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# ORALLOY (93.2 $^{235}$U) BARE METAL ANNULI AND DISKS

**IDENTIFICATION NUMBER:** HEU-MET-FAST-074

**KEY WORDS:** annuli, bare, critical experiment, fast-spectrum, highly enriched, metal, oralloy, uranium

## 1.0 DETAILED DESCRIPTION

### 1.1 Overview of Experiment

A multitude of critical experiments with highly enriched uranium metal were conducted in the 1960s and 1970s at the Oak Ridge Critical Experiments Facility (ORCEF) in support of criticality safety operations at the Y-12 Plant. These experiments served to evaluate the storage, casting, and handling limits for the Y-12 Plant while also providing data for verification of different calculation methods and associated cross-sections for nuclear criticality safety applications. These included both solid cylinders and annuli of various diameters, interacting cylinders of various diameters, parallelepipeds, and reflected cylinders and annuli. The experiments described here involve a series of delayed critical stacks of bare oralloy[a] HEU annuli and disks.

Three of these experiments consist of stacking bare HEU annuli of varying diameters to obtain critical configurations. These annuli have nominal inner and outer diameters (ID/OD) including: 7 inches (″) ID – 9″ OD, 9″ ID – 11″ OD, 11″ ID – 13″ OD, and 13″ ID – 15″ OD. The nominal heights range from 0.125″ to 1.5″. The three experiments themselves range from 7″ – 13″, 7″ – 15″, and 9″ – 15″ in diameter, respectively. The fourth experiment[b] ranges from 7″ – 11″, and along with different annuli, it also includes an 11″ disk and several 7″ diameter disks. All four delayed critical experiments were configured and evaluated by J. T. Mihalczo, J. J. Lynn, and D. E. McCarty from December of 1962 to February 1963 with additional information in their corresponding logbook.[c]

Other experiments were performed in the 1960s at the ORCEF using many of the same highly enriched uranium metal parts. These experiments are characterized as the following: potassium-filled annuli (HEU-MET-FAST-045), bare cylinders (HEU-MET-FAST-051), beryllium-filled annuli (HEU-MET-FAST-059), beryllium-reflected cylinders (HEU-MET-FAST-069), thin-graphite-reflected annuli (HEU-MET-FAST-071), bare annuli (this evaluation), polyethylene-reflected annuli and cylinders (HEU-MET-FAST-076), GROTESQUE (HEU-MET-FAST-081), complex annuli (HEU-MET-FAST-084), and ORSphere (HEU-MET-FAST-100).

This evaluation includes both detailed and simplified model specifications.

### 1.2 Description of Experimental Configuration

[a] Oralloy stands for Oak Ridge Alloy and consists of HEU metal with an $^{235}$U enrichment of 93%.
[b] This experiment is referred to in the logbook as the u-ring due to its shape.
[c] Experimental data for these experiments can be found on pages 13-34, 88-92, 114-122, and 129-134 in logbook 12 R (East Cell – Logbook 1, E-19).

These experiments were performed in the 35 x 35 x 30-feet (ft)-high East Cell of the ORCEF, and the uranium assembly was located approximately 11.7 ft from the 5-ft-thick concrete west wall, 12.7 ft from the 2-ft-thick concrete north wall, and 9.2 ft above the concrete floor.

The first experiment, with a 7″ ID and 13″ OD, consisted of four 7″ – 9″, four 9″ – 11″, and five 11″ – 13″, annuli stacked upon on a diaphragm support structure with two 7″ – 9″, two 9″ – 11″, and six 11″ – 13″ annuli below the diaphragm on a hydraulic support structure. The nominal stack height of the bottom annuli is 3 inches and the top annuli 2 5/8 inches.

The second experiment, with a 7″ ID and 15″ OD, consisted of four 7″ – 9″, three 9″ – 11″, four 11″ – 13″, and four 13″ – 15″ annuli stacked upon on a diaphragm support structure with three 7″ – 9″, three 9″ – 11″, three 11″ – 13″, and four 13″ – 15″ annuli below the diaphragm on a hydraulic support structure as shown in Figure 1.1(minus the support structure). The nominal stack height of the top and bottom annuli are 2.25 and 2 inches respectively.

The third experiment, with a 9″ ID and 15″ OD, consisted of four 9″ – 11″, nine 11″ – 13″, and eight 13″ – 15″ annuli stacked upon on a diaphragm support structure with three 9″ – 11″, three 11″ – 13″, and four 13″ – 15″ annuli below the diaphragm on a hydraulic support structure. The nominal top stack height of the 7″ – 9″ annuli is 3 7/8 inches and the other top annuli 3 15/16 inches. The bottom annuli have a stack height of 2 inches

The fourth experiment consisted of three 7″ – 9″and three 9″ – 11″ annuli stacked upon a diaphragm support structure. An 11″ diameter disc is placed atop this stack and upon it is one 7″ diameter disk, five 7″ – 9″ annuli, and five 11″ – 13″ annuli. There are three 7″ diameter disks, three 7″ – 9″ annuli, and three 11″ – 13″ annuli below the diaphragm on a hydraulic support structure. The nominal stack height of the bottom 7″ disks and annuli are 1 3/8 inches and 3 3/8 inches, respectively. The combined nominal stack height of the top 7″ and 11″ disks is 1 ½ inches and the annuli are 3 15/16 inches.

Detectors consisting of $BF_3$ gas filled and boron-lined ionization chambers were placed 10 to 15 feet away and used for reactor period measurements. The reactivity worth was obtained by using the difference in the two measurements; one without the change and the other with the change. The reactor period was then converted to reactivity using the inhour equation. A neutron source was initially near the assemblies for startup but then withdrawn about 4 feet away into a borated paraffin shield as measurements were performed. Measurements were performed at fission rates such that the neutron fluence coming out of the shield from the startup source was insignificant.[a] Figures 1.1 – 1.4 provide 3D cutaways of the four experiments. Tables 1.1 (a) – (d) lists the different annuli and disks used in the different experiments.

[a] Personal communication between John Bess and John T. Mihalczo, March 2010.

