0.10
 69-       c Water (H, O)
 70-       m63     1001.50c 0.66667
 71-              8016.50c 0.33333
 72-       mt63 lwtr.01t
 73-       c Air (C, N, O, Ar) composition from Attix p.523
 74-       m64     6000.50c -0.000124
 75-             7014.50c -0.755267
 76-             8016.50c -0.231781
 77-            18000.35c -0.012828
 78-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
 79-       m65     6000.50c -0.005
 80-            26000.55c -0.995
 81-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
 82-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
 83-       c adjusted to sum to unity without minor trace elements)
 84-       m67     1001.50c -0.006
 85-             8016.50c -0.5
 86-            11023.50c -0.017
 87-            13027.50c -0.048
 88-            14000.50c -0.315
 89-            19000.50c -0.019
 90-            20000.50c -0.083
 91-            26000.55c -0.012
 92-       c
 93-       mode n
 94-       print 40 60 80 100 110 126
 95-       kcode 4000 1. 20 120
 96-       ksrc  0 0 10
 97-
 total fission nubar data are being used.
1material composition                                                    print table 40

 material
  number     component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01333      92238,  0.31989
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
    64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
    65            6000,  0.02283      26000,  0.97717
    67            1001,  0.11082       8016,  0.58191      11023,  0.01377      13027,  0.03312
                 14000,  0.20878      19000,  0.00905      20000,  0.03855      26000,  0.00400
```

```
 material
  number      component nuclide, mass fraction

    61            8016,  0.11857      92235,  0.03483      92238,  0.84660
    62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                 28000,  0.10000
    63            1001,  0.11192       8016,  0.88808
    64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
    65            6000,  0.00500      26000,  0.99500
    67            1001,  0.00600       8016,  0.50000      11023,  0.01700      13027,  0.04800
                 14000,  0.31500      19000,  0.01900      20000,  0.08300      26000,  0.01200
1cells                                                                                  print table 60

                        atom         gram                                      neutron
        cell  mat      density      density      volume       mass      pieces importance

     1    11    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     2    12   61  6.96288E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     3    13   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     4    14  63s  1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     5     1    0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00      1  1.0000E+00
     6     4   65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04      1  1.0000E+00
     7     7   64  5.35386E-05 1.29300E-03 5.67328E+07 7.33555E+04      1  1.0000E+00
     8     8   67  7.60226E-02 2.35000E+00 2.35619E+09 5.53706E+09      1  1.0000E+00
     9     9    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  0.0000E+00

 total                                    2.41305E+09 5.53714E+09
1cross-section tables                                                                   print table 100

     table    length

                      tables from file critxs

   1001.50c    1153  njoy                                                          (  1301)      79/07/31.
   6000.50c   16126  njoy                                                          (  1306)      79/07/31.
   7014.50c   22772  njoy                                                          (  1275)      79/09/08.
   8016.50c   23669  njoy                                                           ( 1276)     05/14/81
  11023.50c   36270  njoy                                                          (  1311)      79/06/21.
  13027.50c   22891  njoy                                                          (  1313)      79/09/08.
  14000.50c   48275  njoy                                                          (  1314)      79/06/21.
  18000.35c    2182       end185                                                    (  18)       11/01/85
  19000.50c    9766  njoy                                                          (  1150)      79/10/29.
  20000.50c   26104  njoy                                                          (  1320)      79/06/22.
  24000.50c   89104  njoy                                                          (  1324)      79/06/21.
  25055.50c   60097  njoy                                                          (  1325)      79/06/21.
  26000.55c   84136  njoy                                                          ( 260)       10/21/82
  28000.50c   82267  njoy                                                          (  1328)      79/06/21.
  92235.50c   44188  njoy                                    total nu              (  1395)      79/09/12.
  92238.50c   66440  njoy                                    total nu              (  1398)      79/09/13.
   lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                1001     0     010/22/85

  total      645633
```

warning. neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

general	113630
tallies	0
bank	12403
cross sections	645633
total	771666

dump no. 1 on file 10254r nps = 0 coll = 0 ctm = 0.00 nrn = 0

source distribution written to file 10254s cycle = 0

1 warning message so far.

1 starting mcrun. field length = 0 cp0 = 0.02 print table 110

WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside

nps	x	y	z	cell	lattice(i,j,k)	surface	u	v	w	energy	weight	time
1	0.000E+00	0.000E+00	1.000E+01	1			5.085E-01	4.733E-01	7.193E-01	2.209E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			5.085E-01	4.733E-01	7.193E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	5.085E-01	4.733E-01	7.193E-01			
2	0.000E+00	0.000E+00	1.000E+01	1			8.952E-01	-4.447E-01	-2.944E-02	4.904E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			8.952E-01	-4.447E-01	-2.944E-02			
	0.000E+00	0.000E+00	1.000E+01	12		0	8.952E-01	-4.447E-01	-2.944E-02			
3	0.000E+00	0.000E+00	1.000E+01	1			-6.184E-01	-4.495E-01	6.446E-01	3.809E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-6.184E-01	-4.495E-01	6.446E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-6.184E-01	-4.495E-01	6.446E-01			
4	0.000E+00	0.000E+00	1.000E+01	1			9.710E-01	-5.665E-02	-2.323E-01	1.331E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			9.710E-01	-5.665E-02	-2.323E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	9.710E-01	-5.665E-02	-2.323E-01			
5	0.000E+00	0.000E+00	1.000E+01	1			5.861E-01	1.496E-01	-7.963E-01	1.902E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			5.861E-01	1.496E-01	-7.963E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	5.861E-01	1.496E-01	-7.963E-01			
6	0.000E+00	0.000E+00	1.000E+01	1			-6.489E-02	-1.626E-01	9.845E-01	4.410E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-6.489E-02	-1.626E-01	9.845E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-6.489E-02	-1.626E-01	9.845E-01			
7	0.000E+00	0.000E+00	1.000E+01	1			-7.068E-02	3.263E-02	-9.970E-01	4.750E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-7.068E-02	3.263E-02	-9.970E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-7.068E-02	3.263E-02	-9.970E-01			
8	0.000E+00	0.000E+00	1.000E+01	1			-3.915E-01	4.664E-01	-7.932E-01	4.136E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-3.915E-01	4.664E-01	-7.932E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-3.915E-01	4.664E-01	-7.932E-01			
9	0.000E+00	0.000E+00	1.000E+01	1			-2.368E-01	9.215E-01	-3.079E-01	7.453E-02	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-2.368E-01	9.215E-01	-3.079E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-2.368E-01	9.215E-01	-3.079E-01			
10	0.000E+00	0.000E+00	1.000E+01	1			1.946E-01	-3.204E-01	9.271E-01	3.128E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			1.946E-01	-3.204E-01	9.271E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	1.946E-01	-3.204E-01	9.271E-01			
11	0.000E+00	0.000E+00	1.000E+01	1			-6.698E-01	-7.177E-01	-1.905E-01	1.014E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	11(0, 0, 0)			-6.698E-01	-7.177E-01	-1.905E-01			
	0.000E+00	0.000E+00	1.000E+01	12		0	-6.698E-01	-7.177E-01	-1.905E-01			
12	0.000E+00	0.000E+00	1.000E+01	1			-8.398E-01	-4.129E-01	3.524E-01	1.395E+00	1.000E+00	0.000E+00

```
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -8.398E-01 -4.129E-01  3.524E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -8.398E-01 -4.129E-01  3.524E-01
13   0.000E+00  0.000E+00  1.000E+01   1                     -1.714E-01 -8.572E-01  4.857E-01  7.748E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -1.714E-01 -8.572E-01  4.857E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -1.714E-01 -8.572E-01  4.857E-01
14   0.000E+00  0.000E+00  1.000E+01   1                     -2.489E-01 -5.118E-01 -8.222E-01  1.101E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -2.489E-01 -5.118E-01 -8.222E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -2.489E-01 -5.118E-01 -8.222E-01
15   0.000E+00  0.000E+00  1.000E+01   1                     -2.959E-01  2.119E-01  9.314E-01  1.951E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      -2.959E-01  2.119E-01  9.314E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -2.959E-01  2.119E-01  9.314E-01
16   0.000E+00  0.000E+00  1.000E+01   1                      1.395E-01 -9.829E-01  1.202E-01  2.186E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.395E-01 -9.829E-01  1.202E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0  1.395E-01 -9.829E-01  1.202E-01
17   0.000E+00  0.000E+00  1.000E+01   1                      6.909E-01 -7.110E-01  1.307E-01  1.865E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      6.909E-01 -7.110E-01  1.307E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0  6.909E-01 -7.110E-01  1.307E-01
18   0.000E+00  0.000E+00  1.000E+01   1                     -6.580E-01  5.320E-01 -5.329E-01  1.229E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -6.580E-01  5.320E-01 -5.329E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -6.580E-01  5.320E-01 -5.329E-01
19   0.000E+00  0.000E+00  1.000E+01   1                     -9.903E-01 -1.380E-01  1.353E-02  1.305E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.903E-01 -1.380E-01  1.353E-02
     0.000E+00  0.000E+00  1.000E+01  12                   0 -9.903E-01 -1.380E-01  1.353E-02
20   0.000E+00  0.000E+00  1.000E+01   1                      7.462E-01  4.859E-01 -4.551E-01  1.000E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      7.462E-01  4.859E-01 -4.551E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0  7.462E-01  4.859E-01 -4.551E-01
21   0.000E+00  0.000E+00  1.000E+01   1                     -1.977E-01  9.797E-01  3.360E-02  3.990E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -1.977E-01  9.797E-01  3.360E-02
     0.000E+00  0.000E+00  1.000E+01  12                   0 -1.977E-01  9.797E-01  3.360E-02
22   0.000E+00  0.000E+00  1.000E+01   1                     -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.117E-01 -3.647E-01 -1.891E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -9.117E-01 -3.647E-01 -1.891E-01
23   0.000E+00  0.000E+00  1.000E+01   1                     -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -4.287E-01  8.361E-01 -3.423E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -4.287E-01  8.361E-01 -3.423E-01
24   0.000E+00  0.000E+00  1.000E+01   1                      1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.080E-01  3.412E-01 -9.338E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0  1.080E-01  3.412E-01 -9.338E-01
25   0.000E+00  0.000E+00  1.000E+01   1                     -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -9.111E-01 -9.012E-03 -4.122E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -9.111E-01 -9.012E-03 -4.122E-01
26   0.000E+00  0.000E+00  1.000E+01   1                     -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.568E-01 -6.391E-01 -7.249E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -2.568E-01 -6.391E-01 -7.249E-01
27   0.000E+00  0.000E+00  1.000E+01   1                     -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -2.912E-01  8.086E-01  5.113E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -2.912E-01  8.086E-01  5.113E-01
28   0.000E+00  0.000E+00  1.000E+01   1                      1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)      1.472E-01 -9.514E-01  2.705E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0  1.472E-01 -9.514E-01  2.705E-01
29   0.000E+00  0.000E+00  1.000E+01   1                     -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -6.135E-01 -7.645E-01 -1.978E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -6.135E-01 -7.645E-01 -1.978E-01
30   0.000E+00  0.000E+00  1.000E+01   1                     -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -5.702E-01  5.651E-01 -5.963E-01
     0.000E+00  0.000E+00  1.000E+01  12                   0 -5.702E-01  5.651E-01 -5.963E-01
31   0.000E+00  0.000E+00  1.000E+01   1                     -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01  11(   0,   0,   0)     -6.607E-01  5.373E-01 -5.242E-01
```

```
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -6.607E-01  5.373E-01 -5.242E-01
32  0.000E+00  0.000E+00  1.000E+01    1                                    -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -9.742E-02 -3.639E-01 -9.263E-01
33  0.000E+00  0.000E+00  1.000E+01    1                                    -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -1.965E-01 -3.145E-01 -9.287E-01
34  0.000E+00  0.000E+00  1.000E+01    1                                     4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    4.097E-01  8.465E-01 -3.399E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  4.097E-01  8.465E-01 -3.399E-01
35  0.000E+00  0.000E+00  1.000E+01    1                                    -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -4.048E-02  8.831E-01  4.675E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -4.048E-02  8.831E-01  4.675E-01
36  0.000E+00  0.000E+00  1.000E+01    1                                     3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    3.371E-01 -9.269E-01 -1.652E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  3.371E-01 -9.269E-01 -1.652E-01
37  0.000E+00  0.000E+00  1.000E+01    1                                    -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -1.867E-01  9.756E-01 -1.155E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -1.867E-01  9.756E-01 -1.155E-01
38  0.000E+00  0.000E+00  1.000E+01    1                                    -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -2.616E-01  2.336E-01 -9.365E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -2.616E-01  2.336E-01 -9.365E-01
39  0.000E+00  0.000E+00  1.000E+01    1                                     9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    9.780E-01 -7.641E-02 -1.939E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  9.780E-01 -7.641E-02 -1.939E-01
40  0.000E+00  0.000E+00  1.000E+01    1                                     2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    2.580E-01 -7.076E-01  6.578E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  2.580E-01 -7.076E-01  6.578E-01
41  0.000E+00  0.000E+00  1.000E+01    1                                    -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -3.212E-01 -7.678E-01 -5.543E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -3.212E-01 -7.678E-01 -5.543E-01
42  0.000E+00  0.000E+00  1.000E+01    1                                     5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    5.039E-01 -1.460E-01  8.513E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  5.039E-01 -1.460E-01  8.513E-01
43  0.000E+00  0.000E+00  1.000E+01    1                                     6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    6.080E-01  5.487E-01  5.738E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  6.080E-01  5.487E-01  5.738E-01
44  0.000E+00  0.000E+00  1.000E+01    1                                    -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -2.932E-01  9.304E-01 -2.199E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -2.932E-01  9.304E-01 -2.199E-01
45  0.000E+00  0.000E+00  1.000E+01    1                                    -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -8.475E-01 -3.993E-01 -3.497E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -8.475E-01 -3.993E-01 -3.497E-01
46  0.000E+00  0.000E+00  1.000E+01    1                                     1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    1.200E-01 -9.195E-01 -3.743E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  1.200E-01 -9.195E-01 -3.743E-01
47  0.000E+00  0.000E+00  1.000E+01    1                                     7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    7.085E-01  5.879E-01  3.904E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  7.085E-01  5.879E-01  3.904E-01
48  0.000E+00  0.000E+00  1.000E+01    1                                     4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    4.261E-01  9.046E-01  9.254E-03
    0.000E+00  0.000E+00  1.000E+01   12                                  0  4.261E-01  9.046E-01  9.254E-03
49  0.000E+00  0.000E+00  1.000E+01    1                                     5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                    5.431E-01  4.270E-01 -7.230E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0  5.431E-01  4.270E-01 -7.230E-01
50  0.000E+00  0.000E+00  1.000E+01    1                                    -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01   11(   0,   0,   0)                   -1.053E-01 -9.805E-01  1.658E-01
    0.000E+00  0.000E+00  1.000E+01   12                                  0 -1.053E-01 -9.805E-01  1.658E-01
```

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1estimated keff results by cycle                                                    print table 175

 source distribution written to file 10254s          cycle =    20

 source distribution written to file 10254s          cycle =    25

 source distribution written to file 10254s          cycle =    30

 source distribution written to file 10254s          cycle =    35

 source distribution written to file 10254s          cycle =    40

 source distribution written to file 10254s          cycle =    45

 source distribution written to file 10254s          cycle =    50

 source distribution written to file 10254s          cycle =    55

 source distribution written to file 10254s          cycle =    60

 source distribution written to file 10254s          cycle =    65

 source distribution written to file 10254s          cycle =    70

 ************************************************************************************************************
 dump no.    2 on file 10254r       nps =    279647     coll =       9272772     ctm =   15.18     nrn =      143940206


 source distribution written to file 10254s          cycle =    75

 source distribution written to file 10254s          cycle =    80

 source distribution written to file 10254s          cycle =    85

 source distribution written to file 10254s          cycle =    90

 source distribution written to file 10254s          cycle =    95

  estimator      cycle   100   ave of    80 cycles       combination          simple average     combined average      corr
 k(collision)       0.925578       0.908439 0.0020     k(col/abs)          0.909375 0.0016     0.909833 0.0016    0.5837
 k(absorption)      0.941737       0.910310 0.0016     k(abs/tk ln)        0.909891 0.0018     0.910179 0.0016    0.4204
 k(trk length)      0.944255       0.909471 0.0026     k(tk ln/col)        0.908955 0.0022     0.908306 0.0020    0.8360
 rem life(col)   4.1450E+03     3.8411E+03 0.0077     k(col/abs/tk ln)    0.909407 0.0018     0.909869 0.0016
 rem life(abs)   4.1041E+03     3.8426E+03 0.0077     life(col/abs)     3.8418E+03 0.0077   3.8417E+03 0.0077    0.9919
 source points generated   4088

 source distribution written to file 10254s          cycle =   100

 source distribution written to file 10254s          cycle =   105

 source distribution written to file 10254s          cycle =   110

 source distribution written to file 10254s          cycle =   115

  estimator      cycle   116   ave of    96 cycles       combination          simple average     combined average      corr
 k(collision)       0.875658       0.907221 0.0018     k(col/abs)          0.908290 0.0015     0.908856 0.0015    0.6252
 k(absorption)      0.894587       0.909360 0.0015     k(abs/tk ln)        0.908332 0.0017     0.909116 0.0015    0.4703
 k(trk length)      0.870892       0.907304 0.0024     k(tk ln/col)        0.907262 0.0020     0.907209 0.0018    0.8272
```

```
.rem life(col)   3.6637E+03     3.8429E+03 0.0068     k(col/abs/tk ln)    0.907961 0.0017     0.908849 0.0015
 rem life(abs)   3.6116E+03     3.8429E+03 0.0068     life(col/abs)     3.8429E+03 0.0068   3.8429E+03 0.0069   0.9916
 source points generated   3854

  estimator     cycle   117   ave of    97 cycles      combination         simple average    combined average     corr
 k(collision)      0.900276       0.907149 0.0018     k(col/abs)          0.908189 0.0015     0.908732 0.0015   0.6259
 k(absorption)     0.896722       0.909230 0.0015     k(abs/tk ln)        0.908270 0.0017     0.908994 0.0015   0.4678
 k(trk length)     0.907856       0.907309 0.0024     k(tk ln/col)        0.907229 0.0020     0.907127 0.0018   0.8263
 rem life(col)   4.2419E+03     3.8470E+03 0.0069     k(col/abs/tk ln)    0.907896 0.0017     0.908725 0.0015
 rem life(abs)   4.2709E+03     3.8474E+03 0.0068     life(col/abs)     3.8472E+03 0.0068   3.8472E+03 0.0069   0.9917
 source points generated   4115

  estimator     cycle   118   ave of    98 cycles      combination         simple average    combined average     corr
 k(collision)      0.903521       0.907112 0.0018     k(col/abs)          0.908155 0.0015     0.908699 0.0015   0.6261
 k(absorption)     0.906053       0.909197 0.0015     k(abs/tk ln)        0.908282 0.0017     0.908971 0.0015   0.4669
 k(trk length)     0.912887       0.907366 0.0024     k(tk ln/col)        0.907239 0.0020     0.907077 0.0018   0.8252
 rem life(col)   4.2987E+03     3.8516E+03 0.0069     k(col/abs/tk ln)    0.907892 0.0017     0.908692 0.0015
 rem life(abs)   4.3493E+03     3.8525E+03 0.0069     life(col/abs)     3.8520E+03 0.0069   3.8519E+03 0.0069   0.9918
 source points generated   4004

  estimator     cycle   119   ave of    99 cycles      combination         simple average    combined average     corr
 k(collision)      0.912905       0.907170 0.0018     k(col/abs)          0.908262 0.0015     0.908814 0.0014   0.6256
 k(absorption)     0.924581       0.909353 0.0015     k(abs/tk ln)        0.908422 0.0016     0.909121 0.0015   0.4698
 k(trk length)     0.919819       0.907492 0.0023     k(tk ln/col)        0.907331 0.0020     0.907126 0.0018   0.8253
 rem life(col)   3.6239E+03     3.8493E+03 0.0068     k(col/abs/tk ln)    0.908005 0.0016     0.908802 0.0015
 rem life(abs)   3.6544E+03     3.8505E+03 0.0068     life(col/abs)     3.8499E+03 0.0068   3.8498E+03 0.0069   0.9918
 source points generated   4054

  estimator     cycle   120   ave of   100 cycles      combination         simple average    combined average     corr
 k(collision)      0.911804       0.907217 0.0018     k(col/abs)          0.908306 0.0015     0.908857 0.0014   0.6259
 k(absorption)     0.913520       0.909395 0.0015     k(abs/tk ln)        0.908409 0.0016     0.909147 0.0014   0.4683
 k(trk length)     0.900559       0.907423 0.0023     k(tk ln/col)        0.907320 0.0020     0.907189 0.0018   0.8236
 rem life(col)   3.6579E+03     3.8474E+03 0.0068     k(col/abs/tk ln)    0.908011 0.0016     0.908850 0.0014
 rem life(abs)   3.6926E+03     3.8489E+03 0.0068     life(col/abs)     3.8481E+03 0.0068   3.8481E+03 0.0068   0.9918
 source points generated   4013

 source distribution written to file 10254s          cycle =   120
1problem summary

      run terminated when   120 kcode cycles were done.
+                                                                                                  06/07/00 19:29:27
      WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside                       probid =   06/07/00 19:03:31
0
 neutron creation    tracks      weight        energy          neutron loss        tracks      weight        energy
                                 (per source particle)                                         (per source particle)

 source              479622    1.0008E+00    2.0303E+00        escape              126652    2.3231E-01    2.0163E-01
                                                               energy cutoff            0    0.            0.
                                                               time cutoff              0    0.            0.
 weight window            0    0.            0.                weight window            0    0.            0.
 cell importance          0    0.            0.                cell importance          0    0.            0.
 weight cutoff            0    4.3661E-02    2.4615E-05        weight cutoff       353671    4.3732E-02    3.2593E-05
 energy importance        0    0.            0.                energy importance        0    0.            0.
 dxtran                   0    0.            0.                dxtran                   0    0.            0.
 forced collisions        0    0.            0.                forced collisions        0    0.            0.
 exp. transform           0    0.            0.                exp. transform           0    0.            0.
 upscattering             0    0.            4.6438E-08        downscattering           0    0.            1.6943E+00
                                                               capture                  0    3.9955E-01    3.8598E-02
```

(n,xn)	1399	2.2838E-03	1.6427E-03	loss to (n,xn)	698	1.1397E-03	9.5281E-03
fission	0	0.	0.	loss to fission	0	3.7000E-01	8.7863E-02
total	481021	1.0467E+00	2.0319E+00	total	481021	1.0467E+00	2.0319E+00

number of neutrons banked	701	average lifetime, shakes	cutoffs
neutron tracks per source particle	1.0029E+00	escape 6.4950E+03	tco 1.0000E+34
neutron collisions per source particle	3.2838E+01	capture 3.2122E+03	eco 0.0000E+00
total neutron collisions	15749676	capture or escape 3.9734E+03	wc1 -5.0000E-01
net multiplication	1.0011E+00 0.0001	any termination 4.4630E+03	wc2 -2.5000E -01

computer time so far in this run	25.94 minutes	maximum number ever in bank	2
computer time in mcrun	25.92 minutes	bank overflows to backup file	0
source particles per minute	1.8503E+04	field length	0
random numbers generated	244471453	most random numbers used was	9953 in history 235092

range of sampled source weights = 9.0621E-01 to 1.1242E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+0 0	0.0000E+00	0.0000E+00
2	12	8113352	480321	2708443	4.7638E+00	1.5702E-03	7.8481E-01	8.8086E-01	2.6368E+00
3	13	16434775	479287	1125699	1.9562E+00	1.3800E-03	7.5531E-01	8.7892E-01	2.5717E+00
4	14	21791419	479066	8720317	1.4685E+01	1.2239E-03	7.3688E-01	8.7891E-01	1.7966E+00
5	1	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	4	139347	128580	22475	3.9517E-02	2.5489E-03	9.6343E-01	8.9469E-01	3.6006E+00
7	7	180841	129828	6721	1.1681E-02	1.8729E-03	9.3947E-01	8.8871E-01	6.3556E+03
8	8	95422	80834	3166021	4.3144E+00	1.2199E-04	3.4527E-01	6.8995E-01	2.9282E+00
total		46755156	1777916	15749676	2.5770E+01				

1keff results for: WV, HEC, Yankee, 4%, 2 30 gal. drums flooded with air outside probid = 06/07/00 19:03:31

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79526 neutron histories and 100 active cycles with 400096 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 479622 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

---

the final estimated combined collision/absorption/track-length keff = 0.90885 with an estimated standard deviation of 0.00131

the estimated 68, 95, & 99 percent keff confidence intervals are 0.90754 to 0.91016, 0.90624 to 0.91146, and 0.90538 to 0.91232

the estimated collision/absorption neutron removal lifetime = 3.85E-05 seconds with an estimated standard deviation of 2.62E-07

the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.90722	0.00161	0.90561 to 0.90883	0.90401 to 0.91042	0.90297 to 0.91147	
absorption	0.90939	0.00132	0.90807 to 0.91071	0.90677 to 0.91202	0.90591 to 0.91288	
track length	0.90742	0.00210	0.90532 to 0.90952	0.90325 to 0.91160	0.90188 to 0.91296	
col/absorp	0.90886	0.00130	0.90755 to 0.91016	0.90626 to 0.91146	0.90541 to 0.91230	0.6259
abs/trk len	0.90915	0.00131	0.90783 to 0.91046	0.90653 to 0.91176	0.90568 to 0.91261	0.4683
col/trk len	0.90719	0.00161	0.90558 to 0.90880	0.90399 to 0.91039	0.90294 to 0.91144	0.8236
col/abs/trk len	0.90885	0.00131	0.90754 to 0.91016	0.90624 to 0.91146	0.90538 to 0.91232	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.90762	0.00164	0.90598 to 0.90926	0.90435 to 0.91089	0.90328 to 0.91196
absorption	0.90973	0.00135	0.90838 to 0.91107	0.90704 to 0.91241	0.90617 to 0.91329
track length	0.90800	0.00215	0.90584 to 0.91015	0.90371 to 0.91229	0.90231 to 0.91369
col/abs/trk len	0.90920	0.00135	0.90785 to 0.91055	0.90652 to 0.91188	0.90565 to 0.91276

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	3.8481E-05	2.6245E-07	3.8219E-05 to 3.8744E-05	3.7958E-05 to 3.9004E-05	3.7788E-05 to 3.9175E-05
capture	3.0865E-05	2.2955E-07	3.0636E-05 to 3.1095E-05	3.0408E-05 to 3.1323E-05	3.0259E-05 to 3.1472E-05
fission	1.6126E-05	5.0688E-08	1.6075E-05 to 1.6177E-05	1.6025E-05 to 1.6227E-05	1.5992E-05 to 1.6260E-05
escape	6.3046E-05	6.8243E-07	6.2363E-05 to 6.3729E-05	6.1687E-05 to 6.4405E-05	6.1243E-05 to 6.4849E-05

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.9072	0.0016	0.9094	0.0013	0.9074	0.0021	95/95/95	0.90885	0.00131	0.90624-0.91146	0.90538-0.91232
2	50	0.9072	0.0019	0.9094	0.0014	0.9074	0.0023	95/95/95	0.90927	0.00148	0.90630-0.91224	0.90530-0.91323
4	25	0.9072	0.0020	0.9094	0.0013	0.9074	0.0025	95/95/95	0.90945	0.00143	0.90648-0.91242	0.90541-0.91349
5	20	0.9072	0.0017	0.9094	0.0014	0.9074	0.0022	95/95/95	0.90904	0.00165	0.90555-0.91253	0.90425-0.91383
10	10	0.9072	0.0016	0.9094	0.0016	0.9074	0.0025	95/95/95	0.90769	0.00170	0.90366-0.91171	0.90172-0.91365
20	5	0.9072	0.0016	0.9094	0.0019	0.9074	0.0024	95/95/95	0.90761	0.00318	0.89392-0.92130	0.87604-0.93919
25	4	0.9072	0.0014	0.9094	0.0011	0.9074	0.0022	95/95/95	0.90896	0.00107	0.89532-0.92261	0.84062-0.97731

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	1.09953	1.10796	1.10230									
2	4414	0.97216	0.99547	0.97643									
3	3558	0.91875	0.91470	0.90873									
4	3781	0.87802	0.88367	0.87680									
5	3813	0.90547	0.90210	0.90474									
6	4133	0.91399	0.92859	0.91175									

7	4054	0.90192	0.88644	0.91611									
8	3936	0.90266	0.90215	0.88528									
9	3967	0.92078	0.91904	0.93333									
10	4041	0.91174	0.89447	0.91616									
11	3920	0.89986	0.91359	0.88323									
12	4016	0.89407	0.88772	0.88672									
13	3994	0.90947	0.90454	0.91868									
14	4020	0.91526	0.91184	0.91354									
15	4038	0.92167	0.91638	0.91840									
16	4070	0.91330	0.90241	0.92134									
17	3922	0.90277	0.89870	0.90238									
18	3920	0.90980	0.91943	0.90639									
19	4013	0.89395	0.90001	0.89489									
20	3916	0.89585	0.90884	0.88399									
		begin active keff cycles											
21	4066	0.91387	0.90669	0.92871									
22	4150	0.89320	0.90901	0.87991	0.90354	0.01034	0.90785	0.00116	0.90431	0.02440			
23	3896	0.91434	0.91512	0.89144	0.90714	0.00697	0.91027	0.00251	0.90002	0.01472			
24	4094	0.90524	0.90024	0.89676	0.90666	0.00495	0.90776	0.00307	0.89920	0.01044	0.90659	0.00535	32967
25	3975	0.89002	0.90613	0.87153	0.90333	0.00508	0.90744	0.00240	0.89367	0.00980	0.90607	0.00389	50102
26	3982	0.90830	0.91407	0.89812	0.90416	0.00423	0.90854	0.00225	0.89441	0.00804	0.90713	0.00351	51307
27	4035	0.90196	0.91274	0.89499	0.90385	0.00359	0.90914	0.00200	0.89449	0.00679	0.90780	0.00303	59029
28	4002	0.91810	0.92156	0.91410	0.90563	0.00358	0.91070	0.00232	0.89694	0.00637	0.91001	0.00355	38030
29	3978	0.91018	0.92142	0.92661	0.90613	0.00320	0.91189	0.00237	0.90024	0.00652	0.91126	0.00316	42802
30	3951	0.91345	0.91032	0.91531	0.90686	0.00295	0.91173	0.00213	0.90175	0.00602	0.91120	0.00262	56093
31	3981	0.89708	0.90399	0.91344	0.90598	0.00282	0.91103	0.00205	0.90281	0.00555	0.91013	0.00267	49052
32	3939	0.88247	0.89849	0.89460	0.90402	0.00323	0.90998	0.00214	0.90213	0.00511	0.90995	0.00293	37291
33	3920	0.91541	0.90093	0.95148	0.90489	0.00310	0.90929	0.00209	0.90592	0.00604	0.90917	0.00248	48291
34	4150	0.92469	0.92715	0.91025	0.90631	0.00320	0.91056	0.00232	0.90623	0.00560	0.91066	0.00261	40466
35	4066	0.89833	0.88345	0.89365	0.90577	0.00302	0.90875	0.00281	0.90539	0.00528	0.90762	0.00289	30436
36	3832	0.92195	0.93128	0.91615	0.90679	0.00300	0.91016	0.00299	0.90607	0.00499	0.90860	0.00306	25666
37	4141	0.90515	0.92485	0.88998	0.90669	0.00282	0.91103	0.00293	0.90512	0.00478	0.90874	0.00296	25765
38	3994	0.93344	0.89707	0.94363	0.90818	0.00305	0.91025	0.00287	0.90726	0.00499	0.90931	0.00260	31499
39	4015	0.94276	0.90285	0.94442	0.91000	0.00341	0.90986	0.00275	0.90921	0.00511	0.90978	0.00247	33218
40	3978	0.90611	0.90286	0.89070	0.90980	0.00324	0.90951	0.00263	0.90829	0.00493	0.90942	0.00238	33819
41	3769	0.91709	0.90086	0.91555	0.91015	0.00310	0.90910	0.00253	0.90863	0.00471	0.90928	0.00227	35367
42	4083	0.92341	0.92836	0.93778	0.91075	0.00302	0.90997	0.00257	0.90996	0.00468	0.91024	0.00232	32466
43	4017	0.90305	0.91170	0.90437	0.91042	0.00290	0.91005	0.00246	0.90972	0.00448	0.91016	0.00221	34244
44	3913	0.91358	0.90798	0.91961	0.91055	0.00278	0.90996	0.00235	0.91013	0.00431	0.91017	0.00211	36008
45	4027	0.90103	0.88472	0.92122	0.91017	0.00270	0.90895	0.00247	0.91057	0.00415	0.90949	0.00215	33149
46	3978	0.90877	0.91309	0.92425	0.91011	0.00259	0.90911	0.00238	0.91110	0.00403	0.90962	0.00207	34483
47	3982	0.92088	0.92208	0.91748	0.91051	0.00253	0.90959	0.00234	0.91133	0.00388	0.91006	0.00204	34309
48	4056	0.90592	0.90337	0.89864	0.91035	0.00244	0.90937	0.00227	0.91088	0.00377	0.90983	0.00197	35224
49	3931	0.88610	0.88336	0.88227	0.90951	0.00250	0.90847	0.00236	0.90989	0.00377	0.90895	0.00211	29667
50	3874	0.88498	0.90779	0.87596	0.90869	0.00255	0.90845	0.00228	0.90876	0.00381	0.90855	0.00207	29907
51	4050	0.93228	0.91282	0.92349	0.90946	0.00258	0.90859	0.00221	0.90924	0.00372	0.90888	0.00204	29898
52	4131	0.91748	0.93005	0.89727	0.90971	0.00251	0.90926	0.00225	0.90886	0.00362	0.90931	0.00202	29268
53	3888	0.89548	0.91042	0.90122	0.90928	0.00247	0.90930	0.00218	0.90863	0.00351	0.90920	0.00196	30325
54	3911	0.87326	0.89615	0.87974	0.90822	0.00262	0.90891	0.00215	0.90778	0.00351	0.90863	0.00199	28565
55	3925	0.92044	0.90749	0.91581	0.90857	0.00257	0.90887	0.00209	0.90801	0.00342	0.90868	0.00193	29505
56	4287	0.91968	0.89941	0.91865	0.90887	0.00251	0.90861	0.00204	0.90831	0.00334	0.90858	0.00188	30257
57	3973	0.88660	0.88851	0.88726	0.90827	0.00252	0.90806	0.00206	0.90774	0.00329	0.90802	0.00191	28377
58	3877	0.86586	0.88792	0.87386	0.90716	0.00269	0.90753	0.00207	0.90685	0.00333	0.90738	0.00197	26057
59	3870	0.90399	0.90119	0.89582	0.90707	0.00263	0.90737	0.00203	0.90656	0.00325	0.90719	0.00192	26512

60	4179	0.92172	0.90911	0.91363	0.90744	0.00258	0.90741	0.00198	0.90674	0.00318	0.90726	0.00188	27141
61	4083	0.90703	0.92049	0.90929	0.90743	0.00252	0.90773	0.00195	0.90680	0.00310	0.90752	0.00185	27296
62	3954	0.91698	0.91359	0.94448	0.90766	0.00247	0.90787	0.00191	0.90770	0.00315	0.90783	0.00183	27341
63	4088	0.89615	0.91994	0.88843	0.90739	0.00243	0.90815	0.00189	0.90725	0.00311	0.90794	0.00179	27848
64	3917	0.90453	0.90881	0.91788	0.90733	0.00237	0.90817	0.00184	0.90749	0.00305	0.90799	0.00175	28504
65	4098	0.93931	0.91457	0.94744	0.90804	0.00243	0.90831	0.00181	0.90838	0.00311	0.90831	0.00173	28319
66	4170	0.92470	0.91072	0.92456	0.90840	0.00240	0.90836	0.00177	0.90873	0.00306	0.90843	0.00170	28846
67	3974	0.91193	0.92815	0.90891	0.90847	0.00235	0.90878	0.00178	0.90874	0.00300	0.90876	0.00170	28346
68	3918	0.94790	0.94286	0.94974	0.90929	0.00244	0.90949	0.00188	0.90959	0.00306	0.90950	0.00182	24045
69	4186	0.90135	0.90359	0.89478	0.90913	0.00240	0.90937	0.00185	0.90929	0.00301	0.90935	0.00179	24380
70	3867	0.90233	0.92508	0.90248	0.90900	0.00235	0.90969	0.00184	0.90915	0.00295	0.90955	0.00177	24511
71	3982	0.90216	0.91664	0.90095	0.90886	0.00231	0.90982	0.00181	0.90899	0.00290	0.90961	0.00174	24947
72	3913	0.90692	0.91235	0.90618	0.90883	0.00227	0.90987	0.00177	0.90894	0.00284	0.90964	0.00170	25458
73	4092	0.88408	0.90100	0.87972	0.90836	0.00227	0.90971	0.00175	0.90839	0.00284	0.90941	0.00169	25283
74	3977	0.88061	0.89249	0.88107	0.90784	0.00229	0.90939	0.00174	0.90788	0.00283	0.90907	0.00170	24500
75	3985	0.91457	0.91724	0.92554	0.90797	0.00225	0.90953	0.00172	0.90820	0.00280	0.90923	0.00168	24687
76	4163	0.93325	0.92597	0.93546	0.90842	0.00225	0.90982	0.00171	0.90869	0.00279	0.90958	0.00168	24187
77	4101	0.91077	0.91525	0.88402	0.90846	0.00221	0.90992	0.00168	0.90826	0.00278	0.90960	0.00165	24655
78	3918	0.91559	0.92134	0.91268	0.90858	0.00218	0.91012	0.00167	0.90833	0.00273	0.90977	0.00163	24795
79	3991	0.91593	0.90083	0.91626	0.90871	0.00215	0.90996	0.00165	0.90847	0.00269	0.90966	0.00161	25238
80	4060	0.90845	0.91778	0.91963	0.90870	0.00211	0.91009	0.00162	0.90865	0.00265	0.90978	0.00159	25466
81	3939	0.89289	0.90134	0.89609	0.90844	0.00209	0.90994	0.00160	0.90845	0.00261	0.90963	0.00157	25573
82	3906	0.90854	0.92155	0.92838	0.90844	0.00206	0.91013	0.00159	0.90877	0.00259	0.90979	0.00156	25517
83	4101	0.91827	0.93059	0.92167	0.90860	0.00203	0.91046	0.00160	0.90897	0.00256	0.91005	0.00156	24920
84	4061	0.89743	0.92420	0.88414	0.90843	0.00201	0.91067	0.00159	0.90858	0.00255	0.91012	0.00155	25077
85	3822	0.92602	0.90622	0.93825	0.90870	0.00199	0.91060	0.00156	0.90904	0.00255	0.91017	0.00152	25640
86	4072	0.93904	0.92311	0.96556	0.90916	0.00202	0.91079	0.00155	0.90990	0.00265	0.91045	0.00152	25089
87	4071	0.91403	0.91879	0.91843	0.90923	0.00199	0.91091	0.00153	0.91002	0.00261	0.91056	0.00151	25289
88	3965	0.93313	0.92991	0.92967	0.90958	0.00199	0.91119	0.00153	0.91031	0.00259	0.91087	0.00151	24742
89	4146	0.89865	0.90468	0.91048	0.90942	0.00197	0.91110	0.00151	0.91032	0.00255	0.91079	0.00150	24894
90	3816	0.90068	0.89816	0.90427	0.90930	0.00194	0.91091	0.00150	0.91023	0.00252	0.91062	0.00148	24935
91	4004	0.91179	0.91031	0.90566	0.90933	0.00191	0.91090	0.00148	0.91017	0.00248	0.91061	0.00146	25366
92	4065	0.91897	0.91949	0.92286	0.90947	0.00189	0.91102	0.00147	0.91034	0.00245	0.91074	0.00145	25516
93	3972	0.86957	0.89366	0.87878	0.90892	0.00194	0.91079	0.00147	0.90991	0.00246	0.91053	0.00146	24610
94	3787	0.88832	0.88128	0.89858	0.90864	0.00194	0.91039	0.00150	0.90976	0.00243	0.91017	0.00149	23388
95	4090	0.89594	0.90933	0.89442	0.90847	0.00192	0.91037	0.00148	0.90955	0.00241	0.91013	0.00147	23611
96	4007	0.90290	0.90983	0.89889	0.90840	0.00190	0.91037	0.00146	0.90941	0.00238	0.91010	0.00145	23911
97	4026	0.88670	0.88189	0.87834	0.90812	0.00189	0.91000	0.00149	0.90901	0.00238	0.90967	0.00148	22767
98	3928	0.92116	0.90562	0.92119	0.90828	0.00187	0.90994	0.00147	0.90916	0.00236	0.90966	0.00146	23196
99	4190	0.90338	0.90785	0.89860	0.90822	0.00185	0.90991	0.00145	0.90903	0.00233	0.90962	0.00144	23479
100	3944	0.92558	0.94174	0.94426	0.90844	0.00184	0.91031	0.00149	0.90947	0.00234	0.90987	0.00147	22076
101	4088	0.88125	0.88813	0.87962	0.90810	0.00185	0.91004	0.00149	0.90910	0.00234	0.90959	0.00149	21422
102	3825	0.91420	0.90348	0.90488	0.90818	0.00183	0.90996	0.00148	0.90905	0.00231	0.90953	0.00147	21819
103	4085	0.90639	0.91680	0.90261	0.90816	0.00181	0.91004	0.00146	0.90897	0.00229	0.90958	0.00145	22022
104	3950	0.90283	0.89441	0.91831	0.90809	0.00179	0.90985	0.00146	0.90908	0.00226	0.90944	0.00144	22022
105	3989	0.89410	0.90249	0.88954	0.90793	0.00177	0.90977	0.00144	0.90885	0.00225	0.90933	0.00143	22140
106	3945	0.92943	0.93135	0.94592	0.90818	0.00177	0.91002	0.00145	0.90929	0.00226	0.90954	0.00144	21602
107	4182	0.91433	0.91323	0.88151	0.90825	0.00175	0.91005	0.00143	0.90897	0.00226	0.90960	0.00142	22021
108	3902	0.90851	0.90137	0.90649	0.90825	0.00173	0.90996	0.00142	0.90894	0.00223	0.90952	0.00140	22275
109	3933	0.91273	0.92261	0.91069	0.90830	0.00171	0.91010	0.00141	0.90896	0.00221	0.90963	0.00139	22341
110	4066	0.88242	0.89117	0.86584	0.90801	0.00172	0.90989	0.00141	0.90848	0.00224	0.90939	0.00139	21950
111	3854	0.89252	0.88727	0.87854	0.90784	0.00171	0.90964	0.00142	0.90815	0.00224	0.90914	0.00140	21677

112	4019	0.89094	0.89899	0.91325	0.90766	0.00170	0.90952	0.00141	0.90821	0.00221	0.90902	0.00139	21603
113	4009	0.91304	0.91500	0.89748	0.90772	0.00168	0.90958	0.00139	0.90809	0.00219	0.90909	0.00138	21835
114	4020	0.88963	0.90571	0.88105	0.90753	0.00167	0.90954	0.00138	0.90780	0.00219	0.90902	0.00136	21934
115	3940	0.91005	0.90715	0.89687	0.90755	0.00166	0.90952	0.00136	0.90769	0.00217	0.90901	0.00135	22222
116	4047	0.87566	0.89459	0.87089	0.90722	0.00167	0.90936	0.00136	0.90730	0.00218	0.90885	0.00135	21865
117	3854	0.90028	0.89672	0.90786	0.90715	0.00166	0.90923	0.00135	0.90731	0.00216	0.90873	0.00134	21943
118	4115	0.90352	0.90605	0.91289	0.90711	0.00164	0.90920	0.00134	0.90737	0.00213	0.90869	0.00133	22128
119	4004	0.91290	0.92458	0.91982	0.90717	0.00162	0.90935	0.00133	0.90749	0.00212	0.90880	0.00133	22068
120	4054	0.91180	0.91352	0.90056	0.90722	0.00161	0.90939	0.00132	0.90742	0.00210	0.90885	0.00131	22289

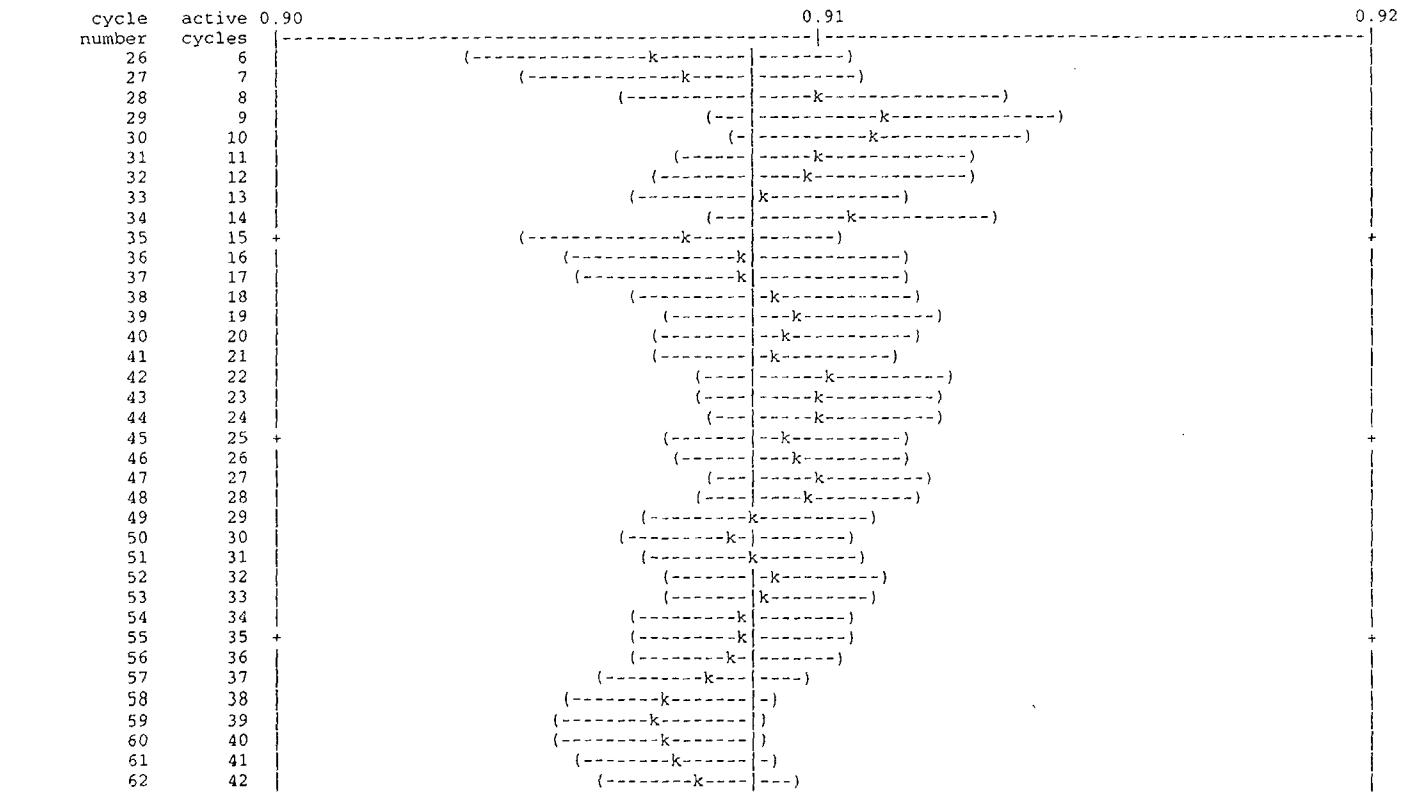
the largest active cycle keffs by estimator are:

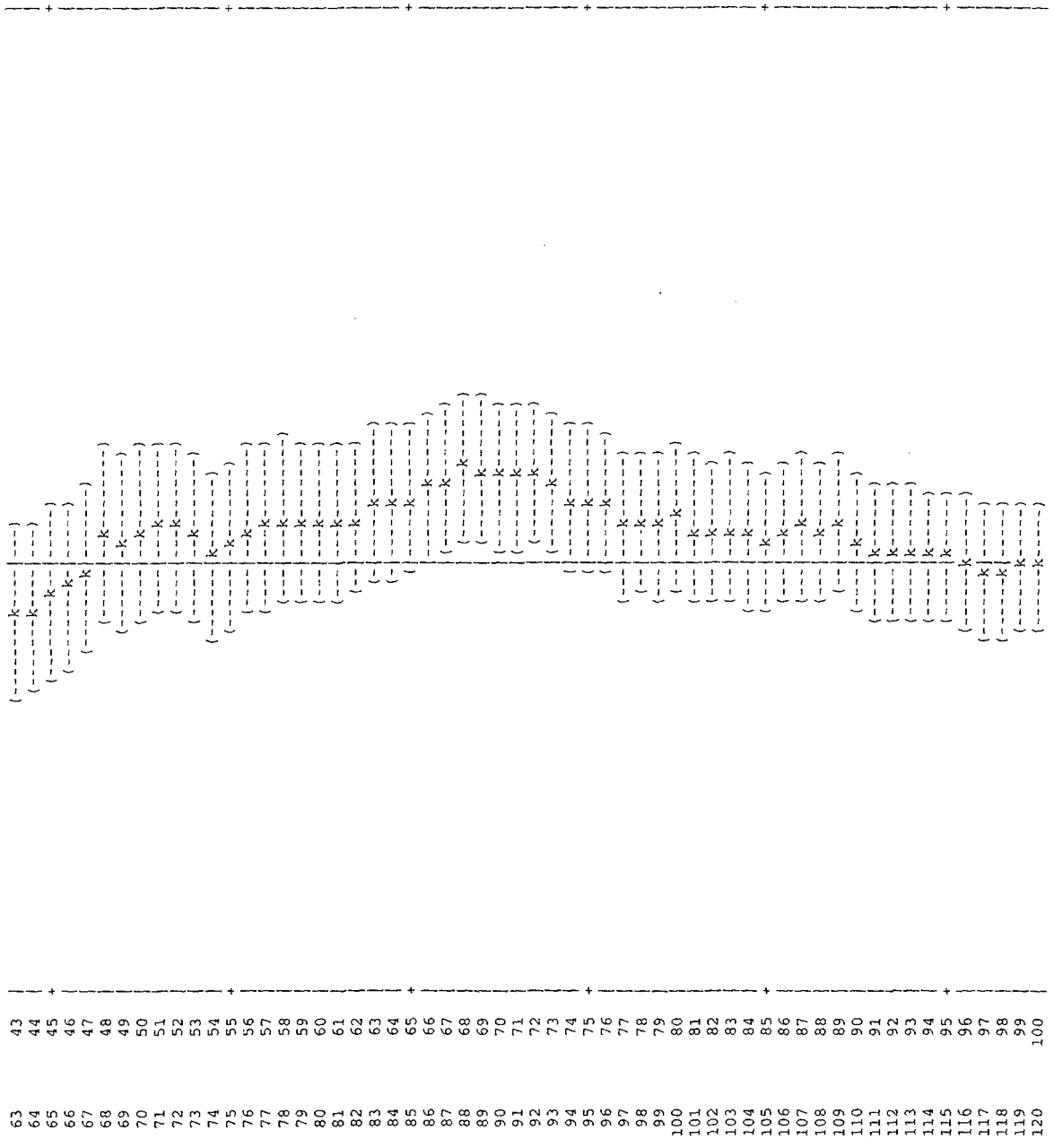
collision 0.94790 on cycle 68
absorption 0.94286 on cycle 68
track length 0.96556 on cycle 86

the smallest active cycle keffs by estimator are:

collision 0.86586 on cycle 58
absorption 0.88128 on cycle 94
track length 0.86584 on cycle 110

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.90885)





|0.90|0.91|0.92|

individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	479622	0.9092	0.0022	0.9111	0.0022	0.9092	0.0025	no/no/no	0.91023	0.00214	0.90597-0.91450	0.90458-0.91589
1	119	475622	0.9076	0.0015	0.9095	0.0014	0.9076	0.0019	99/no/95	0.90875	0.00136	0.90605-0.91145	0.90517-0.91233
2	118	471208	0.9070	0.0014	0.9088	0.0012	0.9070	0.0019	95/95/95	0.90826	0.00118	0.90591-0.91061	0.90514-0.91138
3	117	467650	0.9069	0.0014	0.9087	0.0012	0.9070	0.0019	95/95/95	0.90819	0.00119	0.90582-0.91056	0.90504-0.91133
4	116	463869	0.9072	0.0014	0.9089	0.0012	0.9072	0.0019	95/95/95	0.90840	0.00118	0.90606-0.91075	0.90529-0.91152
5	115	460056	0.9072	0.0014	0.9090	0.0012	0.9073	0.0019	95/95/95	0.90845	0.00119	0.90609-0.91082	0.90532-0.91159
6	114	455923	0.9071	0.0014	0.9088	0.0012	0.9072	0.0019	95/95/95	0.90833	0.00119	0.90597-0.91070	0.90520-0.91147
7	113	451869	0.9072	0.0015	0.9090	0.0012	0.9071	0.0019	95/95/95	0.90852	0.00119	0.90615-0.91089	0.90538-0.91166
8	112	447933	0.9072	0.0015	0.9091	0.0012	0.9073	0.0019	95/95/95	0.90857	0.00120	0.90618-0.91096	0.90540-0.91174
9	111	443966	0.9071	0.0015	0.9090	0.0012	0.9071	0.0019	95/95/95	0.90848	0.00121	0.90607-0.91088	0.90529-0.91166
10	110	439925	0.9071	0.0015	0.9091	0.0012	0.9070	0.0020	95/95/95	0.90858	0.00122	0.90616-0.91101	0.90537-0.91180
11	109	436005	0.9071	0.0015	0.9091	0.0012	0.9072	0.0020	95/95/95	0.90857	0.00123	0.90612-0.91101	0.90533-0.91181
12	108	431989	0.9073	0.0015	0.9093	0.0012	0.9074	0.0020	95/95/95	0.90877	0.00123	0.90633-0.91121	0.90553-0.91201
13	107	427995	0.9072	0.0015	0.9093	0.0012	0.9073	0.0020	95/95/95	0.90880	0.00124	0.90633-0.91127	0.90553-0.91207
14	106	423975	0.9072	0.0015	0.9093	0.0013	0.9073	0.0020	95/95/95	0.90876	0.00125	0.90627-0.91125	0.90546-0.91206
15	105	419937	0.9070	0.0015	0.9092	0.0013	0.9072	0.0020	95/95/95	0.90866	0.00126	0.90615-0.91118	0.90533-0.91199
16	104	415867	0.9070	0.0016	0.9093	0.0013	0.9070	0.0020	95/95/95	0.90871	0.00127	0.90617-0.91124	0.90534-0.91207
17	103	411945	0.9070	0.0016	0.9094	0.0013	0.9071	0.0021	95/95/95	0.90880	0.00128	0.90624-0.91136	0.90541-0.91219
18	102	408025	0.9070	0.0016	0.9093	0.0013	0.9071	0.0021	95/95/95	0.90873	0.00129	0.90615-0.91130	0.90531-0.91214
19	101	404012	0.9071	0.0016	0.9094	0.0013	0.9072	0.0021	95/95/95	0.90882	0.00130	0.90623-0.91141	0.90539-0.91226
20	100*	400096	0.9072	0.0016	0.9094	0.0013	0.9074	0.0021	95/95/95	0.90885	0.00131	0.90624-0.91146	0.90538-0.91232
22	98	391880	0.9073	0.0016	0.9094	0.0013	0.9075	0.0021	95/95/95	0.90889	0.00134	0.90622-0.91155	0.90535-0.91242
24	96	383890	0.9072	0.0017	0.9095	0.0014	0.9078	0.0021	95/95/95	0.90890	0.00137	0.90618-0.91162	0.90529-0.91251
26	94	375933	0.9074	0.0017	0.9094	0.0014	0.9083	0.0022	95/95/95	0.90892	0.00139	0.90615-0.91169	0.90524-0.91260
28	92	367896	0.9074	0.0017	0.9093	0.0014	0.9083	0.0022	95/95/95	0.90878	0.00142	0.90596-0.91160	0.90504-0.91252
30	90	359967	0.9073	0.0018	0.9091	0.0014	0.9081	0.0022	95/95/95	0.90867	0.00144	0.90580-0.91154	0.90486-0.91247
32	88	352047	0.9077	0.0018	0.9093	0.0015	0.9081	0.0023	95/95/95	0.90886	0.00146	0.90596-0.91176	0.90502-0.91271
34	86	343977	0.9074	0.0018	0.9092	0.0015	0.9076	0.0023	95/95/95	0.90870	0.00147	0.90577-0.91164	0.90481-0.91260
36	84	336079	0.9073	0.0018	0.9092	0.0015	0.9077	0.0023	95/95/95	0.90878	0.00147	0.90586-0.91170	0.90490-0.91265
38	82	327944	0.9070	0.0019	0.9092	0.0015	0.9075	0.0023	95/95/95	0.90872	0.00150	0.90574-0.91171	0.90476-0.91268
40	80	319951	0.9066	0.0018	0.9094	0.0015	0.9072	0.0023	95/95/95	0.90874	0.00156	0.90564-0.91184	0.90462-0.91285
42	78	312099	0.9062	0.0019	0.9092	0.0015	0.9067	0.0024	95/95/95	0.90862	0.00158	0.90547-0.91178	0.90444-0.91281
44	76	304169	0.9062	0.0019	0.9092	0.0016	0.9066	0.0024	95/95/95	0.90861	0.00163	0.90537-0.91185	0.90430-0.91291
46	74	296164	0.9062	0.0020	0.9095	0.0016	0.9061	0.0025	95/95/95	0.90900	0.00165	0.90572-0.91228	0.90464-0.91336
48	72	288126	0.9060	0.0020	0.9094	0.0016	0.9061	0.0025	95/95/95	0.90888	0.00168	0.90552-0.91223	0.90442-0.91333
50	70	280321	0.9066	0.0020	0.9098	0.0016	0.9068	0.0025	95/95/95	0.90931	0.00168	0.90595-0.91267	0.90485-0.91378
52	68	272140	0.9060	0.0020	0.9095	0.0016	0.9067	0.0026	95/95/95	0.90886	0.00171	0.90545-0.91228	0.90432-0.91340
54	66	264341	0.9067	0.0020	0.9096	0.0017	0.9072	0.0026	95/95/95	0.90901	0.00172	0.90557-0.91245	0.90444-0.91359
56	64	256129	0.9063	0.0021	0.9098	0.0017	0.9069	0.0027	95/95/95	0.90912	0.00181	0.90551-0.91274	0.90432-0.91393
58	62	248279	0.9073	0.0020	0.9105	0.0017	0.9078	0.0027	95/95/95	0.90966	0.00175	0.90615-0.91317	0.90500-0.91433
60	60	240230	0.9071	0.0021	0.9107	0.0018	0.9079	0.0028	95/95/95	0.90969	0.00183	0.90602-0.91336	0.90481-0.91457
62	58	232193	0.9069	0.0021	0.9105	0.0018	0.9072	0.0028	95/95/95	0.90962	0.00188	0.90584-0.91339	0.90460-0.91464
64	56	224188	0.9071	0.0022	0.9104	0.0019	0.9074	0.0029	95/95/95	0.90963	0.00193	0.90577-0.91350	0.90448-0.91478
66	54	215920	0.9062	0.0022	0.9103	0.0019	0.9063	0.0029	95/95/95	0.90918	0.00205	0.90506-0.91330	0.90369-0.91467
68	52	208028	0.9053	0.0021	0.9093	0.0019	0.9054	0.0029	95/95/95	0.90813	0.00196	0.90418-0.91208	0.90286-0.91339
70	50	199975	0.9054	0.0022	0.9091	0.0019	0.9057	0.0030	95/95/95	0.90814	0.00201	0.90410-0.91219	0.90274-0.91355
72	48	192080	0.9055	0.0023	0.9089	0.0020	0.9058	0.0031	95/95/95	0.90802	0.00208	0.90383-0.91220	0.90243-0.91360

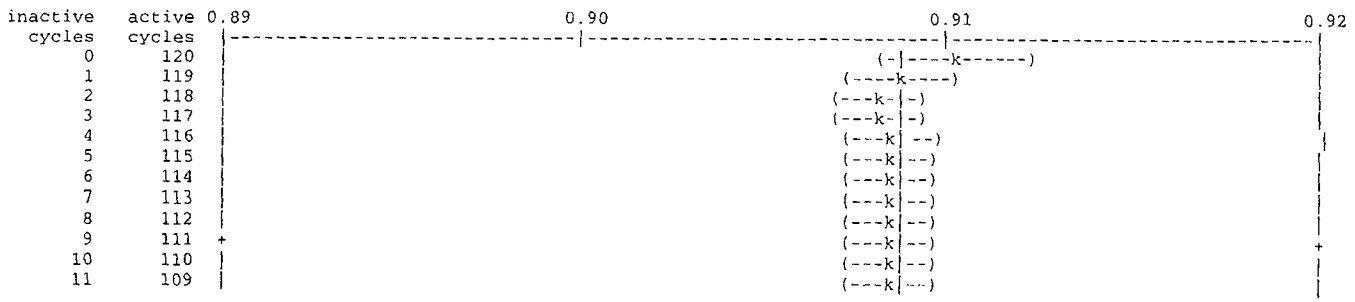
74	46	184011	0.9065	0.0023	0.9094	0.0020	0.9069	0.0031	95/95/95	0.90845	0.00208	0.90426-0.91265	0.90285-0.91406
76	44	175863	0.9057	0.0023	0.9088	0.0021	0.9058	0.0032	95/95/95	0.90775	0.00213	0.90345-0.91204	0.90200-0.91350
78	42	167844	0.9053	0.0024	0.9084	0.0022	0.9062	0.0033	95/95/95	0.90718	0.00219	0.90276-0.91160	0.90126-0.91309
80	40	159793	0.9050	0.0025	0.9084	0.0022	0.9056	0.0034	95/95/95	0.90714	0.00231	0.90245-0.91183	0.90086-0.91342
82	38	151948	0.9052	0.0026	0.9082	0.0023	0.9052	0.0036	95/95/95	0.90724	0.00239	0.90239-0.91209	0.90074-0.91375
84	36	143786	0.9051	0.0027	0.9071	0.0023	0.9054	0.0037	95/95/95	0.90668	0.00238	0.90183-0.91153	0.90017-0.91319
86	34	135892	0.9035	0.0026	0.9067	0.0024	0.9026	0.0033	95/95/95	0.90579	0.00260	0.90049-0.91110	0.89866-0.91293
88	32	127856	0.9022	0.0025	0.9056	0.0024	0.9013	0.0034	95/95/95	0.90445	0.00259	0.89915-0.90974	0.89731-0.91158
90	30	119894	0.9024	0.0027	0.9059	0.0026	0.9009	0.0036	95/95/95	0.90483	0.00278	0.89912-0.91053	0.89712-0.91253
92	28	111825	0.9014	0.0028	0.9052	0.0027	0.8999	0.0037	95/95/95	0.90393	0.00294	0.89788-0.90998	0.89575-0.91211
94	26	104066	0.9032	0.0027	0.9066	0.0027	0.9008	0.0039	95/95/95	0.90556	0.00286	0.89964-0.91148	0.89752-0.91360
96	24	95969	0.9035	0.0029	0.9063	0.0029	0.9011	0.0043	95/95/95	0.90555	0.00304	0.89922-0.91187	0.89693-0.91416
98	22	88015	0.9034	0.0030	0.9075	0.0030	0.9012	0.0044	95/95/95	0.90605	0.00335	0.89903-0.91306	0.89646-0.91563
100	20	79881	0.9023	0.0031	0.9057	0.0028	0.8992	0.0043	95/95/95	0.90511	0.00321	0.89833-0.91189	0.89579-0.91442
102	18	71968	0.9028	0.0031	0.9068	0.0029	0.9000	0.0047	95/95/95	0.90580	0.00345	0.89845-0.91316	0.89564-0.91597
104	16	63933	0.9026	0.0035	0.9070	0.0031	0.8987	0.0051	95/95/95	0.90722	0.00401	0.89856-0.91588	0.89515-0.91929
106	14	55999	0.9013	0.0034	0.9056	0.0030	0.8960	0.0046	99/95/95	0.90428	0.00406	0.89534-0.91322	0.89166-0.91690
108	12	47915	0.8996	0.0038	0.9053	0.0035	0.8963	0.0052	95/95/95	0.90409	0.00495	0.89290-0.91529	0.88801-0.92017
110	10	39916	0.9000	0.0040	0.9050	0.0035	0.8979	0.0052	95/95/95	0.90358	0.00470	0.89247-0.91469	0.88714-0.92002
112	8	32043	0.9021	0.0047	0.9079	0.0035	0.8984	0.0057	95/95/95	0.90793	0.00528	0.89436-0.92149	0.88665-0.92920
114	6	24014	0.9024	0.0057	0.9071	0.0045	0.9015	0.0070	99/95/95	0.90700	0.00680	0.88534-0.92865	0.86726-0.94673
116	4	16027	0.9071	0.0031	0.9102	0.0059	0.9103	0.0041	95/95/95	0.90587	0.00047	0.89992-0.91183	0.87607-0.93568
117	3	12173	0.9094	0.0030	0.9147	0.0054	0.9111	0.0056					
118	2	8058	0.9124	0.0006	0.9191	0.0055	0.9102	0.0096					

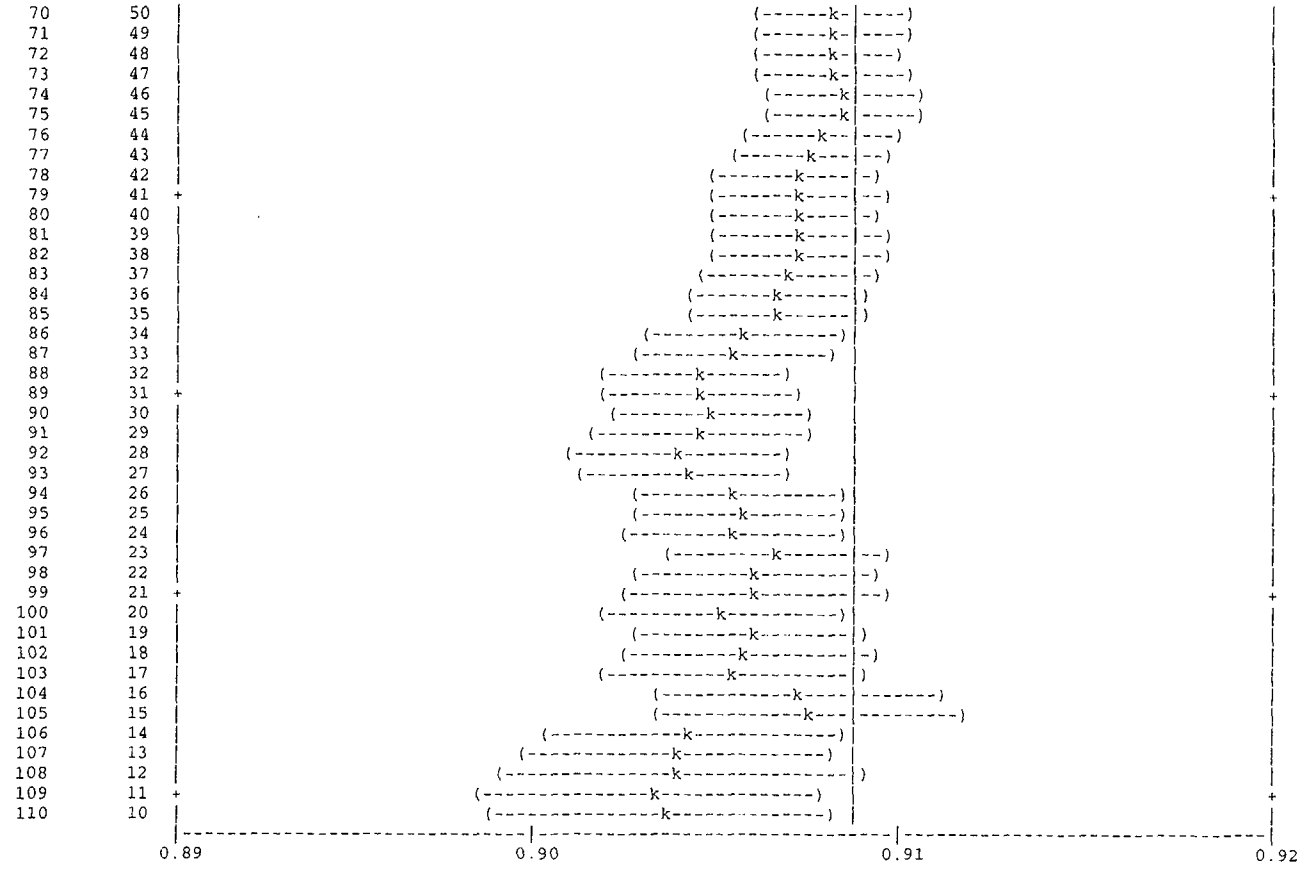
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 116 inactive cycles and 4 active cycles.

the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.90955	0.00177	0.90777 to 0.91133	0.90599 to 0.91311	0.90479 to 0.91430
second half	0.90814	0.00201	0.90612 to 0.91017	0.90410 to 0.91219	0.90274 to 0.91355
final result	0.90885	0.00131	0.90754 to 0.91016	0.90624 to 0.91146	0.90538 to 0.91232

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.90885)





dump no. 3 on file 10254r nps = 479622 coll = 15749676 ctm = 25.92 nrn = 244471453

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 25.94 minutes

mcnp version 4a 10/01/93 06/07/00 19:29:27 probid = 06/07/00 19:03:31

URS

Calculation Cover Page

3065 Southwestern Boulevard
Suite 202
Orchard Park, NY 14127
716 675 7130 Tel
716 675 7137 Fax

Job No: **30822-244-023 /7150** Calculation No: **BUF-2001-019/Rev. 0** Date: **March 19, 2001**

Problem Statement & Calculation Objectives:

To determine the neutron multiplication factors for one and two 30 gallon drums filled with fuel pins arranged in the hexagonal lattice and flooded with water and located next to 7x7x3 array of 30 gallon drums with dry fuel. There is no water outside the drums.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993

Attachments:

Attachment 1: 30 gallon drum dimensions
Attachment 2: Case 1 with MCNP surface and cell numbers
Attachment 3: Case 1 MCNP input file
Attachment 4: Case 1 MCNP output file
Attachment 5: Case 2 with MCNP surface and cell numbers
Attachment 6: Case 2 MCNP input file
Attachment 7: Case 2 MCNP output file

Prepared by:

Signature Igor V. Chichkov — Date 03/19/01

Checked by:

Signature Kevin Roberts — Date 3/28/01

Analysis

Assumptions

The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is unirradiated and 5 w/o enriched
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel pins are arranged in a hexagonal array and fill the 30 gallon drum
- The dry fuel is arranged in the drums with an air to pin ratio a/p = 0.1, corresponding to the most dense packaging
- The flooded fuel is arranged in the drums with a water to pin ratio w/p = 0.5, meaning that 1/3 of the drum is flooded and 2/3 of the drum is occupied by the fuel pins
- Water density is 1 g/cm^3
- The drum and fuel element heights are 72.39 cm (28 1/12 inches)
- The drum diameter is 46.36 cm and the drum height is 72.39 cm
- The air fills outside the drum
- Air density is 0.001293 g/cm^3
- Drum walls are made of 0.175 cm carbon steel.
- The drums stand on a concrete floor and surrounded by concrete walls
- The thickness of the concrete floor and the walls is 3 m

MCNP Model

Neutron multiplication factors were calculated with MCNP4A code. Two different cases were studied:

- **Case 1.** One flooded drum standing next to 7x7x3 array of drums with dry fuel
- **Case 2.** Two flooded drums standing next to 7x7x3 array of drums with dry fuel

Attachments 2 and 5 have the drawings of the models used for case1 and 2 respectively. Examples of MCNP input and output files for both cases can also be found in the Attachments.

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for air (Attix F.H., 1986). Table 2 and 3 show the element weight fractions for stainless steel 304 used in the fuel clad and the carbon steel (Harmon C. D., II et al., 1993) used in the drum walls, respectively. Table 4 shows the element composition of concrete (Harmon C. D., II et al., 1993). The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 5. Molar mass of uranium dioxide (UO_2) can be determined from equation (1).

$$M_{UO_2} = A_U + 2A_{O-16} = f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16} \qquad (1)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)

A_{U-235} = uranium-235 molar mass (g/mole)

A_{U-238} = uranium-238 molar mass (g/mole)

A_{O-16} = oxygen-16 molar mass (g/mole)

f = uranium-235 enrichment

Then the weight fractions for uranium-235 (w_{U-235}), uranium-238 (w_{U-238}), and oxygen-16 (w_{O-16}) are:

$$w_{U-235} = \frac{f\,A_{U-235}}{M_{UO_2}} = \frac{f\,A_{U-235}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (2)$$

$$w_{U-238} = \frac{(1-f)\,A_{U-238}}{M_{UO_2}} = \frac{(1-f)\,A_{U-238}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (3)$$

$$w_{O-16} = \frac{2A_{O-16}}{M_{UO_2}} = \frac{2A_{O-16}}{f\,A_{U-235} + (1-f)\,A_{U-238} + 2A_{O-16}} \qquad (4)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012827

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02
Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Carbon Steel Composition

Element	Weight Fraction
Iron (Fe)	0.995
Carbon (C)	0.005

Table 4. Concrete composition

Element	Weight Fraction
Hydrogen (H)	0.006
Oxygen (O)	0.500
Sodium (Na)	0.017
Aluminum (Al)	0.048
Silicon (Si)	0.315
Potassium (K)	0.019
Calcium (Ca)	0.083
Iron (Fe)	0.012

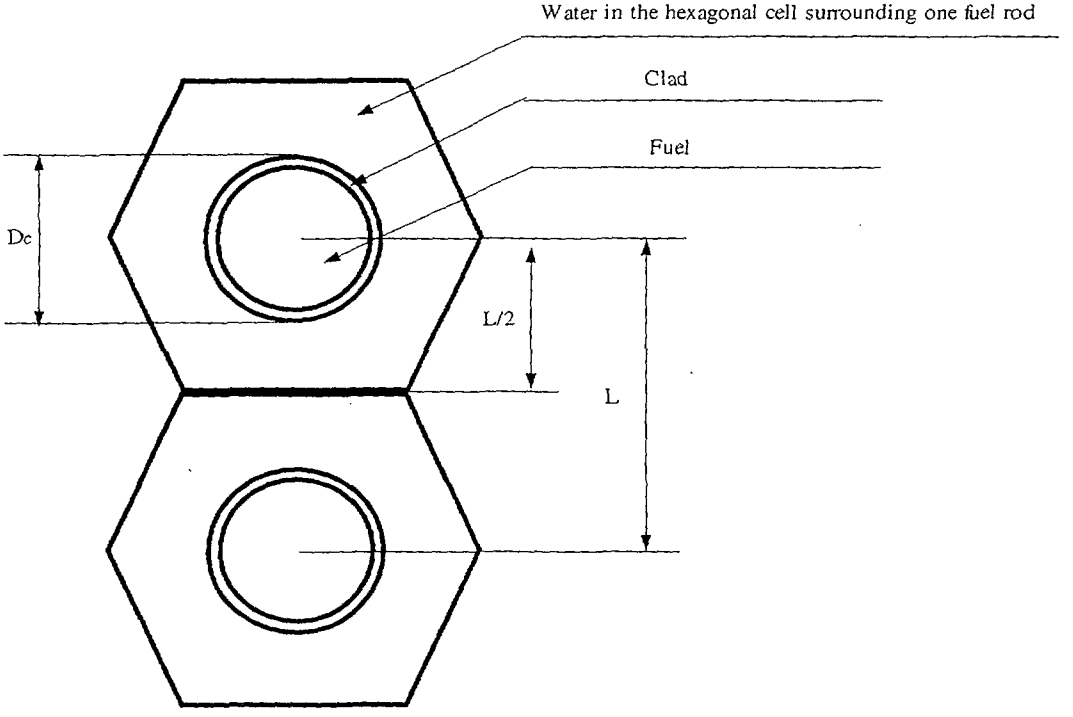
Table 5. Fuel Composition

Element	Weight Fraction
Uranium-235 (^{235}U)	0.0435427
Uranium-238 (^{238}U)	0.8378729
Oxygen (O)	0.1185844

Water to Pin Ratio and Half-distance Between Two Adjacent Rods

To describe the arrangement of the fuel rods, the water to pin and air to pin ratios were stated in the assumptions.. The parameter, which is entered in the MCNP input deck is the half-distance between two adjacent rods. Figure 1 shows the horizontal cross-section of two adjacent fuel rods with water surrounding each rod. This figure shows also the dimension used for the following equations.

Figure 1. Horizontal cross-section of two adjacent fuel rods with water surrounding each rod.



Water to pin ratio can be determined as:

$$w/p = \frac{S_w}{S_p} = \frac{6(L/2)^2 \tan(30^\circ) - \pi D_c^2/4}{\pi D_c^2/4} = \frac{24(L/2)^2 \tan(30^\circ)}{\pi D_c^2} - 1 \qquad (5)$$

Where:

S_w = cross-section area of the water in the hexagonal cell surrounding a pin;

S_p = cross-section area of the pin;

D_c = clad diameter;

$L/2$ = half-distance between two adjacent pins (fuel rods).

Thus, the half-distance between two adjacent pins can be calculated from equation (6) and Table 6 presents the half-distance values corresponding to the water to pin (air to pin) ratios.

$$L/2 = \sqrt{\frac{(w/p+1)\pi D_c^2}{24\tan(30^\circ)}} \qquad (6)$$

Table 6.Half-distance values (L/2) corresponding to the water to pin (w/p) or air to pin (a/p) ratios.

w/p or a/p	0.102658	0.5
L/2, cm	0.4318	0.50366

The air to pin ratio (a/p) equal to 0.102658 in Table 6 corresponds to the maximum densely packed fuel when the half-distance L/2 in the hexagonal fuel array is the same as the outside fuel clad radius R_c or $D_c/2$. This array parameter was used for modeling the dry fuel in the drums arranged in 7x7x3 array. The water to pin ratio (w/p) equal to 0.5 in Table 6 corresponds to flooding of 1/3 volume of the drum. This array parameter was used for modeling the fuel in the flooded drums standing next to the dry array.

Results

The k_{eff} values were calculated for both models (one and two drums) using MCNP 4A code. Tables 7 shows the calculated neutron multiplication factors

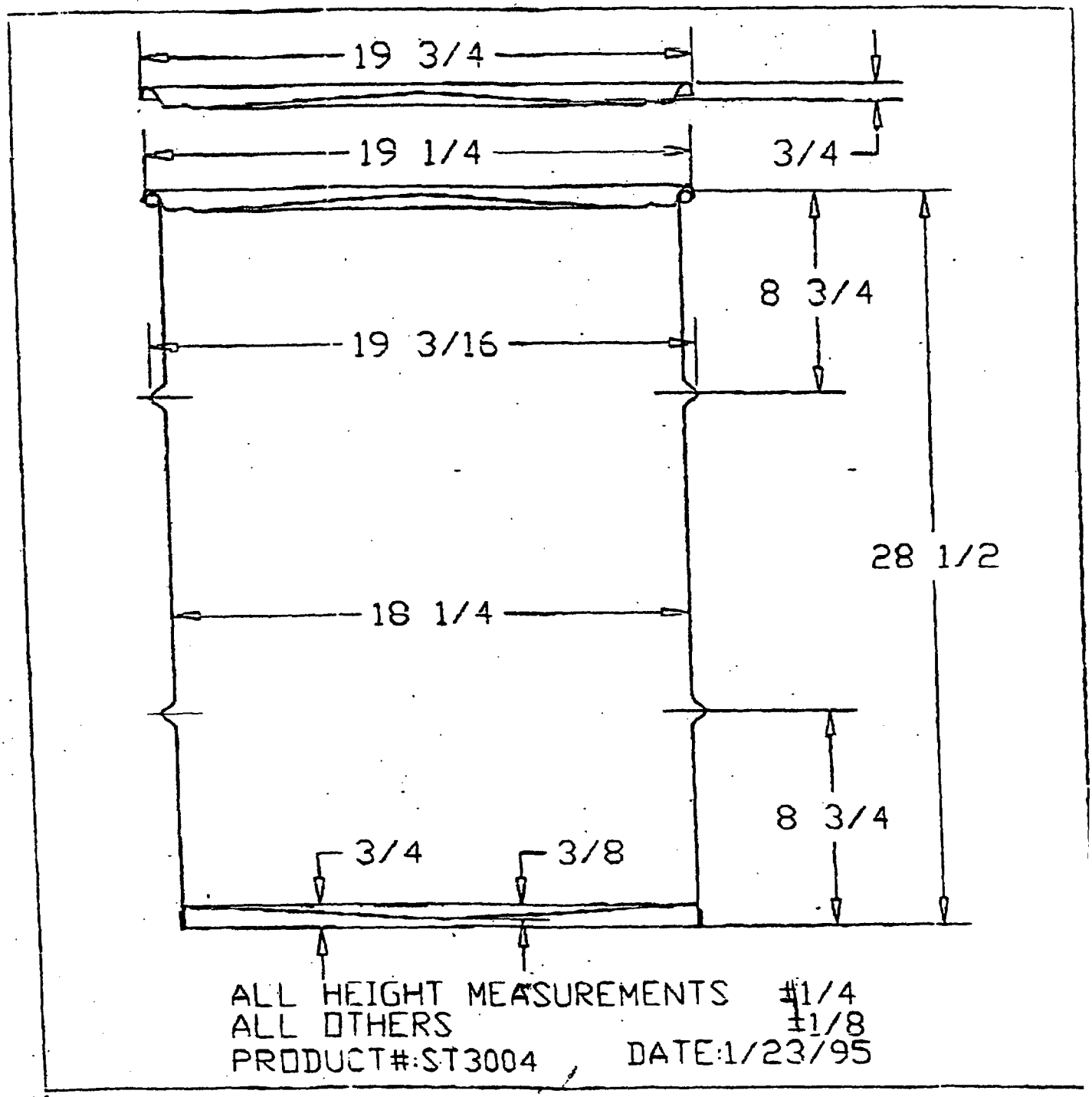
Table 7. MCNP calculated neutron multiplication factors k_{eff} with their standard deviations σ.

	k_{eff}	σ	$k_{eff} + 2\sigma$
Case 1 (one flooded drum next to 7x7x3 dry array)	0.84545	0.00116	0.84777
Case 2 (two flooded drums next to 7x7x3 dry array)	0.91666	0.00105	0.91874

Attachment 1: 30 gallon drum dimensions

COPY

30 GAL 1.5/1.2/1.2mm OPEN HEAD DRUM
UN 1A2/Y1.5/150



ALL HEIGHT MEASUREMENTS ±1/4
ALL OTHERS ±1/8
PRODUCT#:ST3004 DATE:1/23/95

SKOLNIK INDUSTRIES,INC

Attachment 2: Case 1 with MCNP surface and cell numbers

FILE

SUBJECT

WVNS-NCSE-002
Rev. 0

Dames & Moor

Attachment 3: Case 1 MCNP input file

```
                                                                    1f
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c one flooded drum stands next to 7x7x3 array of dry drums
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
c dry fuel in the drum:
c Universe 1 (dry lattice)
11  0         -11 12 -13 14 -15 16 u=1
                  lat=2 fill=2 imp:n=1 $ Hexagonal lattice
c
c Universe 2 (inside the dry lattice)
12 61 -10.4  -17     u=2        imp:n=1 $ fuel rod
13 62  -7.92 -18 17 u=2         imp:n=1 $ SS-304 clad
14 64 -0.001293  18 u=2         imp:n=1 $ air in the lattice cell
c
c
c flooded fuel in the drum:
c Universe 3 (flooded lattice)
21  0         -21 22 -23 24 -25 26 u=3
                  lat=2 fill=4 imp:n=1 $ Hexagonal lattice
c
c Universe 4 (inside the flooded lattice)
22 61 -10.4  -17     u=4        imp:n=1 $ fuel rod
23 62  -7.92 -18 17 u=4         imp:n=1 $ SS-304 clad
24 63 -1.0    18     u=4        imp:n=1 $ water in the lattice cell
c
c
c square lattice of drums with dry fuel:
c Universe 5 (inside the lattice)
33  0      -5  u=5 fill=1  imp:n=1 $ drum filled with dry fuel lattice
34  65  -7.82       5 -6   u=5  imp:n=1 $ drum wall
35  64  -0.001293     6    u=5  imp:n=1 $ air ouside the drum
c
c Universe 6 (drum lattice)
36  0         29 -30 -27 28 u=6
                  lat=1 fill=5 imp:n=1 $ Drum square lattice
c
c
41 0 -46 47 41 -42 2 -8 fill=6 imp:n=1 $ Drum array with dry fuel
c
c Flooded drum:
42 0      -9  2 -3 fill=3  imp:n=1 $ drum filled with flooded fuel lattice
43 65  -7.82       9 -10    2 -3  imp:n=1 $ drum wall
44 64  -0.001293  46 -45 41 -42 2 -8 #42 #43  imp:n=1 $ air ouside the drum
c
45  67 -2.35      40 -43 48 -44 -2 7    imp:n=1 $  concrete floor
46  67 -2.35      2 -8 40 -41 48 -44    imp:n=1 $  west concrete wall
47  67 -2.35      2 -8 42 -43 48 -44    imp:n=1 $  east concrete wall
48  67 -2.35      2 -8 41 -42 45 -44    imp:n=1 $  north concrete wall
49  67 -2.35      2 -8 41 -42 48 -47    imp:n=1 $  south concrete wall
c
50  0        -7 : 8 : -40 : 43 : 44 : -48 imp:n=0 $ Outside world
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ drum bottom plane
3  pz 72.39   $ drum top plane
c
5  c/z 0.0 -24.37 23.005  $ internal wall of the drum with dry fuel
6  c/z 0.0 -24.37 23.180  $ external wall of the drum with dry fuel
c
7  pz -300    $ concrete bottom plane
8  pz 217.17 $ top of 3 tiers of drums
c
c
9  c/z 0.0 24.37 23.005  $ internal wall of the drum with flooded fuel
10 c/z 0.0 24.37 23.180  $ external wall of the drum with flooded fuel
c
40 px -470.58 $ outside west wall
```

1f

```
41 px -170.58 $ inside west wall
42 px  170.58 $ inside east wall
43 px  470.58 $ outside east wall
c
44 py  348.74 $ outside north wall
45 py   48.74 $ inside north wall
46 py   -0.10 $ drum array north boundary
47 py -341.17 $ inside south wall
48 py -641.17 $ outside south wall
c
c the lattice surfaces for dry fuel in the drum
c a/p=0.1 (fuel pins touch each other)
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of dry lattice surfaces
c
c
17 cz  0.3785 $ fuel wall cylinder
18 cz  0.4318 $ clad outer wall cylinder
c
c the lattice surfaces for flooded fuel in the drum
c w/p=0.5
21 p 0.8660254 -0.5 0  0.50362571
22 p 0.8660254 -0.5 0 -0.50362571
23 p 0.8660254  0.5 0  0.50362571
24 p 0.8660254  0.5 0 -0.50362571
25 py  0.50362571
26 py -0.50362571
c end of dry lattice surfaces
c
c square lattice for the drums
27 py  0.0
28 py -48.74
29 px -24.37
30 px  24.37
c end of the drum lattice surfaces
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61     8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62    14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
       28000.50c -0.10
c
c Water (H-1, O-16)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c
c Air (C, N, O, Ar) composition from Attix p.523
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
       18000.35c -0.012828
c
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65     6000.50c -0.005
       26000.55c -0.995
c
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
```

```
                                                        1f
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67     1001.50c -0.006
        8016.50c -0.5
       11023.50c -0.017
       13027.50c -0.048
       14000.50c -0.315
       19000.50c -0.019
       20000.50c -0.083
       26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc    0.000    24.370 36.195
        0.000   -24.370 36.195
        0.000   -73.110 36.195
        0.000  -121.850 36.195
        0.000  -170.590 36.195
        0.000  -219.330 36.195
        0.000  -268.070 36.195
        0.000  -316.810 36.195
       -48.740  -24.370 36.195  -97.480  -24.370 36.195  -146.220  -24.370 36.195
       -48.740  -73.110 36.195  -97.480  -73.110 36.195  -146.220  -73.110 36.195
       -48.740 -121.850 36.195  -97.480 -121.850 36.195  -146.220 -121.850 36.195
       -48.740 -170.590 36.195  -97.480 -170.590 36.195  -146.220 -170.590 36.195
       -48.740 -219.330 36.195  -97.480 -219.330 36.195  -146.220 -219.330 36.195
       -48.740 -268.070 36.195  -97.480 -268.070 36.195  -146.220 -268.070 36.195
       -48.740 -316.810 36.195  -97.480 -316.810 36.195  -146.220 -316.810 36.195
        48.740  -24.370 36.195   97.480  -24.370 36.195   146.220  -24.370 36.195
        48.740  -73.110 36.195   97.480  -73.110 36.195   146.220  -73.110 36.195
        48.740 -121.850 36.195   97.480 -121.850 36.195   146.220 -121.850 36.195
        48.740 -170.590 36.195   97.480 -170.590 36.195   146.220 -170.590 36.195
        48.740 -219.330 36.195   97.480 -219.330 36.195   146.220 -219.330 36.195
        48.740 -268.070 36.195   97.480 -268.070 36.195   146.220 -268.070 36.195
        48.740 -316.810 36.195   97.480 -316.810 36.195   146.220 -316.810 36.195
```

Attachment 4: Case 1 MCNP output file

```
1mcnp     version 4a    ld=10/01/93                    03/09/01 12:03:24
 ************************************************************************          probid =   03/09/01 12:03:24
 name=1f

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
      C The drum height is 28 1/2 inches (72.39 cm)
      c drum wall thickness is 0.157 cm
      c one flooded drum stands next to 7x7x3 array of dry drums
      c
      C Cell cards
      C
      C ---------------------------------------------------------------------
      c inside the drum:
      c
      c dry fuel in the drum:
      c Universe 1 (dry lattice)
      11  0        -11 12 -13 14 -15 16 u=1
                        lat=2 fill=2 imp:n=1 $ Hexagonal lattice
      c
      c Universe 2 (inside the dry lattice)
      12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
      13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
      14 64 -0.001293  18 u=2       imp:n=1 $ air in the lattice cell
      c
      c
      c flooded fuel in the drum:
      c Universe 3 (flooded lattice)
      21  0        -21 22 -23 24 -25 26 u=3
                        lat=2 fill=4 imp:n=1 $ Hexagonal lattice
      c
      c Universe 4 (inside the flooded lattice)
      22 61 -10.4  -17    u=4       imp:n=1 $ fuel rod
      23 62  -7.92 -18 17 u=4       imp:n=1 $ SS-304 clad
      24 63 -1.0    18    u=4       imp:n=1 $ water in the lattice cell
      c
      c
      c square lattice of drums with dry fuel:
      c Universe 5 (inside the lattice)
      33  0     -5  u=5 fill=1  imp:n=1 $ drum filled with dry fuel lattice
      34  65  -7.82      5 -6   u=5  imp:n=1 $ drum wall
      35  64  -0.001293     6   u=5  imp:n=1 $ air ouside the drum
      c
      c Universe 6 (drum lattice)
      36  0        29 -30 -27 28 u=6
                        lat=1 fill=5 imp:n=1 $ Drum square lattice
      c
      c
      41 0 -46 47 41 -42 2 -8 fill=6 imp:n=1 $ Drum array with dry fuel
      c
      c Flooded drum:
      42 0     -9  2 -3 fill=3  imp:n=1 $ drum filled with flooded fuel lattice
      43 65  -7.82      9 -10   2 -3  imp:n=1 $ drum wall
      44 64  -0.001293  46 -45 41 -42 2 -8 #42 #43  imp:n=1 $ air ouside the drum
      c
      45  67 -2.35     40 -43 48 -44 -2 7   imp:n=1 $  concrete floor
      46  67 -2.35     2 -8 40 -41 48 -44   imp:n=1 $  west concrete wall
      47  67 -2.35     2 -8 42 -43 48 -44   imp:n=1 $  east concrete wall
      48  67 -2.35     2 -8 41 -42 45 -44   imp:n=1 $  north concrete wall
      49  67 -2.35     2 -8 41 -42 48 -47   imp:n=1 $  south concrete wall
      c
      50  0       -7 : 8 : -40 : 43 : 44 : -48 imp:n=0 $ Outside world
      c
```

```
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ drum bottom plane
3  pz 72.39   $ drum top plane
c
5  c/z 0.0 -24.37 23.005  $ internal wall of the drum with dry fuel
6  c/z 0.0 -24.37 23.180  $ external wall of the drum with dry fuel
c
7  pz -300   $ concrete bottom plane
8  pz 217.17 $ top of 3 tiers of drums
c
c
9  c/z 0.0 24.37 23.005  $ internal wall of the drum with flooded fuel
10 c/z 0.0 24.37 23.180  $ external wall of the drum with flooded fuel
c
40 px -470.58 $ outside west wall
41 px -170.58 $ inside west wall
42 px  170.58 $ inside east wall
43 px  470.58 $ outside east wall
c
44 py  348.74 $ outside north wall
45 py   48.74 $ inside north wall
46 py   -0.10 $ drum array north boundary
47 py -341.17 $ inside south wall
48 py -641.17 $ outside south wall
c
c the lattice surfaces for dry fuel in the drum
c a/p=0.1 (fuel pins touch each other)
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of dry lattice surfaces
c
c
17 cz  0.3785 $ fuel wall cylinder
18 cz  0.4318 $ clad outer wall cylinder
c
c the lattice surfaces for flooded fuel in the drum
c w/p=0.5
21 p 0.8660254 -0.5 0  0.50362571
22 p 0.8660254 -0.5 0 -0.50362571
23 p 0.8660254  0.5 0  0.50362571
24 p 0.8660254  0.5 0 -0.50362571
25 py  0.50362571
26 py -0.50362571
c end of dry lattice surfaces
c
c square lattice for the drums
27 py  0.0
28 py -48.74
29 px -24.37
30 px  24.37
c end of the drum lattice surfaces
c
C ------------------------------------------------------------------------
```

```
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61     8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62    14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
       28000.50c -0.10
c
c Water (H-1, O-16)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c
c Air (C, N, O, Ar) composition from Attix p.523
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
       18000.35c -0.012828
c
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65     6000.50c -0.005
       26000.55c -0.995
c
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67     1001.50c -0.006
        8016.50c -0.5
       11023.50c -0.017
       13027.50c -0.048
       14000.50c -0.315
       19000.50c -0.019
       20000.50c -0.083
       26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc    0.000    24.370 36.195
        0.000   -24.370 36.195
        0.000   -73.110 36.195
        0.000  -121.850 36.195
        0.000  -170.590 36.195
        0.000  -219.330 36.195
        0.000  -268.070 36.195
        0.000  -316.810 36.195
       -48.740  -24.370 36.195  -97.480  -24.370 36.195  -146.220  -24.370 36.195
       -48.740  -73.110 36.195  -97.480  -73.110 36.195  -146.220  -73.110 36.195
       -48.740 -121.850 36.195  -97.480 -121.850 36.195  -146.220 -121.850 36.195
       -48.740 -170.590 36.195  -97.480 -170.590 36.195  -146.220 -170.590 36.195
```

```
 183-            -48.740 -219.330 36.195  -97.480 -219.330 36.195  -146.220 -219.330 36.195
 184-            -48.740 -268.070 36.195  -97.480 -268.070 36.195  -146.220 -268.070 36.195
 185-            -48.740 -316.810 36.195  -97.480 -316.810 36.195  -146.220 -316.810 36.195
 186-             48.740  -24.370 36.195   97.480  -24.370 36.195   146.220  -24.370 36.195
 187-             48.740  -73.110 36.195   97.480  -73.110 36.195   146.220  -73.110 36.195
 188-             48.740 -121.850 36.195   97.480 -121.850 36.195   146.220 -121.850 36.195
 189-             48.740 -170.590 36.195   97.480 -170.590 36.195   146.220 -170.590 36.195
 190-             48.740 -219.330 36.195   97.480 -219.330 36.195   146.220 -219.330 36.195
 191-             48.740 -268.070 36.195   97.480 -268.070 36.195   146.220 -268.070 36.195
 192-             48.740 -316.810 36.195   97.480 -316.810 36.195   146.220 -316.810 36.195
 193-
 total fission nubar data are being used.
1material composition                                                    print table 40

 material
  number      component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01666      92238,  0.31655
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
    64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
    65            6000,  0.02283      26000,  0.97717
    67            1001,  0.11082       8016,  0.58191      11023,  0.01377      13027,  0.03312
                 14000,  0.20878      19000,  0.00905      20000,  0.03855      26000,  0.00400



 material
  number      component nuclide, mass fraction

    61            8016,  0.11858      92235,  0.04354      92238,  0.83787
    62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                 28000,  0.10000
    63            1001,  0.11192       8016,  0.88808
    64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
    65            6000,  0.00500      26000,  0.99500
    67            1001,  0.00600       8016,  0.50000      11023,  0.01700      13027,  0.04800
                 14000,  0.31500      19000,  0.01900      20000,  0.08300      26000,  0.01200
1cells                                                                   print table 60

                        atom          gram                                        neutron
      cell   mat      density       density       volume        mass        pieces importance

     1    11     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     2    12    61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     3    13    62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     4    14    64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
     5    21     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     6    22    61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     7    23    62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     8    24   63s  1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     9    33     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    10    34    65  8.58651E-02 7.82000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    11    35    64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
    12    36     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
    13    41     0  0.00000E+00 0.00000E+00 2.52698E+07 0.00000E+00      0  1.0000E+00
    14    42     0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00      1  1.0000E+00
    15    43    65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04      1  1.0000E+00
```

```
   16    44   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00     0  1.0000E+00
   17    45   67  7.60226E-02 2.35000E+00 2.79499E+08 6.56823E+08     0  1.0000E+00
   18    46   67  7.60226E-02 2.35000E+00 6.44936E+07 1.51560E+08     0  1.0000E+00
   19    47   67  7.60226E-02 2.35000E+00 6.44936E+07 1.51560E+08     0  1.0000E+00
   20    48   67  7.60226E-02 2.35000E+00 2.22269E+07 5.22333E+07     0  1.0000E+00
   21    49   67  7.60226E-02 2.35000E+00 2.22269E+07 5.22333E+07     0  1.0000E+00
   22    50    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00     0  0.0000E+00

 total                                    4.78332E+08 1.06442E+09
1cross-section tables                                                                    print table 100

    table    length

                      tables from file critxs

  1001.50c    1153  njoy                                                          (  1301)      79/07/31.
  6000.50c   16126  njoy                                                          (  1306)      79/07/31.
  7014.50c   22772  njoy                                                          (  1275)      79/09/08.
  8016.50c   23669  njoy                                                          ( 1276)      05/14/81
 11023.50c   36270  njoy                                                          (  1311)      79/06/21.
 13027.50c   22891  njoy                                                          (  1313)      79/09/08.
 14000.50c   48275  njoy                                                          (  1314)      79/06/21.
 18000.35c    2182      end185                                                     (  18)       11/01/85
 19000.50c    9766  njoy                                                          (  1150)      79/10/29.
 20000.50c   26104  njoy                                                          (  1320)      79/06/22.
 24000.50c   89104  njoy                                                          (  1324)      79/06/21.
 25055.50c   60097  njoy                                                          (  1325)      79/06/21.
 26000.55c   84136  njoy                                                          ( 260)       10/21/82
 28000.50c   82267  njoy                                                          (  1328)      79/06/21.
 92235.50c   44188  njoy                                          total nu        (  1395)      79/09/12.
 92238.50c   66440  njoy                                          total nu        (  1398)      79/09/13.
  lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                1001     0     010/22/85

  total      645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general             122658
     tallies                  0
     bank                 16403
     cross sections      645633

     total               784694

 ******************************************************************************************************************
 dump no.    1 on file 1fr          nps =          0     coll =              0     ctm =    0.00     nrn =              0


 source distribution written to file 1fs             cycle =     0

          1 warning message so far.
1   starting mcrun.      field length =      0      cp0 =  0.02                                      print table 110

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air


 nps   x          y          z       cell lattice(i,j,k)  surface .  u          v          w        energy     weight      time

  1  0.000E+00  2.437E+01  3.620E+01   42                          5.085E-01  4.733E-01  7.193E-01  2.209E+00  1.000E+00  0.000E+00
    -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)          5.085E-01  4.733E-01  7.193E-01
    -1.776E-15  1.960E-01  3.620E+01   22                      0   5.085E-01  4.733E-01  7.193E-01
```

```
 2  0.000E+00  2.437E+01  3.620E+01  42                                    8.952E-01 -4.447E-01 -2.944E-02  4.904E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    8.952E-01 -4.447E-01 -2.944E-02
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  8.952E-01 -4.447E-01 -2.944E-02
 3  0.000E+00  2.437E+01  3.620E+01  42                                   -6.184E-01 -4.495E-01  6.446E-01  3.809E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -6.184E-01 -4.495E-01  6.446E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -6.184E-01 -4.495E-01  6.446E-01
 4  0.000E+00  2.437E+01  3.620E+01  42                                    9.710E-01 -5.665E-02 -2.323E-01  1.331E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    9.710E-01 -5.665E-02 -2.323E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  9.710E-01 -5.665E-02 -2.323E-01
 5  0.000E+00  2.437E+01  3.620E+01  42                                    5.861E-01  1.496E-01 -7.963E-01  1.902E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    5.861E-01  1.496E-01 -7.963E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  5.861E-01  1.496E-01 -7.963E-01
 6  0.000E+00  2.437E+01  3.620E+01  42                                   -6.489E-02 -1.626E-01  9.845E-01  4.410E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -6.489E-02 -1.626E-01  9.845E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -6.489E-02 -1.626E-01  9.845E-01
 7  0.000E+00  2.437E+01  3.620E+01  42                                   -7.068E-02  3.263E-02 -9.970E-01  4.750E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -7.068E-02  3.263E-02 -9.970E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -7.068E-02  3.263E-02 -9.970E-01
 8  0.000E+00  2.437E+01  3.620E+01  42                                   -3.915E-01  4.664E-01 -7.932E-01  4.136E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -3.915E-01  4.664E-01 -7.932E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -3.915E-01  4.664E-01 -7.932E-01
 9  0.000E+00  2.437E+01  3.620E+01  42                                   -2.368E-01  9.215E-01 -3.079E-01  7.453E-02  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -2.368E-01  9.215E-01 -3.079E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -2.368E-01  9.215E-01 -3.079E-01
10  0.000E+00  2.437E+01  3.620E+01  42                                    1.946E-01 -3.204E-01  9.271E-01  3.128E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    1.946E-01 -3.204E-01  9.271E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  1.946E-01 -3.204E-01  9.271E-01
11  0.000E+00  2.437E+01  3.620E+01  42                                   -6.698E-01 -7.177E-01 -1.905E-01  1.014E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -6.698E-01 -7.177E-01 -1.905E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -6.698E-01 -7.177E-01 -1.905E-01
12  0.000E+00  2.437E+01  3.620E+01  42                                   -8.398E-01 -4.129E-01  3.524E-01  1.395E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -8.398E-01 -4.129E-01  3.524E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -8.398E-01 -4.129E-01  3.524E-01
13  0.000E+00  2.437E+01  3.620E+01  42                                   -1.714E-01 -8.572E-01  4.857E-01  7.748E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -1.714E-01 -8.572E-01  4.857E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -1.714E-01 -8.572E-01  4.857E-01
14  0.000E+00  2.437E+01  3.620E+01  42                                   -2.489E-01 -5.118E-01 -8.222E-01  1.101E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -2.489E-01 -5.118E-01 -8.222E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -2.489E-01 -5.118E-01 -8.222E-01
15  0.000E+00  2.437E+01  3.620E+01  42                                   -2.959E-01  2.119E-01  9.314E-01  1.951E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -2.959E-01  2.119E-01  9.314E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -2.959E-01  2.119E-01  9.314E-01
16  0.000E+00  2.437E+01  3.620E+01  42                                    1.395E-01 -9.829E-01  1.202E-01  2.186E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    1.395E-01 -9.829E-01  1.202E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  1.395E-01 -9.829E-01  1.202E-01
17  0.000E+00  2.437E+01  3.620E+01  42                                    6.909E-01 -7.110E-01  1.307E-01  1.865E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    6.909E-01 -7.110E-01  1.307E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  6.909E-01 -7.110E-01  1.307E-01
18  0.000E+00  2.437E+01  3.620E+01  42                                   -6.580E-01  5.320E-01 -5.329E-01  1.229E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -6.580E-01  5.320E-01 -5.329E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -6.580E-01  5.320E-01 -5.329E-01
19  0.000E+00  2.437E+01  3.620E+01  42                                   -9.903E-01 -1.380E-01  1.353E-02  1.305E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -9.903E-01 -1.380E-01  1.353E-02
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -9.903E-01 -1.380E-01  1.353E-02
20  0.000E+00  2.437E+01  3.620E+01  42                                    7.462E-01  4.859E-01 -4.551E-01  1.000E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                    7.462E-01  4.859E-01 -4.551E-01
   -1.776E-15  1.960E-01  3.620E+01  22                                 0  7.462E-01  4.859E-01 -4.551E-01
21  0.000E+00  2.437E+01  3.620E+01  42                                   -1.977E-01  9.797E-01  3.360E-02  3.990E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -1.977E-01  9.797E-01  3.360E-02
   -1.776E-15  1.960E-01  3.620E+01  22                                 0 -1.977E-01  9.797E-01  3.360E-02
22  0.000E+00  2.437E+01  3.620E+01  42                                   -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01  21( -24,  24,   0)                   -9.117E-01 -3.647E-01 -1.891E-01
```

```
   -1.776E-15  1.960E-01  3.620E+01   22
23  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
24  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
25  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
26  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
27  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
28  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
29  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
30  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
31  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
32  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
33  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
34  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
35  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
36  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
37  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
38  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
39  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
40  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
41  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
42  0.000E+00  2.437E+01  3.620E+01   42
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)
   -1.776E-15  1.960E-01  3.620E+01   22
43  0.000E+00  2.437E+01  3.620E+01   42

0 -9.117E-01 -3.647E-01 -1.891E-01
  -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  1.000E+00  0.000E+00
  -4.287E-01  8.361E-01 -3.423E-01
0 -4.287E-01  8.361E-01 -3.423E-01
   1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
   1.080E-01  3.412E-01 -9.338E-01
0  1.080E-01  3.412E-01 -9.338E-01
  -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
  -9.111E-01 -9.012E-03 -4.122E-01
0 -9.111E-01 -9.012E-03 -4.122E-01
  -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
  -2.568E-01 -6.391E-01 -7.249E-01
0 -2.568E-01 -6.391E-01 -7.249E-01
  -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
  -2.912E-01  8.086E-01  5.113E-01
0 -2.912E-01  8.086E-01  5.113E-01
   1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
   1.472E-01 -9.514E-01  2.705E-01
0  1.472E-01 -9.514E-01  2.705E-01
  -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
  -6.135E-01 -7.645E-01 -1.978E-01
0 -6.135E-01 -7.645E-01 -1.978E-01
  -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
  -5.702E-01  5.651E-01 -5.963E-01
0 -5.702E-01  5.651E-01 -5.963E-01
  -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
  -6.607E-01  5.373E-01 -5.242E-01
0 -6.607E-01  5.373E-01 -5.242E-01
  -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
  -9.742E-02 -3.639E-01 -9.263E-01
0 -9.742E-02 -3.639E-01 -9.263E-01
  -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
  -1.965E-01 -3.145E-01 -9.287E-01
0 -1.965E-01 -3.145E-01 -9.287E-01
   4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
   4.097E-01  8.465E-01 -3.399E-01
0  4.097E-01  8.465E-01 -3.399E-01
  -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
  -4.048E-02  8.831E-01  4.675E-01
0 -4.048E-02  8.831E-01  4.675E-01
   3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
   3.371E-01 -9.269E-01 -1.652E-01
0  3.371E-01 -9.269E-01 -1.652E-01
  -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
  -1.867E-01  9.756E-01 -1.155E-01
0 -1.867E-01  9.756E-01 -1.155E-01
  -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
  -2.616E-01  2.336E-01 -9.365E-01
0 -2.616E-01  2.336E-01 -9.365E-01
   9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
   9.780E-01 -7.641E-02 -1.939E-01
0  9.780E-01 -7.641E-02 -1.939E-01
   2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
   2.580E-01 -7.076E-01  6.578E-01
0  2.580E-01 -7.076E-01  6.578E-01
  -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
  -3.212E-01 -7.678E-01 -5.543E-01
0 -3.212E-01 -7.678E-01 -5.543E-01
   5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
   5.039E-01 -1.460E-01  8.513E-01
0  5.039E-01 -1.460E-01  8.513E-01
   6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
```

```
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        6.080E-01  5.487E-01  5.738E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  6.080E-01  5.487E-01  5.738E-01
 44  0.000E+00  2.437E+01  3.620E+01   42                       -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -2.932E-01  9.304E-01 -2.199E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -2.932E-01  9.304E-01 -2.199E-01
 45  0.000E+00  2.437E+01  3.620E+01   42                       -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -8.475E-01 -3.993E-01 -3.497E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -8.475E-01 -3.993E-01 -3.497E-01
 46  0.000E+00  2.437E+01  3.620E+01   42                        1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        1.200E-01 -9.195E-01 -3.743E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  1.200E-01 -9.195E-01 -3.743E-01
 47  0.000E+00  2.437E+01  3.620E+01   42                        7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        7.085E-01  5.879E-01  3.904E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  7.085E-01  5.879E-01  3.904E-01
 48  0.000E+00  2.437E+01  3.620E+01   42                        4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        4.261E-01  9.046E-01  9.254E-03
   -1.776E-15  1.960E-01  3.620E+01   22                     0  4.261E-01  9.046E-01  9.254E-03
 49  0.000E+00  2.437E+01  3.620E+01   42                        5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        5.431E-01  4.270E-01 -7.230E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  5.431E-01  4.270E-01 -7.230E-01
 50  0.000E+00  2.437E+01  3.620E+01   42                       -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -1.053E-01 -9.805E-01  1.658E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -1.053E-01 -9.805E-01  1.658E-01
lestimated keff results by cycle                                                                    print table 175

*****************************************************************************************************************
dump no.    2 on file 1fr          nps =     35244     coll =        3334310     ctm =   16.49     nrn =       64760512

source distribution written to file 1fs            cycle =    20

*****************************************************************************************************************
dump no.    3 on file 1fr          nps =     79727     coll =        6969082     ctm =   32.21     nrn =      133664126

source distribution written to file 1fs            cycle =    21

source distribution written to file 1fs            cycle =    22

source distribution written to file 1fs            cycle =    23

source distribution written to file 1fs            cycle =    25

source distribution written to file 1fs            cycle =    27

source distribution written to file 1fs            cycle =    29

source distribution written to file 1fs            cycle =    31

source distribution written to file 1fs            cycle =    33

source distribution written to file 1fs            cycle =    35

*****************************************************************************************************************
dump no.    4 on file 1fr          nps =    143965     coll =       11385433     ctm =   47.52     nrn =      214154636

source distribution written to file 1fs            cycle =    37

source distribution written to file 1fs            cycle =    39

source distribution written to file 1fs            cycle =    41
```

```
source distribution written to file 1fs             cycle =    43
source distribution written to file 1fs             cycle =    45
source distribution written to file 1fs             cycle =    47
source distribution written to file 1fs             cycle =    49
source distribution written to file 1fs             cycle =    51
source distribution written to file 1fs             cycle =    53
************************************************************************************************************************
dump no.     5 on file 1fr          nps =     215987     coll =       16216221     ctm =    63.17     nrn =       301246191

source distribution written to file 1fs             cycle =    55
source distribution written to file 1fs             cycle =    57
source distribution written to file 1fs             cycle =    59
source distribution written to file 1fs             cycle =    61
source distribution written to file 1fs             cycle =    63
source distribution written to file 1fs             cycle =    65
source distribution written to file 1fs             cycle =    67
source distribution written to file 1fs             cycle =    69
source distribution written to file 1fs             cycle =    71
source distribution written to file 1fs             cycle =    73
************************************************************************************************************************
dump no.     6 on file 1fr          nps =     292251     coll =       21240674     ctm =    79.01     nrn =       391451498

source distribution written to file 1fs             cycle =    75
source distribution written to file 1fs             cycle =    77
source distribution written to file 1fs             cycle =    79
source distribution written to file 1fs             cycle =    81
source distribution written to file 1fs             cycle =    83
source distribution written to file 1fs             cycle =    85
source distribution written to file 1fs             cycle =    87
source distribution written to file 1fs             cycle =    89
source distribution written to file 1fs             cycle =    91
************************************************************************************************************************
dump no.     7 on file 1fr          nps =     364150     coll =       26012007     ctm =    94.42     nrn =       477416399
```