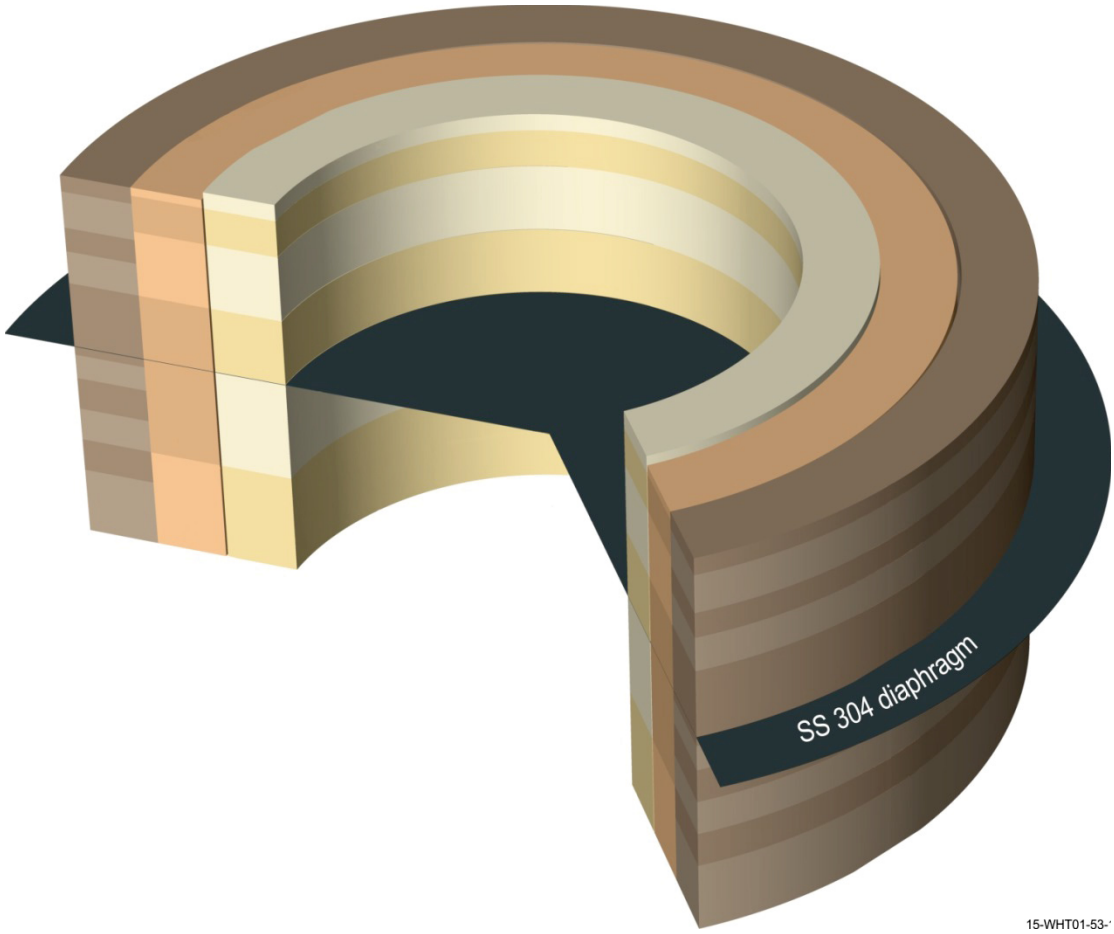


Figure 1.1. Bare Oralloy Metal Annuli Representing Experiment 1.

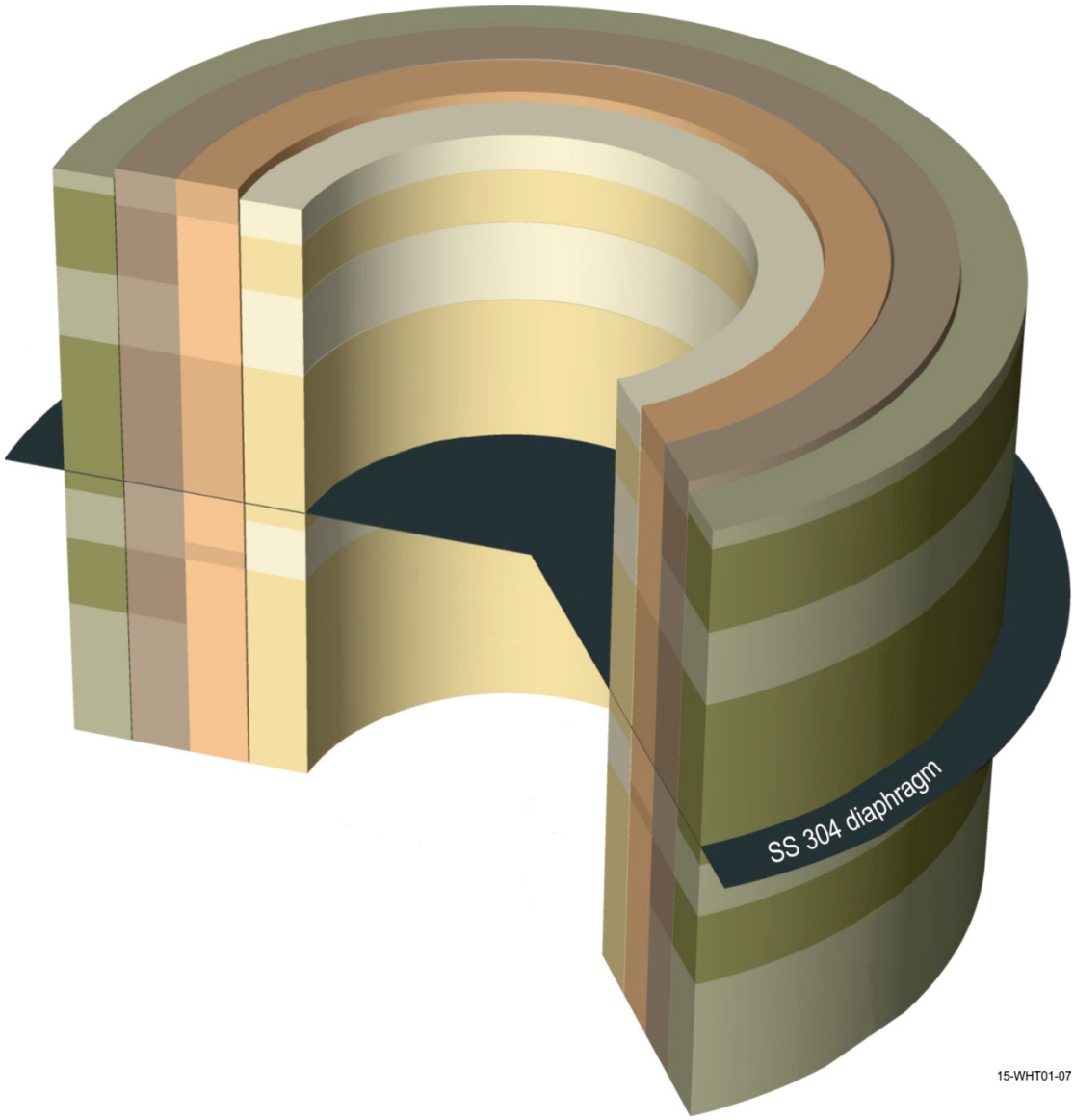


Figure 1.2. Bare Oralloy Metal Annuli Representing Experiment 2.