source distribution written to file 1fs cycle = 93

source distribution written to file 1fs cycle = 95

source distribution written to file 1fs cycle = 97

source distribution written to file 1fs cycle = 99

estimator	cycle 100	ave of 80 cycles		combination	simple average		combined average		corr
k(collision)	0.849057	0.845946	0.0019	k(col/abs)	0.846094	0.0017	0.846205	0.0016	0.7712
k(absorption)	0.845924	0.846242	0.0016	k(abs/tk ln)	0.846854	0.0018	0.846313	0.0016	0.6560
k(trk length)	0.843842	0.847466	0.0023	k(tk ln/col)	0.846706	0.0020	0.845836	0.0020	0.8672
rem life(col)	1.0049E+04	9.5525E+03	0.0056	k(col/abs/tk ln)	0.846551	0.0018	0.846178	0.0016	
rem life(abs)	1.0157E+04	9.5656E+03	0.0053	life(col/abs)	9.5591E+03	0.0054	9.5706E+03	0.0053	0.9664

source points generated 4000

source distribution written to file 1fs cycle = 101

source distribution written to file 1fs cycle = 103

source distribution written to file 1fs cycle = 105

source distribution written to file 1fs cycle = 107

source distribution written to file 1fs cycle = 109

****

dump no. 8 on file 1fr nps = 436506 coll = 30833920 ctm = 109.84 nrn = 564209026

source distribution written to file 1fs cycle = 111

source distribution written to file 1fs cycle = 113

source distribution written to file 1fs cycle = 115

estimator	cycle 116	ave of 96 cycles		combination	simple average		combined average		corr
k(collision)	0.850297	0.845316	0.0017	k(col/abs)	0.845406	0.0015	0.845472	0.0014	0.7458
k(absorption)	0.854321	0.845496	0.0014	k(abs/tk ln)	0.845956	0.0015	0.845575	0.0014	0.6222
k(trk length)	0.844217	0.846415	0.0020	k(tk ln/col)	0.845865	0.0018	0.845297	0.0017	0.8580
rem life(col)	1.0005E+04	9.6377E+03	0.0052	k(col/abs/tk ln)	0.845742	0.0016	0.845505	0.0014	
rem life(abs)	9.8656E+03	9.6427E+03	0.0049	life(col/abs)	9.6402E+03	0.0050	9.6454E+03	0.0048	0.9682

source points generated 4130

estimator	cycle 117	ave of 97 cycles		combination	simple average		combined average		corr
k(collision)	0.862202	0.845490	0.0017	k(col/abs)	0.845488	0.0015	0.845486	0.0014	0.7392
k(absorption)	0.844417	0.845485	0.0014	k(abs/tk ln)	0.845991	0.0015	0.845572	0.0014	0.6210
k(trk length)	0.854372	0.846497	0.0020	k(tk ln/col)	0.845993	0.0018	0.845494	0.0017	0.8566
rem life(col)	9.8243E+03	9.6396E+03	0.0052	k(col/abs/tk ln)	0.845824	0.0016	0.845517	0.0014	
rem life(abs)	9.9535E+03	9.6459E+03	0.0048	life(col/abs)	9.6428E+03	0.0050	9.6492E+03	0.0048	0.9678

source points generated 4001

source distribution written to file 1fs cycle = 117

estimator	cycle 118	ave of 98 cycles		combination	simple average		combined average		corr
k(collision)	0.842462	0.845459	0.0017	k(col/abs)	0.845449	0.0014	0.845441	0.0014	0.7393
k(absorption)	0.840884	0.845438	0.0014	k(abs/tk ln)	0.845959	0.0015	0.845529	0.0014	0.6209
k(trk length)	0.844833	0.846480	0.0020	k(tk ln/col)	0.845969	0.0018	0.845464	0.0017	0.8566
rem life(col)	9.4273E+03	9.6374E+03	0.0051	k(col/abs/tk ln)	0.845792	0.0015	0.845473	0.0014	
rem life(abs)	9.4959E+03	9.6444E+03	0.0048	life(col/abs)	9.6409E+03	0.0049	9.6480E+03	0.0048	0.9678

source points generated 3926

estimator	cycle 119	ave of 99 cycles		combination	simple average		combined average		corr
k(collision)	0.846823	0.845473	0.0017	k(col/abs)	0.845478	0.0014	0.845481	0.0014	0.7391
k(absorption)	0.849826	0.845483	0.0014	k(abs/tk ln)	0.846009	0.0015	0.845574	0.0014	0.6213
k(trk length)	0.851983	0.846536	0.0020	k(tk ln/col)	0.846004	0.0018	0.845477	0.0017	0.8564
rem life(col)	9.6237E+03	9.6373E+03	0.0051	k(col/abs/tk ln)	0.845830	0.0015	0.845512	0.0014	
rem life(abs)	9.6158E+03	9.6441E+03	0.0047	life(col/abs)	9.6407E+03	0.0049	9.6476E+03	0.0047	0.9678

source points generated 4060

source distribution written to file 1fs cycle = 119

estimator	cycle 120	ave of 100 cycles		combination	simple average		combined average		corr
k(collision)	0.833041	0.845348	0.0017	k(col/abs)	0.845383	0.0014	0.845409	0.0014	0.7400
k(absorption)	0.838955	0.845417	0.0014	k(abs/tk ln)	0.845962	0.0015	0.845513	0.0014	0.6213
k(trk length)	0.843558	0.846506	0.0019	k(tk ln/col)	0.845927	0.0017	0.845372	0.0017	0.8545
rem life(col)	9.5517E+03	9.6364E+03	0.0050	k(col/abs/tk ln)	0.845757	0.0015	0.845453	0.0014	
rem life(abs)	9.5041E+03	9.6427E+03	0.0047	life(col/abs)	9.6396E+03	0.0048	9.6459E+03	0.0047	0.9677

source points generated 3914

source distribution written to file 1fs cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

\+ 03/09/01 14:02:36

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 03/09/01 12:03:24

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	480515	9.9893E-01	2.0330E+00	escape	28767	4.3585E-02	2.1744E-02
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	*cell importance*	0	0.	0.
weight cutoff	0	1.2718E-01	5.3125E-04	weight cutoff	452932	1.2711E-01	5.7135E-04
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	8.1070E-08	downscattering	0	0.	1.7542E+00
				capture	0	6.2545E-01	7.3818E-02
(n,xn)	2365	3.6307E-03	2.7423E-03	loss to (n,xn)	1181	1.8137E-03	1.5203E-02
fission	0	0.	0.	loss to fission	0	3.3179E-01	1.7068E-01
total	482880	1.1297E+00	2.0362E+00	total	482880	1.1297E+00	2.0362E+00

number of neutrons banked	1184	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0049E+00	escape	9.4796E+03	tco	1.0000E+34
neutron collisions per source particle	7.0309E+01	capture	9.2458E+03	eco	0.0000E+00
total neutron collisions	33784495	capture or escape	9.2560E+03	wc1	-5.0000E-01
net multiplication	1.0018E+00 0.0001	any termination	1.0942E+04	wc2	-2.5000E-01

computer time so far in this run	119.20 minutes	maximum number ever in bank	2
computer time in mcrun	119.18 minutes	bank overflows to backup file	0
source particles per minute	4.0318E+03	field length	0
random numbers generated	617299831	most random numbers used was	13652 in history 69074

range of sampled source weights = 9.5102E-01 to 1.3527E+00

1neutron activity in each cell print table 126

cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)

1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	12	29784574	271379	9921663	1.2623E+01	2.6377E-02	4.4738E-01	6.3892E-01	2.4788E+00
3	13	62496391	267564	3648721	4.2463E+00	2.5605E-02	4.4518E-01	6.3883E-01	3.0349E+00
4	14	69912441	265987	775	9.2770E-04	2.5331E-02	4.4537E-01	6.3877E-01	5.4106E+03
5	21	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	22	7200277	291109	2354294	3.9843E+00	3.4855E-03	7.4241E-01	8.4479E-01	2.6488E+00
7	23	14807661	289548	969468	1.5978E+00	3.1034E-03	7.2386E-01	8.4373E-01	2.7035E+00
8	24	18043816	289225	3491340	5.6757E+00	2.8545E-03	7.1359E-01	8.4378E-01	1.8104E+00
9	33	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	34	1361853	239981	223936	2.8302E-01	3.4671E-03	4.6421E-01	6.6085E-01	4.3636E+00
11	35	1626045	241375	3533	4.4066E-03	2.4418E-03	4.5040E-01	6.6110E-01	5.2244E+03
12	36	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	41	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	42	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	43	188714	112146	34393	5.3808E-02	1.9069E-03	7.1977E-01	8.1668E-01	3.6572E+00
16	44	479274	168772	8017	1.1474E-02	7.9975E-04	5.1028E-01	7.5542E-01	5.0808E+03
17	45	178795	108183	5543152	6.7619E+00	7.6876E-05	2.0234E-01	6.1363E-01	2.7056E+00
18	46	39792	24588	1132342	1.3721E+00	7.0846E-05	1.8116E-01	6.0810E-01	2.6739E+00
19	47	39092	23972	1088999	1.3145E+00	6.9457E-05	1.7750E-01	6.0573E-01	2.6655E+00
20	48	193173	117948	5175141	6.5435E+00	8.9645E-05	2.2090E-01	6.3674E-01	2.7479E+00
21	49	7283	3880	188721	2.2230E-01	8.0622E-05	1.7891E-01	5.9037E-01	2.6880E+00
total		206359181	2715657	33784495	4.4694E+01				

the initial fission neutron source distribution used the 50 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79727 neutron histories and 100 active cycles with 400788 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 480515 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

the final estimated combined collision/absorption/track-length keff = 0.84545 with an estimated standard deviation of 0.00116

the estimated 68, 95, & 99 percent keff confidence intervals are 0.84429 to 0.84662, 0.84314 to 0.84777, and 0.84238 to 0.84852

the estimated collision/absorption neutron removal lifetime = 9.65E-05 seconds with an estimated standard deviation of 4.50E-07

the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.84535	0.00141	0.84394 to 0.84676	0.84254 to 0.84816	0.84162 to 0.84908	
absorption	0.84542	0.00115	0.84427 to 0.84657	0.84313 to 0.84770	0.84239 to 0.84845	
track length	0.84651	0.00164	0.84486 to 0.84815	0.84324 to 0.84977	0.84217 to 0.85084	
col/absorp	0.84541	0.00115	0.84426 to 0.84656	0.84313 to 0.84769	0.84238 to 0.84844	0.7400

abs/trk len	0.84551	0.00115	0.84436 to 0.84667	0.84322 to 0.84781	0.84247 to 0.84855	0.6213
col/trk len	0.84537	0.00143	0.84394 to 0.84681	0.84252 to 0.84822	0.84159 to 0.84915	0.8545
col/abs/trk len	0.84545	0.00116	0.84429 to 0.84662	0.84314 to 0.84777	0.84238 to 0.84852	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.84574	0.00145	0.84429 to 0.84719	0.84285 to 0.84863	0.84191 to 0.84957
absorption	0.84577	0.00119	0.84458 to 0.84696	0.84340 to 0.84814	0.84263 to 0.84892
track length	0.84693	0.00168	0.84525 to 0.84861	0.84359 to 0.85028	0.84250 to 0.85137
col/abs/trk len	0.84579	0.00121	0.84458 to 0.84700	0.84339 to 0.84820	0.84260 to 0.84899

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	9.6459E-05	4.4973E-07	9.6009E-05 to 9.6909E-05	9.5563E-05 to 9.7355E-05	9.5271E-05 to 9.7647E-05
capture	9.6152E-05	4.5555E-07	9.5696E-05 to 9.6608E-05	9.5245E-05 to 9.7060E-05	9.4949E-05 to 9.7356E-05
fission	5.2651E-05	3.4299E-07	5.2308E-05 to 5.2995E-05	5.1968E-05 to 5.3335E-05	5.1745E-05 to 5.3558E-05
escape	9.8372E-05	1.7571E-06	9.6613E-05 to 1.0013E-04	9.4872E-05 to 1.0187E-04	9.3730E-05 to 1.0301E-04

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.8453	0.0014	0.8454	0.0011	0.8465	0.0016	95/95/95	0.84545	0.00116	0.84314-0.84777	0.84238-0.84852
2	50	0.8453	0.0016	0.8454	0.0013	0.8465	0.0019	95/95/95	0.84542	0.00133	0.84274-0.84810	0.84184-0.84899
4	25	0.8453	0.0019	0.8454	0.0015	0.8465	0.0022	95/95/95	0.84527	0.00163	0.84189-0.84865	0.84068-0.84986
5	20	0.8453	0.0018	0.8454	0.0017	0.8465	0.0020	95/95/95	0.84554	0.00188	0.84156-0.84951	0.84008-0.85100
10	10	0.8453	0.0020	0.8454	0.0021	0.8465	0.0022	95/95/95	0.84459	0.00276	0.83806-0.85112	0.83493-0.85426
20	5	0.8453	0.0017	0.8454	0.0021	0.8465	0.0019	95/99/95	0.84489	0.00284	0.83268-0.85711	0.81672-0.87306
25	4	0.8453	0.0009	0.8454	0.0015	0.8465	0.0011	95/95/95	0.84565	0.00179	0.82296-0.86834	0.73201-0.95928

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	0.71436	0.71881	0.71821									
2	2957	0.72623	0.72381	0.72460									
3	4206	0.71231	0.71079	0.71763									
4	3973	0.71855	0.72142	0.72185									
5	4053	0.70860	0.70805	0.71033									
6	3937	0.72399	0.71811	0.73079									
7	4066	0.70495	0.71344	0.71960									
8	3911	0.71638	0.72795	0.72124									
9	4141	0.72057	0.71476	0.71511									
10	4015	0.72310	0.73481	0.73277									
11	3990	0.73186	0.74153	0.72519									
12	4082	0.76033	0.77057	0.75218									
13	4127	0.74837	0.73794	0.74925									
14	3980	0.75005	0.75521	0.75752									
15	4047	0.76784	0.76004	0.77689									
16	4093	0.77083	0.76915	0.77280									
17	4043	0.79597	0.78975	0.78515									
18	4063	0.78323	0.77664	0.78080									
19	3945	0.81318	0.81229	0.81260									
20	4098	0.81755	0.81101	0.82088									

begin active keff cycles

21	4048	0.83570	0.82466	0.82897								
22	4080	0.82456	0.81686	0.82351	0.83013	0.00557	0.82076	0.00390	0.82624	0.00273		
23	3926	0.80675	0.82631	0.79114	0.82234	0.00843	0.82261	0.00291	0.81454	0.01180		
24	3906	0.82437	0.84030	0.83479	0.82285	0.00598	0.82704	0.00488	0.81960	0.00976	0.82695	0.00479 7146
25	4128	0.84401	0.84032	0.83820	0.82708	0.00628	0.82969	0.00462	0.82332	0.00843	0.83050	0.00620 3467
26	4105	0.83520	0.84751	0.83875	0.82843	0.00530	0.83266	0.00480	0.82589	0.00734	0.83256	0.00535 3936
27	3905	0.82845	0.83288	0.83716	0.82844	0.00448	0.83269	0.00406	0.82750	0.00641	0.83152	0.00428 5328
28	3991	0.83765	0.85051	0.83870	0.82959	0.00405	0.83492	0.00416	0.82890	0.00573	0.83268	0.00432 4627
29	4081	0.85230	0.84173	0.85759	0.83211	0.00437	0.83568	0.00375	0.83209	0.00597	0.83448	0.00372 5610
30	3992	0.85034	0.83342	0.85449	0.83393	0.00431	0.83545	0.00336	0.83433	0.00579	0.83474	0.00316 7086
31	4027	0.84069	0.85455	0.83845	0.83455	0.00395	0.83719	0.00350	0.83470	0.00525	0.83598	0.00331 5934
32	3971	0.86726	0.86728	0.87893	0.83727	0.00452	0.83970	0.00406	0.83839	0.00605	0.83765	0.00371 4368
33	4157	0.83045	0.82837	0.82153	0.83675	0.00419	0.83882	0.00384	0.83709	0.00571	0.83764	0.00332 5027
34	3818	0.85918	0.84502	0.85742	0.83835	0.00420	0.83927	0.00358	0.83854	0.00548	0.83882	0.00320 5084
35	4185	0.85494	0.85264	0.85296	0.83946	0.00406	0.84016	0.00345	0.83951	0.00520	0.83992	0.00318 4838
36	3918	0.86468	0.85813	0.86516	0.84103	0.00411	0.84128	0.00342	0.84111	0.00512	0.84117	0.00322 4446
37	4166	0.83534	0.85420	0.84000	0.84070	0.00388	0.84204	0.00330	0.84104	0.00481	0.84141	0.00305 4699
38	3868	0.85875	0.84522	0.86744	0.84170	0.00379	0.84222	0.00311	0.84251	0.00476	0.84139	0.00286 5065
39	4071	0.86496	0.85720	0.86263	0.84293	0.00379	0.84301	0.00305	0.84357	0.00463	0.84248	0.00290 4713
40	4048	0.83173	0.84403	0.82602	0.84237	0.00364	0.84306	0.00289	0.84269	0.00448	0.84266	0.00275 5027
41	3868	0.84198	0.82708	0.85446	0.84235	0.00346	0.84230	0.00286	0.84325	0.00430	0.84180	0.00281 4590
42	4020	0.84892	0.84859	0.85680	0.84265	0.00331	0.84258	0.00274	0.84387	0.00414	0.84190	0.00269 4786
43	4096	0.86635	0.86339	0.88330	0.84368	0.00333	0.84349	0.00277	0.84558	0.00431	0.84217	0.00266 4694
44	4059	0.82387	0.83308	0.82623	0.84285	0.00329	0.84305	0.00268	0.84478	0.00421	0.84165	0.00262 4639
45	3734	0.84375	0.84842	0.83583	0.84289	0.00316	0.84327	0.00258	0.84442	0.00405	0.84220	0.00252 4827
46	4172	0.82844	0.83214	0.82913	0.84233	0.00309	0.84284	0.00252	0.84383	0.00394	0.84176	0.00247 4847
47	4026	0.83400	0.83966	0.83602	0.84202	0.00298	0.84272	0.00243	0.84354	0.00380	0.84159	0.00239 4993
48	4048	0.83282	0.83081	0.82267	0.84169	0.00289	0.84230	0.00238	0.84280	0.00374	0.84142	0.00227 5314
49	3968	0.84516	0.83464	0.85171	0.84181	0.00280	0.84203	0.00231	0.84310	0.00362	0.84115	0.00221 5408
50	4056	0.85694	0.85907	0.86062	0.84232	0.00275	0.84260	0.00230	0.84369	0.00354	0.84161	0.00221 5284
51	4050	0.85982	0.85722	0.85431	0.84288	0.00272	0.84307	0.00228	0.84403	0.00344	0.84236	0.00222 5063
52	4022	0.84319	0.84071	0.84592	0.84289	0.00263	0.84300	0.00220	0.84409	0.00334	0.84228	0.00215 5233
53	3882	0.81948	0.83729	0.82934	0.84218	0.00265	0.84283	0.00214	0.84364	0.00326	0.84200	0.00215 5092
54	3868	0.84407	0.84442	0.84084	0.84224	0.00257	0.84287	0.00208	0.84356	0.00317	0.84213	0.00208 5294
55	4157	0.84262	0.84043	0.84344	0.84225	0.00249	0.84280	0.00202	0.84356	0.00308	0.84208	0.00202 5474
56	4084	0.85150	0.85823	0.84080	0.84251	0.00244	0.84323	0.00201	0.84348	0.00299	0.84273	0.00202 5305
57	4091	0.84755	0.83928	0.86117	0.84264	0.00237	0.84312	0.00196	0.84396	0.00295	0.84260	0.00199 5370
58	3984	0.85803	0.86225	0.86293	0.84305	0.00235	0.84363	0.00197	0.84446	0.00291	0.84299	0.00200 5197
59	3961	0.84954	0.85335	0.86712	0.84321	0.00229	0.84388	0.00194	0.84504	0.00290	0.84303	0.00196 5243
60	3940	0.84588	0.84323	0.84407	0.84328	0.00223	0.84386	0.00189	0.84501	0.00282	0.84307	0.00191 5430
61	3957	0.88382	0.86814	0.88149	0.84427	0.00239	0.84445	0.00193	0.84590	0.00289	0.84393	0.00199 4897
62	4177	0.88489	0.88130	0.88968	0.84524	0.00253	0.84533	0.00208	0.84695	0.00301	0.84472	0.00214 4123
63	4006	0.84227	0.84593	0.84073	0.84517	0.00247	0.84534	0.00203	0.84680	0.00294	0.84476	0.00209 4250
64	3827	0.84904	0.86496	0.84199	0.84526	0.00241	0.84579	0.00203	0.84669	0.00288	0.84529	0.00209 4162
65	4034	0.85069	0.86387	0.83286	0.84538	0.00236	0.84619	0.00203	0.84638	0.00283	0.84588	0.00208 4127
66	4005	0.85658	0.86852	0.85445	0.84562	0.00232	0.84668	0.00204	0.84656	0.00277	0.84628	0.00209 4016
67	4062	0.83061	0.84005	0.84290	0.84530	0.00230	0.84654	0.00200	0.84648	0.00271	0.84615	0.00207 4013
68	3929	0.85241	0.85371	0.85191	0.84545	0.00225	0.84669	0.00197	0.84659	0.00266	0.84630	0.00203 4089
69	4191	0.82376	0.83515	0.82133	0.84501	0.00225	0.84645	0.00194	0.84608	0.00265	0.84606	0.00201 4077
70	3875	0.84794	0.85403	0.84424	0.84506	0.00221	0.84660	0.00191	0.84604	0.00260	0.84620	0.00198 4145
71	4034	0.82834	0.84094	0.82911	0.84474	0.00219	0.84649	0.00187	0.84571	0.00257	0.84609	0.00195 4170
72	3830	0.85587	0.84969	0.84926	0.84495	0.00215	0.84655	0.00184	0.84578	0.00252	0.84622	0.00190 4304
73	4120	0.85631	0.85485	0.85965	0.84517	0.00212	0.84671	0.00181	0.84604	0.00249	0.84638	0.00187 4358
74	3971	0.84549	0.84199	0.84289	0.84517	0.00208	0.84662	0.00178	0.84598	0.00244	0.84631	0.00183 4465
75	4010	0.84004	0.83820	0.85296	0.84508	0.00205	0.84647	0.00175	0.84611	0.00240	0.84618	0.00181 4488
76	4065	0.84769	0.84278	0.85419	0.84512	0.00201	0.84640	0.00172	0.84625	0.00236	0.84612	0.00178 4567
77	4002	0.87953	0.87455	0.88492	0.84573	0.00207	0.84690	0.00176	0.84693	0.00242	0.84663	0.00183 4271

78	4096	0.85360	0.84531	0.85574	0.84586	0.00204	0.84687	0.00173	0.84708	0.00238	0.84663 0.00179 4370
79	3924	0.85671	0.85578	0.86682	0.84605	0.00201	0.84702	0.00171	0.84742	0.00236	0.84674 0.00177 4395
80	4027	0.85094	0.85673	0.85952	0.84613	0.00198	0.84718	0.00169	0.84762	0.00233	0.84684 0.00176 4410
81	3961	0.85373	0.84289	0.85895	0.84625	0.00195	0.84711	0.00166	0.84781	0.00230	0.84679 0.00173 4492
82	3964	0.83276	0.84275	0.83985	0.84604	0.00193	0.84704	0.00164	0.84768	0.00227	0.84672 0.00171 4514
83	3878	0.83535	0.84801	0.81702	0.84587	0.00191	0.84706	0.00161	0.84719	0.00228	0.84675 0.00167 4655
84	3917	0.83959	0.84342	0.82228	0.84577	0.00188	0.84700	0.00159	0.84680	0.00228	0.84670 0.00163 4795
85	4089	0.85983	0.84740	0.85990	0.84598	0.00186	0.84701	0.00156	0.84700	0.00225	0.84675 0.00160 4909
86	4104	0.84047	0.83373	0.84108	0.84590	0.00183	0.84681	0.00155	0.84691	0.00222	0.84655 0.00159 4927
87	3921	0.83888	0.83448	0.82664	0.84580	0.00181	0.84662	0.00154	0.84661	0.00221	0.84636 0.00156 5004
88	4031	0.82424	0.83200	0.84552	0.84548	0.00181	0.84641	0.00153	0.84659	0.00218	0.84621 0.00157 4878
89	3962	0.84452	0.83876	0.84464	0.84547	0.00179	0.84630	0.00151	0.84657	0.00214	0.84610 0.00155 4944
90	4089	0.82056	0.83057	0.83526	0.84511	0.00180	0.84607	0.00151	0.84640	0.00212	0.84595 0.00155 4833
91	3888	0.83167	0.83723	0.85048	0.84492	0.00178	0.84595	0.00149	0.84646	0.00209	0.84587 0.00154 4820
92	4075	0.84501	0.84388	0.84206	0.84492	0.00175	0.84592	0.00147	0.84640	0.00206	0.84584 0.00152 4905
93	3976	0.84693	0.83758	0.84475	0.84495	0.00173	0.84580	0.00145	0.84638	0.00203	0.84572 0.00150 4980
94	4045	0.86096	0.84882	0.87709	0.84517	0.00172	0.84584	0.00144	0.84679	0.00205	0.84577 0.00148 5019
95	4032	0.84910	0.85483	0.86398	0.84522	0.00170	0.84596	0.00142	0.84702	0.00203	0.84584 0.00147 5019
96	3938	0.85831	0.85301	0.85895	0.84539	0.00168	0.84606	0.00141	0.84718	0.00201	0.84595 0.00146 5075
97	4049	0.85748	0.85576	0.85725	0.84555	0.00167	0.84618	0.00139	0.84731	0.00199	0.84609 0.00144 5108
98	4069	0.86057	0.83859	0.85183	0.84574	0.00166	0.84609	0.00138	0.84737	0.00197	0.84601 0.00142 5229
99	3983	0.85888	0.85875	0.85869	0.84591	0.00165	0.84625	0.00137	0.84751	0.00195	0.84618 0.00141 5232
100	3880	0.84906	0.84592	0.84384	0.84595	0.00163	0.84624	0.00135	0.84747	0.00192	0.84618 0.00139 5325
101	4000	0.82180	0.84110	0.82412	0.84565	0.00163	0.84618	0.00134	0.84718	0.00192	0.84610 0.00137 5352
102	3955	0.84664	0.84429	0.84002	0.84566	0.00161	0.84616	0.00132	0.84709	0.00190	0.84608 0.00135 5447
103	4140	0.84858	0.84697	0.84665	0.84569	0.00160	0.84617	0.00131	0.84708	0.00188	0.84609 0.00134 5525
104	4078	0.82533	0.83435	0.83339	0.84545	0.00159	0.84602	0.00130	0.84692	0.00186	0.84597 0.00133 5494
105	3978	0.83935	0.84103	0.84351	0.84538	0.00158	0.84597	0.00128	0.84688	0.00184	0.84591 0.00132 5540
106	4051	0.83444	0.83737	0.84955	0.84525	0.00156	0.84587	0.00127	0.84691	0.00182	0.84585 0.00131 5538
107	4004	0.84545	0.83975	0.82960	0.84526	0.00155	0.84580	0.00126	0.84671	0.00181	0.84575 0.00129 5650
108	4174	0.85399	0.84841	0.84182	0.84535	0.00153	0.84583	0.00125	0.84666	0.00179	0.84580 0.00127 5748
109	3929	0.83647	0.83584	0.82503	0.84526	0.00152	0.84571	0.00124	0.84641	0.00178	0.84566 0.00126 5798
110	3917	0.85538	0.84137	0.85610	0.84537	0.00150	0.84566	0.00122	0.84652	0.00177	0.84563 0.00125 5871
111	4020	0.85549	0.84792	0.86244	0.84548	0.00149	0.84569	0.00121	0.84670	0.00176	0.84566 0.00123 5928
112	4045	0.86337	0.85583	0.85894	0.84567	0.00149	0.84580	0.00120	0.84683	0.00174	0.84579 0.00122 5954
113	4004	0.82092	0.84665	0.81395	0.84541	0.00150	0.84581	0.00119	0.84648	0.00176	0.84577 0.00121 6025
114	3846	0.84075	0.83012	0.84558	0.84536	0.00148	0.84564	0.00119	0.84647	0.00174	0.84562 0.00121 5983
115	4108	0.83640	0.82300	0.84368	0.84526	0.00147	0.84540	0.00120	0.84644	0.00172	0.84541 0.00122 5830
116	3952	0.85030	0.85432	0.84422	0.84532	0.00145	0.84550	0.00119	0.84641	0.00171	0.84550 0.00121 5878
117	4130	0.86220	0.84442	0.85437	0.84549	0.00145	0.84549	0.00118	0.84650	0.00169	0.84552 0.00119 5962
118	4001	0.84246	0.84088	0.84483	0.84546	0.00144	0.84544	0.00117	0.84648	0.00167	0.84547 0.00118 6015
119	3926	0.84682	0.84983	0.85198	0.84547	0.00142	0.84548	0.00116	0.84654	0.00166	0.84551 0.00117 6065
120	4060	0.83304	0.83895	0.84356	0.84535	0.00141	0.84542	0.00115	0.84651	0.00164	0.84545 0.00116 6086

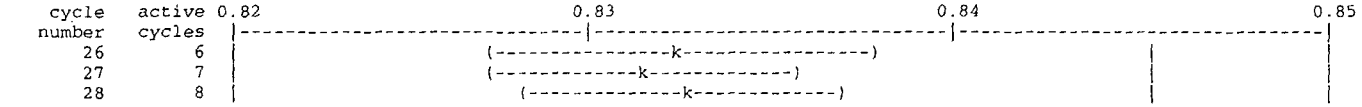
the largest active cycle keffs by estimator are:

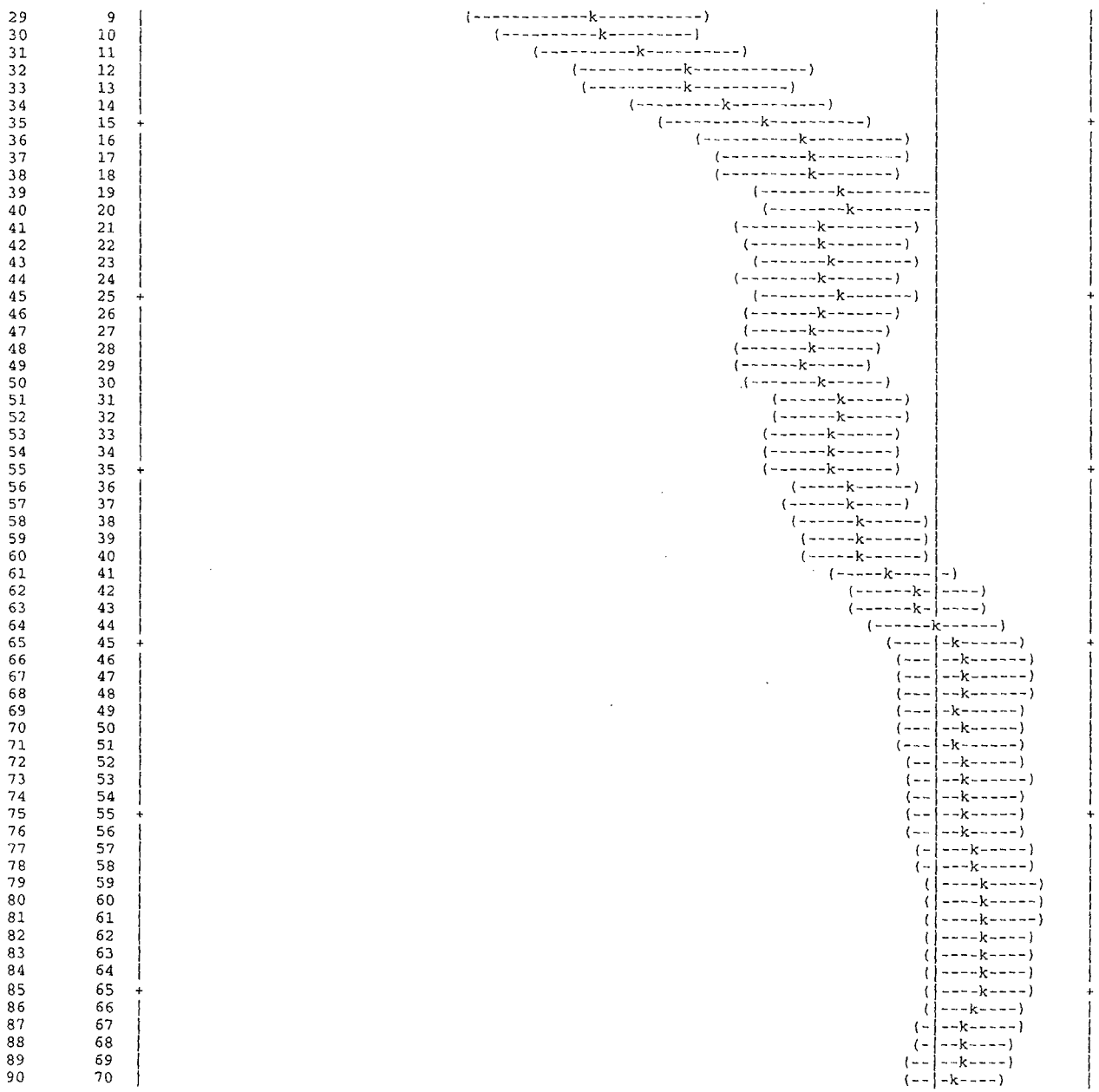
collision 0.88489 on cycle 62
absorption 0.88130 on cycle 62
track length 0.88968 on cycle 62

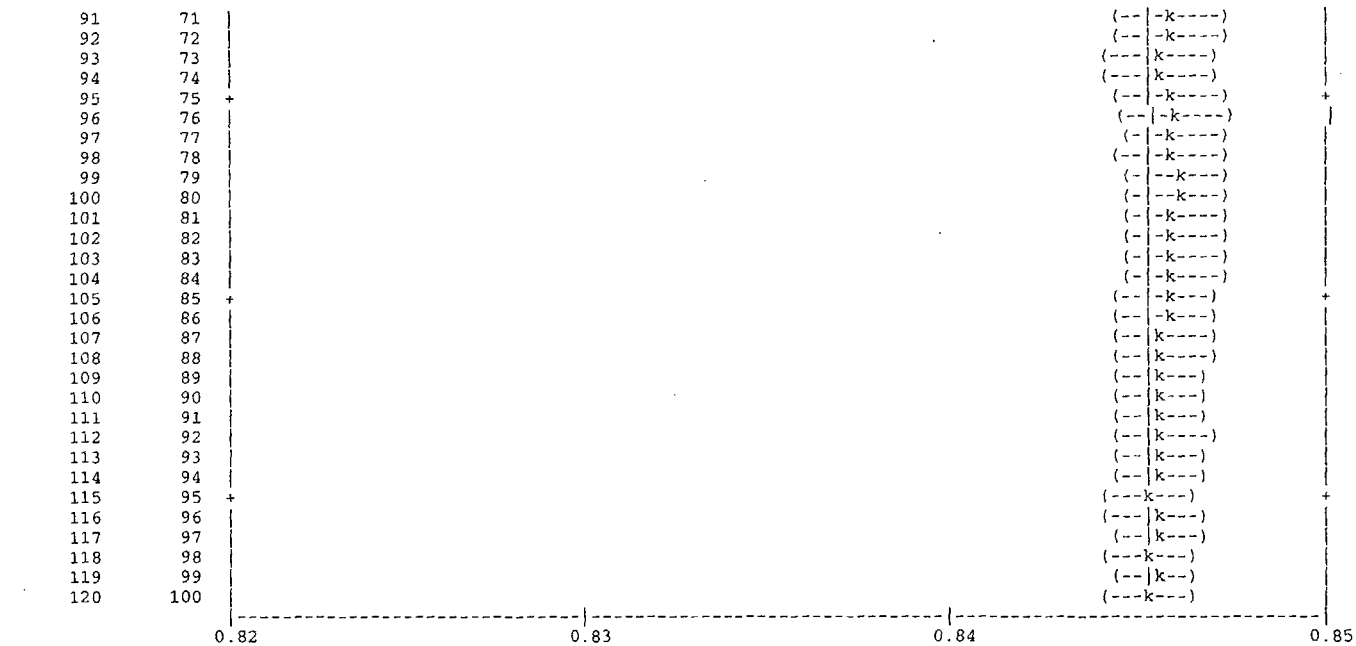
the smallest active cycle keffs by estimator are:

collision 0.80675 on cycle 23
absorption 0.81686 on cycle 22
track length 0.79114 on cycle 23

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.84545)







individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	480515	0.8287	0.0038	0.8288	0.0037	0.8300	0.0039	no/no/no	0.82928	0.00380	0.82170-0.83685	0.81923-0.83932
1	119	476515	0.8297	0.0037	0.8297	0.0036	0.8309	0.0038	no/no/no	0.83014	0.00371	0.82274-0.83754	0.82033-0.83996
2	118	473558	0.8305	0.0037	0.8306	0.0036	0.8318	0.0037	no/no/no	0.83110	0.00363	0.82387-0.83833	0.82151-0.84069
3	117	469352	0.8315	0.0036	0.8317	0.0034	0.8328	0.0036	no/no/no	0.83204	0.00351	0.82505-0.83903	0.82277-0.84131
4	116	465379	0.8325	0.0035	0.8326	0.0033	0.8337	0.0035	no/no/no	0.83295	0.00340	0.82617-0.83972	0.82396-0.84193
5	115	461326	0.8336	0.0033	0.8337	0.0032	0.8348	0.0034	no/no/no	0.83402	0.00324	0.82756-0.84048	0.82545-0.84259
6	114	457389	0.8346	0.0032	0.8347	0.0030	0.8357	0.0033	no/no/no	0.83494	0.00310	0.82876-0.84112	0.82674-0.84313
7	113	453323	0.8357	0.0030	0.8358	0.0029	0.8368	0.0031	no/no/no	0.83575	0.00293	0.82992-0.84159	0.82801-0.84349
8	112	449412	0.8368	0.0028	0.8367	0.0027	0.8378	0.0030	no/no/no	0.83666	0.00278	0.83113-0.84220	0.82932-0.84401
9	111	445271	0.8378	0.0027	0.8378	0.0025	0.8389	0.0028	no/no/no	0.83786	0.00257	0.83274-0.84299	0.83106-0.84467
10	110	441256	0.8389	0.0025	0.8388	0.0024	0.8399	0.0026	no/no/no	0.83869	0.00240	0.83391-0.84348	0.83234-0.84504
11	109	437266	0.8398	0.0023	0.8397	0.0022	0.8409	0.0024	no/no/no	0.83972	0.00224	0.83525-0.84418	0.83380-0.84564
12	108	433184	0.8406	0.0022	0.8403	0.0021	0.8417	0.0023	no/no/no	0.84051	0.00216	0.83621-0.84481	0.83481-0.84621
13	107	429057	0.8414	0.0020	0.8413	0.0019	0.8426	0.0022	no/no/no	0.84142	0.00196	0.83752-0.84532	0.83625-0.84659
14	106	425077	0.8423	0.0019	0.8421	0.0018	0.8434	0.0020	no/no/no	0.84217	0.00178	0.83861-0.84572	0.83746-0.84688
15	105	421030	0.8430	0.0017	0.8429	0.0016	0.8440	0.0019	no/no/no	0.84283	0.00162	0.83960-0.84605	0.83855-0.84710
16	104	416937	0.8437	0.0016	0.8436	0.0015	0.8447	0.0018	99/no/no	0.84352	0.00146	0.84060-0.84644	0.83965-0.84739
17	103	412894	0.8442	0.0016	0.8441	0.0014	0.8453	0.0018	99/no/99	0.84411	0.00139	0.84135-0.84688	0.84045-0.84778
18	102	408831	0.8448	0.0014	0.8448	0.0012	0.8459	0.0017	95/95/95	0.84480	0.00123	0.84235-0.84726	0.84155-0.84806
19	101	404886	0.8451	0.0014	0.8451	0.0012	0.8463	0.0016	95/95/95	0.84513	0.00120	0.84274-0.84752	0.84196-0.84830
20	100*	400788	0.8453	0.0014	0.8454	0.0011	0.8465	0.0016	95/95/95	0.84545	0.00116	0.84314-0.84777	0.84238-0.84852
22	98	392660	0.8457	0.0014	0.8459	0.0011	0.8469	0.0016	95/95/95	0.84599	0.00113	0.84374-0.84824	0.84300-0.84898
24	96	384828	0.8463	0.0014	0.8462	0.0011	0.8476	0.0016	95/95/95	0.84636	0.00113	0.84411-0.84860	0.84338-0.84933

26	94	376595	0.8464	0.0014	0.8462	0.0011	0.8478	0.0016	95/95/95	0.84643	0.00115	0.84414-0.84873	0.84339-0.84947
28	92	368699	0.8467	0.0014	0.8463	0.0012	0.8480	0.0016	95/95/95	0.84653	0.00117	0.84421-0.84885	0.84345-0.84961
30	90	360626	0.8466	0.0014	0.8465	0.0012	0.8479	0.0017	95/95/95	0.84666	0.00118	0.84431-0.84902	0.84354-0.84979
32	88	352628	0.8464	0.0015	0.8462	0.0012	0.8476	0.0017	95/95/95	0.84638	0.00118	0.84403-0.84873	0.84327-0.84950
34	86	344653	0.8465	0.0015	0.8464	0.0012	0.8478	0.0017	95/95/95	0.84664	0.00119	0.84428-0.84901	0.84351-0.84978
36	84	336550	0.8462	0.0015	0.8462	0.0012	0.8475	0.0017	95/95/95	0.84642	0.00120	0.84402-0.84882	0.84324-0.84960
38	82	328516	0.8461	0.0015	0.8461	0.0012	0.8474	0.0017	95/95/95	0.84633	0.00123	0.84388-0.84878	0.84308-0.84958
40	80	320397	0.8461	0.0015	0.8460	0.0012	0.8475	0.0017	95/95/95	0.84624	0.00125	0.84375-0.84874	0.84294-0.84955
42	78	312509	0.8461	0.0016	0.8462	0.0012	0.8472	0.0018	95/95/95	0.84637	0.00126	0.84385-0.84889	0.84303-0.84971
44	76	304354	0.8461	0.0015	0.8462	0.0012	0.8471	0.0017	95/95/95	0.84634	0.00125	0.84385-0.84883	0.84303-0.84964
46	74	296448	0.8464	0.0016	0.8463	0.0013	0.8474	0.0017	95/95/95	0.84653	0.00127	0.84400-0.84907	0.84317-0.84990
48	72	288374	0.8468	0.0016	0.8466	0.0013	0.8479	0.0017	95/95/95	0.84692	0.00128	0.84436-0.84947	0.84353-0.85031
50	70	280350	0.8466	0.0016	0.8466	0.0013	0.8477	0.0018	95/95/95	0.84687	0.00129	0.84428-0.84945	0.84343-0.85030
52	68	272278	0.8465	0.0017	0.8466	0.0013	0.8476	0.0018	95/95/95	0.84679	0.00132	0.84415-0.84944	0.84328-0.85030
54	66	264528	0.8470	0.0017	0.8467	0.0014	0.8480	0.0019	95/95/95	0.84697	0.00135	0.84426-0.84968	0.84337-0.85057
56	64	256287	0.8469	0.0017	0.8466	0.0014	0.8482	0.0019	95/95/95	0.84691	0.00139	0.84413-0.84969	0.84321-0.85061
58	62	248212	0.8468	0.0018	0.8465	0.0014	0.8478	0.0020	95/95/95	0.84672	0.00141	0.84391-0.84954	0.84298-0.85046
60	60	240311	0.8467	0.0018	0.8465	0.0014	0.8475	0.0020	95/95/95	0.84665	0.00144	0.84376-0.84953	0.84281-0.85049
62	58	232177	0.8454	0.0016	0.8455	0.0013	0.8462	0.0018	95/95/95	0.84565	0.00127	0.84310-0.84820	0.84225-0.84904
64	56	224344	0.8454	0.0017	0.8451	0.0013	0.8464	0.0019	95/95/95	0.84536	0.00129	0.84277-0.84795	0.84191-0.84881
66	54	216305	0.8451	0.0017	0.8443	0.0012	0.8465	0.0019	95/95/95	0.84452	0.00125	0.84201-0.84704	0.84117-0.84787
68	52	208314	0.8453	0.0018	0.8442	0.0012	0.8464	0.0020	95/95/95	0.84440	0.00129	0.84181-0.84698	0.84095-0.84785
70	50	200248	0.8456	0.0018	0.8442	0.0013	0.8470	0.0020	95/95/95	0.84443	0.00132	0.84177-0.84709	0.84088-0.84798
72	48	192384	0.8458	0.0018	0.8442	0.0013	0.8473	0.0021	95/95/95	0.84444	0.00138	0.84165-0.84722	0.84072-0.84815
74	46	184293	0.8456	0.0019	0.8440	0.0014	0.8471	0.0021	95/95/95	0.84426	0.00142	0.84140-0.84713	0.84044-0.84809
76	44	176218	0.8456	0.0020	0.8442	0.0014	0.8468	0.0022	95/95/95	0.84436	0.00147	0.84139-0.84733	0.84039-0.84833
78	42	168120	0.8446	0.0019	0.8434	0.0013	0.8457	0.0021	95/95/95	0.84367	0.00131	0.84102-0.84632	0.84013-0.84722
80	40	160169	0.8442	0.0019	0.8428	0.0013	0.8448	0.0021	95/95/95	0.84301	0.00127	0.84043-0.84558	0.83956-0.84645
82	38	152244	0.8442	0.0020	0.8428	0.0013	0.8446	0.0022	95/95/95	0.84296	0.00134	0.84025-0.84567	0.83932-0.84660
84	36	144449	0.8446	0.0021	0.8426	0.0014	0.8460	0.0021	95/95/95	0.84308	0.00145	0.84012-0.84604	0.83911-0.84705
86	34	136256	0.8443	0.0022	0.8427	0.0014	0.8457	0.0022	95/95/95	0.84318	0.00149	0.84014-0.84623	0.83909-0.84728
88	32	128304	0.8451	0.0022	0.8433	0.0015	0.8463	0.0023	95/95/95	0.84378	0.00152	0.84067-0.84690	0.83959-0.84798
90	30	120253	0.8459	0.0022	0.8439	0.0015	0.8467	0.0024	95/95/95	0.84431	0.00156	0.84112-0.84750	0.84000-0.84862
92	28	112290	0.8464	0.0023	0.8441	0.0016	0.8468	0.0025	95/95/95	0.84452	0.00166	0.84110-0.84793	0.83989-0.84914
94	26	104269	0.8459	0.0024	0.8442	0.0017	0.8457	0.0025	95/95/95	0.84447	0.00171	0.84092-0.84801	0.83966-0.84928
96	24	96299	0.8452	0.0025	0.8434	0.0017	0.8444	0.0025	95/95/95	0.84342	0.00170	0.83988-0.84696	0.83860-0.84824
98	22	88181	0.8440	0.0026	0.8430	0.0018	0.8434	0.0026	95/95/95	0.84299	0.00172	0.83938-0.84660	0.83806-0.84792
100	20	80318	0.8430	0.0027	0.8421	0.0018	0.8427	0.0028	95/95/95	0.84213	0.00169	0.83856-0.84570	0.83723-0.84703
102	18	72363	0.8439	0.0028	0.8421	0.0020	0.8438	0.0029	95/95/95	0.84236	0.00191	0.83828-0.84644	0.83672-0.84800
104	16	64145	0.8448	0.0029	0.8422	0.0021	0.8443	0.0032	95/95/95	0.84265	0.00213	0.83804-0.84726	0.83622-0.84907
106	14	56116	0.8459	0.0032	0.8427	0.0024	0.8440	0.0036	95/95/95	0.84285	0.00259	0.83716-0.84854	0.83482-0.85088
108	12	47938	0.8453	0.0037	0.8424	0.0028	0.8454	0.0040	95/95/95	0.84307	0.00285	0.83663-0.84952	0.83382-0.85233
110	10	40092	0.8452	0.0042	0.8432	0.0033	0.8464	0.0042	95/95/99	0.84450	0.00305	0.83730-0.85170	0.83384-0.85516
112	8	32027	0.8416	0.0043	0.8410	0.0036	0.8428	0.0044	95/95/no	0.84207	0.00304	0.83425-0.84989	0.82981-0.85433
114	6	24177	0.8452	0.0043	0.8419	0.0044	0.8471	0.0020	95/95/99	0.84711	0.00245	0.83929-0.85492	0.83277-0.86144
116	4	16117	0.8461	0.0061	0.8435	0.0024	0.8487	0.0027	95/95/95	0.85321	0.01065	0.71787-0.98855	0.17534-1.53109
117	3	11987	0.8408	0.0041	0.8432	0.0033	0.8468	0.0026					
118	2	7986	0.8399	0.0069	0.8444	0.0054	0.8478	0.0042					

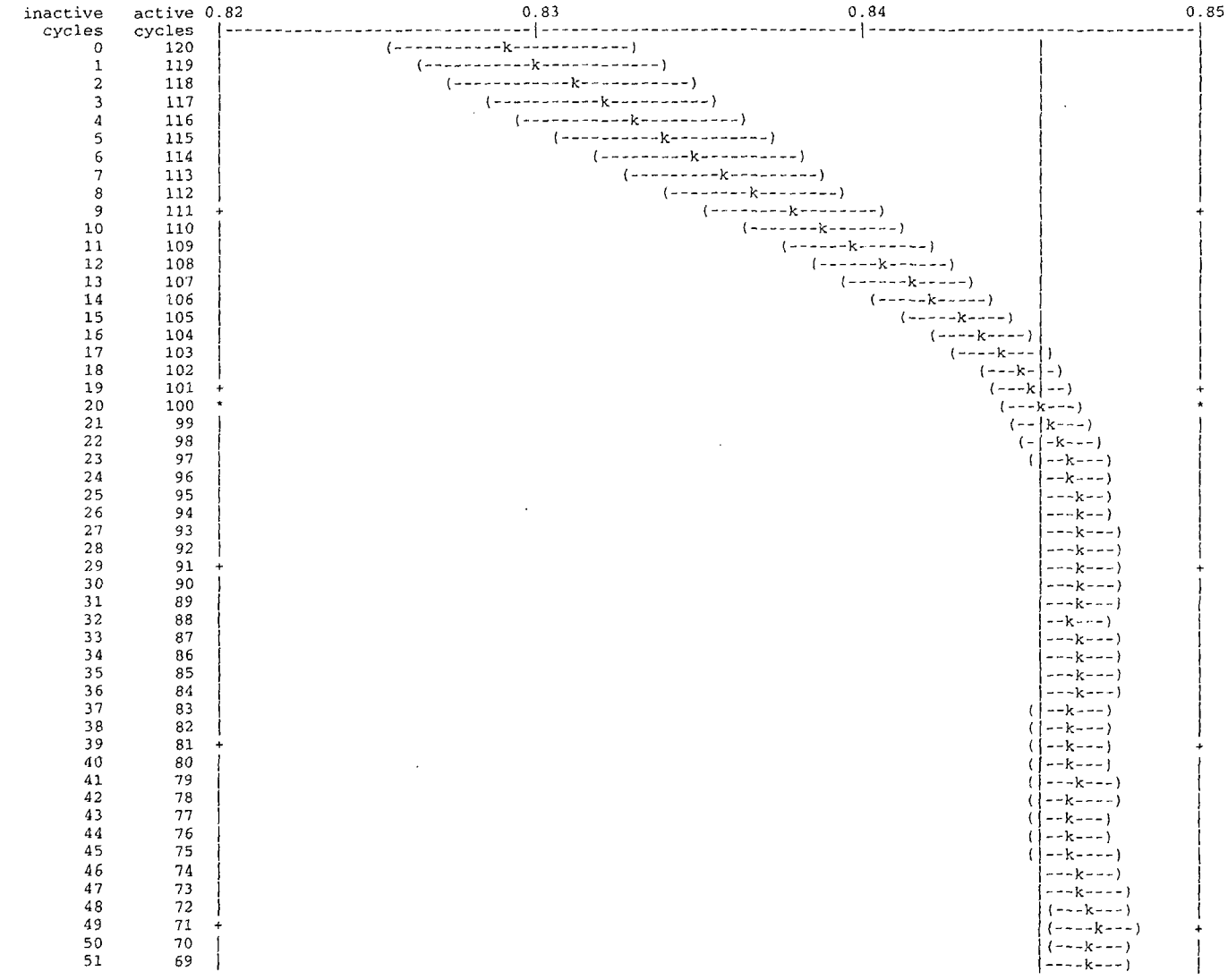
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 23 inactive cycles and 97 active cycles.

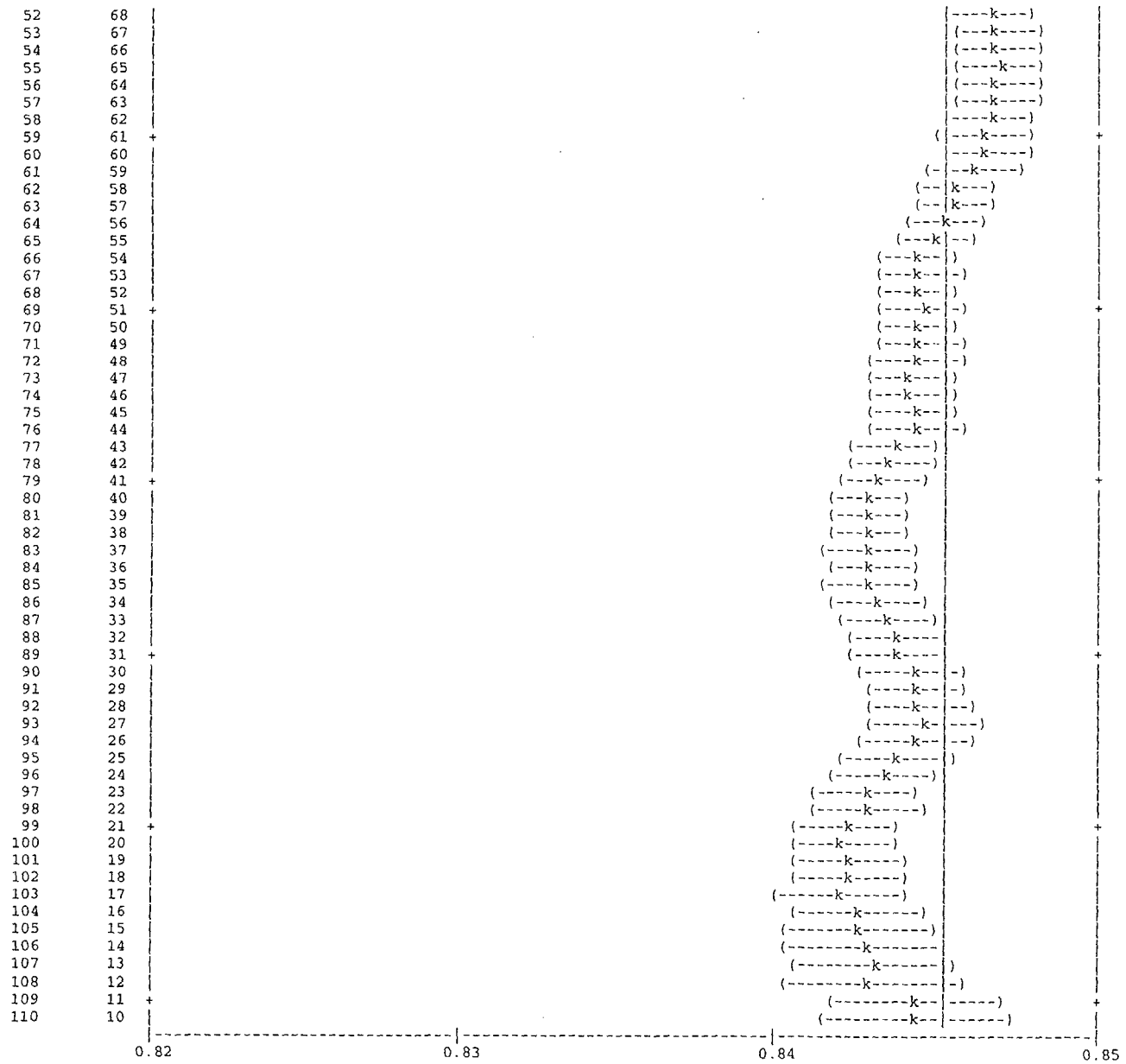
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence

first half	0.84620	0.00198	0.84422 to 0.84819	0.84223 to 0.85018	0.84090 to 0.85151
second half	0.84443	0.00132	0.84310 to 0.84576	0.84177 to 0.84709	0.84088 to 0.84798
final result	0.84545	0.00116	0.84429 to 0.84662	0.84314 to 0.84777	0.84238 to 0.84852

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.84545)




0.82
0.83
0.84
0.85

```
************************************************************************************************************************
dump no.     9 on file 1fr          nps =     480515     coll =       33784495     ctm =  119.18     nrn =       617299831

         1 warning message so far.

run terminated when    120 kcode cycles were done.

computer time =  119.21 minutes

mcnp      version 4a     10/01/93                    03/09/01 14:02:36                    probid =   03/09/01 12:03:24
```

Attachment 5: Case 2 with MCNP surface and cell numbers

FILE

SUBJECT

WVNS-NCSE-002
Rev. 0

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____
BY ____ DATE ____
CHECKED BY ____
COPY TO EO ____

Dames & Mo

945.3

Attachment 6: Case 2 MCNP input file

2f

```
WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
C The drum height is 28 1/2 inches (72.39 cm)
c drum wall thickness is 0.157 cm
c two flooded drums stands next to 7x7x3 array of dry drums
c
C Cell cards
C
C ------------------------------------------------------------------------
c inside the drum:
c
c dry fuel in the drum:
c Universe 1 (dry lattice)
11  0         -11 12 -13 14 -15 16 u=1
                  lat=2 fill=2 imp:n=1 $ Hexagonal lattice
c
c Universe 2 (inside the dry lattice)
12 61 -10.4   -17     u=2       imp:n=1 $ fuel rod
13 62  -7.92 -18 17 u=2         imp:n=1 $ SS-304 clad
14 64 -0.001293  18 u=2         imp:n=1 $ air in the lattice cell
c
c
c flooded fuel in the drum:
c Universe 3 (flooded lattice)
21  0         -21 22 -23 24 -25 26 u=3
                  lat=2 fill=4 imp:n=1 $ Hexagonal lattice
c
c Universe 4 (inside the flooded lattice)
22 61 -10.4   -17     u=4       imp:n=1 $ fuel rod
23 62  -7.92 -18 17 u=4         imp:n=1 $ SS-304 clad
24 63 -1.0     18     u=4       imp:n=1 $ water in the lattice cell
c
c
c square lattice of drums with dry fuel:
c Universe 5 (inside the lattice)
33  0      -5  u=5 fill=1  imp:n=1 $ drum filled with dry fuel lattice
34  65  -7.82       5 -6   u=5  imp:n=1 $ drum wall
35  64  -0.001293      6   u=5  imp:n=1 $ air ouside the drum
c
c Universe 6 (drum lattice)
36  0         29 -30 -27 28 u=6
                  lat=1 fill=5 imp:n=1 $ Drum square lattice
c
c
41 0 -46 47 41 -42 2 -8 fill=6 imp:n=1 $ Drum array with dry fuel
c
c Flooded drums:
42 0      -9  2 -3 fill=3  imp:n=1 $ 1 drum filled with flooded fuel lattice
43 65  -7.82       9 -10   2 -3  imp:n=1 $ 1 drum wall
c
51 0      -51  2 -3 fill=3  imp:n=1 $ 2 drum filled with flooded fuel lattice
52 65  -7.82       51 -52   2 -3  imp:n=1 $ 2 drum wall
c
44 64  -0.001293  46 -45 41 -42 2 -8 #42 #43 #51 #52  imp:n=1 $ air
c
45  67 -2.35      40 -43 48 -44 -2 7   imp:n=1 $  concrete floor
46  67 -2.35      2 -8 40 -41 48 -44   imp:n=1 $  west concrete wall
47  67 -2.35      2 -8 42 -43 48 -44   imp:n=1 $  east concrete wall
48  67 -2.35      2 -8 41 -42 45 -44   imp:n=1 $  north concrete wall
49  67 -2.35      2 -8 41 -42 48 -47   imp:n=1 $  south concrete wall
c
50  0       -7 : 8 : -40 : 43 : 44 : -48 imp:n=0 $ Outside world
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ drum bottom plane
3  pz 72.39   $ drum top plane
c
5  c/z 0.0 -24.37 23.005  $ internal wall of the drum with dry fuel
6  c/z 0.0 -24.37 23.180  $ external wall of the drum with dry fuel
c
7  pz -300    $ concrete bottom plane
8  pz 217.17 $ top of 3 tiers of drums
c
c
```

```
9  c/z  0.0 24.37 23.005  $ internal wall of the 1 drum with flooded fuel
10 c/z  0.0 24.37 23.180  $ external wall of the 1 drum with flooded fuel
c
51  c/z -48.74 24.37 23.005  $ internal wall of the 2 drum with fl. fuel
52  c/z -48.74 24.37 23.180  $ external wall of the 2 drum with fl. fuel
c
40 px -470.58 $ outside west wall
41 px -170.58 $ inside west wall
42 px  170.58 $ inside east wall
43 px  470.58 $ outside east wall
c
44 py  348.74 $ outside north wall
45 py   48.74 $ inside north wall
46 py   -0.10 $ drum array north boundary
47 py -341.17 $ inside south wall
48 py -641.17 $ outside south wall
c
c the lattice surfaces for dry fuel in the drum
c a/p=0.1 (fuel pins touch each other)
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of dry lattice surfaces
c
c
17 cz  0.3785 $ fuel wall cylinder
18 cz  0.4318 $ clad outer wall cylinder
c
c the lattice surfaces for flooded fuel in the drum
c w/p=0.5
21 p 0.8660254 -0.5 0  0.50362571
22 p 0.8660254 -0.5 0 -0.50362571
23 p 0.8660254  0.5 0  0.50362571
24 p 0.8660254  0.5 0 -0.50362571
25 py  0.50362571
26 py -0.50362571
c end of dry lattice surfaces
c
c square lattice for the drums
27 py  0.0
28 py -48.74
29 px -24.37
30 px  24.37
c end of the drum lattice surfaces
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61     8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62    14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
       28000.50c -0.10
c
c Water (H-1, O-16)
m63    1001.50c 0.66667
       8016.50c 0.33333
mt63 lwtr.01t
c
c Air (C, N, O, Ar) composition from Attix p.523
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
```

```
      18000.35c -0.012828
c
c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
m65    6000.50c -0.005
      26000.55c -0.995
c
c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67    1001.50c -0.006
       8016.50c -0.5
      11023.50c -0.017
      13027.50c -0.048
      14000.50c -0.315
      19000.50c -0.019
      20000.50c -0.083
      26000.55c -0.012
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc   0.000    24.370 36.195    -48.740 24.370 36.195
       0.000   -24.370 36.195
       0.000   -73.110 36.195
       0.000  -121.850 36.195
       0.000  -170.590 36.195
       0.000  -219.330 36.195
       0.000  -268.070 36.195
       0.000  -316.810 36.195
      -48.740  -24.370 36.195  -97.480  -24.370 36.195  -146.220  -24.370 36.195
      -48.740  -73.110 36.195  -97.480  -73.110 36.195  -146.220  -73.110 36.195
      -48.740 -121.850 36.195  -97.480 -121.850 36.195  -146.220 -121.850 36.195
      -48.740 -170.590 36.195  -97.480 -170.590 36.195  -146.220 -170.590 36.195
      -48.740 -219.330 36.195  -97.480 -219.330 36.195  -146.220 -219.330 36.195
      -48.740 -268.070 36.195  -97.480 -268.070 36.195  -146.220 -268.070 36.195
      -48.740 -316.810 36.195  -97.480 -316.810 36.195  -146.220 -316.810 36.195
       48.740  -24.370 36.195   97.480  -24.370 36.195   146.220  -24.370 36.195
       48.740  -73.110 36.195   97.480  -73.110 36.195   146.220  -73.110 36.195
       48.740 -121.850 36.195   97.480 -121.850 36.195   146.220 -121.850 36.195
       48.740 -170.590 36.195   97.480 -170.590 36.195   146.220 -170.590 36.195
       48.740 -219.330 36.195   97.480 -219.330 36.195   146.220 -219.330 36.195
       48.740 -268.070 36.195   97.480 -268.070 36.195   146.220 -268.070 36.195
       48.740 -316.810 36.195   97.480 -316.810 36.195   146.220 -316.810 36.195
```

Attachment 7: Case 2 MCNP output file

```
1mcnp     version 4a    ld=10/01/93                    03/12/01 11:38:05
 ************************************************************************          probid =   03/12/01 11:38:05
 name=2f

      WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air
      C The drum height is 28 1/2 inches (72.39 cm)
      c drum wall thickness is 0.157 cm
      c two flooded drums stands next to 7x7x3 array of dry drums
      c
      C Cell cards
      C
      C ---------------------------------------------------------------------
      c inside the drum:
      c
      c dry fuel in the drum:
      c Universe 1 (dry lattice)
      11  0        -11 12 -13 14 -15 16 u=1
                        lat=2 fill=2 imp:n=1 $ Hexagonal lattice
      c
      c Universe 2 (inside the dry lattice)
      12 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
      13 62  -7.92 -18 17 u=2       imp:n=1 $ SS-304 clad
      14 64 -0.001293  18 u=2       imp:n=1 $ air in the lattice cell
      c
      c
      c flooded fuel in the drum:
      c Universe 3 (flooded lattice)
      21  0        -21 22 -23 24 -25 26 u=3
                        lat=2 fill=4 imp:n=1 $ Hexagonal lattice
      c
      c Universe 4 (inside the flooded lattice)
      22 61 -10.4  -17    u=4       imp:n=1 $ fuel rod
      23 62  -7.92 -18 17 u=4       imp:n=1 $ SS-304 clad
      24 63 -1.0    18    u=4       imp:n=1 $ water in the lattice cell
      c
      c
      c square lattice of drums with dry fuel:
      c Universe 5 (inside the lattice)
      33  0     -5  u=5 fill=1  imp:n=1 $ drum filled with dry fuel lattice
      34  65  -7.82      5 -6   u=5  imp:n=1 $ drum wall
      35  64  -0.001293     6   u=5  imp:n=1 $ air ouside the drum
      c
      c Universe 6 (drum lattice)
      36  0        29 -30 -27 28 u=6
                        lat=1 fill=5 imp:n=1 $ Drum square lattice
      c
      c
      41 0 -46 47 41 -42 2 -8 fill=6 imp:n=1 $ Drum array with dry fuel
      c
      c Flooded drums:
      42 0     -9  2 -3 fill=3  imp:n=1 $ 1 drum filled with flooded fuel lattice
      43 65  -7.82      9 -10   2 -3  imp:n=1 $ 1 drum wall
      c
      51 0     -51  2 -3 fill=3  imp:n=1 $ 2 drum filled with flooded fuel lattice
      52 65  -7.82      51 -52   2 -3  imp:n=1 $ 2 drum wall
      c
      44 64  -0.001293  46 -45 41 -42 2 -8 #42 #43 #51 #52  imp:n=1 $ air
      c
      45  67 -2.35     40 -43 48 -44 -2 7   imp:n=1 $  concrete floor
      46  67 -2.35     2 -8 40 -41 48 -44   imp:n=1 $  west concrete wall
      47  67 -2.35     2 -8 42 -43 48 -44   imp:n=1 $  east concrete wall
      48  67 -2.35     2 -8 41 -42 45 -44   imp:n=1 $  north concrete wall
```

```
49  67 -2.35     2 -8 41 -42 48 -47   imp:n=1 $  south concrete wall
c
50  0       -7 : 8 : -40 : 43 : 44 : -48 imp:n=0 $ Outside world
c
C ------------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ------------------------------------------------------------------------
2  pz 0       $ drum bottom plane
3  pz 72.39   $ drum top plane
c
5  c/z 0.0 -24.37 23.005  $ internal wall of the drum with dry fuel
6  c/z 0.0 -24.37 23.180  $ external wall of the drum with dry fuel
c
7  pz -300   $ concrete bottom plane
8  pz 217.17 $ top of 3 tiers of drums
c
c
9  c/z  0.0 24.37 23.005  $ internal wall of the 1 drum with flooded fuel
10 c/z  0.0 24.37 23.180  $ external wall of the 1 drum with flooded fuel
c
51  c/z -48.74 24.37 23.005  $ internal wall of the 2 drum with fl. fuel
52  c/z -48.74 24.37 23.180  $ external wall of the 2 drum with fl. fuel
c
40 px -470.58 $ outside west wall
41 px -170.58 $ inside west wall
42 px  170.58 $ inside east wall
43 px  470.58 $ outside east wall
c
44 py  348.74 $ outside north wall
45 py   48.74 $ inside north wall
46 py   -0.10 $ drum array north boundary
47 py -341.17 $ inside south wall
48 py -641.17 $ outside south wall
c
c the lattice surfaces for dry fuel in the drum
c a/p=0.1 (fuel pins touch each other)
11 p 0.8660254 -0.5 0  0.4318
12 p 0.8660254 -0.5 0 -0.4318
13 p 0.8660254  0.5 0  0.4318
14 p 0.8660254  0.5 0 -0.4318
15 py  0.4318
16 py -0.4318
c end of dry lattice surfaces
c
c
17 cz  0.3785 $ fuel wall cylinder
18 cz  0.4318 $ clad outer wall cylinder
c
c the lattice surfaces for flooded fuel in the drum
c w/p=0.5
21 p 0.8660254 -0.5 0  0.50362571
22 p 0.8660254 -0.5 0 -0.50362571
23 p 0.8660254  0.5 0  0.50362571
24 p 0.8660254  0.5 0 -0.50362571
25 py  0.50362571
26 py -0.50362571
c end of dry lattice surfaces
c
c square lattice for the drums
```

```
121-       27 py  0.0
122-       28 py -48.74
123-       29 px -24.37
124-       30 px  24.37
125-       c end of the drum lattice surfaces
126-       c
127-       C ------------------------------------------------------------------------
128-       c
129-       c Note: next line must be completely blank
130-
131-       c Data cards
132-       c
133-       c Materials
134-       c
135-       c
136-       c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
137-       m61     8016.50c -0.1185844
138-             92235.50c -0.0435427
139-             92238.50c -0.8378729
140-       c
141-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
142-       m62    14000.50c -0.01
143-             24000.50c -0.19
144-             25055.50c -0.02
145-             26000.55c -0.68
146-             28000.50c -0.10
147-       c
148-       c Water (H-1, O-16)
149-       m63    1001.50c 0.66667
150-             8016.50c 0.33333
151-       mt63 lwtr.01t
152-       c
153-       c Air (C, N, O, Ar) composition from Attix p.523
154-       m64     6000.50c -0.000124
155-              7014.50c -0.755267
156-              8016.50c -0.231781
157-             18000.35c -0.012828
158-       c
159-       c Carbon Steel (C, Fe) composition from Crit. Calc. with MCNP p. C-10
160-       m65     6000.50c -0.005
161-             26000.55c -0.995
162-       c
163-       c Concrete (NBS Ordinary) from Harmon at al. Criticality Calculation
164-       c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
165-       c adjusted to sum to unity without minor trace elements)
166-       m67     1001.50c -0.006
167-              8016.50c -0.5
168-             11023.50c -0.017
169-             13027.50c -0.048
170-             14000.50c -0.315
171-             19000.50c -0.019
172-             20000.50c -0.083
173-             26000.55c -0.012
174-       c
175-       mode n
176-       print 40 60 80 100 110 126
177-       kcode 4000 1. 20 120
178-       ksrc    0.000     24.370 36.195     -48.740 24.370 36.195
179-              0.000    -24.370 36.195
180-              0.000    -73.110 36.195
181-              0.000   -121.850 36.195
182-              0.000   -170.590 36.195
```

```
 183-              0.000  -219.330 36.195
 184-              0.000  -268.070 36.195
 185-              0.000  -316.810 36.195
 186-            -48.740   -24.370 36.195  -97.480   -24.370 36.195  -146.220   -24.370 36.195
 187-            -48.740   -73.110 36.195  -97.480   -73.110 36.195  -146.220   -73.110 36.195
 188-            -48.740  -121.850 36.195  -97.480  -121.850 36.195  -146.220  -121.850 36.195
 189-            -48.740  -170.590 36.195  -97.480  -170.590 36.195  -146.220  -170.590 36.195
 190-            -48.740  -219.330 36.195  -97.480  -219.330 36.195  -146.220  -219.330 36.195
 191-            -48.740  -268.070 36.195  -97.480  -268.070 36.195  -146.220  -268.070 36.195
 192-            -48.740  -316.810 36.195  -97.480  -316.810 36.195  -146.220  -316.810 36.195
 193-             48.740   -24.370 36.195   97.480   -24.370 36.195   146.220   -24.370 36.195
 194-             48.740   -73.110 36.195   97.480   -73.110 36.195   146.220   -73.110 36.195
 195-             48.740  -121.850 36.195   97.480  -121.850 36.195   146.220  -121.850 36.195
 196-             48.740  -170.590 36.195   97.480  -170.590 36.195   146.220  -170.590 36.195
 197-             48.740  -219.330 36.195   97.480  -219.330 36.195   146.220  -219.330 36.195
 198-             48.740  -268.070 36.195   97.480  -268.070 36.195   146.220  -268.070 36.195
 199-             48.740  -316.810 36.195   97.480  -316.810 36.195   146.220  -316.810 36.195
 200-
 total fission nubar data are being used.
1material composition                                                          print table 40

 material
  number      component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01666      92238,  0.31655
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
    64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
    65            6000,  0.02283      26000,  0.97717
    67            1001,  0.11082       8016,  0.58191      11023,  0.01377      13027,  0.03312
                 14000,  0.20878      19000,  0.00905      20000,  0.03855      26000,  0.00400




 material
  number      component nuclide, mass fraction

    61            8016,  0.11858      92235,  0.04354      92238,  0.83787
    62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                 28000,  0.10000
    63            1001,  0.11192       8016,  0.88808
    64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
    65            6000,  0.00500      26000,  0.99500
    67            1001,  0.00600       8016,  0.50000      11023,  0.01700      13027,  0.04800
                 14000,  0.31500      19000,  0.01900      20000,  0.08300      26000,  0.01200
1cells                                                                         print table 60

                        atom        gram                                    neutron
      cell  mat      density     density      volume       mass      pieces importance

     1    11    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     2    12   61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     3    13   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     4    14   64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00      0  1.0000E+00
     5    21    0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     6    22   61  6.96366E-02 1.04000E+01 0.00000E+00 0.00000E+00      0  1.0000E+00
     7    23   62  8.70647E-02 7.92000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
     8    24  63s 1.00309E-01 1.00000E+00 0.00000E+00 0.00000E+00      0  1.0000E+00
```

```
     9    33     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00     0  1.0000E+00
    10    34    65  8.58651E-02 7.82000E+00 0.00000E+00 0.00000E+00     0  1.0000E+00
    11    35    64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00     0  1.0000E+00
    12    36     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00     0  1.0000E+00
    13    41     0  0.00000E+00 0.00000E+00 2.52698E+07 0.00000E+00     0  1.0000E+00
    14    42     0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00     1  1.0000E+00
    15    43    65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04     1  1.0000E+00
    16    51     0  0.00000E+00 0.00000E+00 1.20357E+05 0.00000E+00     1  1.0000E+00
    17    52    65  8.58651E-02 7.82000E+00 1.83809E+03 1.43739E+04     1  1.0000E+00
    18    44    64  5.35386E-05 1.29300E-03 0.00000E+00 0.00000E+00     0  1.0000E+00
    19    45    67  7.60226E-02 2.35000E+00 2.79499E+08 6.56823E+08     0  1.0000E+00
    20    46    67  7.60226E-02 2.35000E+00 6.44936E+07 1.51560E+08     0  1.0000E+00
    21    47    67  7.60226E-02 2.35000E+00 6.44936E+07 1.51560E+08     0  1.0000E+00
    22    48    67  7.60226E-02 2.35000E+00 2.22269E+07 5.22333E+07     0  1.0000E+00
    23    49    67  7.60226E-02 2.35000E+00 2.22269E+07 5.22333E+07     0  1.0000E+00
    24    50     0  0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00     0  0.0000E+00

 total                                      4.78454E+08 1.06444E+09
1cross-section tables                                                                print table 100

     table    length

                        tables from file critxs

   1001.50c     1153  njoy                                                    (  1301)      79/07/31.
   6000.50c    16126  njoy                                                    (  1306)      79/07/31.
   7014.50c    22772  njoy                                                    (  1275)      79/09/08.
   8016.50c    23669  njoy                                                    ( 1276)      05/14/81
  11023.50c    36270  njoy                                                    (  1311)      79/06/21.
  13027.50c    22891  njoy                                                    (  1313)      79/09/08.
  14000.50c    48275  njoy                                                    (  1314)      79/06/21.
  18000.35c     2182       end185                                             (  18)       11/01/85
  19000.50c     9766  njoy                                                    (  1150)      79/10/29.
  20000.50c    26104  njoy                                                    (  1320)      79/06/22.
  24000.50c    89104  njoy                                                    (  1324)      79/06/21.
  25055.50c    60097  njoy                                                    (  1325)      79/06/21.
  26000.55c    84136  njoy                                                    ( 260)       10/21/82
  28000.50c    82267  njoy                                                    (  1328)      79/06/21.
  92235.50c    44188  njoy                                  total nu          (  1395)      79/09/12.
  92238.50c    66440  njoy                                  total nu          (  1398)      79/09/13.
   lwtr.01t    10193  hydrogen in light water at 300 degrees kelvin          1001     0     010/22/85

  total       645633

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general             123874
     tallies                  0
     bank                 16403
     cross sections      645633

     total               785910

 ************************************************************************************************************************
 dump no.     1 on file 2fr          nps =          0      coll =              0      ctm =     0.00      nrn =              0


 source distribution written to file 2fs             cycle =      0

          1 warning message so far.
1    starting mcrun.       field length =       0      cp0 =  0.02                                        print table 110
```

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air

nps	x	y	z	cell	lattice(i,j,k)	surface	u	v	w	energy	weight	time
1	0.000E+00	2.437E+01	3.620E+01	42			5.085E-01	4.733E-01	7.193E-01	2.209E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		5.085E-01	4.733E-01	7.193E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	5.085E-01	4.733E-01	7.193E-01			
2	0.000E+00	2.437E+01	3.620E+01	42			8.952E-01	-4.447E-01	-2.944E-02	4.904E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		8.952E-01	-4.447E-01	-2.944E-02			
	-1.776E-15	1.960E-01	3.620E+01	22		0	8.952E-01	-4.447E-01	-2.944E-02			
3	0.000E+00	2.437E+01	3.620E+01	42			-6.184E-01	-4.495E-01	6.446E-01	3.809E-01	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-6.184E-01	-4.495E-01	6.446E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-6.184E-01	-4.495E-01	6.446E-01			
4	0.000E+00	2.437E+01	3.620E+01	42			9.710E-01	-5.665E-02	-2.323E-01	1.331E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		9.710E-01	-5.665E-02	-2.323E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	9.710E-01	-5.665E-02	-2.323E-01			
5	0.000E+00	2.437E+01	3.620E+01	42			5.861E-01	1.496E-01	-7.963E-01	1.902E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		5.861E-01	1.496E-01	-7.963E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	5.861E-01	1.496E-01	-7.963E-01			
6	0.000E+00	2.437E+01	3.620E+01	42			-6.489E-02	-1.626E-01	9.845E-01	4.410E-01	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-6.489E-02	-1.626E-01	9.845E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-6.489E-02	-1.626E-01	9.845E-01			
7	0.000E+00	2.437E+01	3.620E+01	42			-7.068E-02	3.263E-02	-9.970E-01	4.750E-01	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-7.068E-02	3.263E-02	-9.970E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-7.068E-02	3.263E-02	-9.970E-01			
8	0.000E+00	2.437E+01	3.620E+01	42			-3.915E-01	4.664E-01	-7.932E-01	4.136E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-3.915E-01	4.664E-01	-7.932E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-3.915E-01	4.664E-01	-7.932E-01			
9	0.000E+00	2.437E+01	3.620E+01	42			-2.368E-01	9.215E-01	-3.079E-01	7.453E-02	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-2.368E-01	9.215E-01	-3.079E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-2.368E-01	9.215E-01	-3.079E-01			
10	0.000E+00	2.437E+01	3.620E+01	42			1.946E-01	-3.204E-01	9.271E-01	3.128E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		1.946E-01	-3.204E-01	9.271E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	1.946E-01	-3.204E-01	9.271E-01			
11	0.000E+00	2.437E+01	3.620E+01	42			-6.698E-01	-7.177E-01	-1.905E-01	1.014E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-6.698E-01	-7.177E-01	-1.905E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-6.698E-01	-7.177E-01	-1.905E-01			
12	0.000E+00	2.437E+01	3.620E+01	42			-8.398E-01	-4.129E-01	3.524E-01	1.395E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-8.398E-01	-4.129E-01	3.524E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-8.398E-01	-4.129E-01	3.524E-01			
13	0.000E+00	2.437E+01	3.620E+01	42			-1.714E-01	-8.572E-01	4.857E-01	7.748E-01	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-1.714E-01	-8.572E-01	4.857E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-1.714E-01	-8.572E-01	4.857E-01			
14	0.000E+00	2.437E+01	3.620E+01	42			-2.489E-01	-5.118E-01	-8.222E-01	1.101E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-2.489E-01	-5.118E-01	-8.222E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-2.489E-01	-5.118E-01	-8.222E-01			
15	0.000E+00	2.437E+01	3.620E+01	42			-2.959E-01	2.119E-01	9.314E-01	1.951E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-2.959E-01	2.119E-01	9.314E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-2.959E-01	2.119E-01	9.314E-01			
16	0.000E+00	2.437E+01	3.620E+01	42			1.395E-01	-9.829E-01	1.202E-01	2.186E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		1.395E-01	-9.829E-01	1.202E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	1.395E-01	-9.829E-01	1.202E-01			
17	0.000E+00	2.437E+01	3.620E+01	42			6.909E-01	-7.110E-01	1.307E-01	1.865E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		6.909E-01	-7.110E-01	1.307E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	6.909E-01	-7.110E-01	1.307E-01			
18	0.000E+00	2.437E+01	3.620E+01	42			-6.580E-01	5.320E-01	-5.329E-01	1.229E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-6.580E-01	5.320E-01	-5.329E-01			
	-1.776E-15	1.960E-01	3.620E+01	22		0	-6.580E-01	5.320E-01	-5.329E-01			
19	0.000E+00	2.437E+01	3.620E+01	42			-9.903E-01	-1.380E-01	1.353E-02	1.305E+00	9.998E-01	0.000E+00
	-1.776E-15	1.960E-01	3.620E+01	21	(-24, 24, 0)		-9.903E-01	-1.380E-01	1.353E-02			

```
   -1.776E-15   1.960E-01   3.620E+01   22
20  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
21  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
22  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
23  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
24  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
25  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
26  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
27  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
28  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
29  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
30  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
31  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
32  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
33  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
34  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
35  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
36  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
37  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
38  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
39  0.000E+00   2.437E+01   3.620E+01   42
   -1.776E-15   1.960E-01   3.620E+01   21( -24,   24,   0)
   -1.776E-15   1.960E-01   3.620E+01   22
40  0.000E+00   2.437E+01   3.620E+01   42

 0 -9.903E-01 -1.380E-01  1.353E-02
    7.462E-01  4.859E-01 -4.551E-01  1.000E+00  9.998E-01  0.000E+00
    7.462E-01  4.859E-01 -4.551E-01
 0  7.462E-01  4.859E-01 -4.551E-01
   -1.977E-01  9.797E-01  3.360E-02  3.990E+00  9.998E-01  0.000E+00
   -1.977E-01  9.797E-01  3.360E-02
 0 -1.977E-01  9.797E-01  3.360E-02
   -9.117E-01 -3.647E-01 -1.891E-01  2.665E-01  9.998E-01  0.000E+00
   -9.117E-01 -3.647E-01 -1.891E-01
 0 -9.117E-01 -3.647E-01 -1.891E-01
   -4.287E-01  8.361E-01 -3.423E-01  1.156E+00  9.998E-01  0.000E+00
   -4.287E-01  8.361E-01 -3.423E-01
 0 -4.287E-01  8.361E-01 -3.423E-01
    1.080E-01  3.412E-01 -9.338E-01  2.669E+00  9.998E-01  0.000E+00
    1.080E-01  3.412E-01 -9.338E-01
 0  1.080E-01  3.412E-01 -9.338E-01
   -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  9.998E-01  0.000E+00
   -9.111E-01 -9.012E-03 -4.122E-01
 0 -9.111E-01 -9.012E-03 -4.122E-01
   -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  9.998E-01  0.000E+00
   -2.568E-01 -6.391E-01 -7.249E-01
 0 -2.568E-01 -6.391E-01 -7.249E-01
   -2.912E-01  8.086E-01  5.113E-01  1.079E+00  9.998E-01  0.000E+00
   -2.912E-01  8.086E-01  5.113E-01
 0 -2.912E-01  8.086E-01  5.113E-01
    1.472E-01 -9.514E-01  2.705E-01  3.461E+00  9.998E-01  0.000E+00
    1.472E-01 -9.514E-01  2.705E-01
 0  1.472E-01 -9.514E-01  2.705E-01
   -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  9.998E-01  0.000E+00
   -6.135E-01 -7.645E-01 -1.978E-01
 0 -6.135E-01 -7.645E-01 -1.978E-01
   -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  9.998E-01  0.000E+00
   -5.702E-01  5.651E-01 -5.963E-01
 0 -5.702E-01  5.651E-01 -5.963E-01
   -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  9.998E-01  0.000E+00
   -6.607E-01  5.373E-01 -5.242E-01
 0 -6.607E-01  5.373E-01 -5.242E-01
   -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  9.998E-01  0.000E+00
   -9.742E-02 -3.639E-01 -9.263E-01
 0 -9.742E-02 -3.639E-01 -9.263E-01
   -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  9.998E-01  0.000E+00
   -1.965E-01 -3.145E-01 -9.287E-01
 0 -1.965E-01 -3.145E-01 -9.287E-01
    4.097E-01  8.465E-01 -3.399E-01  9.097E-01  9.998E-01  0.000E+00
    4.097E-01  8.465E-01 -3.399E-01
 0  4.097E-01  8.465E-01 -3.399E-01
   -4.048E-02  8.831E-01  4.675E-01  3.360E-01  9.998E-01  0.000E+00
   -4.048E-02  8.831E-01  4.675E-01
 0 -4.048E-02  8.831E-01  4.675E-01
    3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  9.998E-01  0.000E+00
    3.371E-01 -9.269E-01 -1.652E-01
 0  3.371E-01 -9.269E-01 -1.652E-01
   -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  9.998E-01  0.000E+00
   -1.867E-01  9.756E-01 -1.155E-01
 0 -1.867E-01  9.756E-01 -1.155E-01
   -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  9.998E-01  0.000E+00
   -2.616E-01  2.336E-01 -9.365E-01
 0 -2.616E-01  2.336E-01 -9.365E-01
    9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  9.998E-01  0.000E+00
    9.780E-01 -7.641E-02 -1.939E-01
 0  9.780E-01 -7.641E-02 -1.939E-01
    2.580E-01 -7.076E-01  6.578E-01  1.444E+00  9.998E-01  0.000E+00
```

```
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        2.580E-01 -7.076E-01  6.578E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  2.580E-01 -7.076E-01  6.578E-01
 41  0.000E+00  2.437E+01  3.620E+01   42                       -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -3.212E-01 -7.678E-01 -5.543E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -3.212E-01 -7.678E-01 -5.543E-01
 42  0.000E+00  2.437E+01  3.620E+01   42                        5.039E-01 -1.460E-01  8.513E-01  1.502E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        5.039E-01 -1.460E-01  8.513E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  5.039E-01 -1.460E-01  8.513E-01
 43  0.000E+00  2.437E+01  3.620E+01   42                        6.080E-01  5.487E-01  5.738E-01  5.971E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        6.080E-01  5.487E-01  5.738E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  6.080E-01  5.487E-01  5.738E-01
 44  0.000E+00  2.437E+01  3.620E+01   42                       -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -2.932E-01  9.304E-01 -2.199E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -2.932E-01  9.304E-01 -2.199E-01
 45  0.000E+00  2.437E+01  3.620E+01   42                       -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -8.475E-01 -3.993E-01 -3.497E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -8.475E-01 -3.993E-01 -3.497E-01
 46  0.000E+00  2.437E+01  3.620E+01   42                        1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        1.200E-01 -9.195E-01 -3.743E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  1.200E-01 -9.195E-01 -3.743E-01
 47  0.000E+00  2.437E+01  3.620E+01   42                        7.085E-01  5.879E-01  3.904E-01  2.288E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        7.085E-01  5.879E-01  3.904E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  7.085E-01  5.879E-01  3.904E-01
 48  0.000E+00  2.437E+01  3.620E+01   42                        4.261E-01  9.046E-01  9.254E-03  1.230E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        4.261E-01  9.046E-01  9.254E-03
   -1.776E-15  1.960E-01  3.620E+01   22                     0  4.261E-01  9.046E-01  9.254E-03
 49  0.000E+00  2.437E+01  3.620E+01   42                        5.431E-01  4.270E-01 -7.230E-01  1.433E+00  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)        5.431E-01  4.270E-01 -7.230E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0  5.431E-01  4.270E-01 -7.230E-01
 50  0.000E+00  2.437E+01  3.620E+01   42                       -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  9.998E-01  0.000E+00
   -1.776E-15  1.960E-01  3.620E+01   21( -24,  24,   0)       -1.053E-01 -9.805E-01  1.658E-01
   -1.776E-15  1.960E-01  3.620E+01   22                     0 -1.053E-01 -9.805E-01  1.658E-01
lestimated keff results by cycle                                                                    print table 175

*****************************************************************************************************************
dump no.    2 on file 2fr          nps =     39570     coll =        3459227     ctm =   16.11     nrn =       66629998

source distribution written to file 2fs            cycle =    20

source distribution written to file 2fs            cycle =    22

source distribution written to file 2fs            cycle =    24

source distribution written to file 2fs            cycle =    26

source distribution written to file 2fs            cycle =    28

*****************************************************************************************************************
dump no.    3 on file 2fr          nps =    112250     coll =        8041709     ctm =   31.12     nrn =      149598747

source distribution written to file 2fs            cycle =    30

source distribution written to file 2fs            cycle =    32

source distribution written to file 2fs            cycle =    34

source distribution written to file 2fs            cycle =    36

source distribution written to file 2fs            cycle =    38
```

```
source distribution written to file 2fs            cycle =    40
source distribution written to file 2fs            cycle =    42
source distribution written to file 2fs            cycle =    44
source distribution written to file 2fs            cycle =    46
source distribution written to file 2fs            cycle =    48
source distribution written to file 2fs            cycle =    50
************************************************************************************************************************
dump no.    4 on file 2fr          nps =    200190     coll =       13279704     ctm =   46.61     nrn =      242989425

source distribution written to file 2fs            cycle =    52
source distribution written to file 2fs            cycle =    54
source distribution written to file 2fs            cycle =    56
source distribution written to file 2fs            cycle =    58
source distribution written to file 2fs            cycle =    60
source distribution written to file 2fs            cycle =    62
source distribution written to file 2fs            cycle =    64
source distribution written to file 2fs            cycle =    66
source distribution written to file 2fs            cycle =    68
source distribution written to file 2fs            cycle =    70
source distribution written to file 2fs            cycle =    72
************************************************************************************************************************
dump no.    5 on file 2fr          nps =    288457     coll =       18529722     ctm =   62.27     nrn =      336749725

source distribution written to file 2fs            cycle =    74
source distribution written to file 2fs            cycle =    76
source distribution written to file 2fs            cycle =    78
source distribution written to file 2fs            cycle =    80
source distribution written to file 2fs            cycle =    82
source distribution written to file 2fs            cycle =    84
source distribution written to file 2fs            cycle =    86
source distribution written to file 2fs            cycle =    88
source distribution written to file 2fs            cycle =    90
source distribution written to file 2fs            cycle =    92
```

```
**********************************************************************************************************************
dump no.    6 on file 2fr          nps =    372354     coll =       23583635     ctm =   77.28     nrn =       426989250


source distribution written to file 2fs             cycle =    94

source distribution written to file 2fs             cycle =    96

source distribution written to file 2fs             cycle =    98

 estimator     cycle   100   ave of    80 cycles      combination         simple average    combined average     corr
k(collision)      0.900268       0.916048 0.0014     k(col/abs)          0.915897 0.0012     0.915885 0.0012   0.4896
k(absorption)     0.912982       0.915745 0.0013     k(abs/tk ln)        0.915492 0.0014     0.915636 0.0013   0.3308
k(trk length)     0.903805       0.915239 0.0020     k(tk ln/col)        0.915644 0.0016     0.916213 0.0014   0.7960
rem life(col)   7.9129E+03     7.8714E+03 0.0053     k(col/abs/tk ln)    0.915678 0.0013     0.915966 0.0012
rem life(abs)   8.1677E+03     7.8797E+03 0.0051     life(col/abs)     7.8756E+03 0.0052   7.8788E+03 0.0052   0.9623
source points generated   3875

source distribution written to file 2fs             cycle =   100

source distribution written to file 2fs             cycle =   102

source distribution written to file 2fs             cycle =   104

source distribution written to file 2fs             cycle =   106

source distribution written to file 2fs             cycle =   108

source distribution written to file 2fs             cycle =   110

source distribution written to file 2fs             cycle =   112

source distribution written to file 2fs             cycle =   114

**********************************************************************************************************************
dump no.    7 on file 2fr          nps =    460387     coll =       28833959     ctm =   92.83     nrn =       520701573


 estimator     cycle   116   ave of    96 cycles      combination         simple average    combined average     corr
k(collision)      0.911407       0.916537 0.0013     k(col/abs)          0.916529 0.0011     0.916529 0.0011   0.5513
k(absorption)     0.911177       0.916520 0.0013     k(abs/tk ln)        0.916255 0.0013     0.916378 0.0012   0.3222
k(trk length)     0.917651       0.915990 0.0018     k(tk ln/col)        0.916264 0.0015     0.916589 0.0013   0.7740
rem life(col)   7.7949E+03     7.8543E+03 0.0049     k(col/abs/tk ln)    0.916349 0.0012     0.916516 0.0011
rem life(abs)   7.9922E+03     7.8645E+03 0.0048     life(col/abs)     7.8594E+03 0.0048   7.8629E+03 0.0048   0.9647
source points generated   4046

source distribution written to file 2fs             cycle =   116

 estimator     cycle   117   ave of    97 cycles      combination         simple average    combined average     corr
k(collision)      0.928747       0.916663 0.0013     k(col/abs)          0.916655 0.0011     0.916655 0.0011   0.5565
k(absorption)     0.928894       0.916648 0.0013     k(abs/tk ln)        0.916283 0.0012     0.916448 0.0012   0.3151
k(trk length)     0.908944       0.915918 0.0018     k(tk ln/col)        0.916291 0.0014     0.916715 0.0013   0.7641
rem life(col)   8.3359E+03     7.8593E+03 0.0049     k(col/abs/tk ln)    0.916410 0.0012     0.916621 0.0011
rem life(abs)   8.5437E+03     7.8715E+03 0.0048     life(col/abs)     7.8654E+03 0.0048   7.8680E+03 0.0049   0.9640
source points generated   4059

 estimator     cycle   118   ave of    98 cycles      combination         simple average    combined average     corr
k(collision)      0.921975       0.916718 0.0013     k(col/abs)          0.916742 0.0011     0.916742 0.0011   0.5578
k(absorption)     0.928296       0.916766 0.0013     k(abs/tk ln)        0.916300 0.0012     0.916507 0.0012   0.3077
k(trk length)     0.907667       0.915834 0.0018     k(tk ln/col)        0.916276 0.0014     0.916771 0.0013   0.7598
rem life(col)   7.6367E+03     7.8570E+03 0.0049     k(col/abs/tk ln)    0.916439 0.0012     0.916694 0.0011
rem life(abs)   7.7553E+03     7.8703E+03 0.0048     life(col/abs)     7.8637E+03 0.0048   7.8667E+03 0.0048   0.9637
```

source points generated 3995

source distribution written to file 2fs cycle = 118

estimator	cycle 119	ave of 99 cycles		combination	simple average		combined average		corr
k(collision)	0.921051	0.916761	0.0013	k(col/abs)	0.916852	0.0011	0.916851	0.0011	0.5567
k(absorption)	0.934281	0.916943	0.0013	k(abs/tk ln)	0.916410	0.0012	0.916640	0.0012	0.3082
k(trk length)	0.920158	0.915877	0.0017	k(tk ln/col)	0.916319	0.0014	0.916815	0.0013	0.7600
rem life(col)	8.2575E+03	7.8611E+03	0.0048	k(col/abs/tk ln)	0.916527	0.0012	0.916807	0.0011	
rem life(abs)	8.2392E+03	7.8740E+03	0.0047	life(col/abs)	7.8676E+03	0.0047	7.8707E+03	0.0048	0.9640

source points generated 4104

estimator	cycle 120	ave of 100 cycles		combination	simple average		combined average		corr
k(collision)	0.895651	0.916550	0.0013	k(col/abs)	0.916686	0.0011	0.916687	0.0011	0.5634
k(absorption)	0.904769	0.916822	0.0013	k(abs/tk ln)	0.916164	0.0012	0.916470	0.0012	0.3223
k(trk length)	0.878718	0.915506	0.0018	k(tk ln/col)	0.916028	0.0014	0.916645	0.0013	0.7690
rem life(col)	7.9358E+03	7.8618E+03	0.0048	k(col/abs/tk ln)	0.916292	0.0012	0.916659	0.0011	
rem life(abs)	7.9378E+03	7.8747E+03	0.0047	life(col/abs)	7.8682E+03	0.0047	7.8713E+03	0.0047	0.9640

source points generated 3931

source distribution written to file 2fs cycle = 120

1problem summary

run terminated when 120 kcode cycles were done.