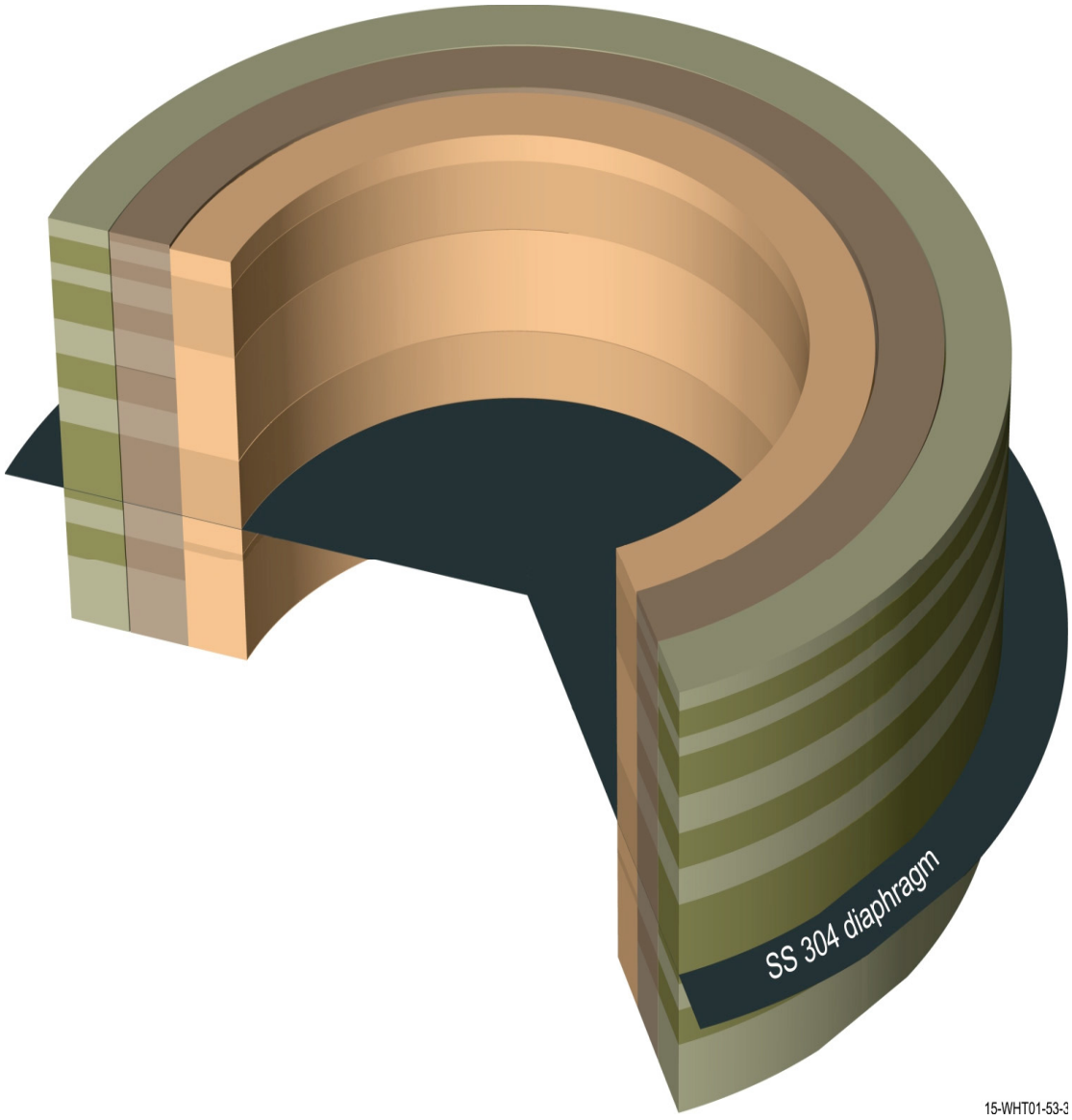


Figure 1.3. Bare Oralloy Metal Annuli and Disks Representing Experiment 3.

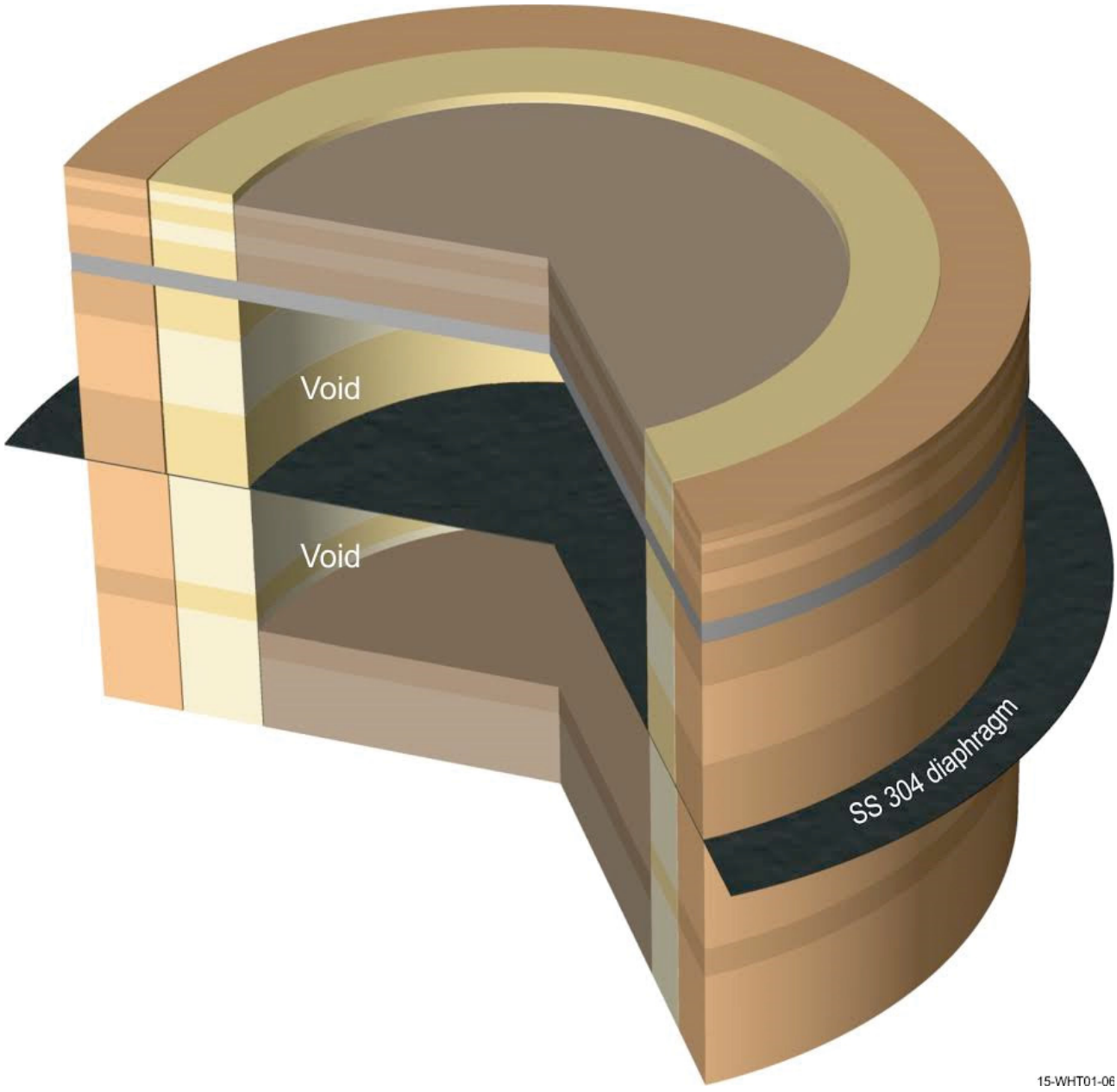


Figure 1.4. Bare Oralloy Metal Annuli and Disks Representing Experiment 4.

Table 1.1 (a). Uranium Annuli for Experiment 1 (in. = inch).

| **Configuration (1) 7″ – 13″** | **Part Number** | **Mass (g)** | **Height (in.)** | **Inner Diameter (in.)** | **Outer Diameter (in.)** |
|---|---|---|---|---|---|
| 11″ – 13″ (Upper) | 2756 | 11567 | 1.0002 | 11.0036 | 12.9967 |
| | 2751 | 5822 | 0.50355 | 11.0015 | 12.99575 |
| | 2749 | 4360 | 0.3774 | 11.003 | 12.9955 |
| | 2755 | 6514 | 0.5635 | 11.003 | 12.99595 |
| | 2782 | 2914 | 0.25175 | 11.0035 | 12.9956 |
| 9″ – 11″ (Upper) | 2745 | 9634 | 0.999 | 9.001 | 10.9965 |
| | 2776 | 9644 | 1.0015 | 9.0015 | 10.9965 |
| | 2767 | 5410 | 0.562 | 9.001 | 10.996 |
| | 2744 | 1223 | 0.12675 | 9.0065 | 10.99675 |
| 7″ – 9″ (Upper) | 2762 | 7703 | 0.99925 | 7.00375 | 8.99625 |
| | 2738 | 7710 | 1.0012 | 7.00375 | 8.99575 |
| | 2737 | 4336 | 0.5625 | 7.0015 | 8.9965 |
| | 2774 | 1930 | 0.2500 | 7.0030 | 8.99650 |
| 11″ – 13″ (Lower) | 2757 | 11575 | 1.00155 | 11.0025 | 12.996 |
| | 2752 | 5811 | 0.50325 | 11.0025 | 12.9955 |
| | 2754 | 5826 | 0.5036 | 11.004 | 12.9953 |
| | 2753 | 5782 | 0.5013 | 11.003 | 12.99675 |
| | 2750 | 4336 | 0.37545 | 11.0015 | 12.9945 |
| | 2780 | 1440 | 0.12485 | 11.002 | 12.99605 |
| 9″ – 11″ (Lower) | 2748 | 14462 | 1.5 | 9.0025 | 10.9975 |
| | 2747 | 14436 | 1.4999 | 9.002 | 10.99675 |
| 7″ – 9″ (Lower) | 2741 | 11568 | 1.5003 | 7.0025 | 8.9965 |
| | 2740 | 11568 | 1.5 | 7.0025 | 8.99625 |

Table 1.1 (b). Uranium Annuli for Experiment 2 (in. = inch).

| **Configuration (2) 7″ – 15″** | **Part Number** | **Mass (g)** | **Height (in.)** | **Inner Diameter (in.)** | **Outer Diameter (in.)** |
|---|---|---|---|---|---|
| 13″ – 15″ (Upper) | 2739 | 13461 | 0.9945 | 13.0027 | 14.9955 |
| | 2760 | 6743 | 0.5 | 13.002 | 14.995 |
| | 2766 | 7605 | 0.563 | 13.001 | 14.9965 |
| | 2758 | 1685 | 0.1245 | 12.9965 | 14.99665 |
| | 2757 | 11575 | 1.00155 | 11.0025 | 12.996 |

| | | | | | |
|---|---|---|---|---|---|
| 11″ – 13″ (Upper | 2752 | 5811 | 0.50325 | 11.0025 | 12.9955 |
| | 2753 | 5782 | 0.5013 | 11.003 | 12.99675 |
| | 2782 | 2914 | 0.25175 | 11.0035 | 12.9956 |
| 9″ – 11″ (Upper) | 2776 | 9644 | 1.0015 | 9.0015 | 10.9965 |
| | 2745 | 9634 | 0.999 | 9.001 | 10.9965 |
| | 2779 | 2417 | 0.251 | 9.0015 | 10.997 |
| 7″ – 9″ (Upper) | 2738 | 7710 | 1.0012 | 7.00375 | 8.99575 |
| | 2737 | 4336 | 0.5625 | 7.0015 | 8.9965 |
| | 2736 | 2895 | 0.37635 | 7.0026 | 8.996 |
| | 2775 | 1917 | 0.2485 | 7.0040 | 8.99675 |
| 13″ – 15″ (Lower) | 2735 | 13409 | 0.9985 | 13.002 | 14.9935 |
| | 2848 | 6748 | 0.5019 | 13.0031 | 14.9964 |
| | 2785 | 5043 | 0.3747 | 13.00285 | 14.99575 |
| | 2761 | 1706 | 0.1265 | 13.001 | 14.99475 |
| 11″ – 13″ (Lower) | 2756 | 11567 | 1.0002 | 11.0036 | 12.9967 |
| | 2754 | 5826 | 0.5036 | 11.004 | 12.9953 |
| | 2751 | 5822 | 0.50355 | 11.0015 | 12.99575 |
| 9″ – 11″ (Lower) | 2748 | 14462 | 1.5 | 9.0025 | 10.9975 |
| | 2746 | 1238 | 0.12865 | 9.00175 | 10.9965 |
| | 2742 | 3617 | 0.3751 | 9.0015 | 10.99675 |
| 7″ – 9″ (Lower) | 2740 | 11568 | 1.5 | 7.0025 | 8.99625 |
| | 2829 | 2895 | 0.37625 | 7.00315 | 8.99625 |
| | 2773 | 962 | 0.1260 | 7.0015 | 8.99700 |

Table 1.1 (c). Uranium Annuli for Experiment 3 (in. = inch).

| **Configuration (3) 9″ – 15″** | **Part Number** | **Mass (g)** | **Height (in.)** | **Inner Diameter (in.)** | **Outer Diameter (in.)** |
|---|---|---|---|---|---|
| 13″ – 15″ (Upper) | 2739 | 13461 | 0.9945 | 13.0027 | 14.9955 |
| | 2786 | 6717 | 0.49465 | 13.0025 | 14.9950 |
| | 2760 | 6743 | 0.5 | 13.002 | 14.995 |
| | 2787 | 6788 | 0.5044 | 13.0015 | 14.995 |
| | 2766 | 7605 | 0.563 | 13.001 | 14.9965 |
| | 2886 | 3384 | 0.25145 | 13.0025 | 14.9966 |
| | 2784 | 5039 | 0.3725 | 13.0015 | 14.9945 |
| | 2885 | 5043 | 0.3747 | 13.00285 | 14.99575 |

| | | | | | |
|---|---|---|---|---|---|
| 11″ – 13″ (Upper) | 2757 | 11575 | 1.00155 | 11.0025 | 12.996 |
| | 2752 | 5811 | 0.50325 | 11.0025 | 12.9955 |
| | 2753 | 5782 | 0.5013 | 11.003 | 12.99675 |
| | 2755 | 6514 | 0.5635 | 11.003 | 12.99595 |
| | 2749 | 4360 | 0.3774 | 11.003 | 12.9955 |
| | 2750 | 4336 | 0.37545 | 11.0015 | 12.9945 |
| | 2783 | 2888 | 0.25075 | 11.003 | 12.9956 |
| | 2782 | 2914 | 0.25175 | 11.0035 | 12.9956 |
| | 2780 | 1440 | 0.12485 | 11.002 | 12.99605 |
| 9″ – 11″ (Upper) | 2776 | 9644 | 1.0015 | 9.0015 | 10.9965 |
| | 2747 | 14436 | 1.4999 | 9.002 | 10.99675 |
| | 2745 | 9634 | 0.999 | 9.001 | 10.9965 |
| | 2743 | 3621 | 0.374 | 9.0025 | 10.9965 |
| 13″ – 15″ (Lower) | 2735 | 13409 | 0.9985 | 13.002 | 14.9935 |
| | 2848 | 6748 | 0.5019 | 13.0031 | 14.9964 |
| | 2785 | 5043 | 0.3747 | 13.00285 | 14.99575 |
| | 2761 | 1706 | 0.1265 | 13.001 | 14.99475 |
| 11″ – 13″ (Lower) | 2756 | 11567 | 1.0002 | 11.0036 | 12.9967 |
| | 2754 | 5826 | 0.5036 | 11.004 | 12.9953 |
| | 2751 | 5822 | 0.50355 | 11.0015 | 12.99575 |
| 9″ – 11″ (Lower) | 2748 | 14462 | 1.5 | 9.0025 | 10.9975 |
| | 2746 | 1238 | 0.12865 | 9.00175 | 10.9965 |
| | 2742 | 3617 | 0.3751 | 9.0015 | 10.99675 |