+ 03/12/01 13:14:27

WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 03/12/01 11:38:05

0

neutron creation	tracks	weight (per source particle)	energy (per source particle)	neutron loss	tracks	weight (per source particle)	energy (per source particle)
source	480567	9.9882E-01	2.0367E+00	escape	21308	3.2651E-02	1.6793E-02
				energy cutoff	0	0.	0.
				time cutoff	0	0.	0.
weight window	0	0.	0.	weight window	0	0.	0.
cell importance	0	0.	0.	cell importance	0	0.	0.
weight cutoff	0	1.1358E-01	4.2320E-04	weight cutoff	460435	1.1314E-01	4.4120E-04
energy importance	0	0.	0.	energy importance	0	0.	0.
dxtran	0	0.	0.	dxtran	0	0.	0.
forced collisions	0	0.	0.	forced collisions	0	0.	0.
exp. transform	0	0.	0.	exp. transform	0	0.	0.
upscattering	0	0.	7.2128E-08	downscattering	0	0.	1.7791E+00
				capture	0	6.0670E-01	6.7615E-02
(n,xn)	2348	3.6391E-03	2.6857E-03	loss to (n,xn)	1172	1.8164E-03	1.5146E-02
fission	0	0.	0.	loss to fission	0	3.6173E-01	1.6072E-01
total	482915	1.1160E+00	2.0398E+00	total	482915	1.1160E+00	2.0398E+00

number of neutrons banked	1176	average lifetime, shakes		cutoffs	
neutron tracks per source particle	1.0049E+00	escape	8.1932E+03	tco	1.0000E+34
neutron collisions per source particle	6.2500E+01	capture	7.6772E+03	eco	0.0000E+00
total neutron collisions	30035334	capture or escape	7.6940E+03	wc1	-5.0000E-01
net multiplication	1.0018E+00 0.0001	any termination	9.2306E+03	wc2	-2.5000E-01

computer time so far in this run	96.35 minutes	maximum number ever in bank	2
computer time in mcrun	96.33 minutes	bank overflows to backup file	0
source particles per minute	4.9887E+03	field length	0
random numbers generated	542110173	most random numbers used was	14035 in history 110317

range of sampled source weights = 9.3787E-01 to 1.3527E+00

1neutron activity in each cell print table 126

cell	tracks entering	population	collisions	collisions * weight	number weighted	flux weighted	average track weight	average track mfp

					(per history)	energy	energy	(relative)	(cm)
1	11	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	12	21357846	207529	7118915	9.0714E+00	2.5417E-02	4.4576E-01	6.3977E-01	2.4773E+00
3	13	44812828	204514	2626153	3.0640E+00	2.4724E-02	4.4414E-01	6.3963E-01	3.0253E+00
4	14	50121412	203164	566	6.9061E-04	2.4580E-02	4.4402E-01	6.3966E-01	5.3983E+03
5	21	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	22	9416062	360860	3093115	5.1925E+00	3.2932E-03	7.2749E-01	8.3897E-01	2.6371E+00
7	23	19322467	359221	1279273	2.0922E+00	2.9342E-03	7.0872E-01	8.3789E-01	2.6819E+00
8	24	23561128	358844	4612513	7.4373E+00	2.6995E-03	6.9900E-01	8.3788E-01	1.7881E+00
9	33	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	34	987650	185805	162666	2.0738E-01	3.5651E-03	4.6835E-01	6.6645E-01	4.3291E+00
11	35	1179876	187426	2637	3.3092E-03	2.5410E-03	4.5801E-01	6.6831E-01	5.2309E+03
12	36	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	41	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	42	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	43	181283	97564	34583	5.3559E-02	1.8295E-03	6.6367E-01	8.1083E-01	3.6353E+00
16	51	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
17	52	181091	97361	34632	5.3695E-02	1.8293E-03	6.7952E-01	8.1232E-01	3.6326E+00
18	44	512987	185453	5862	8.4187E-03	8.6182E-04	5.2306E-01	7.5711E-01	5.1256E+03
19	45	153728	91875	4812985	5.9271E+00	7.8737E-05	2.1120E-01	6.1997E-01	2.7175E+00
20	46	31418	19503	874358	1.0605E+00	6.8979E-05	1.7479E-01	6.0904E-01	2.6630E+00
21	47	22186	13991	636109	7.6815E-01	6.9573E-05	1.7669E-01	6.0630E-01	2.6681E+00
22	48	172372	105390	4635719	5.9182E+00	9.0796E-05	2.3074E-01	6.4323E-01	2.7588E+00
23	49	4030	2102	105248	1.2545E-01	8.0059E-05	1.7037E-01	5.9653E-01	2.6827E+00
total		172018364	2680602	30035334	4.0984E+01				

1keff results for: WV, HEC, Yankee, 5%, inf. lat. of 30 gal. drums with no ins., air probid = 03/12/01 11:38:05

the initial fission neutron source distribution used the 51 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 79963 neutron histories and 100 active cycles with 400604 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 480567 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 95 percent confidence level
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

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the final estimated combined collision/absorption/track-length keff = 0.91666 with an estimated standard deviation of 0.00105

the estimated 68, 95, & 99 percent keff confidence intervals are 0.91561 to 0.91771, 0.91458 to 0.91874, and 0.91390 to 0.91942

the estimated collision/absorption neutron removal lifetime = 7.87E-05 seconds with an estimated standard deviation of 3.74E-07

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the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr
collision	0.91655	0.00117	0.91538 to 0.91772	0.91423 to 0.91887	0.91347 to 0.91963	

absorption	0.91682	0.00116	0.91566 to 0.91799	0.91451 to 0.91914	0.91375 to 0.91989	
track length	0.91551	0.00163	0.91388 to 0.91713	0.91227 to 0.91875	0.91121 to 0.91980	
col/absorp	0.91669	0.00104	0.91565 to 0.91772	0.91462 to 0.91875	0.91395 to 0.91942	0.5634
abs/trk len	0.91647	0.00108	0.91539 to 0.91755	0.91431 to 0.91863	0.91361 to 0.91933	0.3223
col/trk len	0.91664	0.00117	0.91547 to 0.91782	0.91430 to 0.91898	0.91354 to 0.91975	0.7690
col/abs/trk len	0.91666	0.00105	0.91561 to 0.91771	0.91458 to 0.91874	0.91390 to 0.91942	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	0.91679	0.00118	0.91561 to 0.91797	0.91444 to 0.91914	0.91367 to 0.91990
absorption	0.91722	0.00122	0.91600 to 0.91844	0.91479 to 0.91965	0.91400 to 0.92044
track length	0.91595	0.00167	0.91428 to 0.91762	0.91262 to 0.91927	0.91153 to 0.92036
col/abs/trk len	0.91702	0.00108	0.91594 to 0.91810	0.91487 to 0.91917	0.91416 to 0.91988

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	7.8713E-05	3.7363E-07	7.8339E-05 to 7.9087E-05	7.7969E-05 to 7.9458E-05	7.7726E-05 to 7.9701E-05
capture	7.8326E-05	3.6803E-07	7.7957E-05 to 7.8694E-05	7.7593E-05 to 7.9059E-05	7.7353E-05 to 7.9298E-05
fission	3.9752E-05	2.4918E-07	3.9502E-05 to 4.0001E-05	3.9255E-05 to 4.0248E-05	3.9093E-05 to 4.0410E-05
escape	8.3459E-05	1.8856E-06	8.1571E-05 to 8.5346E-05	7.9702E-05 to 8.7215E-05	7.8477E-05 to 8.8440E-05

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	0.9166	0.0012	0.9168	0.0012	0.9155	0.0016	95/95/95	0.91666	0.00105	0.91458-0.91874	0.91390-0.91942
2	50	0.9166	0.0012	0.9168	0.0012	0.9155	0.0017	95/95/95	0.91660	0.00109	0.91441-0.91879	0.91368-0.91952
4	25	0.9166	0.0012	0.9168	0.0013	0.9155	0.0017	95/95/95	0.91665	0.00121	0.91414-0.91917	0.91324-0.92007
5	20	0.9166	0.0008	0.9168	0.0013	0.9155	0.0015	95/95/95	0.91696	0.00084	0.91520-0.91872	0.91454-0.91938
10	10	0.9166	0.0010	0.9168	0.0017	0.9155	0.0018	95/95/95	0.91736	0.00088	0.91527-0.91944	0.91427-0.92044
20	5	0.9166	0.0014	0.9168	0.0023	0.9155	0.0020	95/95/95	0.91706	0.00051	0.91485-0.91927	0.91197-0.92215
25	4	0.9166	0.0014	0.9168	0.0024	0.9155	0.0024	95/95/95	0.91689	0.00024	0.91383-0.91996	0.90152-0.93227

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4001	0.73257	0.73245	0.73020									
2	2957	0.73194	0.73565	0.73753									
3	3992	0.74405	0.73478	0.74307									
4	4046	0.73759	0.74167	0.73220									
5	4082	0.75037	0.74931	0.74375									
6	4182	0.77177	0.76175	0.75711									
7	4020	0.78585	0.77468	0.79673									
8	4144	0.80102	0.80242	0.79292									
9	4080	0.80847	0.79922	0.81823									
10	4066	0.80062	0.80457	0.78952									
11	4007	0.82189	0.83907	0.83725									
12	4189	0.83269	0.83193	0.83403									
13	4033	0.85248	0.84672	0.83798									
14	4105	0.86080	0.87723	0.86427									
15	3967	0.87577	0.88122	0.87388									
16	4008	0.89561	0.88419	0.91283									
17	4125	0.88729	0.89951	0.90216									
18	3997	0.89899	0.90669	0.91177									

19	3992	0.89472	0.90665	0.88246									
20	3970	0.90045	0.91376	0.90234									
		begin active keff cycles											
21	4093	0.92500	0.93043	0.91398									
22	4101	0.90458	0.88974	0.89281	0.91479	0.01021	0.91008	0.02034	0.90339	0.01058			
23	3909	0.89425	0.91994	0.89111	0.90794	0.00904	0.91337	0.01220	0.89930	0.00736			
24	3990	0.90268	0.90525	0.91088	0.90663	0.00652	0.91134	0.00886	0.90219	0.00595	0.90467	0.01224	1852
25	4053	0.91792	0.90473	0.91623	0.90889	0.00554	0.91002	0.00699	0.90500	0.00540	0.90748	0.00763	3849
26	4089	0.90527	0.90061	0.90689	0.90828	0.00456	0.90845	0.00592	0.90532	0.00442	0.90686	0.00544	6329
27	3978	0.91698	0.90221	0.90807	0.90953	0.00405	0.90756	0.00508	0.90571	0.00376	0.90699	0.00460	7607
28	4074	0.93757	0.92766	0.93419	0.91303	0.00496	0.91007	0.00507	0.90927	0.00482	0.91017	0.00588	4123
29	3997	0.90704	0.89139	0.89842	0.91237	0.00442	0.90799	0.00493	0.90806	0.00442	0.90956	0.00569	3925
30	3788	0.90867	0.91058	0.90691	0.91200	0.00397	0.90825	0.00441	0.90795	0.00396	0.90946	0.00495	4696
31	4041	0.90823	0.91003	0.90387	0.91165	0.00361	0.90841	0.00400	0.90758	0.00360	0.90929	0.00449	5191
32	4053	0.88496	0.90384	0.87486	0.90943	0.00398	0.90803	0.00367	0.90485	0.00427	0.90888	0.00467	4391
33	3954	0.92817	0.91012	0.93892	0.91087	0.00393	0.90819	0.00338	0.90747	0.00472	0.91002	0.00384	5995
34	4170	0.91479	0.91525	0.91278	0.91115	0.00365	0.90870	0.00317	0.90785	0.00439	0.91048	0.00356	6480
35	3927	0.91438	0.91077	0.91705	0.91137	0.00341	0.90884	0.00295	0.90846	0.00413	0.91057	0.00323	7369
36	3982	0.88909	0.89537	0.88506	0.90997	0.00348	0.90799	0.00289	0.90700	0.00413	0.90946	0.00325	6795
37	3824	0.91013	0.90173	0.88673	0.90998	0.00327	0.90763	0.00274	0.90581	0.00406	0.90942	0.00311	7011
38	4095	0.92377	0.91144	0.93204	0.91075	0.00317	0.90784	0.00259	0.90727	0.00410	0.90974	0.00286	7840
39	4066	0.91785	0.92400	0.90945	0.91112	0.00302	0.90869	0.00259	0.90738	0.00388	0.91044	0.00287	7395
40	3965	0.91975	0.92333	0.92695	0.91155	0.00290	0.90942	0.00257	0.90836	0.00380	0.91125	0.00267	8113
41	4024	0.90294	0.91446	0.90189	0.91114	0.00279	0.90966	0.00245	0.90805	0.00363	0.91120	0.00251	8783
42	3984	0.91061	0.91839	0.89793	0.91112	0.00266	0.91006	0.00237	0.90759	0.00349	0.91142	0.00246	8737
43	4083	0.92100	0.92792	0.91642	0.91155	0.00258	0.91083	0.00240	0.90798	0.00336	0.91207	0.00247	8331
44	3990	0.92710	0.91404	0.92442	0.91220	0.00255	0.91097	0.00230	0.90866	0.00329	0.91239	0.00241	8405
45	4074	0.93065	0.91384	0.93388	0.91294	0.00256	0.91108	0.00221	0.90967	0.00331	0.91271	0.00232	8652
46	4047	0.93910	0.93924	0.93369	0.91394	0.00265	0.91216	0.00238	0.91059	0.00331	0.91369	0.00257	6812
47	4005	0.91908	0.90809	0.91793	0.91413	0.00256	0.91201	0.00230	0.91087	0.00320	0.91365	0.00248	7034
48	3903	0.92628	0.91395	0.94629	0.91457	0.00251	0.91208	0.00221	0.91213	0.00333	0.91366	0.00230	7942
49	4003	0.92474	0.92089	0.92669	0.91492	0.00244	0.91239	0.00216	0.91263	0.00325	0.91398	0.00223	8138
50	3965	0.90445	0.91409	0.91742	0.91457	0.00239	0.91244	0.00208	0.91279	0.00315	0.91359	0.00210	8898
51	3887	0.92312	0.94061	0.91500	0.91484	0.00232	0.91335	0.00221	0.91286	0.00305	0.91439	0.00215	8233
52	4115	0.90860	0.91829	0.91871	0.91465	0.00226	0.91351	0.00215	0.91305	0.00296	0.91429	0.00205	8783
53	3967	0.92360	0.92425	0.92352	0.91492	0.00221	0.91383	0.00211	0.91336	0.00288	0.91460	0.00201	8895
54	4144	0.92816	0.92591	0.92049	0.91531	0.00218	0.91419	0.00207	0.91357	0.00280	0.91493	0.00200	8694
55	4009	0.90256	0.92906	0.90534	0.91494	0.00214	0.91461	0.00206	0.91334	0.00273	0.91499	0.00192	9147
56	3976	0.91552	0.92710	0.91388	0.91496	0.00208	0.91496	0.00203	0.91335	0.00266	0.91519	0.00188	9345
57	4035	0.92115	0.93209	0.89704	0.91513	0.00203	0.91542	0.00203	0.91291	0.00262	0.91535	0.00188	9010
58	4124	0.90141	0.91025	0.88607	0.91477	0.00201	0.91529	0.00198	0.91221	0.00265	0.91521	0.00186	8945
59	3882	0.91478	0.91732	0.90782	0.91477	0.00196	0.91534	0.00193	0.91209	0.00258	0.91524	0.00182	9129
60	4010	0.93712	0.93334	0.95709	0.91533	0.00199	0.91579	0.00193	0.91322	0.00275	0.91594	0.00180	9134
61	4030	0.89752	0.91057	0.90173	0.91489	0.00199	0.91566	0.00189	0.91294	0.00270	0.91561	0.00178	9117
62	3825	0.92478	0.92447	0.92577	0.91513	0.00195	0.91587	0.00186	0.91324	0.00265	0.91583	0.00175	9231
63	4121	0.92211	0.90386	0.94988	0.91529	0.00192	0.91559	0.00183	0.91410	0.00273	0.91558	0.00169	9616
64	4051	0.91490	0.90586	0.90453	0.91528	0.00187	0.91537	0.00180	0.91388	0.00267	0.91550	0.00166	9766
65	3942	0.92883	0.91391	0.93902	0.91558	0.00185	0.91534	0.00176	0.91444	0.00267	0.91560	0.00162	10015
66	4093	0.93387	0.93416	0.96006	0.91598	0.00186	0.91575	0.00177	0.91543	0.00280	0.91598	0.00160	9984
67	4008	0.91647	0.90922	0.90751	0.91599	0.00182	0.91561	0.00174	0.91526	0.00274	0.91595	0.00157	10175
68	3926	0.91614	0.92807	0.90591	0.91599	0.00178	0.91587	0.00172	0.91507	0.00269	0.91612	0.00155	10264
69	4025	0.92310	0.91836	0.93955	0.91614	0.00175	0.91592	0.00169	0.91556	0.00268	0.91615	0.00151	10536
70	4125	0.90895	0.89762	0.91092	0.91599	0.00172	0.91555	0.00169	0.91547	0.00263	0.91589	0.00151	10402
71	3994	0.90590	0.91038	0.90503	0.91580	0.00170	0.91545	0.00166	0.91527	0.00259	0.91574	0.00148	10508
72	3978	0.91648	0.91589	0.91477	0.91581	0.00166	0.91546	0.00163	0.91526	0.00254	0.91575	0.00145	10718
73	3993	0.92583	0.92372	0.92435	0.91600	0.00164	0.91562	0.00161	0.91543	0.00249	0.91593	0.00144	10753
74	3982	0.92850	0.92424	0.92604	0.91623	0.00163	0.91577	0.00159	0.91563	0.00245	0.91613	0.00143	10723

75	4038	0.91119	0.92168	0.92953	0.91614	0.00160	0.91588	0.00156	0.91588	0.00242	0.91606	0.00140	10967
76	3910	0.91505	0.90625	0.90881	0.91612	0.00157	0.91571	0.00154	0.91575	0.00238	0.91599	0.00138	11126
77	4073	0.90857	0.92126	0.90872	0.91599	0.00155	0.91581	0.00152	0.91563	0.00234	0.91597	0.00135	11346
78	3923	0.90727	0.91218	0.91357	0.91584	0.00153	0.91574	0.00149	0.91559	0.00230	0.91583	0.00133	11451
79	3953	0.91970	0.90899	0.91701	0.91590	0.00151	0.91563	0.00147	0.91562	0.00226	0.91582	0.00131	11642
80	4040	0.92516	0.93085	0.91322	0.91606	0.00149	0.91588	0.00147	0.91558	0.00223	0.91605	0.00131	11444
81	4050	0.90539	0.90890	0.91736	0.91588	0.00147	0.91577	0.00145	0.91561	0.00219	0.91586	0.00130	11439
82	3920	0.91351	0.91559	0.90510	0.91584	0.00145	0.91577	0.00143	0.91544	0.00216	0.91586	0.00128	11633
83	4064	0.92425	0.90786	0.90964	0.91598	0.00143	0.91564	0.00141	0.91535	0.00213	0.91589	0.00126	11778
84	4037	0.91279	0.92249	0.90961	0.91593	0.00141	0.91575	0.00139	0.91526	0.00210	0.91592	0.00124	11968
85	3943	0.91875	0.90229	0.92684	0.91597	0.00139	0.91554	0.00138	0.91543	0.00207	0.91583	0.00122	12080
86	4029	0.91678	0.92796	0.89861	0.91598	0.00137	0.91573	0.00138	0.91518	0.00206	0.91595	0.00121	12110
87	4017	0.90205	0.92869	0.89779	0.91577	0.00137	0.91592	0.00137	0.91492	0.00204	0.91594	0.00120	12304
88	3981	0.93308	0.90922	0.93204	0.91603	0.00137	0.91582	0.00135	0.91517	0.00203	0.91601	0.00118	12419
89	4130	0.89170	0.90474	0.88785	0.91568	0.00139	0.91566	0.00134	0.91478	0.00204	0.91576	0.00119	12019
90	3821	0.92982	0.92059	0.92811	0.91588	0.00139	0.91573	0.00133	0.91497	0.00202	0.91589	0.00118	12038
91	4057	0.91687	0.91975	0.90465	0.91589	0.00137	0.91579	0.00131	0.91482	0.00199	0.91594	0.00117	12165
92	3978	0.91165	0.89565	0.91696	0.91583	0.00135	0.91551	0.00132	0.91485	0.00196	0.91576	0.00117	12030
93	3958	0.91426	0.90643	0.90802	0.91581	0.00133	0.91539	0.00131	0.91476	0.00194	0.91570	0.00115	12129
94	3996	0.91951	0.91513	0.92248	0.91586	0.00132	0.91538	0.00129	0.91486	0.00192	0.91571	0.00114	12302
95	4011	0.91521	0.90889	0.92596	0.91585	0.00130	0.91530	0.00128	0.91501	0.00190	0.91565	0.00112	12461
96	3968	0.92572	0.92820	0.93156	0.91598	0.00129	0.91547	0.00127	0.91523	0.00188	0.91580	0.00112	12456
97	4090	0.91433	0.92126	0.91252	0.91596	0.00127	0.91554	0.00126	0.91519	0.00186	0.91583	0.00110	12624
98	3965	0.93739	0.92674	0.94805	0.91624	0.00128	0.91569	0.00125	0.91561	0.00188	0.91603	0.00110	12406
99	4101	0.91717	0.92318	0.89755	0.91625	0.00127	0.91578	0.00124	0.91538	0.00187	0.91610	0.00109	12465
100	3844	0.90027	0.91298	0.90380	0.91605	0.00127	0.91575	0.00122	0.91524	0.00186	0.91597	0.00109	12502
101	3875	0.90676	0.90698	0.91726	0.91593	0.00126	0.91564	0.00121	0.91526	0.00183	0.91583	0.00108	12528
102	3953	0.94053	0.93332	0.93325	0.91623	0.00128	0.91585	0.00121	0.91548	0.00182	0.91607	0.00110	11938
103	4265	0.93189	0.92916	0.93625	0.91642	0.00128	0.91601	0.00121	0.91573	0.00182	0.91625	0.00110	11799
104	3916	0.91421	0.91369	0.91448	0.91640	0.00126	0.91599	0.00120	0.91572	0.00180	0.91622	0.00108	11941
105	4004	0.93214	0.92450	0.92155	0.91658	0.00126	0.91609	0.00119	0.91579	0.00178	0.91635	0.00108	11841
106	3996	0.92509	0.95736	0.90367	0.91668	0.00125	0.91657	0.00127	0.91565	0.00176	0.91663	0.00111	11063
107	3954	0.92672	0.92512	0.92973	0.91680	0.00124	0.91666	0.00126	0.91581	0.00175	0.91674	0.00111	11100
108	3942	0.91386	0.91915	0.90722	0.91676	0.00123	0.91669	0.00124	0.91571	0.00173	0.91674	0.00109	11224
109	4006	0.91247	0.91528	0.91493	0.91671	0.00121	0.91668	0.00123	0.91570	0.00171	0.91670	0.00108	11353
110	3970	0.90955	0.90387	0.92901	0.91663	0.00120	0.91653	0.00122	0.91585	0.00170	0.91658	0.00107	11402
111	4129	0.92984	0.92140	0.91542	0.91678	0.00120	0.91659	0.00121	0.91585	0.00168	0.91666	0.00107	11396
112	4078	0.93657	0.93532	0.94897	0.91699	0.00120	0.91679	0.00121	0.91621	0.00170	0.91689	0.00108	11101
113	4106	0.90641	0.91553	0.90662	0.91688	0.00120	0.91678	0.00120	0.91610	0.00169	0.91683	0.00107	11188
114	3853	0.91296	0.91417	0.92254	0.91684	0.00118	0.91675	0.00119	0.91617	0.00167	0.91679	0.00105	11323
115	4011	0.89331	0.90029	0.89738	0.91659	0.00120	0.91658	0.00119	0.91597	0.00166	0.91657	0.00106	10993
116	3976	0.91141	0.91118	0.91765	0.91654	0.00119	0.91652	0.00118	0.91599	0.00165	0.91652	0.00105	11089
117	4046	0.92875	0.92889	0.90894	0.91666	0.00118	0.91665	0.00117	0.91592	0.00163	0.91662	0.00105	11032
118	4059	0.92197	0.92830	0.90767	0.91672	0.00117	0.91677	0.00117	0.91583	0.00162	0.91669	0.00104	11063
119	3995	0.92105	0.93428	0.92016	0.91676	0.00116	0.91694	0.00117	0.91588	0.00160	0.91681	0.00104	11057
120	4104	0.89565	0.90477	0.87872	0.91655	0.00117	0.91682	0.00116	0.91551	0.00163	0.91666	0.00105	10830

the largest active cycle keffs by estimator are:

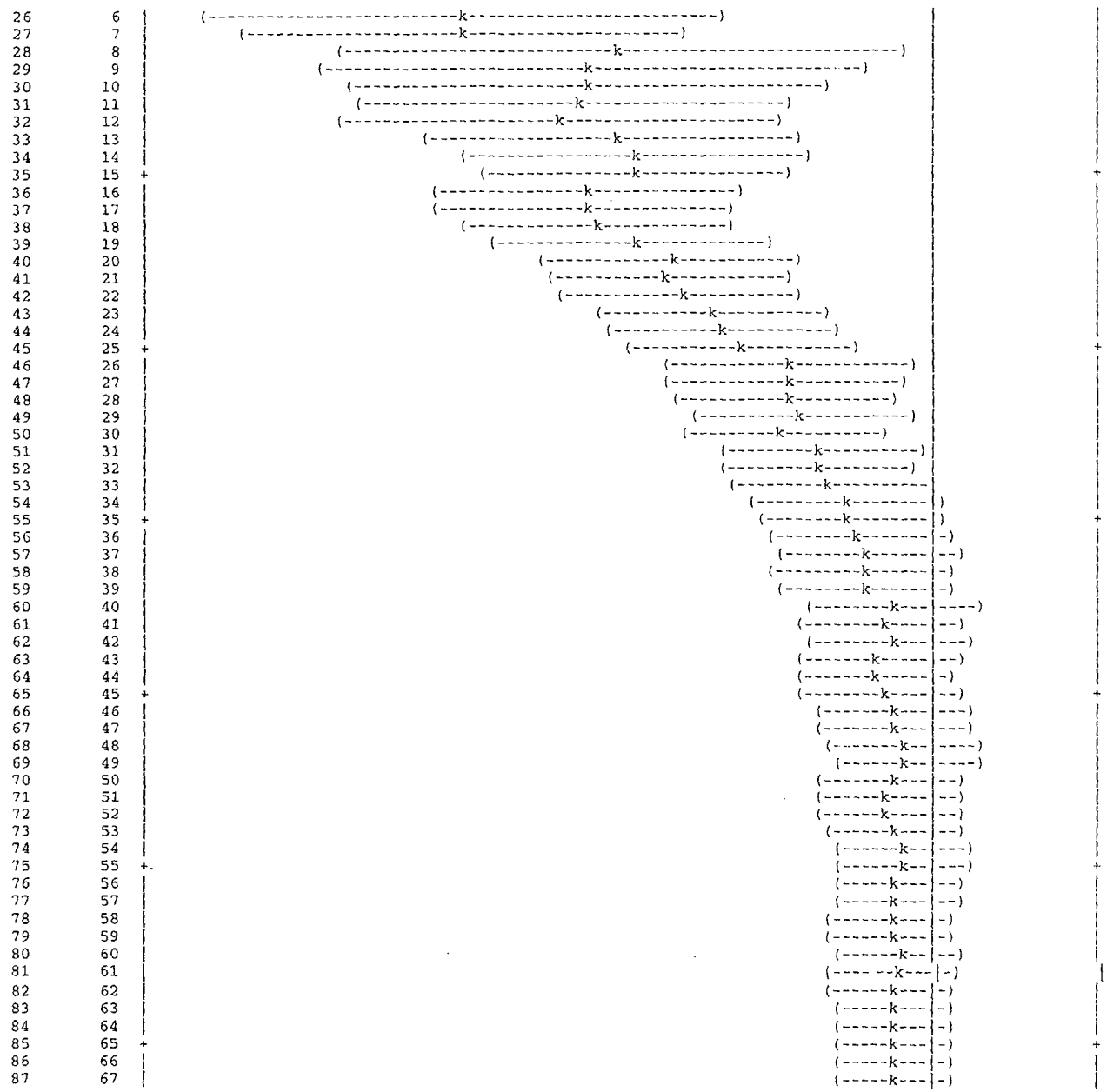
collision 0.94053 on cycle 102
absorption 0.95736 on cycle 106
track length 0.96006 on cycle 66

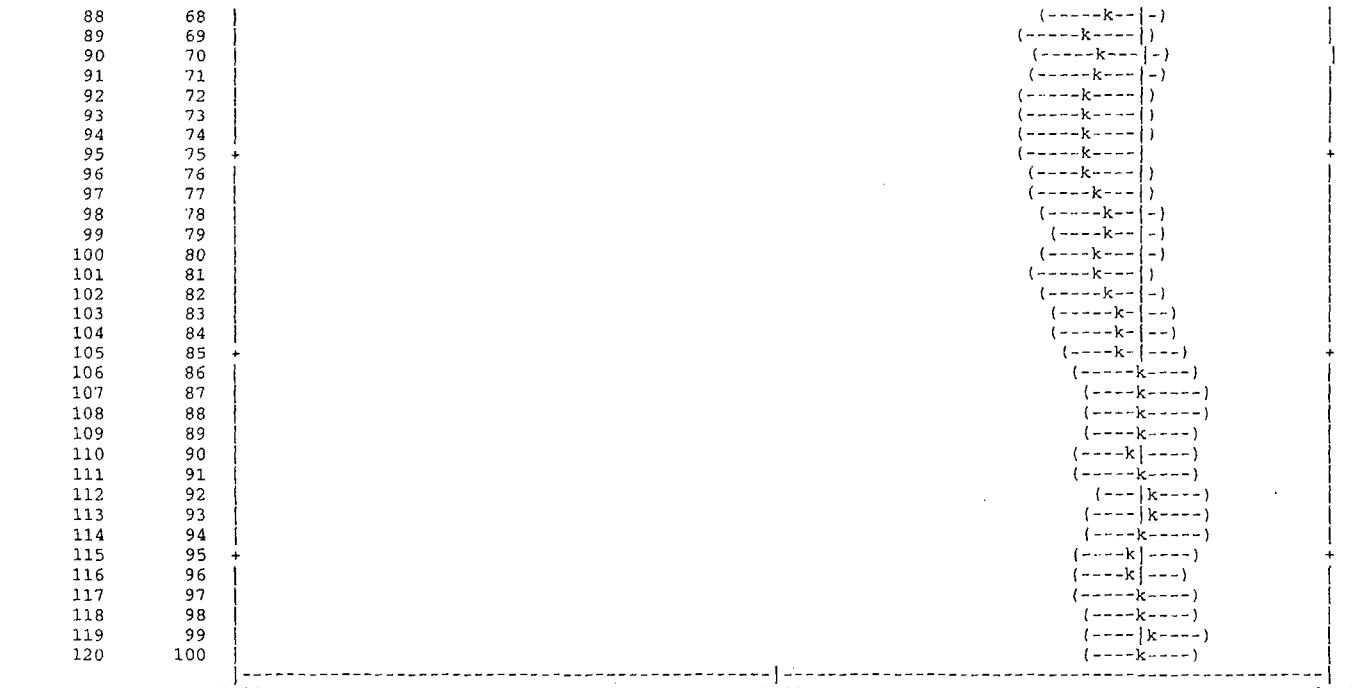
the smallest active cycle keffs by estimator are:

collision 0.88496 on cycle 32
absorption 0.88974 on cycle 22
track length 0.87486 on cycle 32

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 0.91666)

```
   cycle   active 0.90                              0.91                              0.92
  number   cycles  |----------------------------------------|----------------------------------------|
```





1individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	480567	0.9003	0.0041	0.9009	0.0042	0.8996	0.0043	no/no/no	0.90055	0.00416	0.89226-0.90884	0.88955-0.91154
1	119	476566	0.9017	0.0039	0.9023	0.0040	0.9010	0.0040	no/no/no	0.90195	0.00394	0.89409-0.90980	0.89153-0.91236
2	118	473609	0.9032	0.0037	0.9037	0.0037	0.9024	0.0038	no/no/no	0.90342	0.00370	0.89606-0.91079	0.89366-0.91319
3	117	469617	0.9045	0.0034	0.9052	0.0035	0.9038	0.0036	no/no/no	0.90486	0.00345	0.89799-0.91174	0.89574-0.91398
4	116	465571	0.9060	0.0031	0.9066	0.0032	0.9052	0.0033	no/no/no	0.90623	0.00316	0.89993-0.91252	0.89787-0.91458
5	115	461489	0.9073	0.0029	0.9079	0.0029	0.9066	0.0030	no/no/no	0.90755	0.00287	0.90183-0.91327	0.89996-0.91513
6	114	457307	0.9085	0.0026	0.9092	0.0026	0.9080	0.0028	no/no/no	0.90877	0.00260	0.90359-0.91395	0.90190-0.91564
7	113	453287	0.9096	0.0024	0.9104	0.0024	0.9089	0.0026	no/no/no	0.91004	0.00236	0.90533-0.91474	0.90380-0.91627
8	112	449143	0.9106	0.0022	0.9114	0.0022	0.9100	0.0024	no/no/no	0.91097	0.00216	0.90667-0.91528	0.90526-0.91669
9	111	445063	0.9115	0.0020	0.9124	0.0019	0.9108	0.0023	no/no/no	0.91205	0.00195	0.90817-0.91593	0.90691-0.91719
10	110	440997	0.9125	0.0018	0.9134	0.0017	0.9119	0.0020	no/no/no	0.91298	0.00167	0.90965-0.91632	0.90856-0.91741
11	109	436990	0.9133	0.0016	0.9140	0.0016	0.9126	0.0019	no/no/no	0.91369	0.00152	0.91066-0.91672	0.90967-0.91771
12	108	432801	0.9141	0.0014	0.9148	0.0014	0.9133	0.0018	no/no/no	0.91446	0.00133	0.91181-0.91711	0.91095-0.91797
13	107	428768	0.9147	0.0013	0.9154	0.0012	0.9140	0.0017	95/95/95	0.91506	0.00118	0.91271-0.91741	0.91194-0.91818
14	106	424663	0.9152	0.0012	0.9158	0.0012	0.9145	0.0016	95/95/95	0.91545	0.00111	0.91323-0.91767	0.91251-0.91839
15	105	420696	0.9155	0.0012	0.9161	0.0012	0.9149	0.0016	95/95/95	0.91579	0.00106	0.91367-0.91791	0.91298-0.91861
16	104	416688	0.9157	0.0012	0.9164	0.0011	0.9149	0.0016	95/95/95	0.91607	0.00105	0.91398-0.91816	0.91330-0.91884
17	103	412563	0.9160	0.0012	0.9166	0.0011	0.9150	0.0016	95/95/95	0.91629	0.00104	0.91422-0.91836	0.91355-0.91903
18	102	408566	0.9162	0.0012	0.9167	0.0011	0.9151	0.0016	95/95/95	0.91643	0.00104	0.91435-0.91851	0.91368-0.91918
19	101	404574	0.9164	0.0012	0.9168	0.0012	0.9154	0.0016	95/95/95	0.91657	0.00104	0.91450-0.91863	0.91382-0.91931
20	100*	400604	0.9166	0.0012	0.9168	0.0012	0.9155	0.0016	95/95/95	0.91666	0.00105	0.91458-0.91874	0.91390-0.91942

22	98	392410	0.9166	0.0012	0.9170	0.0011	0.9158	0.0016	95/95/95	0.91675	0.00104	0.91468-0.91882	0.91401-0.91949
24	96	384511	0.9170	0.0012	0.9171	0.0012	0.9161	0.0017	95/95/95	0.91698	0.00105	0.91489-0.91907	0.91421-0.91975
26	94	376369	0.9171	0.0012	0.9174	0.0012	0.9162	0.0017	95/95/95	0.91720	0.00106	0.91509-0.91930	0.91440-0.91999
28	92	368317	0.9169	0.0012	0.9174	0.0012	0.9160	0.0017	95/95/95	0.91712	0.00106	0.91500-0.91924	0.91431-0.91993
30	90	360532	0.9171	0.0012	0.9178	0.0012	0.9163	0.0017	95/95/95	0.91742	0.00106	0.91531-0.91953	0.91462-0.92022
32	88	352438	0.9175	0.0012	0.9180	0.0012	0.9170	0.0017	95/95/95	0.91774	0.00105	0.91566-0.91983	0.91498-0.92051
34	86	344314	0.9174	0.0012	0.9181	0.0012	0.9168	0.0017	95/95/95	0.91775	0.00107	0.91562-0.91989	0.91492-0.92059
36	84	336405	0.9178	0.0012	0.9185	0.0012	0.9171	0.0017	95/95/95	0.91811	0.00105	0.91602-0.92020	0.91534-0.92088
38	82	328486	0.9178	0.0012	0.9188	0.0012	0.9173	0.0017	95/95/95	0.91829	0.00106	0.91617-0.92040	0.91548-0.92109
40	80	320455	0.9178	0.0012	0.9187	0.0012	0.9173	0.0018	95/95/95	0.91821	0.00109	0.91605-0.92037	0.91534-0.92108
42	78	312447	0.9181	0.0012	0.9187	0.0013	0.9177	0.0018	95/95/95	0.91838	0.00110	0.91618-0.92058	0.91546-0.92130
44	76	304374	0.9179	0.0013	0.9187	0.0013	0.9177	0.0018	95/95/95	0.91829	0.00113	0.91603-0.92054	0.91530-0.92128
46	74	296253	0.9175	0.0013	0.9185	0.0013	0.9172	0.0018	95/95/95	0.91795	0.00113	0.91570-0.92020	0.91497-0.92094
48	72	288345	0.9173	0.0013	0.9187	0.0013	0.9168	0.0018	95/95/95	0.91796	0.00116	0.91564-0.92027	0.91488-0.92103
50	70	280377	0.9174	0.0013	0.9187	0.0013	0.9167	0.0019	95/95/95	0.91797	0.00119	0.91560-0.92035	0.91483-0.92112
52	68	272375	0.9174	0.0013	0.9184	0.0013	0.9167	0.0019	95/95/95	0.91786	0.00120	0.91546-0.92026	0.91467-0.92105
54	66	264264	0.9172	0.0014	0.9182	0.0014	0.9165	0.0020	95/95/95	0.91764	0.00123	0.91519-0.92010	0.91438-0.92090
56	64	256279	0.9174	0.0014	0.9179	0.0014	0.9167	0.0021	95/95/95	0.91760	0.00126	0.91508-0.92013	0.91424-0.92096
58	62	248120	0.9176	0.0014	0.9178	0.0014	0.9175	0.0020	95/95/95	0.91769	0.00128	0.91514-0.92025	0.91429-0.92110
60	60	240228	0.9174	0.0014	0.9175	0.0015	0.9170	0.0020	95/95/95	0.91739	0.00128	0.91483-0.91995	0.91399-0.92079
62	58	232373	0.9176	0.0014	0.9175	0.0015	0.9171	0.0020	95/95/95	0.91749	0.00130	0.91489-0.92009	0.91403-0.92095
64	56	224201	0.9175	0.0015	0.9180	0.0015	0.9168	0.0020	95/95/95	0.91764	0.00134	0.91496-0.92033	0.91407-0.92122
66	54	216166	0.9170	0.0015	0.9177	0.0015	0.9156	0.0019	95/95/95	0.91700	0.00133	0.91434-0.91967	0.91345-0.92056
68	52	208232	0.9171	0.0015	0.9177	0.0016	0.9159	0.0019	95/95/95	0.91708	0.00137	0.91433-0.91983	0.91342-0.92075
70	50	200082	0.9171	0.0016	0.9181	0.0016	0.9155	0.0019	95/95/95	0.91718	0.00139	0.91438-0.91999	0.91344-0.92093
72	48	192110	0.9174	0.0016	0.9183	0.0016	0.9158	0.0020	95/95/95	0.91740	0.00144	0.91450-0.92030	0.91353-0.92127
74	46	184135	0.9169	0.0017	0.9181	0.0017	0.9154	0.0021	95/95/95	0.91707	0.00148	0.91408-0.92007	0.91307-0.92107
76	44	176187	0.9171	0.0018	0.9182	0.0018	0.9152	0.0021	95/95/95	0.91711	0.00154	0.91399-0.92022	0.91294-0.92127
78	42	168191	0.9175	0.0018	0.9183	0.0018	0.9154	0.0022	95/95/95	0.91727	0.00162	0.91400-0.92054	0.91289-0.92165
80	40	160198	0.9173	0.0019	0.9182	0.0019	0.9154	0.0024	95/95/95	0.91724	0.00168	0.91384-0.92064	0.91268-0.92179
82	38	152228	0.9177	0.0020	0.9185	0.0020	0.9156	0.0025	95/95/95	0.91756	0.00176	0.91398-0.92113	0.91276-0.92235
84	36	144127	0.9177	0.0021	0.9187	0.0021	0.9160	0.0026	95/95/95	0.91774	0.00184	0.91400-0.92147	0.91272-0.92275
86	34	136155	0.9177	0.0022	0.9189	0.0021	0.9161	0.0027	95/95/95	0.91798	0.00194	0.91402-0.92193	0.91266-0.92329
88	32	128157	0.9177	0.0022	0.9189	0.0022	0.9162	0.0027	95/95/95	0.91801	0.00206	0.91378-0.92223	0.91231-0.92370
90	30	120206	0.9181	0.0022	0.9194	0.0023	0.9168	0.0027	95/95/95	0.91835	0.00208	0.91408-0.92261	0.91259-0.92411
92	28	112171	0.9184	0.0023	0.9202	0.0023	0.9172	0.0029	95/95/95	0.91915	0.00218	0.91467-0.92364	0.91308-0.92523
94	26	104217	0.9185	0.0025	0.9209	0.0024	0.9173	0.0031	95/95/95	0.91984	0.00233	0.91502-0.92465	0.91330-0.92637
96	24	96238	0.9183	0.0027	0.9211	0.0026	0.9164	0.0033	95/95/95	0.91970	0.00251	0.91448-0.92492	0.91259-0.92680
98	22	88183	0.9177	0.0028	0.9209	0.0028	0.9151	0.0033	95/95/95	0.91870	0.00270	0.91305-0.92435	0.91098-0.92642
100	20	80238	0.9186	0.0029	0.9211	0.0030	0.9166	0.0034	95/95/95	0.91925	0.00285	0.91323-0.92526	0.91098-0.92751
102	18	72410	0.9180	0.0029	0.9212	0.0032	0.9156	0.0037	95/95/95	0.91875	0.00307	0.91219-0.92530	0.90969-0.92780
104	16	64229	0.9174	0.0031	0.9212	0.0036	0.9144	0.0039	95/95/95	0.91800	0.00340	0.91065-0.92535	0.90776-0.92824
106	14	56229	0.9158	0.0034	0.9184	0.0030	0.9146	0.0044	95/95/95	0.91833	0.00345	0.91074-0.92593	0.90761-0.92906
108	12	48333	0.9150	0.0038	0.9178	0.0034	0.9140	0.0049	95/95/95	0.91755	0.00404	0.90841-0.92669	0.90442-0.93067
110	10	40357	0.9158	0.0046	0.9194	0.0039	0.9124	0.0057	95/95/95	0.92003	0.00520	0.90773-0.93233	0.90183-0.93824
112	8	32150	0.9114	0.0044	0.9172	0.0043	0.9075	0.0050	95/95/95	0.91449	0.00774	0.89459-0.93439	0.88327-0.94571
114	6	24191	0.9120	0.0060	0.9180	0.0058	0.9051	0.0062	95/95/95	0.91297	0.01238	0.87357-0.95237	0.84067-0.98527
116	4	16204	0.9169	0.0073	0.9241	0.0066	0.9039	0.0088	95/95/95	0.98556	0.01568	0.78630-1.18481	0.00000-1.98356
117	3	12158	0.9129	0.0086	0.9224	0.0090	0.9022	0.0123					
118	2	8099	0.9084	0.0127	0.9195	0.0148	0.8994	0.0207					

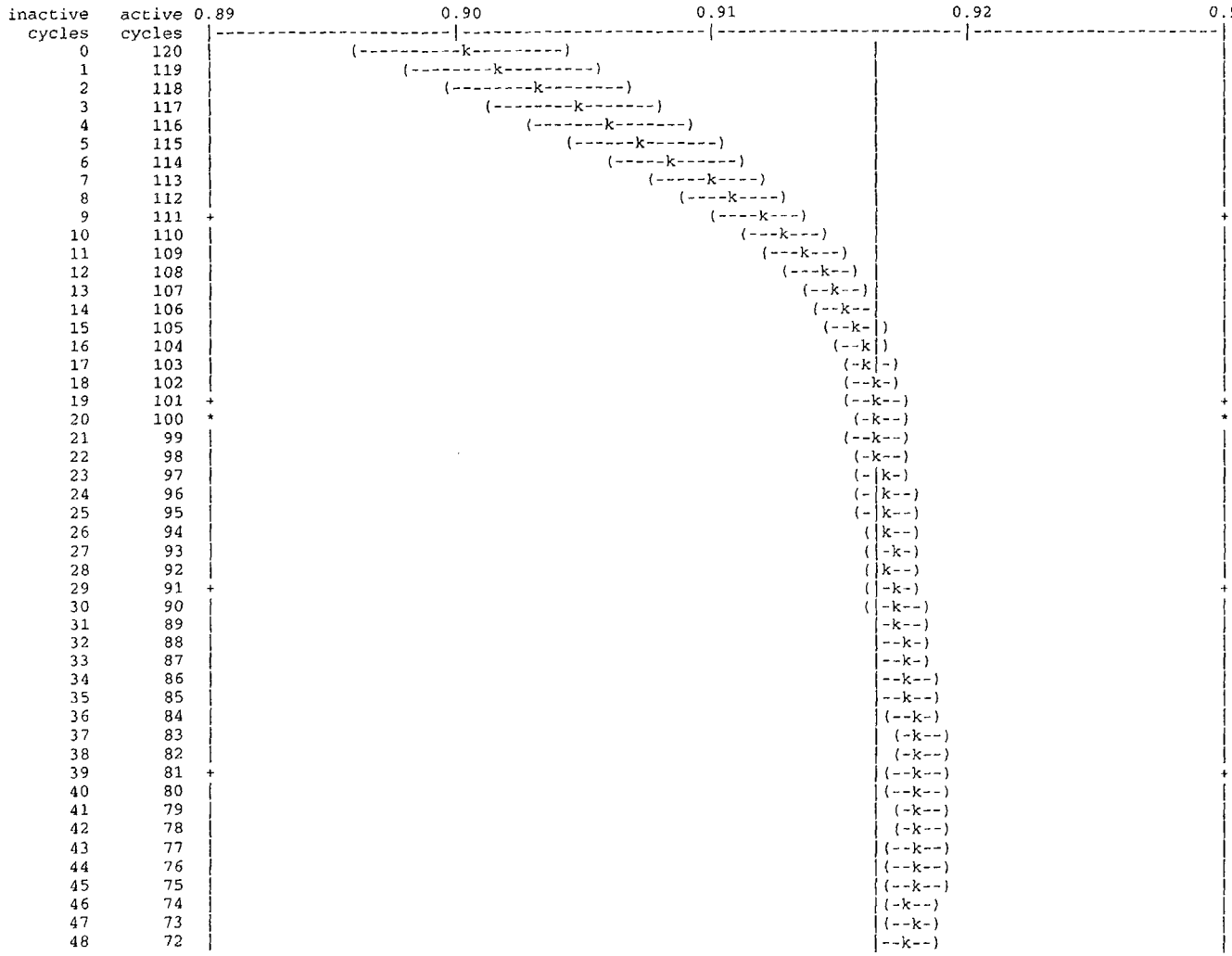
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 22 inactive cycles and 98 active cycles.

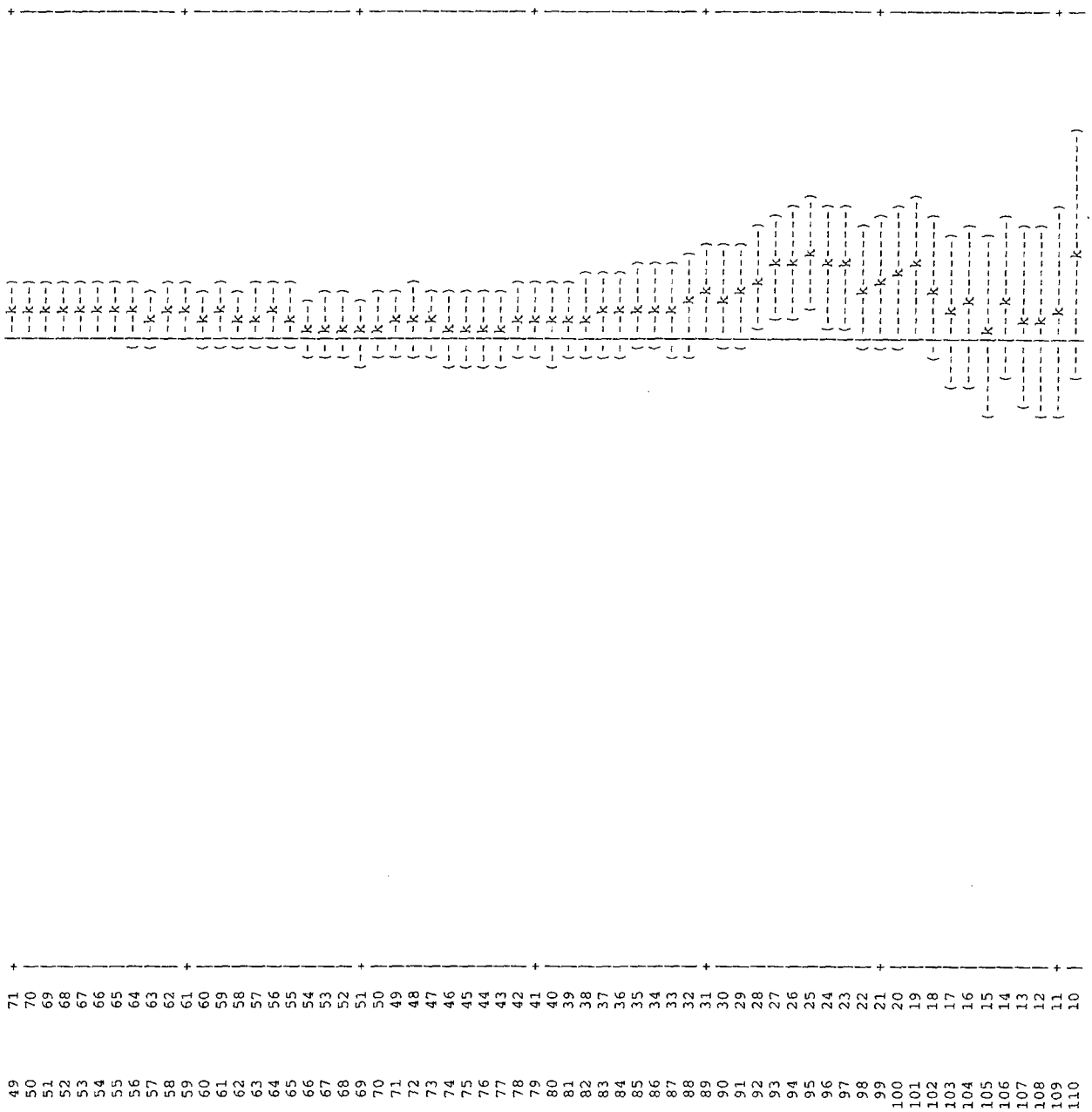
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.

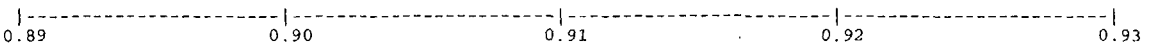
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	0.91589	0.00151	0.91438 to 0.91741	0.91286 to 0.91892	0.91185 to 0.91994
second half	0.91718	0.00139	0.91578 to 0.91858	0.91438 to 0.91999	0.91344 to 0.92093
final result	0.91666	0.00105	0.91561 to 0.91771	0.91458 to 0.91874	0.91390 to 0.91942

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
lplot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 0.91666)







dump no. 8 on file 2fr nps = 480567 coll = 30035334 ctm = 96.33 nrn = 542110173

1 warning message so far.

run terminated when 120 kcode cycles were done.

computer time = 96.36 minutes

mcnp version 4a 10/01/93 03/12/01 13:14:27 probid = 03/12/01 11:38:05

URS

Calculation Cover Page

3065 Southwestern Boulevard
Suite 202
Orchard Park, NY 14127
716 675 7130 Tel
716 675 7137 Fax

Job No: **30822-244-023 /7150** Calculation No: **BUF-2001-021/Rev. 0** Date: **March 21, 2001**

Problem Statement & Calculation Objectives:

To determine the neutron multiplication factor for a hemispherical pile of fuel in the GPC sump area. The pile is flooded with water up to the GPC floor level and it is dry above the floor level.

References and Data Available:

J. F. Briemiester, ed., MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory, Los Alamos NM, 1993
C. D. Harmon, II et al., Criticality Calculations with MCNP: A Primer, Manual LA-12827, Los Alamos National Laboratory, Los Alamos NM, 1993
URS Calculation No BUF-200-062/Rev.1

Attachments:

Attachment 1: GPC drawings
Attachment 2: MCNP model with surface and cell numbers
Attachment 3: Radius and coordinates of the center of the fuel pile
Attachment 4: Concrete composition
Attachment 5: MCNP input file
Attachment 6: MCNP output file

Prepared by:

Signature Igor V. Chichkov — Date 03/28/01

Checked by:

Signature Kevin Roberts — Date 3/29/01

Analysis

Assumptions

The following assumptions were taken for the adopted model:

- The studied fuel is uranium dioxide (UO_2), composed of O-16, U-235, and U-238
- The fuel is unirradiated 5 w/o enriched
- Fuel density is 10.4 g/cm^3
- Fuel rod diameter is 0.757 cm
- There is no gap between the fuel rod and the clad
- Clad outside diameter is 0.8636 cm
- Clad material is stainless steel 304
- Clad density is 7.92 g/cm^3
- Fuel pins are arranged in a hexagonal array
- Water density is 1 g/cm^3
- The space between the fuel pins is filled with water for the part of the pile located below the floor level and filled with air above the floor level
- Air density is 0.001293 g/cm^3
- The total volume of the pile is 60 ft^3 (BUF-200-062/Rev.1)

MCNP Model

Neutron multiplication factors were calculated with MCNP4A code. The dimensions used in the model were based on the GPC drawings in Attachment 1. The sketch of the pile model with MCNP surface and cell numbers is given in Attachment 2. Attachment 3 contains the calculation of height of the fuel pile. Examples of MCNP input and output files can be found in Attachments 5 and 6, respectively.

Air, Clad, Fuel and Concrete Composition

Table 1 shows the element weight fractions for an air (Attix F.H., 1986). Table 2 shows the element weight fractions for stainless steel 304 used in the fuel clad. Table 3 shows the element composition of the high density concrete used in the GPC walls and floors. A. Jake Nello (URS Corporation) provided the necessary

calculations for the high density concrete composition. His calculations are in Attachment 4. The element weight fractions of the fuel were calculated based on the above listed assumptions and given in Table 4. Molar mass of uranium dioxide (UO_2) can be determined from equation (1).

$$M_{UO_2} = A_U + 2\,A_{O\text{-}16} = f\,A_{U\text{-}235} + (1-f)\,A_{U\text{-}238} + 2\,A_{O\text{-}16} \qquad (1)$$

Where:

M_{UO_2} = uranium dioxide molar mass (g/mole)

A_U = uranium molar mass (g/mole)

$A_{U\text{-}235}$ = uranium-235 molar mass (g/mole)

$A_{U\text{-}238}$ = uranium-238 molar mass (g/mole)

$A_{O\text{-}16}$ = oxygen-16 molar mass (g/mole)

f = uranium-235 enrichment

Then the weight fractions for uranium-235 ($w_{U\text{-}235}$), uranium-238 ($w_{U\text{-}238}$), and oxygen-16 ($w_{O\text{-}16}$) are:

$$w_{U\text{-}235} = \frac{f\,A_{U\text{-}235}}{M_{UO_2}} = \frac{f\,A_{U\text{-}235}}{f\,A_{U\text{-}235} + (1-f)\,A_{U\text{-}238} + 2\,A_{O\text{-}16}} \qquad (2)$$

$$w_{U\text{-}238} = \frac{(1-f)\,A_{U\text{-}238}}{M_{UO_2}} = \frac{(1-f)\,A_{U\text{-}238}}{f\,A_{U\text{-}235} + (1-f)\,A_{U\text{-}238} + 2\,A_{O\text{-}16}} \qquad (3)$$

$$w_{O\text{-}16} = \frac{2\,A_{O\text{-}16}}{M_{UO_2}} = \frac{2\,A_{O\text{-}16}}{f\,A_{U\text{-}235} + (1-f)\,A_{U\text{-}238} + 2\,A_{O\text{-}16}} \qquad (4)$$

Table 1. Air composition

Element	Weight Fraction
Carbon (C)	0.000124
Nitrogen (N)	0.755267
Oxygen (O)	0.231781
Argon (Ar)	0.012827

Table 2. Stainless Steel 304 Composition

Element	Weight Fraction
Silicon (Si)	0.01
Chromium (Cr)	0.19
Manganese (Mn)	0.02
Iron (Fe)	0.68
Nickel (Ni)	0.10

Table 3. Concrete composition

Element	Weight Fraction
Aluminum (Al)	0.0024
Iron (Fe)	0.4444
Calcium (Ca)	0.0408
Magnesium (Mg)	0.0021
Sulfur (S)	0.0009
Sodium (Na)	0.0003
Carbon (C)	0.0012
Oxygen (O)	0.3454
Titanium (Ti)	0.1580
Hydrogen (H)	0.0056
Silicon (Si)	0.0087

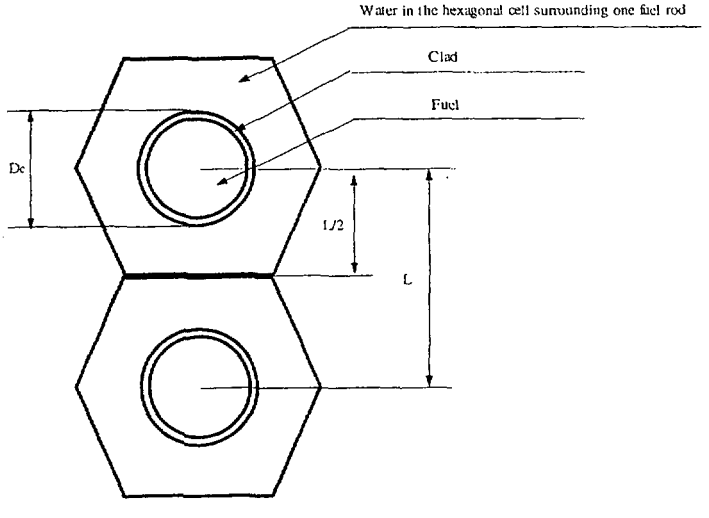
Table 4. Fuel Composition

Element	Weight Fraction
Uranium-235 (^{235}U)	0.0435427
Uranium-238 (^{238}U)	0.8378729
Oxygen (O)	0.1185844

Water to Pin Ratio and Half-distance Between Two Adjacent Rods

To find the optimum moderation configuration, calculations for fuel rod arrangements with different water-to-pin ratios were performed. The parameter, which is entered in the MCNP input deck is the half-distance between two adjacent rods. Figure 1 shows the horizontal cross-section of two adjacent fuel rods with water surrounding each rod. This figure shows also the dimension used for the following equations.

Figure 1. Horizontal cross-section of two adjacent fuel rods with water surrounding each rod.



Water to pin ratio can be determined as:

$$w/p = \frac{S_w}{S_p} = \frac{6(L/2)^2 \tan(30^o) - \pi D_c^2/4}{\pi D_c^2/4} = \frac{24(L/2)^2 \tan(30^o)}{\pi D_c^2} - 1 \qquad (5)$$

Where:

S_w = cross-section area of the water in the hexagonal cell surrounding a pin;

S_p = cross-section area of the pin;

D_c = clad diameter;

$L/2$ = half-distance between two adjacent pins (fuel rods).

Thus, the half-distance between two adjacent pins can be calculated from equation (6) and Table 6 presents the half-distance values corresponding to some water to pin ratios.

$$L/2 = \sqrt{\frac{(w/p+1)\pi D_c^2}{24\tan(30^o)}} \qquad (6)$$

Table 6.Half-distance values (L/2) corresponding to given water to pin ratios (w/p)

w/p	0.102658	0.5	1	2	3	4	5
L/2, cm	0.4318	0.503626	0.58154	0.71223	0.82242	0.91949	1.007251

The water to pin ratio (w/p) equal to 0.102658 in Table 6 corresponds to the maximum densely packed fuel when the half-distance L/2 in the hexagonal fuel array is the same as the outside fuel clad radius R_c or $D_c/2$.

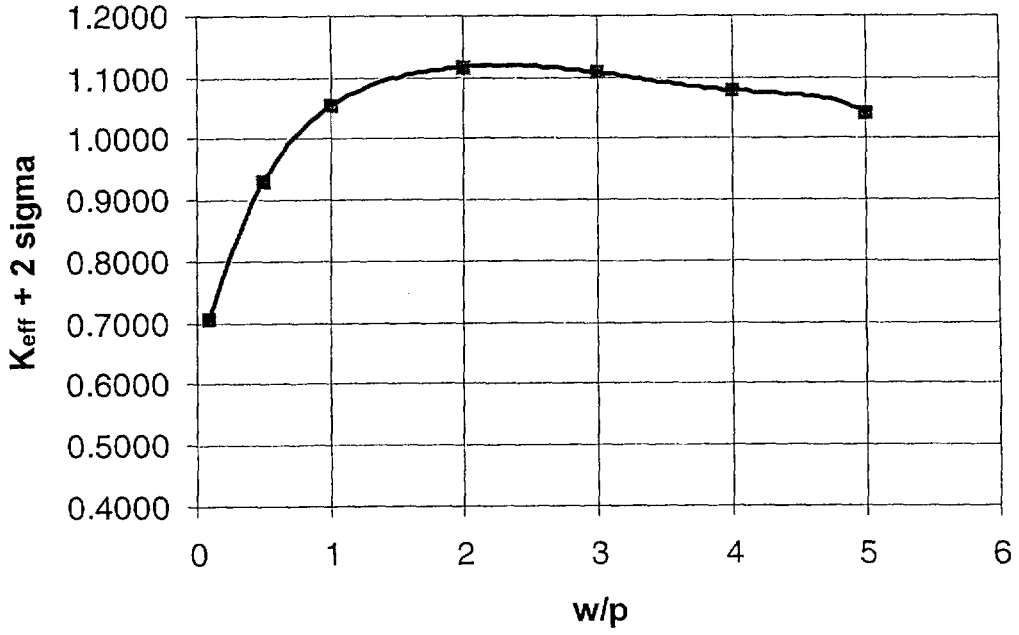
Results

The k_{eff} values were calculated using MCNP 4A code. Tables 7 shows the neutron multiplication factors and Figures 2 plots the calculated $k_{eff} + 2\sigma$ values.

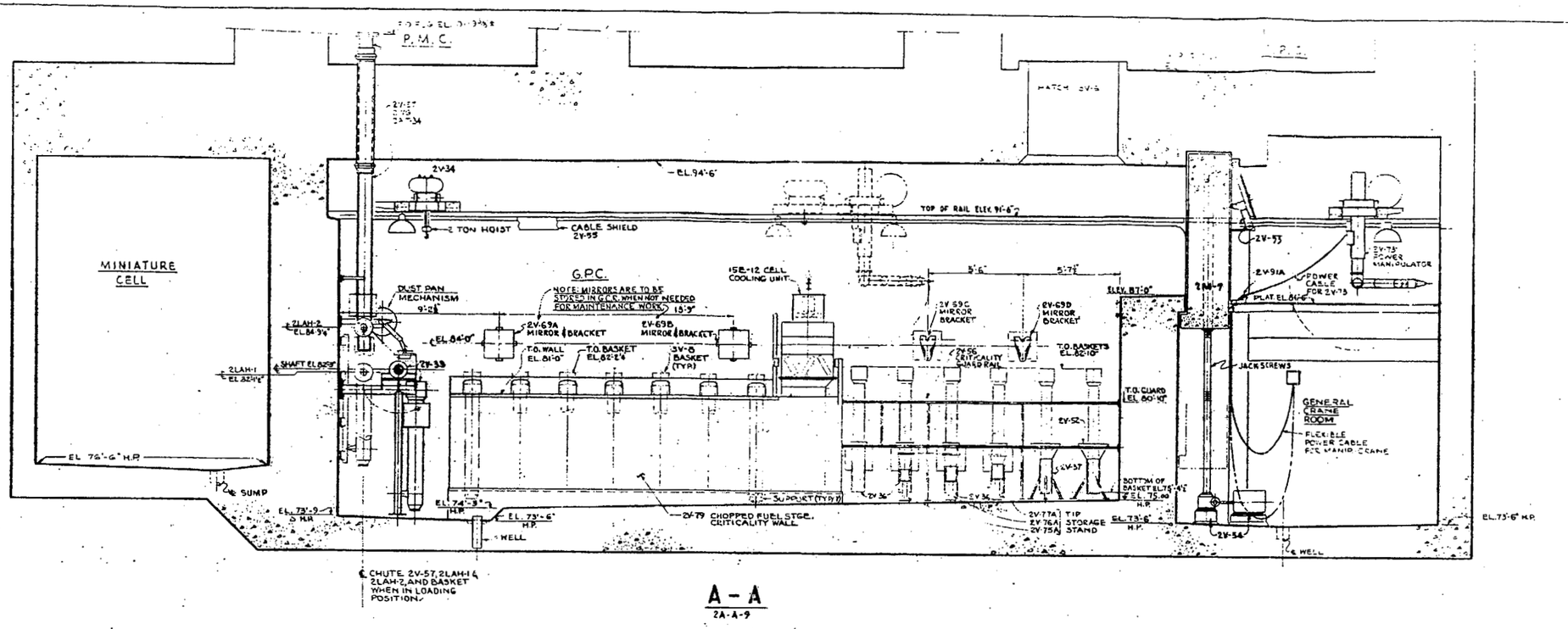
Table 7. MCNP calculated neutron multiplication factors k_{eff} with their standard deviations σ

w/p	k_{eff}	σ	$k_{eff} + 2\sigma$
0.1	0.7029	0.00074	0.7043
0.5	0.9307	0.00097	0.9326
1	1.0535	0.00101	1.0555
2	1.1156	0.0010	1.1176
3	1.1059	0.0011	1.1082
4	1.0771	0.0011	1.0792
5	1.0399	0.00117	1.0423

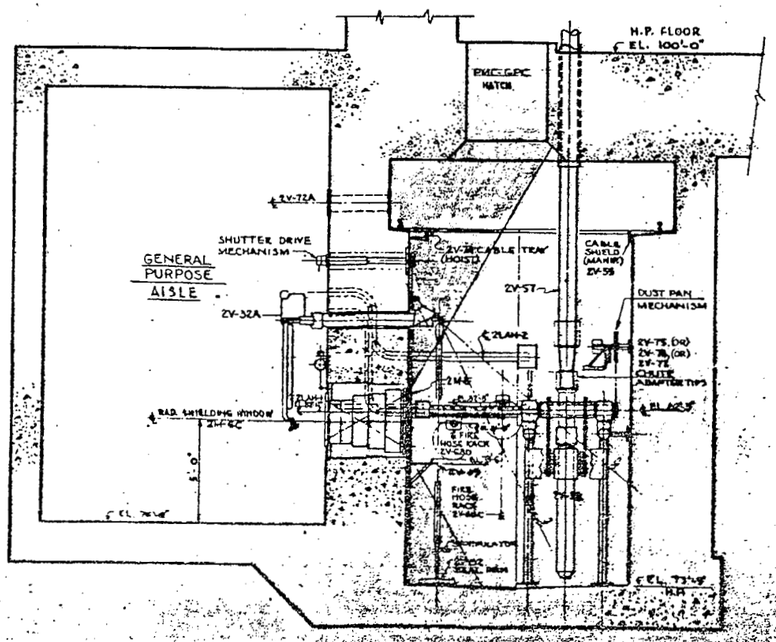
Figure 2. $k_\infty + 2\sigma$ values.



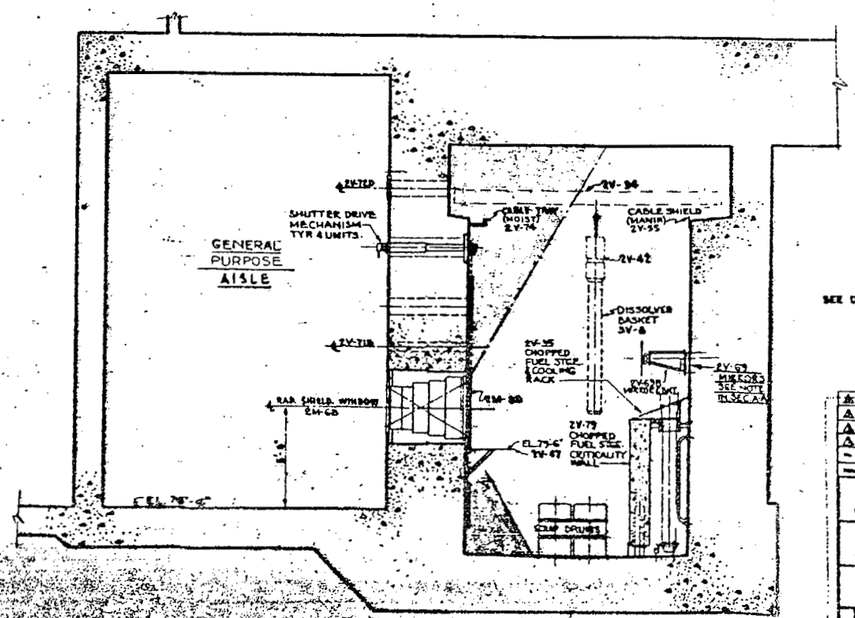
Attachment 1: GPC drawings



A – A
2A-A-9



C – C
2A-A-9



D – D
2A-A-9

SEE DWG. 2A-A-9 FOR COMPLETE DESCRIPTION OF EQUIPMENT.

SCALE 0 1 2 3 4 5 10FT. FIG. V-3-5 b

A	4	ADDED 2V-96 CABLE TRAY TO SHIELD & REVISED SHUTTER DRIVE MECH. TYP. 4 UNITS	2V	6/81	
A	3	GENERAL REVISION	2V	6-1-81	
A	2	GENERAL REVISION	2V	11-6	3-31-81
A	1	ISSUED FOR CONSTRUCTION		8/80	12/5/80
No.		REVISIONS	BY	CHK'D	APP'D

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EQUIPMENT ARRANGEMENT GENERAL PURPOSE CELL SECTIONS SHEET #1

4413 2A-A-10 3

ORIGINAL
NOV 1, 2000
RECORDS CENTER

SCRAP REMOVAL AREA
PMC
TRANSFER CHUTE PMC TO MC
DECON. HEADER
SCRAP DRUM DECONTAMINATION & SPRAY HEADER
SHUTTER OPERATING MECHANISM (TYP. 3 UNITS)
CELL LIGHT FIXTURES
GEN. PURPOSE CELL
WINDOW SHUTTERS
RAD. SHIELD. WINDOWS
GENERAL CRANE ROOM
DOOR
MINIATURE CELL
AIR LOCK
DOOR OPERATING UNIT
SEAL PAN
B-B
2A-A-9
STEEL SHIELDING WALL
SCRAP REMOVAL AREA
CPC
GENERAL PURPOSE AISLE
GPC
MAINTENANCE PORT
PERISCOPE PORT
RAD. SHIELD. WINDOW
SCRAP DRUM
E-E
2A-A-9
CRANE & MANIPULATOR DECONTAMINATION SPRAY HEADERS
GENERAL PURPOSE AISLE
F-F
2A-A-9
SEE DWG. 2A-A-9 FOR COMPLETE DESCRIPTION OF EQUIPMENT.
ISSUED FOR CONSTRUCTION
GENERAL REVISION
BECHTEL CORPORATION
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EQUIPMENT ARRANGEMENT
GENERAL PURPOSE CELL
SECTIONS SHEET #2
4413 2A-A-11

FIG. 43-5C

15A-Q-5

GENERAL NOTES

1. FOR LOCATION OF COORDINATE POINTS SEE OVERALL PLAN DWG. 5A-A-[illegible]
2. FOR LOCATION OF LINER AREAS SEE DWG 5A-M-56.
3. FOR LOCATION OF PIPE PENETRATIONS AND EMBEDDED STEEL SEE DWG 5A-Q-5. VERIFY REQUIREMENTS OF ALL SERVICES FOR ADDITIONAL PENETRATIONS BEFORE POURING CONCRETE.
4. FOR ADDITIONAL GENERAL NOTES SEE DWG 15A-Q-4.
5. NO BACKFILL TO BE PLACED AGAINST WALLS UNTIL ROOF SLAB HAS BEEN IN PLACE FOR 14 DAYS.

(NOTES CONTINUED ON DWG. 15A-Q-5)

PLAN AT EL. 100.00'　　SECTIONAL PLAN BELOW EL. 94.50'　　FLOOR PLAN

SIZE A

LIST OF MATERIAL

ITEM	QUAN.	DESCRIPTION	ORDER NO.
1	867	CU. YDS. CONCRETE (2500 PSI MIX B)	FIELD
2	[illegible]	REINFORCING STEEL NO. / LBS	15-Q-5
3	30	CU. YDS. CONCRETE (BEDDING SLAB)	FIELD
4	1-LOT	WATERPROOFING MEMBRANE (PLASTICIZED POLYVINYL CHLORIDE SHEET) 8 MIL MIN. THICKNESS	FIELD
5	1-LOT	ADHESIVE FOR APPLICATION OF WATERPROOFING MEMBRANE	FIELD
6	.75	CU. YDS. HIGH DENSITY CONCRETE MIX A	FIELD
7	20	[illegible] LG. TYPE 2 ANCHOR BOLT [illegible] NUTS [illegible] THREAD LENGTH (STAINLESS STL.)	15-Q-6
8	1	[illegible] PER DET. 17	FIELD
9	1-LOT	[illegible] GRATING "IRVING" TYPE [illegible] OR EQUAL	FIELD
10	1	FRAME [illegible] PER DET. 16	FIELD
11	8	[illegible] LG. TYPE 2 ANCHOR BOLT W/ 1-HEX. NUT. 7" THREAD LENGTH (C.S.)	15-Q-6
12	4	[illegible] LG. TYPE 2 ANCHOR BOLT W/ 1-HEX. NUT. 9" THREAD LENGTH (C.S.)	15-Q-6
13	2	[illegible] x 2'-0" PER DET. 19	FIELD
14	1	[illegible] x 1'-6" PER DET. 20	FIELD
15	26	1" LOCK NUTS (STAINLESS STL.)	15-Q-6
16	4	1" x 2'-0"(L) LG. TYPE 2 ANCHOR BOLT W/ 1-HEX NUT 7" THREAD LENGTH (C.S.)	15-Q-6
17	350	LIN. FT. [illegible] PLASTICIZED POLYVINYL CHLORIDE [illegible] WATERSTOP, TYPE [illegible] AS MANUFACTURED BY WATER SEALS, INC. OF CHICAGO	FIELD
18	32	1" x 1'-0"(L) LG. TYPE 2 ANCHOR BOLT W/ 2-HEX NUTS (4" THRD LGTH) STAINLESS STL.	15-Q-6
19	34	[illegible] x 1'-2"(L) LG. TYPE 2 ANCHOR BOLT W/ 2-HEX NUTS (4" THRD LGTH) STAINLESS STL.	15-Q-6
20	96	5/8" x 1'-5"(L) LG. TYPE 2 ANCHOR BOLT W/ 1-HEX NUT (2½" THRD LGTH) STAINLESS STL.	15-Q-6
21	1	DOOR FRAME (CARBON STL) PER DET. 24 DWG. 15A-Q-10	15-M-14
22	1	DOOR FRAME (CARBON STL) PER DET. 25 DWG. 15A-Q-10	15-M-14
23	1	[illegible] (C.S.) HATCH FRAME PER DET. 46 DWG. 15A-Q-52	15M-19
24	55	LIN. FT. OF [illegible] (CARBON STL) PER DET. 2 DWG. 15A-M-78	FIELD
25	40	LIN. FT. OF STAINLESS [illegible] PER DET. 3 DWG. 15A-M-78	FIELD
26	1-LOT	PIPING PENETRATIONS PER DET. [illegible] DWG. 15A-Q-9	FIELD
27	1-LOT	½" INSULATING FIBERBOARD	FIELD
28	2	EMBEDMENT [illegible] PER DET. 39 DWG. 15A-Q-10	15-M-14
29	4	1" x 2'-3"(L) LG. TYPE 2 ANCHOR BOLT W/2 HEX NUTS 5½" THRD LGTH, STAINLESS STL.	FIELD
30	8	PIPE SLEEVE PER DET. 28 & 29 DWG. 15A-Q-10	15-M-14
31	1	PIPE SLEEVE PER DET. 30 DWG. 15A-Q-10	15-M-14
32	1	MNTG. [illegible] PER DET. 3[illegible] DWG. 15A-Q-10	15-M-14
33	1	MNTG. [illegible] PER DET. 32 DWG. 15A-Q-10	15-M-14
34	1	MNTG. BOX PER DET. 33 DWG. 15A-Q-10	15-M-14
35	4	MNTG. [illegible] PER DET. 34 & 35 DWG. 15A-Q-10	15-M-14
36	1	MNTG. [illegible] PER DET. 36 DWG. 15A-Q-10	15-M-14
37	1	MNTG. [illegible] PER DET. 37 DWG. 15A-Q-10	15-M-14
38	1	[illegible] PER DET. 38 DWG. 15A-Q-10	15-M-14
39	44	[illegible] BASE [illegible] PER DET. 27 DWG. 15A-Q-10	15-M-14
40	44	½" LEVELING [illegible] PER DET. 27 DWG. 15A-Q-10	15-M-14
41	124	LIN. FT. 60# ASCE. CRANE RAIL	15-M-14
43	1	SET (2) HINGED RAIL ASSEMBLIES PER DWG. [illegible]-T-31	15-V-39
44	1	DOOR FRAME (CARBON STL) PER DET. 40 DWG. 15A-Q-10	15-M-14
45	9	[illegible] LG. TYPE 2 ANCHOR BOLT WITH 1 [illegible] HEX NUT [illegible] STAINLESS STEEL	15-Q-6
46	3	PIPE SLEEVE PER DET. 41	15-M-14
47	3	WALL PLATE PER DET. 42	15-M-14
48	[illegible]	½" STAINLESS STEEL INSERT PER DET. 43	15-M-14
49	1	HATCH COVER (GALV.) PER DET. 44 DWG. 15A-Q-52	15M-19
50	16	1" x 1'-6"(L) LG. TYPE 1 ANCH. BOLT, THREAD LENGTH 5½", (THREAD [illegible]) [illegible]	15-Q-6

NOTE:
FOR LIST OF REFERENCE DRAWINGS SEE DWG. 15A-Q-8.

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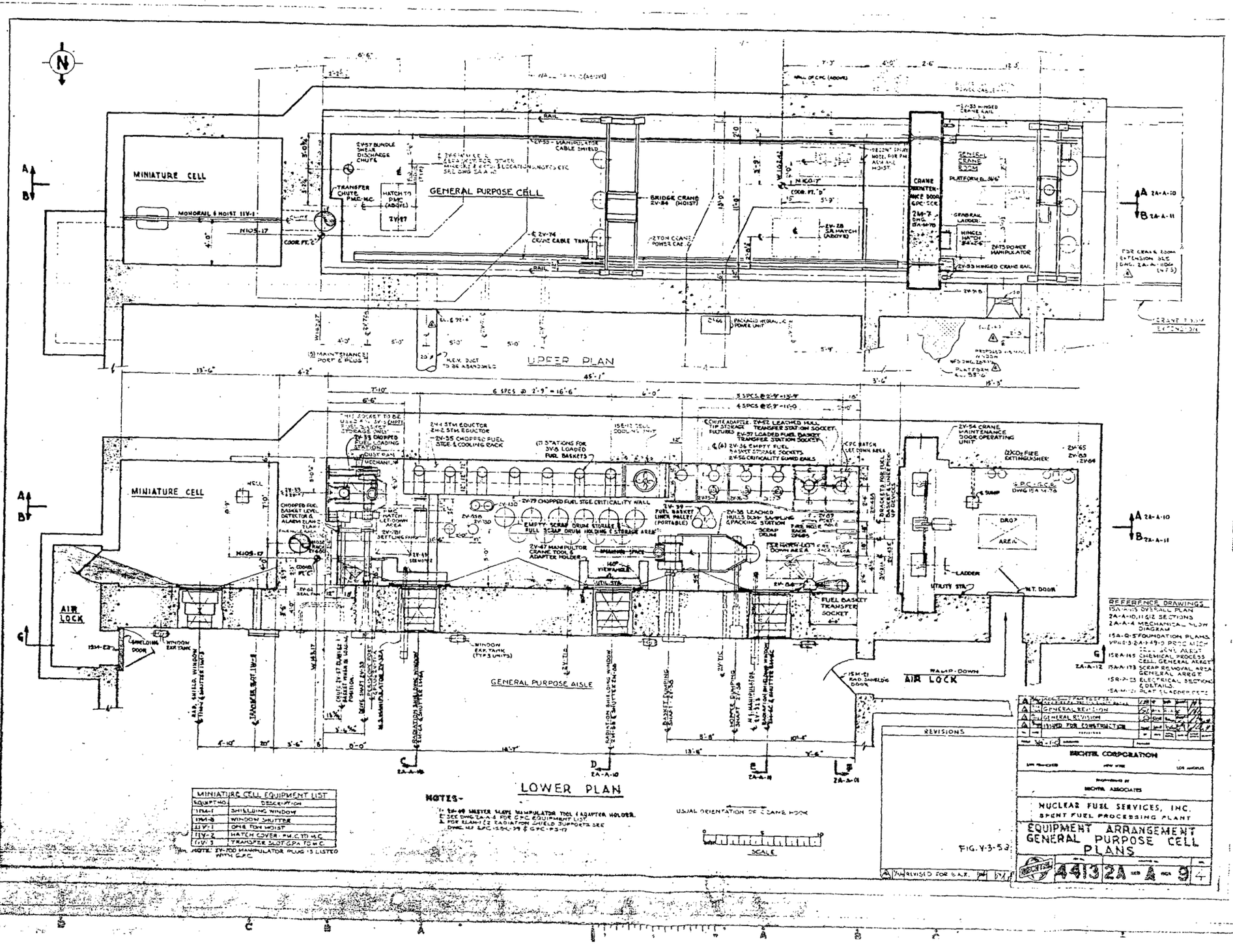
FOUNDATION PLANS
GENERAL PURPOSE CELL & MINIATURE CELL

4413　15A-Q-5　11


2A-A-9
MINIATURE CELL
GENERAL PURPOSE CELL
UPPER PLAN
LOWER PLAN
AIR LOCK
GENERAL PURPOSE AISLE
REFERENCE DRAWINGS
MINIATURE CELL EQUIPMENT LIST
NOTES-
USUAL ORIENTATION OF CRANE HOOK
SCALE
REVISIONS
BECHTEL CORPORATION
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SPENT FUEL PROCESSING PLANT
EQUIPMENT ARRANGEMENT
GENERAL PURPOSE CELL
PLANS
4413 2A-A-9

Attachment 2: MCNP model with surface and cell numbers

45-3

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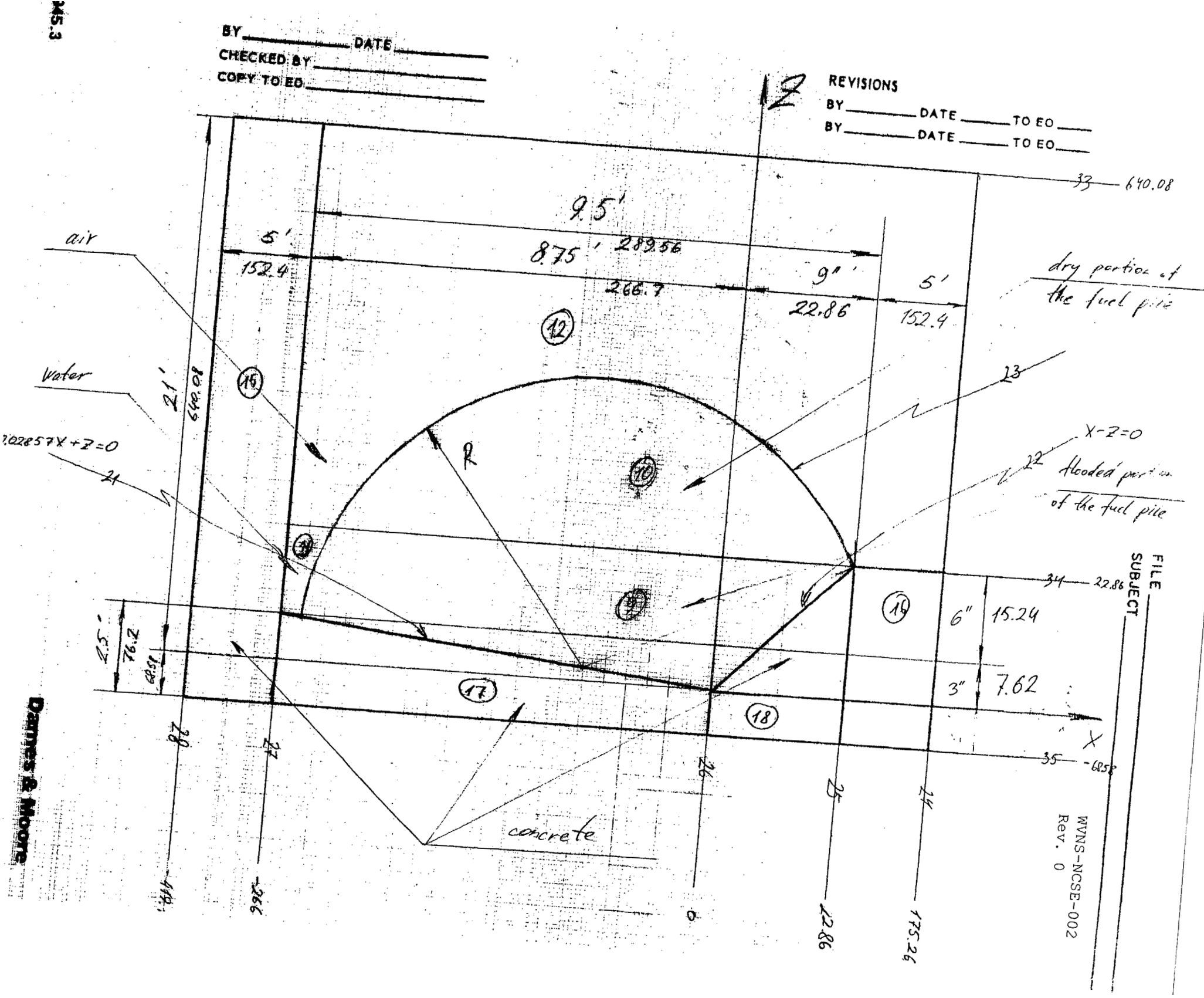
REVISIONS
BY _____ DATE _____ TO EO _____
BY _____ DATE _____ TO EO _____



Daniel & Moore

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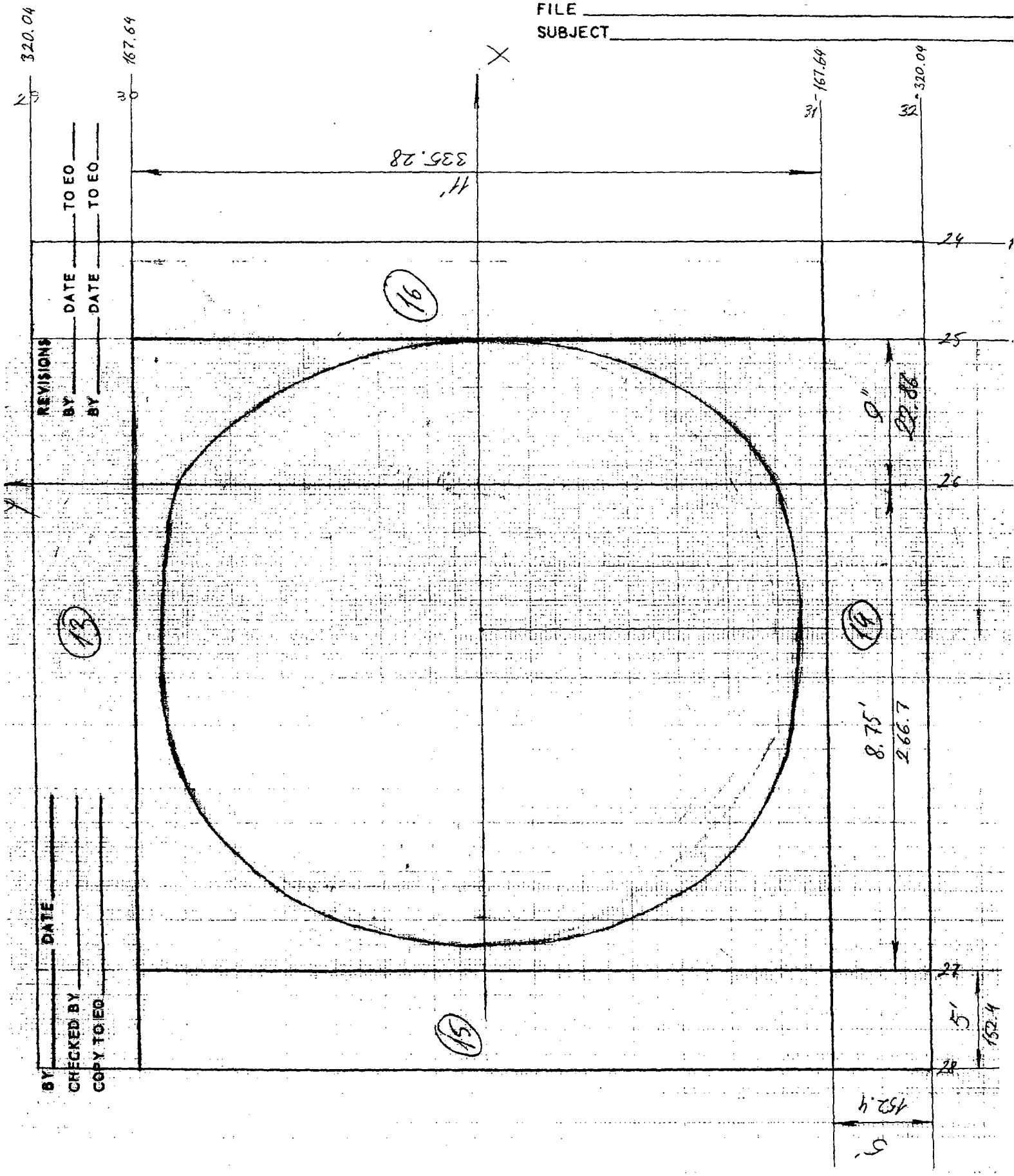
Rev. 0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320.04
167.64
335.28
167.64
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BY DATE TO EO
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16
15
13
14
24
25
26
27
28
8.75'
266.7
9"
228.6
5'
152.4
452.4
5'

Attachment 3: Radius and coordinates of the center of the fuel pile

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Center of the sphere coordinates:

$X_o = -a\cos\varphi$

$Y_o = 0$

$Z_o = a\sin\varphi$

$tg\,\varphi = \frac{7.62}{266.7} = 0.02857 \Rightarrow \varphi = 0.02856$ Radians

$$\frac{R}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{a}{\sin\gamma}$$

$\alpha = \pi - \frac{\pi}{4} - \varphi = \frac{3\pi}{4} - \varphi = 2.3276$ Radians

$\sin\alpha = \sin(2.3276) = 0.727004$

$b = 9''\sqrt{2} = (12.73)' = 32.33$ cm

$$\sin\beta = \frac{b\sin\alpha}{R} = \frac{23.50}{R}$$

$$\beta = \arcsin\left(\frac{23.50}{R}\right)$$

$\gamma = \pi - \alpha - \beta$

$\gamma = 0.813948 - \arcsin\left(\frac{23.50}{R}\right)$

$$a = \frac{R\sin\gamma}{\sin\alpha}$$

$$a = \frac{R\sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004}$$

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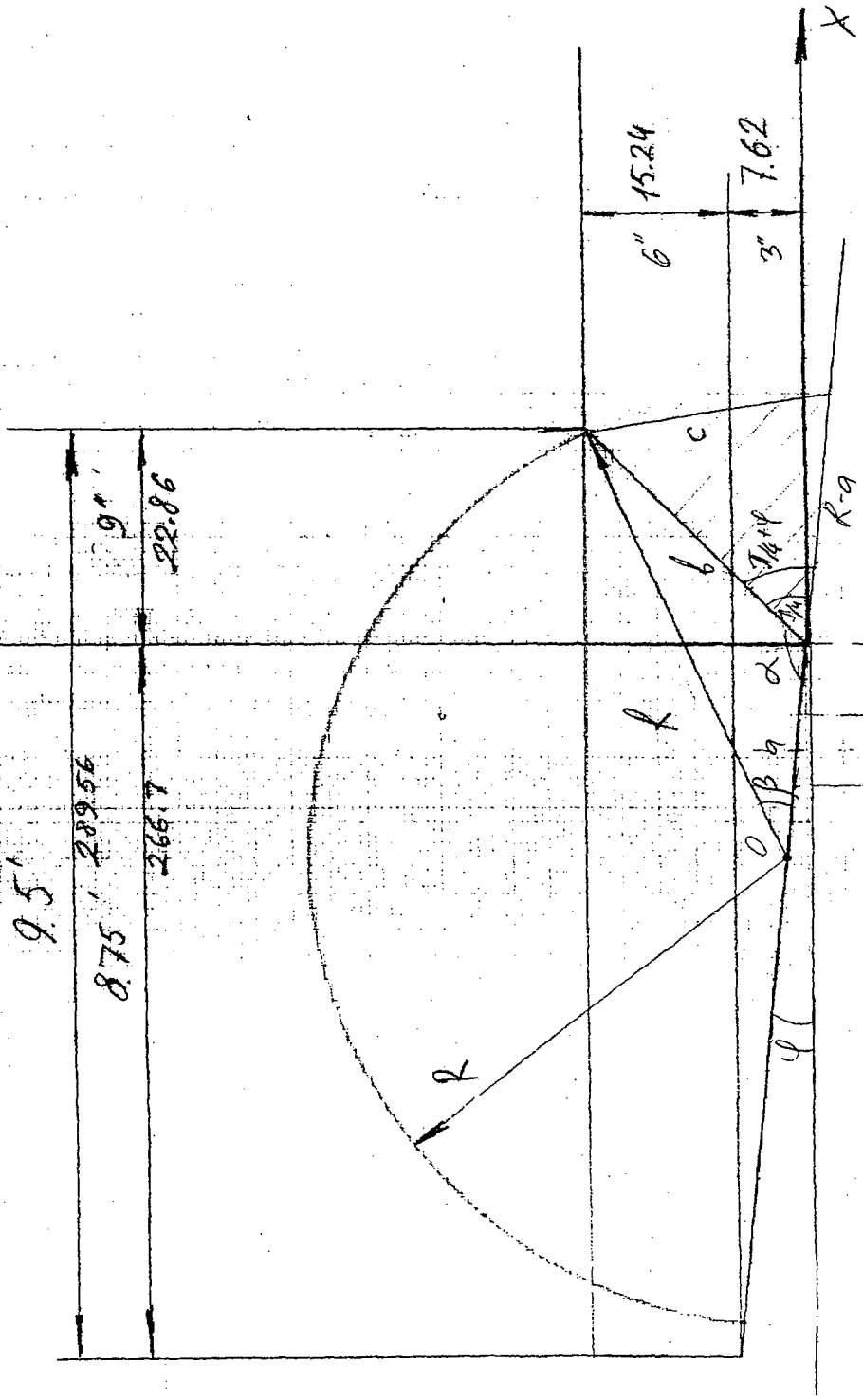

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CHECKED BY _____
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Volume of the spherical region

$$V = \frac{4}{3}\pi R^3\left(\frac{1}{2} - \frac{S_{slice}}{\pi R^2}\right)$$

where $\frac{S_{slice}}{\pi R^2}$ = slice fraction

Area of the shaded slice:

$$S_{slice} = S_{triangle} + S_{segment}$$

$$S_{triangle} = \frac{1}{2}(R-a)\,b\sin\left(\frac{\pi}{4}+\varphi\right)$$

$$S_{segment} = \frac{1}{2}(\beta - \sin\beta)R^2 = \frac{1}{2}\left[\arcsin\left(\frac{23.50}{R}\right) - \frac{23.50}{R}\right]R^2$$

$$b\sin\left(\frac{\pi}{4}+\varphi\right) = 32.33\times\sin\left(\frac{\pi}{4}+0.02856\right) = 23.50$$

$$a = \frac{R\sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004}$$

$$S_{triangle} = \frac{1}{2}\times 23.50\times\left(R - \frac{R\sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004}\right)$$

$$S_{slice} = \frac{1}{2}\left\{\left[\arcsin\left(\frac{23.50}{R}\right) - \frac{23.50}{R}\right]R^2 + 23.50\times\left(R - \frac{R\sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004}\right)\right\}$$

$$V = \frac{2}{3}\pi R^3\left\{1 - \frac{\left[\arcsin\left(\frac{23.50}{R}\right) - \frac{23.50}{R}\right]R^2 + 23.50\left(R - \frac{R\sin\left[0.813948 - \arcsin\frac{23.}{R}\right.}{0.727004}\right.}{\pi R^2}\right.$$

$$V = 60\ ft^3 = 1699010.80\ cm^3$$

To find R the following equation was solved

$$169910.80 = \frac{2}{3}\pi R^3\left\{1 - \frac{\left[\arcsin\left(\frac{23.50}{R}\right) - \frac{23.50}{R}\right]R^2 + 23.50\left(R - \frac{R\sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004}\right)}{\pi R^2}\right\}$$

$$R = 93.964 \text{ cm}$$

Then

$$a = \frac{93.964 \times \sin\left[0.813948 - \arcsin\left(\frac{23.50}{R}\right)\right]}{0.727004} = 68.78267$$

$$X_o = -a\cos\varphi = -68.78267 \times \cos(0.02856) = -68.75461$$

$$Y_o = 0$$

$$Z_o = a\sin\varphi = 68.78265 \times \sin(0.02856) = 1.964417$$

Attachment 4: Concrete composition

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

WVNS-NCSE-002
Rev. 0

Sheet No. 1 / 8
Calc. No. BUF-2007-05
Rev. No. 0.00
By AJN Date 4/26/
Chk'd. JW Date 4/27/00

Job No. 30322-244-7150 Job CRITICALITY SAFETY
Client WVNS Subject HIGH DENSITY CONCRETE COMPOSITION

PROBLEM: DETERMINE THE WEIGHT FRACTION OF EACH ELEMENT IN A THEORETICAL BATCH OF CONCRETE HAVING A UNIT WEIGHT (DRY) OF 236 lbs/ft³.