Table 1.1 (d). Uranium Annuli and Disks for Experiment 4 (in. = inch).

| **Configuration (4) 7″ – 11″** | **Part Number** | **Mass (g)** | **Height (in.)** | **Inner Diameter (in.)** | **Outer Diameter (in.)** |
|---|---|---|---|---|---|
| 9″ – 11″ (Upper) | 2745 | 9634 | 0.999 | 9.001 | 10.9965 |
| | 2776 | 9644 | 1.0015 | 9.0015 | 10.9965 |
| | 2767 | 5410 | 0.562 | 9.001 | 10.996 |
| | 2743 | 3621 | 0.374 | 9.0025 | 10.9965 |
| | 2778 | 2411 | 0.2510 | 9.0020 | 10.9965 |

| | | | | | |
|---|---|---|---|---|---|
| | 2779 | 14462 | 1.5 | 9.0025 | 10.9975 |
| | 2746[a] | 1223 | 0.12675 | 9.0065 | 10.99675 |
| | 2746 | 1238 | 0.12865 | 9.00175 | 10.9965 |
| 7″ – 9″ (Upper) | 2762 | 7703 | 0.99925 | 7.00375 | 8.99625 |
| | 2738 | 7710 | 1.0012 | 7.00375 | 8.99575 |
| | 2737 | 4336 | 0.5625 | 7.0015 | 8.9965 |
| | 2736 | 2895 | 0.37635 | 7.0026 | 8.996 |
| | 2775 | 1917 | 0.2485 | 7.0040 | 8.99675 |
| | 2774 | 1930 | 0.2500 | 7.0030 | 8.99650 |
| | 2773 | 962 | 0.1260 | 7.0015 | 8.99700 |
| | 2763 | 953 | 0.1243 | 7.0038 | 8.9958 |
| 7″ & 11″ Disks (Upper) | 2803 (11″) | 7220 | 0.24725 | - | 10.9965 |
| | 2732 (7″) | 11814 | 1.00125 | - | 6.996 |
| 9″ – 11″ (Lower) | 2747 | 14436 | 1.4999 | 9.002 | 10.99675 |
| | 2742 | 3617 | 0.3751 | 9.0015 | 10.99675 |
| | 2748 | 14462 | 1.5 | 9.0025 | 10.9975 |
| 7″ – 9″ (Lower) | 2740 | 11568 | 1.5 | 7.0025 | 8.99625 |
| | 2829 | 2895 | 0.37625 | 7.00315 | 8.99625 |
| | 2741 | 11568 | 1.5003 | 7.0025 | 8.9965 |
| 7″ Disks (Lower) | 2770 | 2955 | 0.25025 | - | 6.9957 |
| | 2731 | 11841 | 1.0027 | - | 6.9965 |
| | 2769 | 1495 | 0.1265 | - | 6.9965 |

**1.2.1 General Assembly Procedure –** These experiments were each constructed on a vertical assembly machine as seen in Figure 1.5. This consisted primarily of a hydraulic lift (22-inch vertical motion) to support the lower section and a stationary upper section (the upper support shown in Figure 1.5 was not used in these experiments).

For these unreflected experiments (i.e., no significant amounts of reflector material were purposely placed around the periphery of the experiments), the uranium metal of the lower section was held in place by the lower support stand. This lower section was supported on 0.125-inch-thick aluminum edges, oriented vertically 120 degrees apart (visible in Figure 1.6). The upper section was supported by four vertical posts, which held a low-mass support consisting of two 30-inch-ID, 2-inch wide, 0.5-inch-thick, aluminum clamping rings bolted together and supported off vertical poles by aluminum tubing (visible in Figure 1.6).

[a] Part 2746 is listed, but the correct values are for part 2744.

Note that Figure 1.6 shows an unreflected uranium metal cylinder assembly, but these unreflected uranium metal annuli/disk critical experiments were assembled on the same vertical lift with the same support structure as shown in this figure. The 30-inch-diameter clamping rings held a 0.010-inch-thick stainless steel (304L) diaphragm on which the upper uranium metal section was supported. The lower section was supported on a low-mass support stand (sometimes referred to as a support tower) mounted in the vertical position and also shown in Figure 1.6. The 0.5-inch-thick, 18-inch-diameter aluminum base of this support stand was bolted to the 1-inch-thick, 18-inch-diameter stainless steel table of the vertical lift as shown in Figure 1.6. The lower surface of the uranium was at a height of 36 inches above the aluminum base. Small aluminum pieces bolted to the 120° vertical members restrained lateral motion of the lower section. These low mass supports were used to minimize the reflection effects of the support structure. The aluminum base of the support stand is type Al6061 and the stainless steel table is type 304L.[a] Additional structural detail for the lower support stand and diaphragm clamping ring are given in Appendix B.

Experiments were assembled by mounting a fixed height of uranium metal annuli and disks on the lower section, after which different uranium parts were added to the upper section until near delayed criticality was achieved. For these experiments, the lower section was then raised until it made contact with the diaphragm and actually slightly lifted the upper section of material mounted on the diaphragm. The slight lifting of the top section by the bottom section was used to compensate for the sag of the diaphragm due to the weight of the upper material. The lifting of the diaphragm was monitored to the nearest 0.001 inches and the lower section was moved up only until the diaphragm was level. Due to the thickness of the smallest uranium parts, the system could rarely be adjusted to exactly delayed criticality. For most assemblies the uranium mass of the upper section was adjusted until a self-sustaining fission chain reaction occurred with a measurable positive stable reactor period. For assemblies that were slightly subcritical, an additional hydrogenous reflector (small piece of Plexiglas) was added as a reflector to achieve a self-sustaining chain reaction. When the fission rate achieved a value from which a negative reactor period could be measured, the Plexiglas was quickly (within a fraction of a second)[b] removed to measure the resulting negative reactor period.

**1.2.2 Stack Height of Annuli and Discs –** Assembly heights at different angular locations for the experiments were typically measured to within ±0.001 inches by stacking them on a precision flat surface and measuring the distance between the upper surface of uranium and the precision flat surface. Multiple measurements were performed with all parts assembled in the same vertical order and orientation as that in the critical experiment, which stacked annuli azimuthally such that the part numbers were always oriented towards the north wall. The part numbers were scribed on the upper surface of the part. This operation presented no criticality safety problems in hand stacking since the annuli were only one-inch-thick radially.

For the experiments with uranium metal on the lower support stand, the heights were measured with the uranium on the lower support stand as the assemblies were disassembled. That is, for a 15-inch-OD cylinder, the height of the outer annulus (13-15 inches) was measured at several locations azimuthally. After the height measurements for this annular ring were made, the annular ring was removed from the support stand and the height of the 11-13 inch annular ring measured. This process continued until the height of the central stack was measured. The stack height was measured directly with the lower support table in the withdrawn position since the top and bottom of the stacks are accessible. The micrometer read out to 0.001 inches and was repeatable at any azimuthal location. The standard deviation associated with the averages of the azimuthal measurements provides the uncertainty in the thickness.[c]

[a] Personal communication between John D. Bess and John T. Mihalczo, February 2010.
[b] Personal communication between John D. Bess and John T. Mihalczo in HEU-MET-FAST-076, June 2006.
[c] Personal communication between John D. Bess and John T. Mihalczo, March 2010.