ASSUMPTIONS: (1) CEMENT WILL BE PORTLAND TYPE I (ASTM C150) (SG=3.15)
(2) NO AIR ENTRAINMENT
(3) FINE AGGREGATE WILL BE SPECULAR HEMATITE (FM=2.30)
(4) COARSE AGGREGATE WILL BE ILMENITE. (CRUSHED @ 1")
(5) SLUMP AT PLACEMENT WAS APPROXIMATELY 2-3"
(6) ASSUME 4500 PSI, @ 215-240 lbs/ft³

SOLUTION: FIRST DETERMINE THE CONCRETE MIX MATERIAL COMPOSITION FROM ACI 211.1-91,

WATER CONTENT IS APPROXIMATED AT 300 lbs/CY, WITH AN ENTRAPPED AIR QUANTITY OF 1.5%, DUE TO AN ASSUMED ROUNDED RATHER THAN ANGULAR STONE UTILIZATION.

WATER-CEMENT RATIO WILL BE @ 0.52.

THUS, THE REQUIRED CEMENT CONTENT IS,
300 lb/CY ÷ 0.52 = 577 lb/CY

THE QUANTITY OF COARSE AGGREGATE IS, (USE TABLE 6.3.6)
0.72 × 27 ft³ = 19.44 ft³ OF COARSE AGGREGATE PER CY. (DRY RODDED). SINCE COARSE AGG. WEIGHT IS 165 lb/CF, THE DRY WEIGHT OF COARSE AGG. WILL BE 19.44 ft³ × 165 WHICH YIELDS 3208 lbs.

THE REQUIRED FINE AGGREGATE IS DETERMINED ON AN ABSOLUTE VOLUME BASIS. THEREFORE,

VOLUME OF WATER = $\frac{300\ lb}{62.4\ lb/ft^3} = 4.8\ ft^3$

VOLUME OF AIR = $0.015 \times 27\ ft^3 = 0.41\ ft^3$

SOLID VOLUME OF CEMENT = $\frac{577\ lb}{3.15 \times 62.4\ lb/ft^3} = 2.94\ ft^3$

SOLID VOLUME OF COARSE AGGREGATE = $\frac{3209\ lb}{4.61 \times 62.4\ lb/ft^3} = 11.15\ lb$

TOTAL VOLUME OF ALL INGREDIENTS LESS FINE AGGREGATE = $19.29\ ft^3$

SOLID VOLUME OF FINE AGGREGATE = $27\ ft^3 - 19.29\ ft^3 = 7.71\ ft^3$

REQUIRED WEIGHT OF FINE AGGREGATE = $7.71\ ft^3\ (4.95)\ 62.4\ lb/ft^3 \cong 2381.5$
$= 2382\ lbs$

THEREFORE, IN SUMMARY

	MATERIAL	MASS/CY
(TYPE I)	PORTLAND CEMENT	577 lb
	SPECULAR HEMATITE	2382 lb
	ILMENITE	3209 lb
	WATER	300 lb
		(239.5 lb/ft³) WET (DENSITY)
		@ 236 DRY

ELEMENTAL COMPOSITION - BASED UPON WEIGHT %

CEMENT - PORTLAND TYPE I -

577 lb / 6467 lb = 0.09 x 100 = 9 % by weight

SPECULAR HEMATITE -

2382 lb / 6467 lb = 0.36 x 100 = 37 % by weight

ILMENITE -

3209 lb / 6467 lb = 0.50 x 100 = 50 % by weight

WATER -

300 lb / 6467 lb = 0.05 x 100 = 5 % by weight

CHEMICAL COMPOSITIONS -

	COMPOUND	%	ELEMENT	%
PORTLAND CEMENT -	SiO_2	20.72	Si	
	Al_2O_3	5.12	Al	
	Fe_2O_3	2.27	Fe	
	CaO	63.54	Ca	
	MgO	3.84	Mg	
	SO_3	2.70	S	
	Na_2O	0.41	Na	
	LOI (%C)	1.30	C	1.3
			O	

SiO_2 -

Si : (1) (28.0855 g/mole) = 28.0855 g/mole
O : (2) (15.9994 g/mole) = 31.9988 g/mole

MOLECULAR WEIGHT = 28.0855 + 31.9988 = 60.0843 g/mole

MASS FRACTION Si = 28.0855 / 60.0843 = 46.74 %
MASS FRACTION O = 31.9988 / 60.0843 = 53.26 %

Al_2O_3 -

Al : (2) (26.98154 g/mole) = 53.96308 g/mole
O : (3) (15.9994 g/mole) = 47.9982 g/mole

MOLECULAR WEIGHT = 101.96128 g/mole

MASS FRACTION Al = 52.93 %
MASS FRACTION O = 47.07 %

Fe_2O_3 -

Fe : (2)(55.847) = 111.694 g/mole
O : (3) (15.9994) = 47.9982 g/mole

MOLECULAR WEIGHT = 159.6922 g/mole

MASS FRACTION Fe = 69.94 %
" " O = 30.05 %

CaO -

Ca : (1) (40.08) = 40.08 g/mole
O : (1) (15.9994) = 15.9994 g/mole

MOLEC. WEIGHT = 56.0794 g/mole
MASS FRACTION Ca = 71.47 %
MASS FRACTION O = 28.52 %

MgO

Mg : (1)(24.305) = 24.305 g/mole
O : (1)(15.9994) = 15.9994 g/mole
MOLEC. WEIGHT = 40.3044 g/mole
MASS FRACTION Mg = 60.30 %
" " O = 39.69 %

SO_3

S : (1)(32.06) = 32.06
O : (3)(15.9994) = 47.9982
MOLEC. WEIGHT = 80.0582 g/mole
MASS FRACTION S = 40.04 %
" " O = 59.95 %

Na_2O -

Na : (2)(22.98977) = 45.93954
O : (1)(15.9994) = 15.9994
MOLEC. WEIGHT Na = 61.93894
MASS FRACTION O = 74.16 %
" " = 25.83 %

Carbon 1.30 % (GIVEN)

PERCENTAGE OF ELEMENT IN CEMENT.

20.72% SiO_2 — Si - 46.74/100 (20.72) = 9.69%
O - 53.26/100 (20.72) = 11.03 %

5.12% Al_2O_3 — Al - 52.93/100 (5.12) = 2.71 %
O - 47.07/100 · (5.12) = 2.40 %

2.27% Fe_2O_3 — Fe - 69.94 (1/100) (2.27) = 1.58
O - 3005 (1/100) (2.27) = 0.68 %

63.54% CaO	Ca	$71.47\left(\frac{1}{100}\right)(63.54)$ =	45.41 %
	O	$28.52\left(\frac{1}{100}\right)(63.54)$ =	18.12 %
3.84 % MgO	Mg	$60.30\left(\frac{1}{100}\right)$ 3.84 =	2.31 %
	O	$39.69\left(\frac{1}{100}\right)$ 3.84 =	1.52 %
2.70 % SO_3	S	$40.04\left(\frac{1}{100}\right)$ 2.70 =	1.08 %
	O	$59.95\left(\frac{1}{100}\right)$ 2.70 =	1.61 %
0.41 % Na_2O	Na	$74.16\left(\frac{1}{100}\right)$ 0.41 =	0.30 %
	O	$25.83\left(\frac{1}{100}\right)$ 0.41 =	0.105 %
C	C		1.30 %

SUMMARY OF ELEMENT IN CEMENT

Si	9.68%
Al	2.71 %
Fe	1.5%
Ca	45.41 %
Mg	2.31 %
S	1.08%
Na	0.3 %
C	1.3 %
O	35.5 %

PERCENTAGE OF ELEMENT IN SPECULAR HEMATITE

Fe_2O_3	Fe	70 %
	O	30%

PERCENTAGE OF ELEMENT IN ILMENITE

$FeTiO_3$ Fe - 36.8 % Ti - 31.6% O - 31.6%

PERCENTAGE OF ELEMENT IN H_2O

H_2O

H : (2)(1.0079) = 2.0158 g/mole
O : (1)(15.9994) = 15.9994 g/mole
MOLEC. WGT = 18.0152 g/mole
MASS FRACTION H = 11.19 %
" " O = 88.81 %

ELEMENTAL WEIGHT PERCENTAGES FOR 236 lb/ft³ CONCRETE

CEMENT (9% BY WEIGHT) PORTLAND TYPE I

Si -	9.68	$\frac{1}{100}$	9	= 0.87
Al -	2.71	$\frac{1}{100}$	9	= 0.24
Fe -	1.5			= 0.14
Ca -	45.41			= 4.09
Mg -	2.31			= 0.21
S -	1.00			= 0.09
Na -	0.3			= 0.03
C -	1.3			= 0.12
O -	35.5			= 3.20

FINE AGG. (37% BY WEIGHT) SPECULAR HEMATITE Fe_2O_3

Fe -	70	$\frac{1}{100}$	37	= 25.9
O -	30	$\frac{1}{100}$	37	= 11.1

COARSE AGG (50% BY WEIGHT) ILMENITE

Fe -	36.8	$\frac{1}{100}$	50	= 18.4
Ti -	31.6	$\frac{1}{100}$	50	= 15.8
O -	31.6	$\frac{1}{100}$	50	= 15.8

H_2O (5%)

H -	11.19	$\frac{1}{100}$	5	= 0.56
O -	88.81	$\frac{1}{100}$	5	= 4.44

HIGH DENSITY CONCRETE

DENSITY = 236 lb/ft³ (3.78 g/cc)

NUCLIDE	WT %	WT. FRAC.	ATOM. DENSITY
Al	0.24	0.0024	
Fe	44.44	0.4444	
Ca	4.08	0.0408	
Mg	0.21	0.0021	
S	0.09	0.0009	
Na	0.03	0.0003	
C	0.12	0.0012	
O	34.54	0.3454	
Ti	15.8	0.1580	
H	0.56	0.0056	
Si	0.87	0.0087	

Attachment 5: MCNP input file

10col3

```
WV, HEC, Yankee, 5%, pile in the sump of GPC
c
C Cell cards
C
c ---------------------------------------------------------------------
c Universe 1. Fuel rod, clad and water outside the clad
c
1 61 -10.4  -17    u=1       imp:n=1 $ fuel rod
2 62 -7.92  -18 17 u=1       imp:n=1 $ SS-304 clad
3 63 -1.0    18    u=1       imp:n=1 $ water outside the clad
c
c ---------------------------------------------------------------------
c Universe 2. Fuel rod, clad and air outside the clad
c
4 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
5 62 -7.92  -18 17 u=2       imp:n=1 $ SS-304 clad
6 64 -0.001293  18 u=2       imp:n=1 $ air outside the clad
c
c ---------------------------------------------------------------------
c Universe 3. Fuel hexagonal lattice with water outside the fuel pins
c
7  0        -11 12 -13 14 -15 16 u=3
              lat=2 fill=1 imp:n=1 $ Hexagonal lattice
c ---------------------------------------------------------------------
c Universe 4. Fuel hexagonal lattice with air outside the fuel pins
c
8  0        -11 12 -13 14 -15 16 u=4
              lat=2 fill=2 imp:n=1 $ Hexagonal lattice
c ---------------------------------------------------------------------
c
9  0        21 -22 -23 -34 fill=3  imp:n=1 $ flooded part of fuel pile
10 0        34 -23        fill=4   imp:n=1 $ unflooded part of fuel pile
11 63 -1.0  21 -34 23 27 -25 -30 31 -22 imp:n=1 $ water arround the fuel pile
12 64 -0.001293  34 23 -33 -30 31 27 -24  imp:n=1 $ air outside the pile
13 67 -3.78 -29 30 28 -24 35 -33 imp:n=1 $ north concrete wall
14 67 -3.78 -31 32 28 -24 35 -33 imp:n=1 $ south concrete wall
15 67 -3.78 28 -27 31 -30 35 -33 imp:n=1 $ west concrete wall
16 67 -3.78 25 -24 31 -30 35 -34 imp:n=1 $ concrete floor
17 67 -3.78 27 -26 -21 35 31 -30 imp:n=1 $ long concrete wedge
18 67 -3.78 26 -25  22 35 31 -30 imp:n=1 $ short concrete wedge
19 0 -28 : 24 : 33 : -35 : 29 : -32 imp:n=0 $ outside world
C ---------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
C ---------------------------------------------------------------------
c
c begin the lattice surfaces
11 p 0.8660254 -0.5 0  0.581537
12 p 0.8660254 -0.5 0 -0.581537
13 p 0.8660254  0.5 0  0.581537
14 p 0.8660254  0.5 0 -0.581537
15 py  0.581537
16 py -0.581537
c end of lattice surfaces
c
17 cz 0.3785 $ fuel wall cylinder
18 cz 0.4318 $ clad outer wall cylinder
c
21 p 0.02857 0 1 0 $ sump long slope
22 p 1 0 -1 0 $ sump short sharp slope
23 s -68.76 0 1.964417 93.96384 $ fuel pile sphere
24 px 175.26 $ east system boundary
25 px 22.86  $ floor-slope boundary
26 px 0      $ boundary between two slopes
27 px -266.7 $ west wall inside boundary
28 px -419.1 $ west system boundary
29 py 320.04 $ north system boundary
30 py 167.64 $ north wall boundary
31 py -167.64 $ south wall boundary
32 py -320.04 $ south system boundary
33 pz 640.08 $ top system boundary
34 pz 22.86  $ floor
35 pz -68.58 $ bottom system boundary
c
C ---------------------------------------------------------------------
c
```

```
                                                        10col3
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c
c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
m61     8016.50c -0.1185844
       92235.50c -0.0435427
       92238.50c -0.8378729
c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
m62    14000.50c -0.01
       24000.50c -0.19
       25055.50c -0.02
       26000.55c -0.68
       28000.50c -0.10
c Water (H, O)
m63     1001.50c 0.66667
        8016.50c 0.33333
mt63 lwtr.01t
c Air (C, N, O, Ar) composition from Attix p.523
m64     6000.50c -0.000124
        7014.50c -0.755267
        8016.50c -0.231781
       18000.35c -0.012828
c High Density Concrete (Jake Nello's (D&M) calculation)
c (Al, Fe, Ca, Mg, S, Na, C, O, Ti, H, Si)
m67     13027.50c -0.0024
        26000.55c -0.4444
        20000.50c -0.0408
        12000.50c -0.0021
        16032.50c -0.0009
        11023.50c -0.0003
         6000.50c -0.0012
         8016.50c -0.3454
        22000.50c -0.1580
         1001.50c -0.0056
        14000.50c -0.0087
c
mode n
print 40 60 80 100 110 126
kcode 4000 1. 20 120
ksrc  0 0 10
```

Attachment 6: MCNP output file

```
1mcnp     version 4a    ld=10/01/93                    03/19/01 17:13:38
*************************************************************************          probid =   03/19/01 17:13:38
name=10col3

      WV, HEC, Yankee, 5%, pile in the sump of GPC
      c
      C Cell cards
      C
      c ---------------------------------------------------------------------
      c Universe 1. Fuel rod, clad and water outside the clad
      c
      1 61 -10.4  -17    u=1       imp:n=1 $ fuel rod
      2 62 -7.92  -18 17 u=1       imp:n=1 $ SS-304 clad
      3 63 -1.0    18    u=1       imp:n=1 $ water outside the clad
      c
      c ---------------------------------------------------------------------
      c Universe 2. Fuel rod, clad and air outside the clad
      c
      4 61 -10.4  -17    u=2       imp:n=1 $ fuel rod
      5 62 -7.92  -18 17 u=2       imp:n=1 $ SS-304 clad
      6 64 -0.001293  18 u=2       imp:n=1 $ air outside the clad
      c
      c ---------------------------------------------------------------------
      c Universe 3. Fuel hexagonal lattice with water outside the fuel pins
      c
      7  0        -11 12 -13 14 -15 16 u=3
                       lat=2 fill=1 imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      c Universe 4. Fuel hexagonal lattice with air outside the fuel pins
      c
      8  0        -11 12 -13 14 -15 16 u=4
                       lat=2 fill=2 imp:n=1 $ Hexagonal lattice
      c ---------------------------------------------------------------------
      c
      9  0        21 -22 -23 -34 fill=3  imp:n=1 $ flooded part of fuel pile
      10 0        34 -23        fill=4   imp:n=1 $ unflooded part of fuel pile
      11 63 -1.0  21 -34 23 27 -25 -30 31 -22 imp:n=1 $ water arround the fuel pile
      12 64 -0.001293  34 23 -33 -30 31 27 -24  imp:n=1 $ air outside the pile
      13 67 -3.78 -29 30 28 -24 35 -33 imp:n=1 $ north concrete wall
      14 67 -3.78 -31 32 28 -24 35 -33 imp:n=1 $ south concrete wall
      15 67 -3.78 28 -27 31 -30 35 -33 imp:n=1 $ west concrete wall
      16 67 -3.78 25 -24 31 -30 35 -34 imp:n=1 $ concrete floor
      17 67 -3.78 27 -26 -21 35 31 -30 imp:n=1 $ long concrete wedge
      18 67 -3.78 26 -25  22 35 31 -30 imp:n=1 $ short concrete wedge
      19 0 -28 : 24 : 33 : -35 : 29 : -32 imp:n=0 $ outside world
      C ---------------------------------------------------------------------
      c
      c Note: next line must be completely blank

      c Surface cards
      C ---------------------------------------------------------------------
      c
      c begin the lattice surfaces
      11 p 0.8660254 -0.5 0  0.581537
      12 p 0.8660254 -0.5 0 -0.581537
      13 p 0.8660254  0.5 0  0.581537
      14 p 0.8660254  0.5 0 -0.581537
      15 py  0.581537
      16 py -0.581537
      c end of lattice surfaces
      c
      17 cz 0.3785 $ fuel wall cylinder
```

```
59-       18 cz 0.4318 $ clad outer wall cylinder
60-       c
61-       21 p 0.02857 0 1 0 $ sump long slope
62-       22 p 1 0 -1 0 $ sump short sharp slope
63-       23 s -68.76 0 1.964417 93.96384 $ fuel pile sphere
64-       24 px 175.26 $ east system boundary
65-       25 px 22.86  $ floor-slope boundary
66-       26 px 0      $ boundary between two slopes
67-       27 px -266.7 $ west wall inside boundary
68-       28 px -419.1 $ west system boundary
69-       29 py 320.04 $ north system boundary
70-       30 py 167.64 $ north wall boundary
71-       31 py -167.64 $ south wall boundary
72-       32 py -320.04 $ south system boundary
73-       33 pz 640.08 $ top system boundary
74-       34 pz 22.86  $ floor
75-       35 pz -68.58 $ bottom system boundary
76-       c
77-       C ------------------------------------------------------------------------
78-       c
79-       c Note: next line must be completely blank
80-
81-       c Data cards
82-       c
83-       c Materials
84-       c
85-       c
86-       c Fresh Yankee fuel 5% enrichment (O-16, U-235, U-238)
87-       m61     8016.50c -0.1185844
88-             92235.50c -0.0435427
89-             92238.50c -0.8378729
90-       c Clad material, SS-304 (Si, Cr, Mn, Fe, Ni)
91-       m62   14000.50c -0.01
92-             24000.50c -0.19
93-             25055.50c -0.02
94-             26000.55c -0.68
95-             28000.50c -0.10
96-       c Water (H, O)
97-       m63     1001.50c 0.66667
98-             8016.50c 0.33333
99-       mt63 lwtr.01t
100-      c Air (C, N, O, Ar) composition from Attix p.523
101-      m64     6000.50c -0.000124
102-            7014.50c -0.755267
103-            8016.50c -0.231781
104-           18000.35c -0.012828
105-      c High Density Concrete (Jake Nello's (D&M) calculation)
106-      c (Al, Fe, Ca, Mg, S, Na, C, O, Ti, H, Si)
107-      m67    13027.50c -0.0024
108-            26000.55c -0.4444
109-            20000.50c -0.0408
110-            12000.50c -0.0021
111-            16032.50c -0.0009
112-            11023.50c -0.0003
113-             6000.50c -0.0012
114-             8016.50c -0.3454
115-            22000.50c -0.1580
116-             1001.50c -0.0056
117-            14000.50c -0.0087
118-      c
119-      mode n
120-      print 40 60 80 100 110 126
```

```
 121-        kcode 4000 1. 20 120
 122-        ksrc  0 0 10
 123-
 total fission nubar data are being used.
1material composition                                                    print table 40

 the sum of the fractions of material   67 was 1.009800E+00

 material
  number      component nuclide, atom fraction

    61            8016,  0.66678      92235,  0.01666      92238,  0.31655
    62           14000,  0.01950      24000,  0.20018      25055,  0.01994      26000,  0.66703
                 28000,  0.09334
    63            1001,  0.66667       8016,  0.33333
 associated thermal s(a,b) data sets:    lwtr.01t
    64            6000,  0.00015       7014,  0.78443       8016,  0.21075      18000,  0.00467
    67           13027,  0.00222      26000,  0.19868      20000,  0.02542      12000,  0.00216
                 16032,  0.00070      11023,  0.00033       6000,  0.00249       8016,  0.53915
                 22000,  0.08239       1001,  0.13873      14000,  0.00773



 material
  number      component nuclide, mass fraction

    61            8016,  0.11858      92235,  0.04354      92238,  0.83787
    62           14000,  0.01000      24000,  0.19000      25055,  0.02000      26000,  0.68000
                 28000,  0.10000
    63            1001,  0.11192       8016,  0.88808
    64            6000,  0.00012       7014,  0.75527       8016,  0.23178      18000,  0.01283
    67           13027,  0.00238      26000,  0.44009      20000,  0.04040      12000,  0.00208
                 16032,  0.00089      11023,  0.00030       6000,  0.00119       8016,  0.34205
                 22000,  0.15647       1001,  0.00555      14000,  0.00862

 warning.    1 of the materials had unnormalized fractions.
1cells                                                                   print table 60
```

cell	mat	atom density	gram density	volume	mass	pieces	neutron importance
1	61	6.96366E-02	1.04000E+01	0.00000E+00	0.00000E+00	0	1.0000E+00
2	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
3	63s	1.00309E-01	1.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
4	61	6.96366E-02	1.04000E+01	0.00000E+00	0.00000E+00	0	1.0000E+00
5	62	8.70647E-02	7.92000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
6	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
7	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
8	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
9	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
10	0	0.00000E+00	0.00000E+00	1.16752E+06	0.00000E+00	1	1.0000E+00
11	63s	1.00309E-01	1.00000E+00	0.00000E+00	0.00000E+00	0	1.0000E+00
12	64	5.35386E-05	1.29300E-03	0.00000E+00	0.00000E+00	0	1.0000E+00
13	67	9.02887E-02	3.78000E+00	6.41908E+07	2.42641E+08	0	1.0000E+00
14	67	9.02887E-02	3.78000E+00	6.41908E+07	2.42641E+08	0	1.0000E+00
15	67	9.02887E-02	3.78000E+00	3.62102E+07	1.36874E+08	0	1.0000E+00
16	67	9.02887E-02	3.78000E+00	4.67228E+06	1.76612E+07	0	1.0000E+00
17	67	9.02887E-02	3.78000E+00	6.47304E+06	2.44681E+07	0	1.0000E+00
18	67	9.02887E-02	3.78000E+00	6.13237E+05	2.31803E+06	0	1.0000E+00
19	0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0	0.0000E+00

```
 total                                    1.77518E+08 6.66604E+08

         1 warning message so far.
1cross-section tables                                                                                    print table 100

     table    length

                        tables from file critxs

   1001.50c    1153  njoy                                                                  (  1301)      79/07/31.
   6000.50c   16126  njoy                                                                  (  1306)      79/07/31.
   7014.50c   22772  njoy                                                                  (  1275)      79/09/08.
   8016.50c   23669  njoy                                                                   ( 1276)     05/14/81
  11023.50c   36270  njoy                                                                  (  1311)      79/06/21.
  12000.50c   39283  njoy                                                                  (  1312)      79/08/30.
  13027.50c   22891  njoy                                                                  (  1313)      79/09/08.
  14000.50c   48275  njoy                                                                  (  1314)      79/06/21.
  16032.50c    2684  njoy                                                                  (  1316)      79/10/29.
  18000.35c    2182      end185                                                              (   18)       11/01/85
  20000.50c   26104  njoy                                                                  (  1320)      79/06/22.
  22000.50c   25231  njoy                                                                  (  1322)      79/06/21.
  24000.50c   89104  njoy                                                                  (  1324)      79/06/21.
  25055.50c   60097  njoy                                                                  (  1325)      79/06/21.
  26000.55c   84136  njoy                                                                  ( 260)       10/21/82
  28000.50c   82267  njoy                                                                  (  1328)      79/06/21.
  92235.50c   44188  njoy                                          total nu                (  1395)      79/09/12.
  92238.50c   66440  njoy                                          total nu                (  1398)      79/09/13.
   lwtr.01t   10193  hydrogen in light water at 300 degrees kelvin                      1001     0     010/22/85

  total      703065

 warning.  neutron energy cutoff is below some cross-section tables.
1decimal words of dynamically allocated storage

     general             122228
     tallies                  0
     bank                 12403
     cross sections      703065

     total               837696

 ******************************************************************************************************************
 dump no.    1 on file 10col3r      nps =         0     coll =              0     ctm =    0.00     nrn =              0


 source distribution written to file 10col3s         cycle =     0

         2 warning messages so far.
1   starting mcrun.      field length =      0      cp0 =  0.02                                          print table 110

      WV, HEC, Yankee, 5%, pile in the sump of GPC


 nps   x          y          z       cell lattice(i,j,k)  surface    u          v          w        energy     weight      time

  1  0.000E+00  0.000E+00  1.000E+01    9                          5.085E-01  4.733E-01  7.193E-01  2.209E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)       5.085E-01  4.733E-01  7.193E-01
     0.000E+00  0.000E+00  1.000E+01    1                      0  5.085E-01  4.733E-01  7.193E-01
  2  0.000E+00  0.000E+00  1.000E+01    9                          8.952E-01 -4.447E-01 -2.944E-02  4.904E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)       8.952E-01 -4.447E-01 -2.944E-02
     0.000E+00  0.000E+00  1.000E+01    1                      0  8.952E-01 -4.447E-01 -2.944E-02
```

3	0.000E+00	0.000E+00	1.000E+01	9					-6.184E-01	-4.495E-01	6.446E-01	3.809E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-6.184E-01	-4.495E-01	6.446E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-6.184E-01	-4.495E-01	6.446E-01			
4	0.000E+00	0.000E+00	1.000E+01	9					9.710E-01	-5.665E-02	-2.323E-01	1.331E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		9.710E-01	-5.665E-02	-2.323E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	9.710E-01	-5.665E-02	-2.323E-01			
5	0.000E+00	0.000E+00	1.000E+01	9					5.861E-01	1.496E-01	-7.963E-01	1.902E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		5.861E-01	1.496E-01	-7.963E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	5.861E-01	1.496E-01	-7.963E-01			
6	0.000E+00	0.000E+00	1.000E+01	9					-6.489E-02	-1.626E-01	9.845E-01	4.410E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-6.489E-02	-1.626E-01	9.845E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-6.489E-02	-1.626E-01	9.845E-01			
7	0.000E+00	0.000E+00	1.000E+01	9					-7.068E-02	3.263E-02	-9.970E-01	4.750E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-7.068E-02	3.263E-02	-9.970E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-7.068E-02	3.263E-02	-9.970E-01			
8	0.000E+00	0.000E+00	1.000E+01	9					-3.915E-01	4.664E-01	-7.932E-01	4.136E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-3.915E-01	4.664E-01	-7.932E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-3.915E-01	4.664E-01	-7.932E-01			
9	0.000E+00	0.000E+00	1.000E+01	9					-2.368E-01	9.215E-01	-3.079E-01	7.453E-02	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-2.368E-01	9.215E-01	-3.079E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-2.368E-01	9.215E-01	-3.079E-01			
10	0.000E+00	0.000E+00	1.000E+01	9					1.946E-01	-3.204E-01	9.271E-01	3.128E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		1.946E-01	-3.204E-01	9.271E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	1.946E-01	-3.204E-01	9.271E-01			
11	0.000E+00	0.000E+00	1.000E+01	9					-6.698E-01	-7.177E-01	-1.905E-01	1.014E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-6.698E-01	-7.177E-01	-1.905E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-6.698E-01	-7.177E-01	-1.905E-01			
12	0.000E+00	0.000E+00	1.000E+01	9					-8.398E-01	-4.129E-01	3.524E-01	1.395E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-8.398E-01	-4.129E-01	3.524E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-8.398E-01	-4.129E-01	3.524E-01			
13	0.000E+00	0.000E+00	1.000E+01	9					-1.714E-01	-8.572E-01	4.857E-01	7.748E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-1.714E-01	-8.572E-01	4.857E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-1.714E-01	-8.572E-01	4.857E-01			
14	0.000E+00	0.000E+00	1.000E+01	9					-2.489E-01	-5.118E-01	-8.222E-01	1.101E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-2.489E-01	-5.118E-01	-8.222E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-2.489E-01	-5.118E-01	-8.222E-01			
15	0.000E+00	0.000E+00	1.000E+01	9					-2.959E-01	2.119E-01	9.314E-01	1.951E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-2.959E-01	2.119E-01	9.314E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-2.959E-01	2.119E-01	9.314E-01			
16	0.000E+00	0.000E+00	1.000E+01	9					1.395E-01	-9.829E-01	1.202E-01	2.186E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		1.395E-01	-9.829E-01	1.202E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	1.395E-01	-9.829E-01	1.202E-01			
17	0.000E+00	0.000E+00	1.000E+01	9					6.909E-01	-7.110E-01	1.307E-01	1.865E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		6.909E-01	-7.110E-01	1.307E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	6.909E-01	-7.110E-01	1.307E-01			
18	0.000E+00	0.000E+00	1.000E+01	9					-6.580E-01	5.320E-01	-5.329E-01	1.229E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-6.580E-01	5.320E-01	-5.329E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-6.580E-01	5.320E-01	-5.329E-01			
19	0.000E+00	0.000E+00	1.000E+01	9					-9.903E-01	-1.380E-01	1.353E-02	1.305E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-9.903E-01	-1.380E-01	1.353E-02			
	0.000E+00	0.000E+00	1.000E+01	1				0	-9.903E-01	-1.380E-01	1.353E-02			
20	0.000E+00	0.000E+00	1.000E+01	9					7.462E-01	4.859E-01	-4.551E-01	1.000E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		7.462E-01	4.859E-01	-4.551E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	7.462E-01	4.859E-01	-4.551E-01			
21	0.000E+00	0.000E+00	1.000E+01	9					-1.977E-01	9.797E-01	3.360E-02	3.990E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-1.977E-01	9.797E-01	3.360E-02			
	0.000E+00	0.000E+00	1.000E+01	1				0	-1.977E-01	9.797E-01	3.360E-02			
22	0.000E+00	0.000E+00	1.000E+01	9					-9.117E-01	-3.647E-01	-1.891E-01	2.665E-01	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-9.117E-01	-3.647E-01	-1.891E-01			
	0.000E+00	0.000E+00	1.000E+01	1				0	-9.117E-01	-3.647E-01	-1.891E-01			
23	0.000E+00	0.000E+00	1.000E+01	9					-4.287E-01	8.361E-01	-3.423E-01	1.156E+00	1.000E+00	0.000E+00
	0.000E+00	0.000E+00	1.000E+01	7(	0,	0,	0)		-4.287E-01	8.361E-01	-3.423E-01			

```
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -4.287E-01  8.361E-01 -3.423E-01
24  0.000E+00  0.000E+00  1.000E+01    9                                      1.080E-01  3.412E-01 -9.338E-01  2.669E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     1.080E-01  3.412E-01 -9.338E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  1.080E-01  3.412E-01 -9.338E-01
25  0.000E+00  0.000E+00  1.000E+01    9                                     -9.111E-01 -9.012E-03 -4.122E-01  2.185E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -9.111E-01 -9.012E-03 -4.122E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -9.111E-01 -9.012E-03 -4.122E-01
26  0.000E+00  0.000E+00  1.000E+01    9                                     -2.568E-01 -6.391E-01 -7.249E-01  4.225E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -2.568E-01 -6.391E-01 -7.249E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -2.568E-01 -6.391E-01 -7.249E-01
27  0.000E+00  0.000E+00  1.000E+01    9                                     -2.912E-01  8.086E-01  5.113E-01  1.079E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -2.912E-01  8.086E-01  5.113E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -2.912E-01  8.086E-01  5.113E-01
28  0.000E+00  0.000E+00  1.000E+01    9                                      1.472E-01 -9.514E-01  2.705E-01  3.461E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     1.472E-01 -9.514E-01  2.705E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  1.472E-01 -9.514E-01  2.705E-01
29  0.000E+00  0.000E+00  1.000E+01    9                                     -6.135E-01 -7.645E-01 -1.978E-01  1.836E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -6.135E-01 -7.645E-01 -1.978E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -6.135E-01 -7.645E-01 -1.978E-01
30  0.000E+00  0.000E+00  1.000E+01    9                                     -5.702E-01  5.651E-01 -5.963E-01  4.556E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -5.702E-01  5.651E-01 -5.963E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -5.702E-01  5.651E-01 -5.963E-01
31  0.000E+00  0.000E+00  1.000E+01    9                                     -6.607E-01  5.373E-01 -5.242E-01  6.415E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -6.607E-01  5.373E-01 -5.242E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -6.607E-01  5.373E-01 -5.242E-01
32  0.000E+00  0.000E+00  1.000E+01    9                                     -9.742E-02 -3.639E-01 -9.263E-01  2.764E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -9.742E-02 -3.639E-01 -9.263E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -9.742E-02 -3.639E-01 -9.263E-01
33  0.000E+00  0.000E+00  1.000E+01    9                                     -1.965E-01 -3.145E-01 -9.287E-01  2.785E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -1.965E-01 -3.145E-01 -9.287E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -1.965E-01 -3.145E-01 -9.287E-01
34  0.000E+00  0.000E+00  1.000E+01    9                                      4.097E-01  8.465E-01 -3.399E-01  9.097E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     4.097E-01  8.465E-01 -3.399E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  4.097E-01  8.465E-01 -3.399E-01
35  0.000E+00  0.000E+00  1.000E+01    9                                     -4.048E-02  8.831E-01  4.675E-01  3.360E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -4.048E-02  8.831E-01  4.675E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -4.048E-02  8.831E-01  4.675E-01
36  0.000E+00  0.000E+00  1.000E+01    9                                      3.371E-01 -9.269E-01 -1.652E-01  6.376E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     3.371E-01 -9.269E-01 -1.652E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  3.371E-01 -9.269E-01 -1.652E-01
37  0.000E+00  0.000E+00  1.000E+01    9                                     -1.867E-01  9.756E-01 -1.155E-01  2.186E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -1.867E-01  9.756E-01 -1.155E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -1.867E-01  9.756E-01 -1.155E-01
38  0.000E+00  0.000E+00  1.000E+01    9                                     -2.616E-01  2.336E-01 -9.365E-01  7.314E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -2.616E-01  2.336E-01 -9.365E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -2.616E-01  2.336E-01 -9.365E-01
39  0.000E+00  0.000E+00  1.000E+01    9                                      9.780E-01 -7.641E-02 -1.939E-01  2.997E-01  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     9.780E-01 -7.641E-02 -1.939E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  9.780E-01 -7.641E-02 -1.939E-01
40  0.000E+00  0.000E+00  1.000E+01    9                                      2.580E-01 -7.076E-01  6.578E-01  1.444E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     2.580E-01 -7.076E-01  6.578E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  2.580E-01 -7.076E-01  6.578E-01
41  0.000E+00  0.000E+00  1.000E+01    9                                     -3.212E-01 -7.678E-01 -5.543E-01  1.914E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                    -3.212E-01 -7.678E-01 -5.543E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0 -3.212E-01 -7.678E-01 -5.543E-01
42  0.000E+00  0.000E+00  1.000E+01    9                                      5.039E-01 -1.460E-01  8.513E-01  1.502E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     5.039E-01 -1.460E-01  8.513E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  5.039E-01 -1.460E-01  8.513E-01
43  0.000E+00  0.000E+00  1.000E+01    9                                      6.080E-01  5.487E-01  5.738E-01  5.971E+00  1.000E+00  0.000E+00
    0.000E+00  0.000E+00  1.000E+01    7(   0,   0,   0)                     6.080E-01  5.487E-01  5.738E-01
    0.000E+00  0.000E+00  1.000E+01    1                                    0  6.080E-01  5.487E-01  5.738E-01
44  0.000E+00  0.000E+00  1.000E+01    9                                     -2.932E-01  9.304E-01 -2.199E-01  1.827E+00  1.000E+00  0.000E+00
```

```
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)        -2.932E-01  9.304E-01 -2.199E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0 -2.932E-01  9.304E-01 -2.199E-01
 45  0.000E+00  0.000E+00  1.000E+01    9                          -8.475E-01 -3.993E-01 -3.497E-01  1.928E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)        -8.475E-01 -3.993E-01 -3.497E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0 -8.475E-01 -3.993E-01 -3.497E-01
 46  0.000E+00  0.000E+00  1.000E+01    9                           1.200E-01 -9.195E-01 -3.743E-01  1.351E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)         1.200E-01 -9.195E-01 -3.743E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0  1.200E-01 -9.195E-01 -3.743E-01
 47  0.000E+00  0.000E+00  1.000E+01    9                           7.085E-01  5.879E-01  3.904E-01  2.288E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)         7.085E-01  5.879E-01  3.904E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0  7.085E-01  5.879E-01  3.904E-01
 48  0.000E+00  0.000E+00  1.000E+01    9                           4.261E-01  9.046E-01  9.254E-03  1.230E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)         4.261E-01  9.046E-01  9.254E-03
     0.000E+00  0.000E+00  1.000E+01    1                        0  4.261E-01  9.046E-01  9.254E-03
 49  0.000E+00  0.000E+00  1.000E+01    9                           5.431E-01  4.270E-01 -7.230E-01  1.433E+00  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)         5.431E-01  4.270E-01 -7.230E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0  5.431E-01  4.270E-01 -7.230E-01
 50  0.000E+00  0.000E+00  1.000E+01    9                          -1.053E-01 -9.805E-01  1.658E-01  6.572E-01  1.000E+00  0.000E+00
     0.000E+00  0.000E+00  1.000E+01    7(   0,    0,    0)        -1.053E-01 -9.805E-01  1.658E-01
     0.000E+00  0.000E+00  1.000E+01    1                        0 -1.053E-01 -9.805E-01  1.658E-01
1estimated keff results by cycle                                                                                print table 175

 source distribution written to file 10col3s         cycle =    20

 source distribution written to file 10col3s         cycle =    23

 source distribution written to file 10col3s         cycle =    26

 source distribution written to file 10col3s         cycle =    29

 source distribution written to file 10col3s         cycle =    32

 source distribution written to file 10col3s         cycle =    35

 source distribution written to file 10col3s         cycle =    38

 ************************************************************************************************************************
 dump no.    2 on file 10col3r      nps =    160201     coll =        6731447     ctm =   15.22     nrn =      106717274

 source distribution written to file 10col3s         cycle =    41

 source distribution written to file 10col3s         cycle =    44

 source distribution written to file 10col3s         cycle =    47

 source distribution written to file 10col3s         cycle =    50

 source distribution written to file 10col3s         cycle =    53

 source distribution written to file 10col3s         cycle =    56

 source distribution written to file 10col3s         cycle =    59

 source distribution written to file 10col3s         cycle =    62

 source distribution written to file 10col3s         cycle =    65

 source distribution written to file 10col3s         cycle =    68

 source distribution written to file 10col3s         cycle =    71
```

```
source distribution written to file 10col3s         cycle =    74

source distribution written to file 10col3s         cycle =    77

********************************************************************************************************************
dump no.     3 on file 10col3r      nps =     316465     coll =       13633739     ctm =    30.35     nrn =       214851690


source distribution written to file 10col3s         cycle =    80

source distribution written to file 10col3s         cycle =    83

source distribution written to file 10col3s         cycle =    86

source distribution written to file 10col3s         cycle =    89

source distribution written to file 10col3s         cycle =    92

source distribution written to file 10col3s         cycle =    95

source distribution written to file 10col3s         cycle =    98

 estimator      cycle   100   ave of     80 cycles      combination          simple average     combined average      corr
k(collision)       1.068863       1.054063 0.0015     k(col/abs)          1.053863 0.0011     1.053759 0.0011    0.5312
k(absorption)      1.057333       1.053662 0.0011     k(abs/tk ln)        1.053869 0.0013     1.053703 0.0011    0.4203
k(trk length)      1.078056       1.054075 0.0020     k(tk ln/col)        1.054069 0.0016     1.054062 0.0015    0.7624
rem life(col)    2.7824E+03     2.4763E+03 0.0105     k(col/abs/tk ln)    1.053933 0.0013     1.053758 0.0011
rem life(abs)    2.7635E+03     2.4822E+03 0.0102     life(col/abs)     2.4792E+03 0.0103   2.4818E+03 0.0103    0.9737
source points generated   4076

source distribution written to file 10col3s         cycle =   101

source distribution written to file 10col3s         cycle =   104

source distribution written to file 10col3s         cycle =   107

source distribution written to file 10col3s         cycle =   110

source distribution written to file 10col3s         cycle =   113

 estimator      cycle   116   ave of     96 cycles      combination          simple average     combined average      corr
k(collision)       1.040570       1.053061 0.0013     k(col/abs)          1.053058 0.0010     1.053057 0.0010    0.5038
k(absorption)      1.065249       1.053055 0.0010     k(abs/tk ln)        1.053036 0.0012     1.053052 0.0010    0.4348
k(trk length)      1.045213       1.053016 0.0018     k(tk ln/col)        1.053038 0.0015     1.053063 0.0013    0.7754
rem life(col)    2.6474E+03     2.4966E+03 0.0091     k(col/abs/tk ln)    1.053044 0.0012     1.053060 0.0010
rem life(abs)    2.7484E+03     2.5062E+03 0.0090     life(col/abs)     2.5014E+03 0.0090   2.5021E+03 0.0091    0.9656
source points generated   4017

source distribution written to file 10col3s         cycle =   116

 estimator      cycle   117   ave of     97 cycles      combination          simple average     combined average      corr
k(collision)       1.044639       1.052974 0.0013     k(col/abs)          1.053052 0.0010     1.053092 0.0010    0.4971
k(absorption)      1.060316       1.053130 0.0010     k(abs/tk ln)        1.052941 0.0012     1.053095 0.0010    0.4194
k(trk length)      1.027449       1.052752 0.0018     k(tk ln/col)        1.052863 0.0015     1.052989 0.0013    0.7750
rem life(col)    2.5406E+03     2.4970E+03 0.0090     k(col/abs/tk ln)    1.052952 0.0012     1.053109 0.0010
rem life(abs)    2.5990E+03     2.5072E+03 0.0089     life(col/abs)     2.5021E+03 0.0089   2.5027E+03 0.0091    0.9654
source points generated   3937

 estimator      cycle   118   ave of     98 cycles      combination          simple average     combined average      corr
k(collision)       1.042732       1.052869 0.0013     k(col/abs)          1.053076 0.0010     1.053177 0.0010    0.4794
k(absorption)      1.068083       1.053283 0.0010     k(abs/tk ln)        1.052915 0.0012     1.053204 0.0010    0.3966
k(trk length)      1.032703       1.052548 0.0018     k(tk ln/col)        1.052708 0.0015     1.052894 0.0013    0.7765
```

```
rem life(col)   2.4376E+03     2.4964E+03 0.0089     k(col/abs/tk ln)    1.052900 0.0012     1.053198 0.0010
rem life(abs)   2.4533E+03     2.5066E+03 0.0088     life(col/abs)     2.5015E+03 0.0088   2.5022E+03 0.0090   0.9654
source points generated   4010

*****************************************************************************************************************
dump no.    4 on file 10col3r      nps =    472313     coll =       20501942     ctm =   45.48     nrn =      322729803


 estimator     cycle   119   ave of    99 cycles      combination         simple average    combined average     corr
k(collision)      1.074737       1.053090 0.0013     k(col/abs)          1.053263 0.0010     1.053351 0.0010   0.4915
k(absorption)     1.068530       1.053437 0.0010     k(abs/tk ln)        1.053124 0.0012     1.053374 0.0010   0.4090
k(trk length)     1.078610       1.052811 0.0018     k(tk ln/col)        1.052951 0.0015     1.053113 0.0013   0.7814
rem life(col)   2.7354E+03     2.4989E+03 0.0089     k(col/abs/tk ln)    1.053113 0.0012     1.053370 0.0010
rem life(abs)   2.7418E+03     2.5090E+03 0.0088     life(col/abs)     2.5039E+03 0.0087   2.5046E+03 0.0089   0.9658
source points generated   4191

source distribution written to file 10col3s         cycle =   119

 estimator     cycle   120   ave of   100 cycles      combination         simple average    combined average     corr
k(collision)      1.056440       1.053124 0.0013     k(col/abs)          1.053335 0.0010     1.053439 0.0010   0.4913
k(absorption)     1.064316       1.053546 0.0010     k(abs/tk ln)        1.053208 0.0012     1.053477 0.0010   0.4100
k(trk length)     1.058841       1.052871 0.0018     k(tk ln/col)        1.052997 0.0014     1.053145 0.0013   0.7815
rem life(col)   2.3485E+03     2.4974E+03 0.0088     k(col/abs/tk ln)    1.053180 0.0012     1.053457 0.0010
rem life(abs)   2.3605E+03     2.5075E+03 0.0087     life(col/abs)     2.5024E+03 0.0087   2.5031E+03 0.0089   0.9660
source points generated   3945

source distribution written to file 10col3s         cycle =   120
1problem summary

     run terminated when   120 kcode cycles were done.
+                                                                                                  03/19/01 17:59:56
     WV, HEC, Yankee, 5%, pile in the sump of GPC                                        probid =   03/19/01 17:13:38
0
 neutron creation     tracks      weight        energy          neutron loss        tracks      weight        energy
                                 (per source particle)                                          (per source particle)

 source               480514    9.9893E-01    2.0330E+00        escape               21831    3.2073E-02    1.6154E-02
                                                                 energy cutoff            0    0.            0.
                                                                 time cutoff              0    0.            0.
 weight window             0    0.            0.                weight window            0    0.            0.
 cell importance           0    0.            0.                cell importance          0    0.            0.
 weight cutoff             0    7.8209E-02    1.0230E-04        weight cutoff       459648    7.8354E-02    9.5895E-05
 energy importance         0    0.            0.                energy importance        0    0.            0.
 dxtran                    0    0.            0.                dxtran                   0    0.            0.
 forced collisions         0    0.            0.                forced collisions        0    0.            0.
 exp. transform            0    0.            0.                exp. transform           0    0.            0.
 upscattering              0    0.            4.3365E-08        downscattering           0    0.            1.8424E+00
                                                                 capture                  0    5.4340E-01    4.6849E-02
 (n,xn)                 1920    3.0195E-03    2.2257E-03        loss to (n,xn)         955    1.5024E-03    1.2679E-02
 fission                   0    0.            0.                loss to fission          0    4.2483E-01    1.1721E-01
    total            482434    1.0802E+00.   2.0353E+00            total           482434    1.0802E+00    2.0353E+00

  number of neutrons banked                      965        average lifetime, shakes              cutoffs
  neutron tracks per source particle     1.0040E+00          escape            1.3652E+04          tco   1.0000E+34
  neutron collisions per source particle 4.3423E+01          capture           2.0653E+03          eco   0.0000E+00
  total neutron collisions                 20865595          capture or escape 2.4368E+03          wc1  -5.0000E-01
  net multiplication              1.0015E+00 0.0001          any termination   2.7082E+03          wc2  -2.5000E-01

computer time so far in this run    46.31 minutes           maximum number ever in bank        2
computer time in mcrun              46.29 minutes           bank overflows to backup file      0
source particles per minute            1.0381E+04           field length                       0
random numbers generated                328420724           most random numbers used was     9142 in history   255509
```

range of sampled source weights = 9.4229E-01 to 1.0590E+00

1neutron activity in each cell print table 126

	cell	tracks entering	population	collisions	collisions * weight (per history)	number weighted energy	flux weighted energy	average track weight (relative)	average track mfp (cm)
1	1	7784294	459088	2614498	4.4951E+00	1.7171E-03	7.5154E-01	8.6504E-01	2.6056E+00
2	2	15658206	457414	1074193	1.8269E+00	1.4839E-03	7.2208E-01	8.6292E-01	2.5558E+00
3	3	20837496	457171	8205210	1.3587E+01	1.3047E-03	7.0298E-01	8.6278E-01	1.7548E+00
4	4	7601297	143960	2478629	3.4861E+00	2.0070E-02	5.5381E-01	7.0251E-01	2.5715E+00
5	5	16048402	142808	898003	1.1758E+00	1.9190E-02	5.5238E-01	7.0287E-01	3.0988E+00
6	6	21298404	142393	1835	2.4549E-03	1.8177E-02	5.5295E-01	7.0356E-01	5.7686E+03
7	7	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8	8	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	9	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	10	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
11	11	23281	16417	1668755	1.8345E+00	5.1018E-05	2.3653E-01	5.9018E-01	8.1193E-01
12	12	81753	41097	6311	8.3401E-03	1.0397E-03	4.4470E-01	6.9153E-01	4.9576E+03
13	13	18110	15336	329700	4.4746E-01	3.4743E-04	2.6921E-01	6.8581E-01	1.9646E+00
14	14	17655	14953	324591	4.3852E-01	3.3192E-04	2.5854E-01	6.8200E-01	1.9424E+00
15	15	11691	9849	201611	2.6859E-01	2.9723E-04	2.4513E-01	6.7183E-01	1.9218E+00
16	16	8869	6618	126307	1.8484E-01	3.4720E-04	3.1583E-01	7.4067E-01	2.0336E+00
17	17	136663	88282	2538903	4.0662E+00	4.8146E-04	4.3703E-01	8.1179E-01	2.1814E+00
18	18	30855	17478	397049	6.3302E-01	4.6728E-04	4.3042E-01	8.0874E-01	2.1735E+00
total		89556976	2012864	20865595	3.2455E+01				

1keff results for: WV, HEC, Yankee, 5%, pile in the sump of GPC probid = 03/19/01 17:13:38

the initial fission neutron source distribution used the 1 source points that were input on the ksrc card.
the criticality problem was scheduled to skip 20 cycles and run a total of 120 cycles with nominally 4000 neutrons per cycle.
this problem has run 20 inactive cycles with 80137 neutron histories and 100 active cycles with 400377 neutron histories.

this calculation has completed the requested number of keff cycles using a total of 480514 fission neutron source histories.
all cells with fissionable material were sampled and had fission neutron source points.

the results of the w test for normality applied to the individual collision, absorption, and track-length keff cycle values are:

the k(collision) cycle values appear normally distributed at the 95 percent confidence level
the k(absorption) cycle values appear normally distributed at the 99 percent confidence level, but not at 95 percent
the k(trk length) cycle values appear normally distributed at the 95 percent confidence level

---

the final estimated combined collision/absorption/track-length keff = 1.05346 with an estimated standard deviation of 0.00101

the estimated 68, 95, & 99 percent keff confidence intervals are 1.05245 to 1.05446, 1.05145 to 1.05546, and 1.05080 to 1.05611

the estimated collision/absorption neutron removal lifetime = 2.50E-05 seconds with an estimated standard deviation of 2.22E-07

---

the estimated average keffs, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence	corr

collision	1.05312	0.00137	1.05176 to 1.05449	1.05040 to 1.05584	1.04952 to 1.05673	
absorption	1.05355	0.00105	1.05250 to 1.05459	1.05146 to 1.05563	1.05078 to 1.05631	
track length	1.05287	0.00185	1.05102 to 1.05473	1.04918 to 1.05656	1.04798 to 1.05777	
col/absorp	1.05344	0.00100	1.05243 to 1.05444	1.05144 to 1.05544	1.05079 to 1.05609	0.4913
abs/trk len	1.05348	0.00104	1.05244 to 1.05452	1.05141 to 1.05555	1.05073 to 1.05622	0.4100
col/trk len	1.05314	0.00137	1.05177 to 1.05452	1.05042 to 1.05587	1.04953 to 1.05676	0.7815
col/abs/trk len	1.05346	0.00101	1.05245 to 1.05446	1.05145 to 1.05546	1.05080 to 1.05611	

if the largest of each keff occurred on the next cycle, the keff results and 68, 95, and 99 percent confidence intervals would be:

keff estimator	keff	standard deviation	68% confidence	95% confidence	99% confidence
collision	1.05349	0.00140	1.05209 to 1.05490	1.05070 to 1.05629	1.04979 to 1.05720
absorption	1.05375	0.00106	1.05269 to 1.05481	1.05165 to 1.05586	1.05096 to 1.05655
track length	1.05327	0.00188	1.05139 to 1.05516	1.04953 to 1.05702	1.04831 to 1.05824
col/abs/trk len	1.05371	0.00103	1.05268 to 1.05474	1.05167 to 1.05575	1.05100 to 1.05642

the estimated collision/absorption neutron lifetimes, one standard deviations, and 68, 95, and 99 percent confidence intervals are:

type	lifetime(sec)	standard deviation	68% confidence	95% confidence	99% confidence
removal	2.5031E-05	2.2183E-07	2.4809E-05 to 2.5253E-05	2.4589E-05 to 2.5473E-05	2.4445E-05 to 2.5617E-05
capture	2.0970E-05	1.7167E-07	2.0798E-05 to 2.1142E-05	2.0628E-05 to 2.1312E-05	2.0516E-05 to 2.1423E-05
fission	1.3390E-05	5.5841E-08	1.3334E-05 to 1.3446E-05	1.3279E-05 to 1.3501E-05	1.3243E-05 to 1.3538E-05
escape	1.5494E-04	3.9751E-06	1.5096E-04 to 1.5892E-04	1.4702E-04 to 1.6286E-04	1.4444E-04 to 1.6544E-04

laverage individual and combined collision/absorption/track-length keff results for 7 different batch sizes

cycles per keff batch	number of k batches	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/trk	average k(c/a/t) k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
1	100	1.0531	0.0014	1.0535	0.0010	1.0529	0.0019	95/99/95	1.05346	0.00101	1.05145-1.05546	1.05080-1.05611
2	50	1.0531	0.0013	1.0535	0.0011	1.0529	0.0018	95/95/95	1.05343	0.00101	1.05140-1.05546	1.05072-1.05614
4	25	1.0531	0.0014	1.0535	0.0012	1.0529	0.0017	95/95/95	1.05346	0.00117	1.05103-1.05589	1.05016-1.05676
5	20	1.0531	0.0013	1.0535	0.0013	1.0529	0.0018	95/95/95	1.05342	0.00120	1.05089-1.05594	1.04995-1.05689
10	10	1.0531	0.0014	1.0535	0.0013	1.0529	0.0021	95/95/95	1.05350	0.00131	1.05041-1.05658	1.04893-1.05806
20	5	1.0531	0.0012	1.0535	0.0007	1.0529	0.0013	95/95/95	1.05343	0.00097	1.04924-1.05763	1.04376-1.06311
25	4	1.0531	0.0019	1.0535	0.0008	1.0529	0.0023	95/95/95	1.05385	0.00015	1.05191-1.05578	1.04417-1.06352

lindividual and average keff estimator results by cycle

keff cycle	neutron histories	keff estimators by cycle k(coll)	k(abs)	k(track)	average keff estimators and deviations k(coll)	st dev	k(abs)	st dev	k(track)	st dev	average k(c/a/t) k(c/a/t)	st dev	fom
1	4000	1.04806	1.08701	1.04314									
2	4211	0.98094	0.98403	0.96985									
3	3806	1.01363	1.01364	1.00853									
4	4170	1.00064	1.00208	1.00663									
5	3993	1.00433	1.00319	1.00365									
6	3944	1.03059	1.01360	1.00299									
7	4168	1.02381	1.01809	1.00531									
8	3994	1.04865	1.04274	1.02312									
9	4060	1.03563	1.03515	1.02970									
10	4034	1.03483	1.02341	1.03399									
11	3935	1.04215	1.04768	1.05032									
12	3965	1.05120	1.03809	1.04695									
13	4079	1.02252	1.02516	1.03709									
14	3916	1.03660	1.04766	1.03607									
15	4038	1.04519	1.05280	1.03040									
16	3956	1.02171	1.01579	1.04236									
17	3928	1.04182	1.05358	1.05080									

18	4022	1.04143	1.02600	1.04259								
19	3975	1.02427	1.03687	1.04351								
20	3943	1.06314	1.06160	1.07134								
		begin active keff cycles										
21	4245	1.06172	1.05517	1.05106								
22	4074	1.02347	1.05464	1.01044	1.04259	0.01912	1.05490	0.00027	1.03075	0.02031		
23	3777	1.05879	1.05047	1.05055	1.04799	0.01229	1.05342	0.00149	1.03735	0.01346		
24	4188	1.06464	1.07447	1.09205	1.05215	0.00964	1.05868	0.00536	1.05103	0.01666	1.05862	0.00223 143949
25	4042	1.05507	1.06399	1.07431	1.05274	0.00749	1.05974	0.00429	1.05568	0.01372	1.05769	0.00219 119583
26	3896	1.05200	1.06124	1.04358	1.05261	0.00611	1.05999	0.00351	1.05367	0.01138	1.05873	0.00229 91731
27	3957	1.05937	1.06531	1.07785	1.05358	0.00526	1.06075	0.00306	1.05712	0.01022	1.05849	0.00193 111003
28	3995	1.09062	1.05917	1.09232	1.05821	0.00649	1.06056	0.00266	1.06152	0.00988	1.05905	0.00145 171725
29	4113	1.06918	1.05277	1.09362	1.05943	0.00585	1.05969	0.00250	1.06509	0.00942	1.05801	0.00220 66169
30	3879	1.03158	1.05150	1.02477	1.05664	0.00593	1.05887	0.00238	1.06106	0.00934	1.05723	0.00209 66376
31	3870	1.06339	1.06688	1.06468	1.05726	0.00540	1.05960	0.00227	1.06139	0.00845	1.05808	0.00209 60374
32	4094	1.04779	1.04829	1.04897	1.05647	0.00499	1.05866	0.00228	1.06035	0.00779	1.05716	0.00213 53297
33	3933	1.05137	1.06634	1.04393	1.05607	0.00461	1.05925	0.00218	1.05909	0.00727	1.05792	0.00212 49978
34	3994	1.05375	1.04373	1.04552	1.05591	0.00427	1.05814	0.00230	1.05812	0.00680	1.05697	0.00205 49496
35	4018	1.03705	1.03778	1.04912	1.05465	0.00417	1.05678	0.00254	1.05752	0.00636	1.05564	0.00257 29174
36	3905	1.03885	1.05101	1.03647	1.05366	0.00402	1.05642	0.00240	1.05620	0.00609	1.05527	0.00244 30320
37	4033	1.06591	1.04756	1.05279	1.05438	0.00385	1.05590	0.00231	1.05600	0.00573	1.05519	0.00222 34547
38	4078	1.06207	1.05348	1.06822	1.05481	0.00365	1.05577	0.00219	1.05668	0.00544	1.05509	0.00209 36899
39	3949	1.07043	1.05610	1.06838	1.05563	0.00355	1.05578	0.00207	1.05730	0.00519	1.05532	0.00197 39190
40	4024	1.04533	1.04201	1.01869	1.05512	0.00341	1.05510	0.00208	1.05537	0.00528	1.05502	0.00187 41464
41	3856	1.05218	1.06722	1.04231	1.05498	0.00324	1.05567	0.00206	1.05474	0.00506	1.05559	0.00187 39301
42	4101	1.05485	1.04313	1.04863	1.05497	0.00309	1.05510	0.00204	1.05447	0.00484	1.05522	0.00182 39611
43	4061	1.03229	1.03935	1.06447	1.05399	0.00312	1.05442	0.00207	1.05490	0.00464	1.05423	0.00205 29873
44	3951	1.04773	1.04954	1.06296	1.05373	0.00299	1.05421	0.00199	1.05524	0.00446	1.05397	0.00199 30446
45	4066	1.05372	1.04444	1.03760	1.05373	0.00287	1.05382	0.00195	1.05453	0.00433	1.05371	0.00191 31600
46	4101	1.06378	1.06214	1.07152	1.05411	0.00279	1.05414	0.00190	1.05519	0.00421	1.05400	0.00186 31991
47	3984	1.05789	1.04345	1.07032	1.05425	0.00269	1.05375	0.00187	1.05575	0.00409	1.05370	0.00183 31953
48	4039	1.06266	1.05137	1.05038	1.05455	0.00260	1.05366	0.00181	1.05555	0.00395	1.05376	0.00176 33326
49	3968	1.04155	1.06228	1.05303	1.05410	0.00255	1.05396	0.00177	1.05547	0.00381	1.05385	0.00169 34581
50	3914	1.04335	1.04986	1.05055	1.05375	0.00249	1.05382	0.00171	1.05530	0.00369	1.05364	0.00165 35192
51	4034	1.07531	1.06623	1.09175	1.05444	0.00251	1.05422	0.00170	1.05648	0.00375	1.05399	0.00166 33789
52	4123	1.05623	1.05134	1.05266	1.05450	0.00243	1.05413	0.00165	1.05636	0.00364	1.05396	0.00160 35042
53	3894	1.06193	1.06875	1.06561	1.05472	0.00237	1.05458	0.00166	1.05664	0.00354	1.05434	0.00160 33984
54	4013	1.04462	1.06181	1.04323	1.05442	0.00231	1.05479	0.00163	1.05625	0.00345	1.05446	0.00156 34962
55	3947	1.04692	1.04740	1.03939	1.05421	0.00226	1.05458	0.00159	1.05576	0.00339	1.05427	0.00152 35740
56	4062	1.04550	1.04947	1.02965	1.05397	0.00221	1.05444	0.00156	1.05504	0.00337	1.05416	0.00147 36890
57	4019	1.04597	1.06809	1.04001	1.05375	0.00216	1.05481	0.00156	1.05463	0.00330	1.05440	0.00146 36710
58	4053	1.04571	1.04907	1.05695	1.05354	0.00211	1.05465	0.00152	1.05469	0.00322	1.05421	0.00143 36792
59	3952	1.05291	1.05902	1.03715	1.05352	0.00206	1.05477	0.00149	1.05424	0.00316	1.05435	0.00140 37592
60	3989	1.06562	1.06567	1.06469	1.05383	0.00203	1.05504	0.00148	1.05450	0.00310	1.05464	0.00140 36956
61	4022	1.03870	1.04772	1.01968	1.05346	0.00201	1.05486	0.00145	1.05366	0.00314	1.05447	0.00137 37291
62	3919	1.02625	1.03715	1.02185	1.05281	0.00207	1.05444	0.00148	1.05290	0.00315	1.05405	0.00142 33829
63	4009	1.04325	1.04681	1.03246	1.05259	0.00203	1.05426	0.00145	1.05242	0.00312	1.05391	0.00140 34203
64	3991	1.04313	1.05034	1.06626	1.05237	0.00199	1.05417	0.00142	1.05274	0.00306	1.05373	0.00138 34183
65	4023	1.04135	1.02739	1.05593	1.05213	0.00197	1.05358	0.00151	1.05281	0.00299	1.05312	0.00146 29981
66	4014	1.04675	1.04039	1.03781	1.05201	0.00193	1.05329	0.00151	1.05248	0.00294	1.05288	0.00144 30061
67	4032	1.04727	1.05233	1.04458	1.05191	0.00189	1.05327	0.00147	1.05231	0.00289	1.05284	0.00141 30674
68	4009	1.03079	1.03702	1.03005	1.05147	0.00190	1.05293	0.00148	1.05185	0.00286	1.05249	0.00143 29132
69	4004	1.07097	1.06461	1.05768	1.05187	0.00190	1.05317	0.00147	1.05197	0.00281	1.05283	0.00143 28481
70	4157	1.06212	1.05532	1.05771	1.05207	0.00187	1.05321	0.00144	1.05208	0.00275	1.05292	0.00141 29027
71	3922	1.06387	1.04965	1.06931	1.05230	0.00185	1.05314	0.00142	1.05242	0.00272	1.05292	0.00137 29769
72	4023	1.02923	1.03819	1.03826	1.05186	0.00187	1.05285	0.00142	1.05215	0.00268	1.05261	0.00139 28425
73	3911	1.04322	1.06231	1.05745	1.05170	0.00184	1.05303	0.00140	1.05225	0.00263	1.05267	0.00137 28708

74	4042	1.07548	1.06922	1.07940	1.05214 0.00186	1.05333 0.00141	1.05275 0.00263	1.05302 0.00139	27612
75	4198	1.04738	1.06181	1.04715	1.05205 0.00183	1.05349 0.00139	1.05265 0.00258	1.05311 0.00137	27857
76	3895	1.07528	1.06490	1.09227	1.05247 0.00184	1.05369 0.00138	1.05336 0.00263	1.05334 0.00136	27611
77	4120	1.05925	1.05968	1.06600	1.05259 0.00181	1.05380 0.00136	1.05358 0.00260	1.05344 0.00134	27930
78	3893	1.05620	1.05809	1.05390	1.05265 0.00178	1.05387 0.00134	1.05359 0.00255	1.05352 0.00132	28372
79	3953	1.08016	1.04295	1.08377	1.05311 0.00181	1.05368 0.00133	1.05410 0.00256	1.05346 0.00129	29096
80	4115	1.06703	1.05946	1.07152	1.05335 0.00180	1.05378 0.00131	1.05439 0.00253	1.05358 0.00128	29331
81	3906	1.05698	1.05379	1.05749	1.05341 0.00177	1.05378 0.00129	1.05444 0.00249	1.05360 0.00125	29863
82	3915	1.05950	1.04641	1.05059	1.05350 0.00174	1.05366 0.00127	1.05438 0.00245	1.05354 0.00123	30424
83	3995	1.03611	1.03257	1.02910	1.05323 0.00174	1.05333 0.00130	1.05397 0.00245	1.05322 0.00125	29034
84	3889	1.06737	1.06869	1.06257	1.05345 0.00172	1.05357 0.00130	1.05411 0.00241	1.05347 0.00126	28406
85	4079	1.05440	1.07070	1.03946	1.05346 0.00170	1.05383 0.00131	1.05388 0.00238	1.05370 0.00126	27943
86	3897	1.05592	1.06173	1.06793	1.05350 0.00167	1.05395 0.00129	1.05410 0.00236	1.05378 0.00124	28235
87	4024	1.05854	1.05851	1.04225	1.05358 0.00165	1.05402 0.00127	1.05392 0.00233	1.05388 0.00123	28563
88	3989	1.06201	1.04231	1.05618	1.05370 0.00163	1.05385 0.00127	1.05395 0.00229	1.05378 0.00121	28898
89	4002	1.07856	1.06148	1.08578	1.05406 0.00165	1.05396 0.00125	1.05441 0.00231	1.05395 0.00120	28762
90	4061	1.02713	1.03092	1.02731	1.05368 0.00167	1.05363 0.00128	1.05403 0.00231	1.05361 0.00124	26853
91	3842	1.05103	1.06132	1.07136	1.05364 0.00164	1.05374 0.00126	1.05427 0.00229	1.05365 0.00122	27173
92	4055	1.06798	1.06486	1.04537	1.05384 0.00163	1.05389 0.00126	1.05415 0.00226	1.05386 0.00122	26923
93	4049	1.05259	1.05259	1.04807	1.05382 0.00161	1.05387 0.00124	1.05406 0.00223	1.05384 0.00120	27319
94	3910	1.06797	1.05992	1.06552	1.05401 0.00160	1.05395 0.00122	1.05422 0.00220	1.05395 0.00119	27479
95	4143	1.06179	1.05711	1.05729	1.05412 0.00158	1.05400 0.00121	1.05426 0.00218	1.05402 0.00117	27766
96	3944	1.05631	1.04235	1.04977	1.05414 0.00156	1.05384 0.00120	1.05420 0.00215	1.05391 0.00116	27904
97	3934	1.06609	1.06623	1.04737	1.05430 0.00155	1.05400 0.00120	1.05411 0.00212	1.05409 0.00116	27640
98	4032	1.02952	1.04309	1.02562	1.05398 0.00156	1.05386 0.00119	1.05375 0.00213	1.05390 0.00116	27323
99	3839	1.04559	1.03423	1.05571	1.05388 0.00154	1.05362 0.00120	1.05377 0.00210	1.05368 0.00117	26666
100	4049	1.06886	1.05733	1.07806	1.05406 0.00154	1.05366 0.00119	1.05408 0.00209	1.05376 0.00116	26880
101	4076	1.04517	1.04476	1.05357	1.05395 0.00152	1.05355 0.00118	1.05407 0.00207	1.05364 0.00115	26936
102	3970	1.04426	1.04675	1.04090	1.05383 0.00151	1.05347 0.00117	1.05391 0.00205	1.05355 0.00114	27105
103	4043	1.04735	1.04573	1.04931	1.05376 0.00149	1.05338 0.00116	1.05385 0.00203	1.05346 0.00113	27250
104	4100	1.04227	1.05501	1.02348	1.05362 0.00148	1.05340 0.00114	1.05349 0.00203	1.05345 0.00111	27604
105	3996	1.05264	1.05421	1.04557	1.05361 0.00146	1.05341 0.00113	1.05340 0.00201	1.05346 0.00110	27939
106	4073	1.05432	1.05982	1.06548	1.05362 0.00145	1.05348 0.00112	1.05354 0.00199	1.05352 0.00109	28209
107	4084	1.07344	1.06093	1.08012	1.05384 0.00145	1.05357 0.00111	1.05384 0.00199	1.05363 0.00108	28200
108	4043	1.01164	1.04199	1.01239	1.05336 0.00151	1.05343 0.00110	1.05337 0.00203	1.05342 0.00109	27505
109	3805	1.05288	1.06314	1.07121	1.05336 0.00149	1.05354 0.00110	1.05357 0.00201	1.05350 0.00108	27682
110	4167	1.06062	1.03652	1.04853	1.05344 0.00148	1.05335 0.00110	1.05352 0.00199	1.05337 0.00107	27602
111	4013	1.04873	1.04834	1.04433	1.05339 0.00146	1.05330 0.00109	1.05342 0.00197	1.05332 0.00106	27847
112	3928	1.04266	1.04430	1.03682	1.05327 0.00145	1.05320 0.00108	1.05324 0.00196	1.05322 0.00106	27914
113	3913	1.04867	1.04892	1.05030	1.05322 0.00144	1.05315 0.00107	1.05320 0.00194	1.05317 0.00105	28165
114	3990	1.04941	1.04633	1.04835	1.05318 0.00142	1.05308 0.00106	1.05315 0.00192	1.05311 0.00104	28358
115	4052	1.05417	1.03833	1.04791	1.05319 0.00141	1.05293 0.00106	1.05310 0.00190	1.05299 0.00103	28287
116	3972	1.04057	1.06525	1.04521	1.05306 0.00140	1.05306 0.00106	1.05302 0.00188	1.05306 0.00102	28497
117	4017	1.04464	1.06032	1.02745	1.05297 0.00139	1.05313 0.00105	1.05275 0.00188	1.05311 0.00101	28724
118	3937	1.04273	1.06808	1.03270	1.05287 0.00138	1.05328 0.00105	1.05255 0.00187	1.05320 0.00101	28740
119	4010	1.07474	1.06853	1.07861	1.05309 0.00138	1.05344 0.00105	1.05281 0.00187	1.05337 0.00101	28244
120	4191	1.05644	1.06432	1.05884	1.05312 0.00137	1.05355 0.00105	1.05287 0.00185	1.05346 0.00101	28294

the largest active cycle keffs by estimator are:

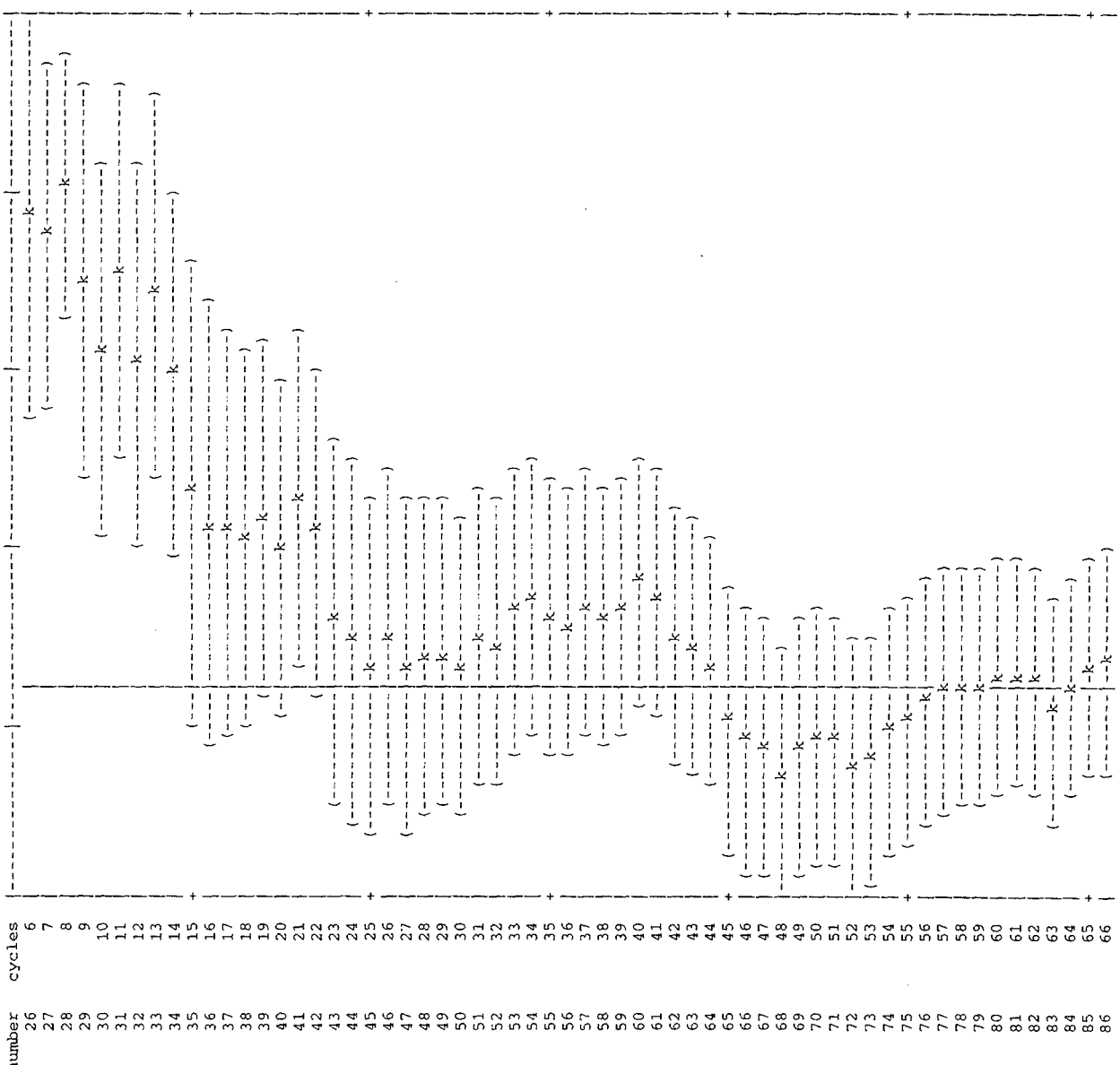
collision 1.09062 on cycle 28
absorption 1.07447 on cycle 24
track length 1.09362 on cycle 29

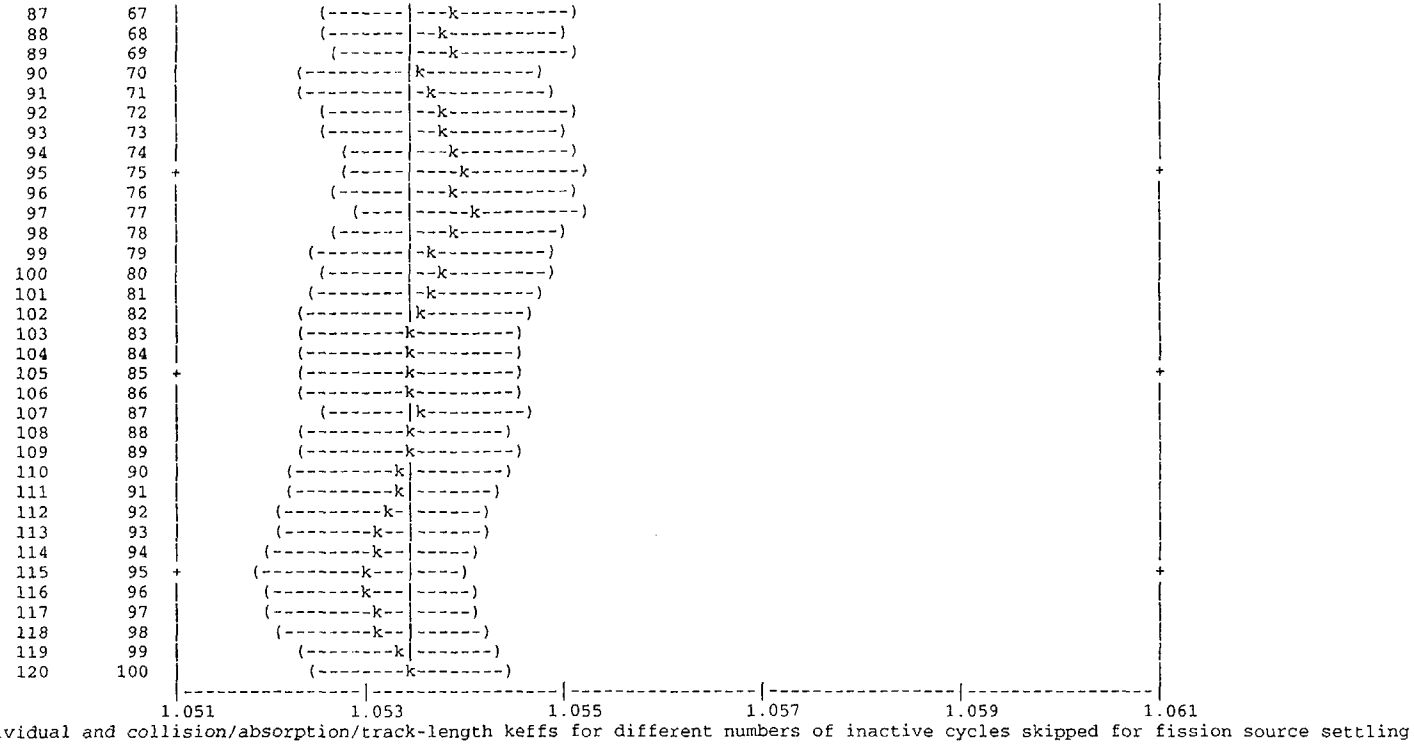
the smallest active cycle keffs by estimator are:

collision 1.01164 on cycle 108
absorption 1.02739 on cycle 65
track length 1.01044 on cycle 22

1plot of the estimated col/abs/track-length keff one standard deviation interval versus cycle number (| = final keff = 1.05346)

cycle active 1.051 1.053 1.055 1.057 1.059 1.061


number
cycles



1individual and collision/absorption/track-length keffs for different numbers of inactive cycles skipped for fission source settling

skip cycles	active cycles	active neutrons	average keff estimators and deviations k(col)	st dev	k(abs)	st dev	k(trk)	st dev	normality co/ab/tl	average k(c/a/t)	st dev	k(c/a/t) confidence intervals 95% confidence	99% confidence
0	120	480514	1.0494	0.0015	1.0499	0.0014	1.0489	0.0019	no/no/95	1.04972	0.00139	1.04695-1.05249	1.04605-1.05339
1	119	476514	1.0494	0.0016	1.0495	0.0014	1.0489	0.0020	no/no/95	1.04954	0.00138	1.04678-1.05230	1.04588-1.05320
2	118	472303	1.0500	0.0015	1.0501	0.0013	1.0496	0.0019	95/no/95	1.05008	0.00128	1.04753-1.05262	1.04670-1.05345
3	117	468497	1.0503	0.0014	1.0504	0.0013	1.0499	0.0018	95/no/95	1.05038	0.00125	1.04789-1.05287	1.04708-1.05368
4	116	464327	1.0507	0.0014	1.0508	0.0012	1.0503	0.0018	95/95/95	1.05081	0.00118	1.04845-1.05317	1.04768-1.05394
5	115	460334	1.0511	0.0013	1.0512	0.0012	1.0507	0.0018	95/95/95	1.05122	0.00112	1.04899-1.05345	1.04827-1.05418
6	114	456390	1.0513	0.0013	1.0516	0.0011	1.0511	0.0017	95/95/95	1.05149	0.00109	1.04931-1.05366	1.04860-1.05438
7	113	452222	1.0515	0.0013	1.0519	0.0011	1.0516	0.0017	95/95/95	1.05177	0.00107	1.04964-1.05389	1.04895-1.05458
8	112	448228	1.0515	0.0013	1.0519	0.0011	1.0518	0.0017	95/95/95	1.05184	0.00107	1.04970-1.05398	1.04900-1.05468
9	111	444168	1.0517	0.0013	1.0521	0.0011	1.0520	0.0017	95/95/95	1.05199	0.00107	1.04985-1.05413	1.04916-1.05483
10	110	440134	1.0518	0.0014	1.0524	0.0011	1.0522	0.0017	95/95/95	1.05223	0.00106	1.05012-1.05434	1.04944-1.05503
11	109	436199	1.0519	0.0014	1.0524	0.0011	1.0522	0.0017	95/95/95	1.05228	0.00107	1.05016-1.05441	1.04947-1.05510
12	108	432234	1.0519	0.0014	1.0525	0.0011	1.0522	0.0018	95/95/95	1.05239	0.00107	1.05025-1.05452	1.04956-1.05522
13	107	428155	1.0522	0.0014	1.0528	0.0011	1.0524	0.0018	95/95/95	1.05264	0.00105	1.05055-1.05473	1.04987-1.05541
14	106	424239	1.0524	0.0014	1.0528	0.0011	1.0525	0.0018	95/95/95	1.05271	0.00106	1.05061-1.05481	1.04992-1.05550
15	105	420201	1.0524	0.0014	1.0528	0.0011	1.0527	0.0018	95/95/95	1.05273	0.00107	1.05061-1.05485	1.04992-1.05555
16	104	416245	1.0527	0.0014	1.0532	0.0011	1.0528	0.0018	95/95/95	1.05307	0.00102	1.05104-1.05510	1.05038-1.05576
17	103	412317	1.0528	0.0014	1.0532	0.0011	1.0529	0.0018	95/95/95	1.05310	0.00103	1.05105-1.05514	1.05039-1.05581
18	102	408295	1.0529	0.0014	1.0535	0.0010	1.0530	0.0018	95/99/95	1.05334	0.00101	1.05132-1.05535	1.05067-1.05601
19	101	404320	1.0532	0.0014	1.0536	0.0010	1.0531	0.0018	95/95/95	1.05354	0.00100	1.05155-1.05553	1.05090-1.05618

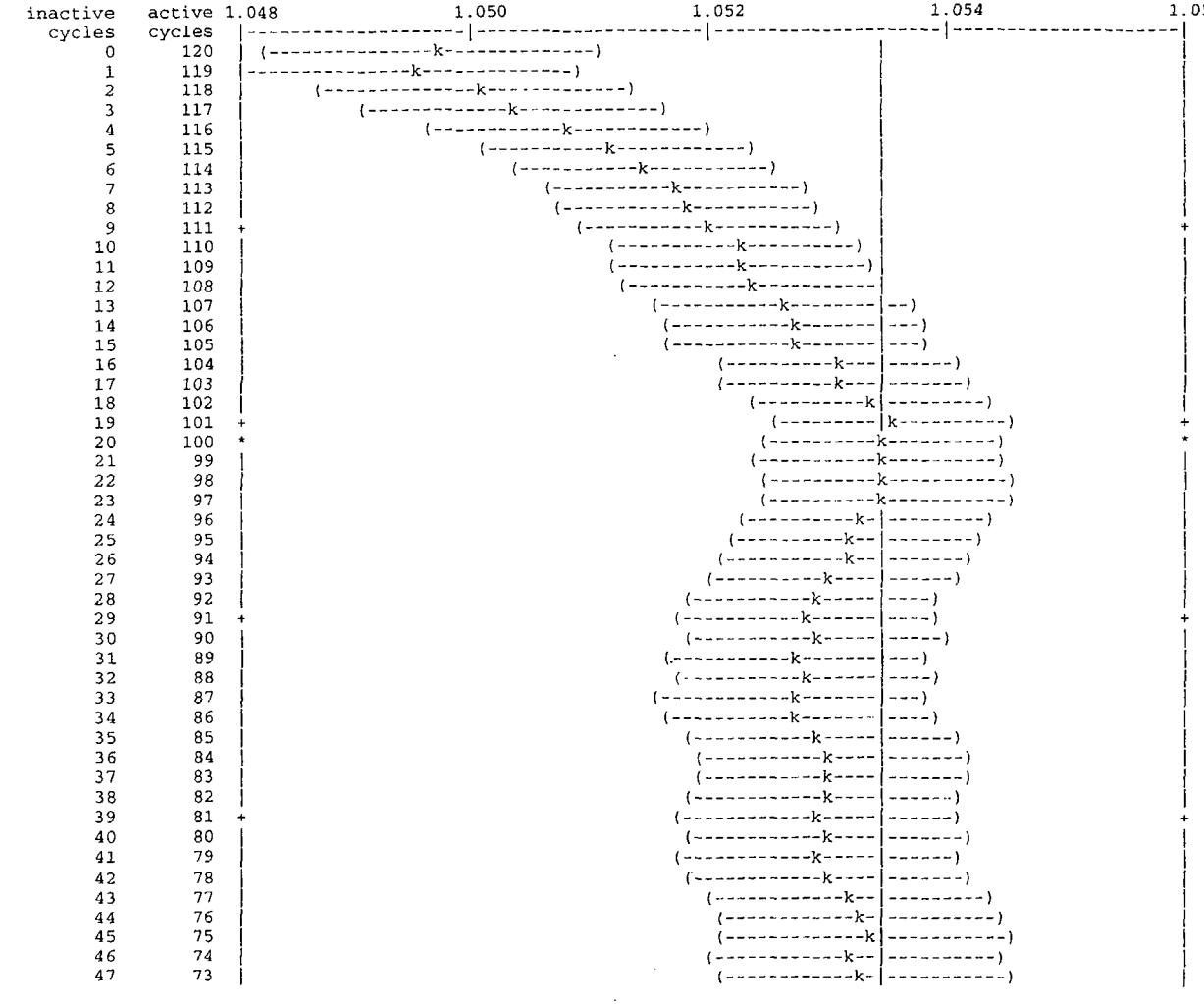
20	100*	400377	1.0531	0.0014	1.0535	0.0010	1.0529	0.0019	95/99/95	1.05346	0.00101	1.05145-1.05546	1.05080-1.05611
22	98	392058	1.0533	0.0014	1.0535	0.0011	1.0533	0.0018	95/99/95	1.05347	0.00102	1.05143-1.05551	1.05077-1.05617
24	96	384093	1.0532	0.0014	1.0533	0.0011	1.0529	0.0018	95/99/95	1.05330	0.00103	1.05125-1.05535	1.05058-1.05601
26	94	376155	1.0532	0.0014	1.0531	0.0011	1.0528	0.0019	95/99/95	1.05315	0.00105	1.05106-1.05523	1.05038-1.05591
28	92	368203	1.0527	0.0014	1.0529	0.0011	1.0521	0.0018	95/99/95	1.05287	0.00105	1.05077-1.05496	1.05009-1.05565
30	90	360211	1.0527	0.0014	1.0530	0.0011	1.0520	0.0018	95/99/95	1.05288	0.00107	1.05074-1.05502	1.05005-1.05572
32	88	352247	1.0527	0.0014	1.0528	0.0011	1.0519	0.0018	95/99/95	1.05279	0.00109	1.05062-1.05495	1.04992-1.05566
34	86	344320	1.0527	0.0014	1.0528	0.0011	1.0520	0.0019	95/99/95	1.05276	0.00110	1.05056-1.05495	1.04984-1.05567
36	84	336397	1.0530	0.0014	1.0530	0.0012	1.0522	0.0019	95/99/95	1.05301	0.00111	1.05079-1.05523	1.05007-1.05595
38	82	328286	1.0528	0.0015	1.0531	0.0012	1.0520	0.0019	95/99/95	1.05298	0.00114	1.05071-1.05525	1.04996-1.05599
40	80	320313	1.0526	0.0015	1.0532	0.0012	1.0522	0.0019	95/95/95	1.05300	0.00116	1.05069-1.05530	1.04994-1.05606
42	78	312356	1.0526	0.0015	1.0531	0.0012	1.0524	0.0020	95/95/95	1.05297	0.00118	1.05062-1.05531	1.04986-1.05608
44	76	304344	1.0529	0.0015	1.0533	0.0012	1.0521	0.0020	95/95/95	1.05327	0.00119	1.05090-1.05564	1.05012-1.05641
46	74	296177	1.0528	0.0016	1.0533	0.0013	1.0521	0.0020	95/95/95	1.05321	0.00121	1.05079-1.05563	1.04999-1.05642
48	72	288154	1.0526	0.0016	1.0535	0.0013	1.0518	0.0021	95/95/95	1.05329	0.00125	1.05080-1.05577	1.04998-1.05659
50	70	280272	1.0529	0.0016	1.0534	0.0013	1.0518	0.0021	95/95/95	1.05333	0.00128	1.05077-1.05588	1.04993-1.05672
52	68	272115	1.0525	0.0017	1.0533	0.0013	1.0512	0.0021	95/95/95	1.05307	0.00130	1.05046-1.05567	1.04960-1.05653
54	66	264208	1.0525	0.0017	1.0529	0.0013	1.0511	0.0022	95/95/95	1.05279	0.00132	1.05014-1.05544	1.04927-1.05631
56	64	256199	1.0526	0.0017	1.0530	0.0014	1.0517	0.0022	95/95/95	1.05293	0.00136	1.05021-1.05564	1.04932-1.05653
58	62	248127	1.0529	0.0018	1.0529	0.0014	1.0518	0.0023	95/95/95	1.05287	0.00139	1.05008-1.05565	1.04916-1.05657
60	60	240186	1.0527	0.0018	1.0526	0.0014	1.0518	0.0023	95/95/95	1.05259	0.00142	1.04975-1.05542	1.04881-1.05636
62	58	232245	1.0534	0.0018	1.0529	0.0015	1.0529	0.0023	95/95/95	1.05301	0.00142	1.05016-1.05586	1.04922-1.05680
64	56	224245	1.0537	0.0019	1.0531	0.0015	1.0530	0.0023	95/95/95	1.05322	0.00147	1.05028-1.05617	1.04930-1.05715
66	54	216208	1.0541	0.0019	1.0538	0.0015	1.0532	0.0024	95/95/95	1.05386	0.00144	1.05096-1.05676	1.05000-1.05773
68	52	208167	1.0547	0.0019	1.0541	0.0015	1.0538	0.0024	95/95/95	1.05427	0.00145	1.05135-1.05720	1.05038-1.05817
70	50	200006	1.0542	0.0020	1.0539	0.0015	1.0537	0.0025	95/99/95	1.05399	0.00149	1.05100-1.05698	1.05000-1.05798
72	48	192061	1.0545	0.0020	1.0543	0.0016	1.0537	0.0026	95/99/95	1.05444	0.00150	1.05143-1.05746	1.05042-1.05846
74	46	184108	1.0543	0.0020	1.0538	0.0016	1.0530	0.0026	95/99/95	1.05405	0.00153	1.05097-1.05713	1.04993-1.05816
76	44	176015	1.0540	0.0021	1.0534	0.0016	1.0523	0.0026	95/99/95	1.05359	0.00158	1.05040-1.05678	1.04933-1.05785
78	42	168002	1.0538	0.0021	1.0531	0.0017	1.0519	0.0027	95/95/95	1.05333	0.00165	1.04999-1.05667	1.04886-1.05781
80	40	159934	1.0528	0.0021	1.0532	0.0017	1.0506	0.0026	95/95/95	1.05308	0.00173	1.04957-1.05658	1.04838-1.05777
82	38	152113	1.0525	0.0022	1.0534	0.0018	1.0504	0.0028	95/99/95	1.05309	0.00182	1.04940-1.05679	1.04813-1.05805
84	36	144229	1.0525	0.0023	1.0535	0.0018	1.0507	0.0029	95/95/95	1.05320	0.00177	1.04959-1.05681	1.04835-1.05804
86	34	136253	1.0524	0.0024	1.0528	0.0018	1.0505	0.0030	95/95/95	1.05267	0.00182	1.04897-1.05638	1.04768-1.05767
88	32	128240	1.0519	0.0025	1.0529	0.0019	1.0506	0.0031	95/95/95	1.05271	0.00191	1.04881-1.05661	1.04746-1.05797
90	30	120177	1.0518	0.0024	1.0534	0.0018	1.0502	0.0030	95/95/95	1.05292	0.00183	1.04916-1.05668	1.04785-1.05799
92	28	112280	1.0513	0.0025	1.0527	0.0019	1.0496	0.0031	95/95/95	1.05237	0.00189	1.04848-1.05626	1.04710-1.05764
94	26	104321	1.0506	0.0026	1.0524	0.0020	1.0490	0.0033	95/95/95	1.05194	0.00200	1.04781-1.05607	1.04633-1.05754
96	24	96234	1.0499	0.0028	1.0526	0.0022	1.0487	0.0036	95/95/95	1.05186	0.00215	1.04739-1.05634	1.04577-1.05796
98	22	88268	1.0501	0.0028	1.0524	0.0022	1.0498	0.0038	99/95/95	1.05164	0.00209	1.04728-1.05601	1.04568-1.05761
100	20	80380	1.0494	0.0029	1.0531	0.0023	1.0481	0.0039	99/95/95	1.05221	0.00217	1.04764-1.05678	1.04593-1.05849
102	18	72334	1.0499	0.0032	1.0539	0.0024	1.0481	0.0043	99/95/95	1.05320	0.00233	1.04822-1.05818	1.04632-1.06008
104	16	64191	1.0505	0.0036	1.0543	0.0027	1.0496	0.0046	95/95/95	1.05361	0.00253	1.04813-1.05908	1.04597-1.06124
106	14	56122	1.0501	0.0041	1.0539	0.0031	1.0488	0.0051	95/95/95	1.05339	0.00294	1.04691-1.05987	1.04425-1.06254
108	12	47995	1.0514	0.0027	1.0544	0.0034	1.0492	0.0043	95/95/95	1.05334	0.00233	1.04806-1.05862	1.04576-1.06092
110	10	40023	1.0503	0.0032	1.0553	0.0035	1.0471	0.0045	99/95/95	1.05370	0.00311	1.04633-1.06107	1.04280-1.06460
112	8	32082	1.0514	0.0038	1.0575	0.0040	1.0487	0.0055	95/95/95	1.05508	0.00366	1.04566-1.06449	1.04030-1.06985
114	6	24179	1.0522	0.0052	1.0608	0.0047	1.0485	0.0076	95/99/95	1.05849	0.00478	1.04329-1.07369	1.03060-1.08639
116	4	16155	1.0546	0.0074	1.0653	0.0019	1.0494	0.0119	95/95/95	1.06571	0.00339	1.02266-1.10877	0.85005-1.28138
117	3	12138	1.0580	0.0093	1.0670	0.0013	1.0567	0.0133					
118	2	8201	1.0656	0.0091	1.0664	0.0021	1.0687	0.0099					

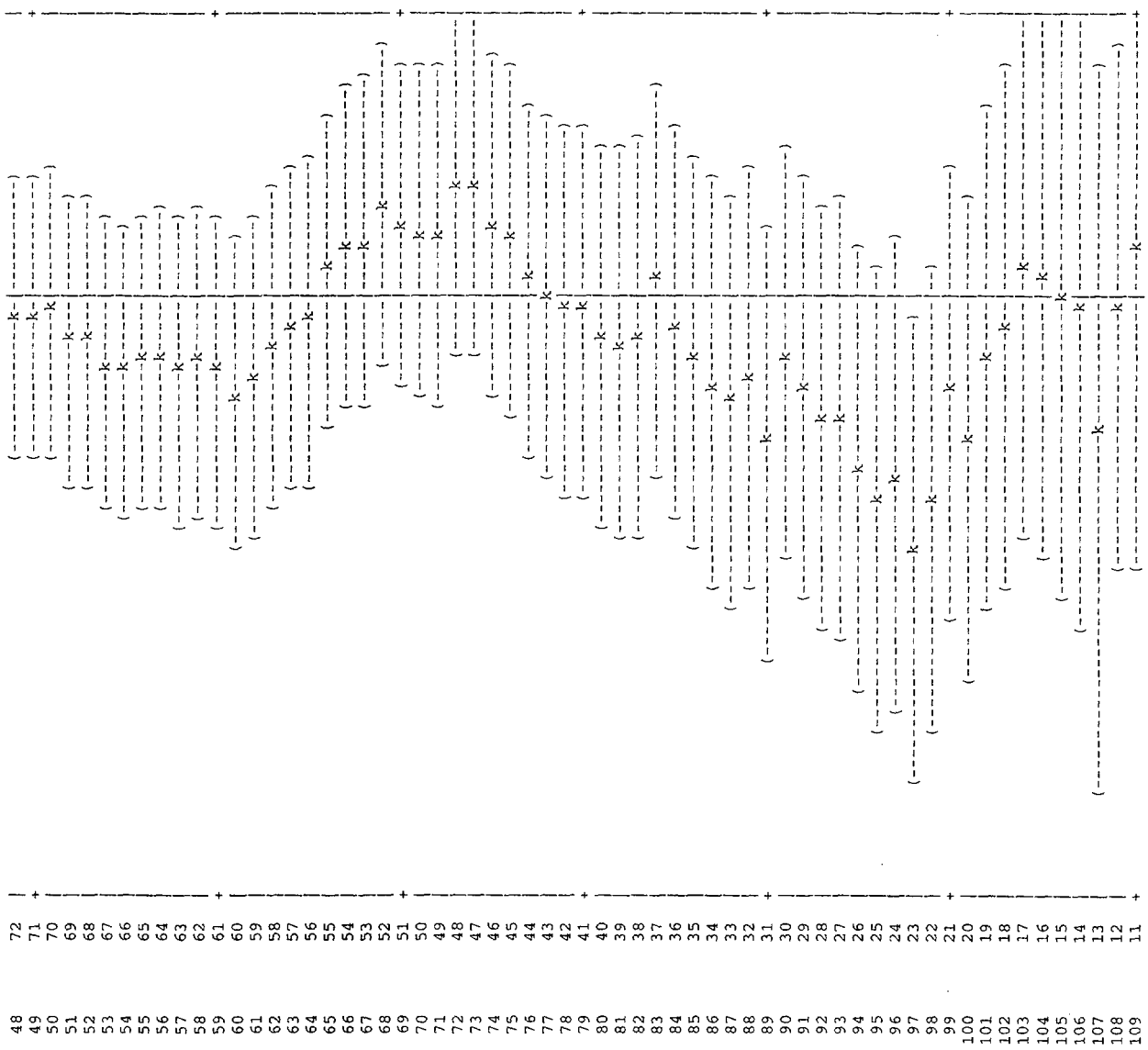
the minimum estimated standard deviation for the col/abs/tl keff estimator occurs with 19 inactive cycles and 101 active cycles.

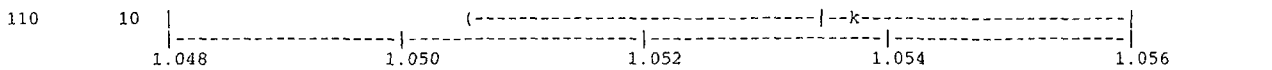
the first active half of the problem skips 20 cycles and uses 50 active cycles; the second half skips 70 and uses 50 cycles.
the col/abs/trk-len keff, one standard deviation, and 68, 95, and 99 percent intervals for each active half of the problem are:

problem	keff	standard deviation	68% confidence	95% confidence	99% confidence
first half	1.05292	0.00141	1.05151 to 1.05434	1.05010 to 1.05575	1.04915 to 1.05670
second half	1.05399	0.00149	1.05250 to 1.05549	1.05100 to 1.05698	1.05000 to 1.05798
final result	1.05346	0.00101	1.05245 to 1.05446	1.05145 to 1.05546	1.05080 to 1.05611

the first and second half values of k(collision/absorption/track length) appear to be the same at the 68 percent confidence level.
1plot of the estimated col/abs/track-length keff one standard deviation interval by active cycle number (| = final keff = 1.05346)





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************************************************************************************************************************
dump no.     5 on file 10col3r      nps =     480514     coll =       20865595     ctm =   46.29     nrn =      328420724

        2 warning messages so far.

run terminated when    120 kcode cycles were done.

computer time =    46.31 minutes

mcnp      version 4a     10/01/93                    03/19/01 17:59:57                  probid =    03/19/01 17:13:38
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