The series of stack height measurements recorded in the logbook are given in Table 1.2 (a) – (d). The average stack heights were calculated and reported in the original logbooks. The standard deviation has been calculated using the original data.

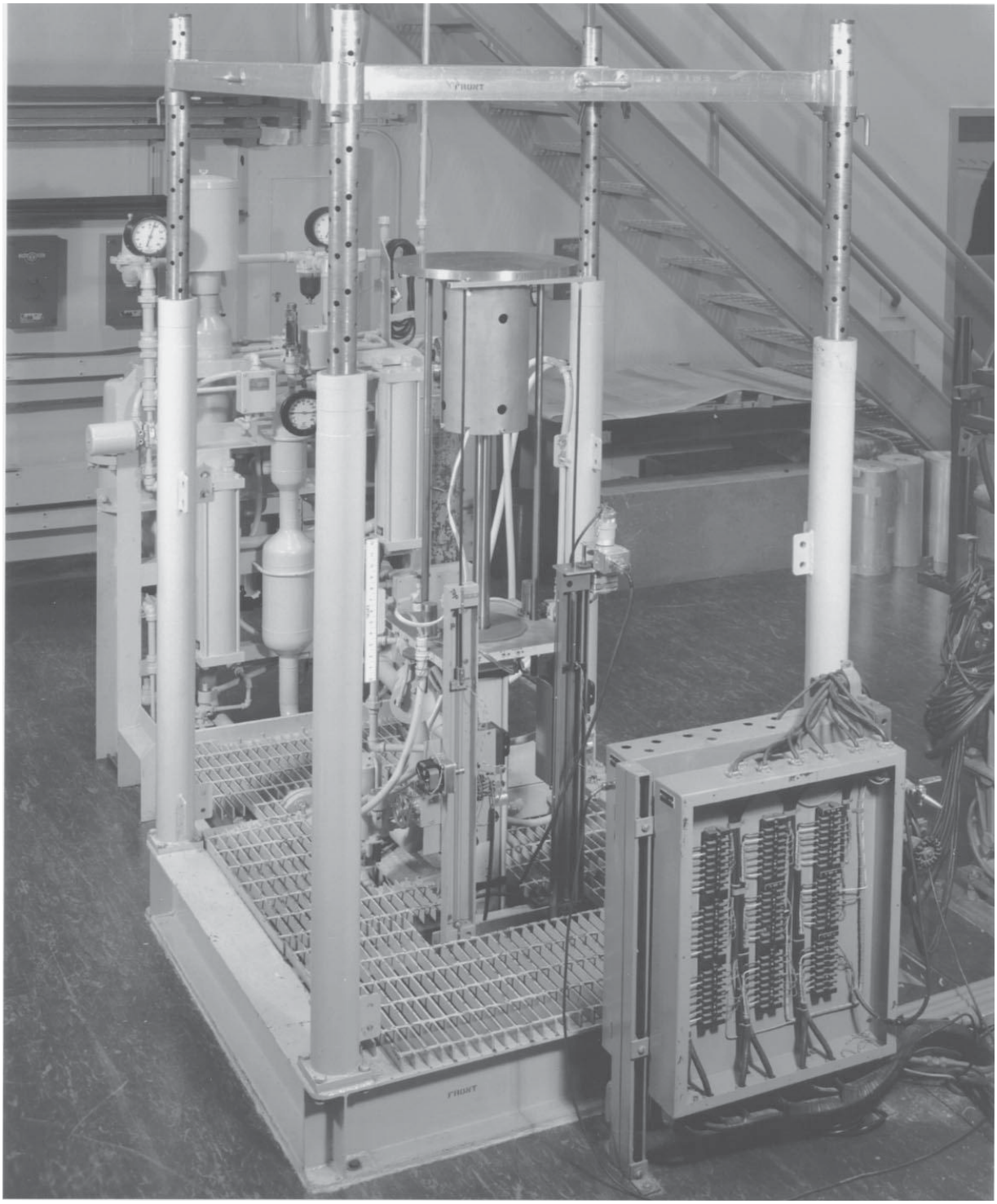

Figure 1.5. Photograph of the Vertical Assembly Machine with the Movable Table Up.
(The upper support shown in this photograph was not used in these measurements).

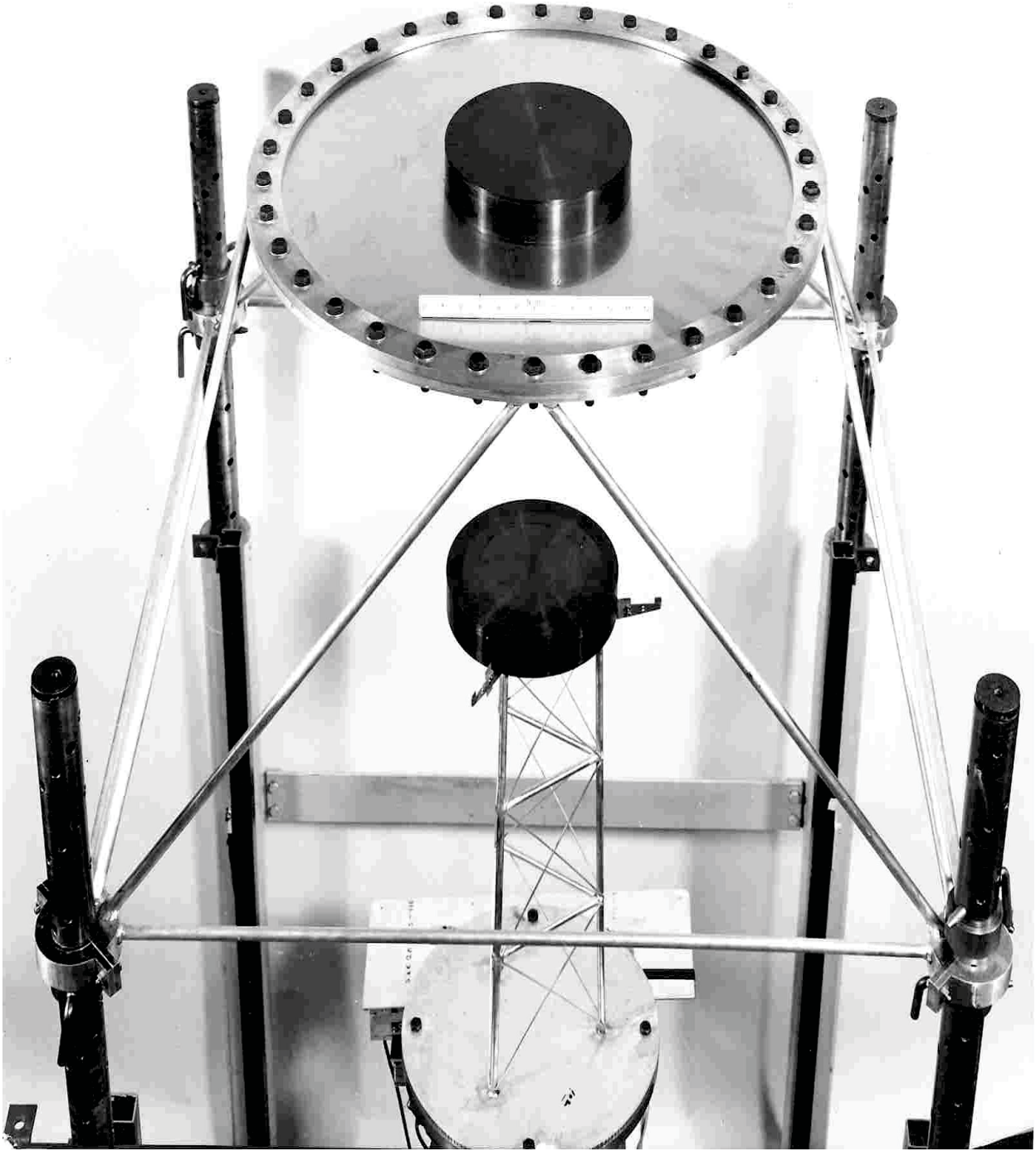

Figure 1.6. A Typical Uranium Metal Assembly of Two Interacting 11-inch –Diameter Cylinders on the Vertical Assembly Machine.[a]

[a] Photo 39380, Oak Ridge National Laboratory photo of a bare uranium assembly. This same support structure was used for internally Be moderated, unreflected uranium metal annuli and top-Be reflected experiments.

Table 1.2 (a). Logbook Stack Height Measurements (inches).

| **Experiment 1**<br>**7″ ID – 13″ OD**[a] | **11″ – 13″** | **9″ – 11″** | **7″ – 9″** |
|---|---|---|---|
| Top[b] | 2.696 | 2.690 | 2.614 |
| 1σ | 0.001 | 0.002 | 0.002 |
| | | | |
| Bottom | 3.010 | 3.005 | 3.005 |
| | 3.010 | 3.004 | 3.006 |
| | 3.009 | 3.000 | 3.002 |
| | 3.009 | 3.003 | 3.002 |
| | 3.008 | 3.005 | 3.001 |
| | 3.009 | 3.007 | 3.002 |
| | 3.010 | 3.005 | 3.002 |
| | 3.010 | 3.005 | - |
| Average[c] | 3.009 | 3.004 | 3.003 |
| 1σ[d] | 0.001 | 0.002 | 0.002 |
| | | | |
| Total[b] | 5.705 | 5.694 | 5.817 |

[a] Stack height measurements for bottom configuration were obtained on page 92 of logbook 12R (East Cell – Logbook 1, E-19).

[b] Measurements of the top stack were not found in the logbook, however, they can be derived from the total measurement heights that are reported in reference 1.

[c] Average values were determined by summing up the individual measurements and dividing by the total number of measurements. Section 1.2.2 describes the measuring procedure used.

[d] Standard deviations are calculated by summing the square of the difference between the measured values and the average value. This quantity is then divided by the total number of measurements taken and finaly the square root is computed.

Table 1.2 (b). Logbook Stack Height Measurements (inches).

| **Experiment 2** **7″ ID – 15″ OD**[a] | **13″ – 15″** | **11″ – 13″** | **9″ – 11″** | **7″ – 9″** |
|---|---|---|---|---|
| Top[a] | 2.193 | 2.261 | 2.253 | 2.191 |
| | 2.193 | 2.260 | 2.254 | 2.191 |
| | 2.194 | 2.261 | 2.253 | 2.191 |
| | 2.192 | 2.260 | 2.2535 | 2.191 |
| | 2.192 | 2.2595 | 2.253 | 2.190 |
| | 2.191 | 2.260 | 2.252 | 2.190 |
| | - | 2.260 | 2.2515 | - |
| Average | 2.193 | 2.260 | 2.253 | 2.191 |
| 1σ | 0.001 | 0.001 | 0.001 | 0.001 |
| | | | | |
| Bottom[a] | 2.005 | 2.006 | 2.003 | 2.005 |
| | 2.006 | 2.004 | 2.005 | 2.003 |
| | 2.007 | 2.005 | 2.006 | 2.004 |
| | 2.008 | 2.005 | 2.003 | 2.006 |
| | 2.007 | 2.006 | 2.003 | 2.004 |
| | 2.007 | 2.005 | 2.004 | 2.004 |
| | 2.006 | - | - | - |
| Average | 2.007 | 2.005 | 2.004 | 2.004 |
| 1σ | 0.001 | 0.001 | 0.001 | 0.001 |
| | | | | |
| Total[b] | 4.199 | 4.265 | 4.255 | 4.195 |

[a] Stack height measurements for top and bottom configurations were obtained on page 118 of logbook 12R (East Cell – Logbook 1, E-19).
[b] Total measurement heights reported in reference 1.

Table 1.2 (c). Logbook Stack Height Measurements (inches).

| **Experiment 3**<br>**9″ ID – 15″ OD** | **13″ – 15″** | **11″ – 13″** | **9″ – 11″** |
|---|---|---|---|
| Top[a] | 3.953 | 3.950 | 3.877 |
| | 3.955 | 3.954 | 3.878 |
| | 3.955 | 3.954 | 3.878 |
| | 3.954 | 3.952 | 3.877 |
| | 3.952 | 3.951 | 3.876 |
| | 3.956 | 3.951 | 3.876 |
| | 3.953 | 3.953 | 3.876 |
| Average | 3.954 | 3.952 | 3.877 |
| 1σ | 0.001 | 0.002 | 0.001 |
| | | | |
| Bottom[a] | 2.005 | 2.006 | 2.003 |
| | 2.006 | 2.004 | 2.005 |
| | 2.007 | 2.005 | 2.006 |
| | 2.008 | 2.005 | 2.003 |
| | 2.007 | 2.006 | 2.003 |
| | 2.007 | 2.005 | 2.004 |
| | 2.006 | - | - |
| Average | 2.007 | 2.005 | 2.004 |
| 1σ | 0.001 | 0.001 | 0.001 |
| | | | |
| Total[b] | 5.961 | 5.957 | 5.881 |

[a] Stack height measurements for top and bottom configurations were obtained on pages 128 and 118 respectively of logbook 12R (East Cell – Logbook 1, E-19).
[b] Total measurement heights reported in reference 1.

Table 1.2 (d). Logbook Stack Height Measurements (inches).

| **Experiment 4 (7″ – 11″)** | **9″ – 11″** | **7″ – 9″** | **7″ & 11″ Disks** |
|---|---|---|---|
| Top[a] | 3.945 | 3.937 | 1.250 |
| | 3.945 | 3.940 | 1.249 |
| | 3.945 | 3.937 | 1.245 |
| | 3.947 | 3.944 | 1.248 |
| | 3.945 | 3.935 | 1.254 |
| | 3.945 | 3.936 | 1.251 |
| | 3.946 | 3.941 | 1.249 |
| | 3.947 | 3.938 | 1.245 |
| | - | 3.942 | 1.247 |
| | - | 3.937 | 1.255 |
| Average | 3.946 | 3.939 | 1.249 |
| 1σ | 0.001 | 0.003 | 0.003 |
| | | | **7″ Disks** |
| Bottom[a] | 3.375 | 3.375 | 1.379 |
| | 3.374 | 3.375 | 1.380 |
| | 3.375 | 3.374 | 1.381 |
| | 3.373 | 3.376 | 1.380 |
| | 3.375 | 3.376 | 1.380 |
| | 3.377 | 3.376 | 1.380 |
| | 3.375 | - | - |
| | 3.372 | - | - |
| | 3.374 | - | - |
| Average | 3.374 | 3.375 | 1.380 |
| 1σ | 0.001 | 0.001 | 0.001 |
| | | | |
| Total[b] | 7.320 ± 0.002 | 7.314 ± 0.003 | - |

[a] Stack height measurements for top and bottom configurations were obtained on page 32 of logbook 12R (East Cell – Logbook 1, E-19).
[b] Total is the summation of the averages.

### 1.2.3 Assembly Alignment

Radial Alignment of Upper Section: The assembly of the upper section was carried out by adding uranium metal to the top of the Type 304L stainless steel diaphragm. Using a ruler, uranium was positioned the appropriate distance from the inside of the aluminum clamping ring, which held the 0.010-inch-thick stainless diaphragm. A layer of uranium metal for an 11-inch-diameter annulus typically consists of a 7-inch-ID / 9-inch-OD annulus, and a 9-inch-ID / 11-inch-OD annulus. About half of the material was added to the diaphragm and the location of the material was continuously adjusted with a precise high-quality level in one direction and then the level was rotated 90° on the top of the uranium. If the assembly was not exactly centered on the diaphragm, it would not be precisely level because of the sag in the diaphragm as it was loaded. Two precisely machined steel blocks (±0.0001 inches) were used to squeeze the outside radial surface of the uranium metal until it was aligned. An edge of the machined block was then held at one outside radial location, squeezing the uranium together until no light was visible between the machined block and the uranium metal. This process was repeated 90° from the position of the original adjustment, rechecked again at the original position, and small adjustments made if necessary. This process continued until the outside radii of the parts were precisely aligned and the upper section assembly was complete. The squeezing procedure was performed by one individual while another person observed the light coming through small gaps between the blocks and the uranium metal[a]. The alignment of outer radii of the upper or lower section was less than ±0.001 inches. Of course, if two positions 90° apart are adjusted, the positions at 180° and 270° can be off only by the difference in the diameters of the outside parts.

Radial Alignment of Lower Section: For the lower section, the uranium parts were centrally located on the lower support stand and the same procedure was used except that the leveling of the parts was accomplished by shimming with aluminum foil (various thicknesses of aluminum foil were available). The foil was placed between the three 120° upper edges of the lower support stand and the lowest parts.

Radial Alignment Accuracy Summary: Uncertainty in radial alignment of uranium metal parts on each half is ±0.001 inch.

Lateral Alignment of Upper Section with the Lower Section: For these experiments, the alignment of the upper and lower sections was adjusted and verified using the Lateral Alignment Fixture shown in Figure 1.5. There were two identical fixtures used for lateral alignment between the upper section and the lower section. They were U-shaped and were machined out of 0.375-inch-thick aluminum. The end pieces were carefully machined by the Y-12 shops to be perpendicular to the long direction of the fixture and coplanar with each other. When leveled properly, the front face of the 4×4×½-inch-thick end pieces were vertical and in the same plane to within ±0.001 inch. In use, the lower side of the upper leg rested on the top surface of the clamping ring for the diaphragm. The fixture was perpendicular to the outer radial surface of the annuli and was moved inward until it touched the uranium of the top section. The leveling screws were adjusted until the fixture was level.

The second fixture was placed 90° apart from the first in a similar manner. Both fixtures were moved back slightly, and the lower section was raised until it was at the height of the lower leg of the U-shaped fixtures. Both fixtures were then nearly adjusted properly. Removal or additions of material from the upper section sometimes required small leveling adjustments. The fixtures were moved in until they touched uranium (either on the upper or the lower section). When lack of contact was observed at either of the front faces of the fixture, the lower section was lowered to the full-out position, and the position of the uranium on the lower support stand was adjusted. Finally, the lower lift table was raised and the alignment was checked.

[a] Personal communication between John D. Bess and John T. Mihalczo, March 2010.

The process was repeated several times as necessary. The final 0.005-inch adjustments were usually made by moving the upper section. This was a long and tedious procedure, which took one to two hours or more as needed but was always performed and resulted in uranium metal of the upper and lower sections being aligned within ±0.005 inch.

Lateral Alignment Accuracy Summary: Upper and lower assembly uranium metal alignment uncertainty is ±0.005 inch.

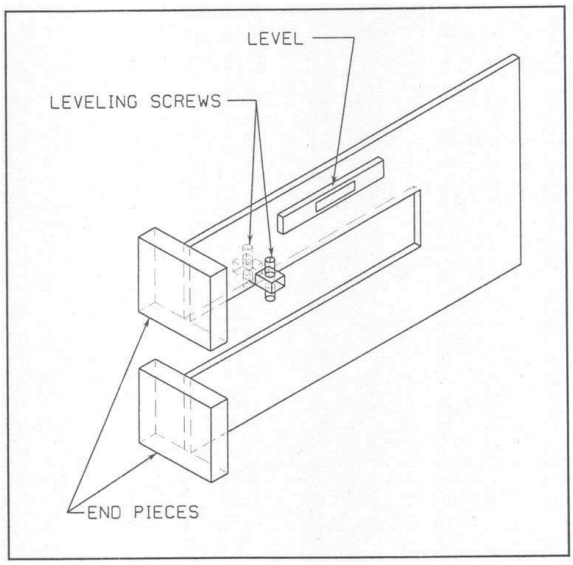


Figure 1.5. Sketch of Fixture for Lateral Alignment of Uranium.

### 1.2.4 Reactivity Effects of Support Structure

The support structure that was used to assemble these experiments was made up of the 0.010-inch-(0.0254-cm)-thick Type 304L stainless steel diaphragm, low-mass aluminum support stand, and two 30-inch-diameter, 2-inch-(5.08-cm)-wide, 0.5-inch-(1.27-cm)-thick diaphragm clamping rings bolted together. The support structure reactivity worth consisted primarily of the reactivity effects of the diaphragm, the diaphragm support rings, and the low-mass support stand. The reactivity worth of each of these three parts of the support structure was measured.

Additional figures depicting the assembly support are provided in Appendix B.

A positive reactivity effect means that the reactivity of the critical assembly increased due to the inclusion of that item in the assembly. Therefore, removing that particular item from the experiment resulted in a decrease in the neutron multiplication factor. A negative reactivity effect means that the reactivity of the assembly decreased due to the item's inclusion. The Type 304L stainless steel diaphragm in all experiments typically reduced the $k_{eff}$ of the system since it separated uranium metal halves and introduced neutron absorbing material between them. The presence of the diaphragm support ring and low-mass support stand of the lower section generally resulted in a positive reactivity addition. The presence of the support ring and low-mass stand provided neutron reflection to the system. The combined reactivity effect of all other supports, such as the four vertical poles and tubing for the diaphragm support ring, was reported to be less than one cent and was not evaluated.

The reactivity of the support structure, when measured, was evaluated by assembling the system to delayed criticality or a known measured reactivity, adding additional support structure, and obtaining the reactivity of the support structure from the measured reactor period for the assembly with and without the additional support structure. The effect of the lower support stand was evaluated using an inverted support stand, like that for the lower section, which was added to the top of the upper section. Care was taken in suspending it so that it would not compress the materials of the assembly. To estimate the effect of the diaphragm and clamping ring, their thicknesses were doubled and the reactivity change was measured. Where multiple instruments were used to measure the reactor period, the reactivity values obtained were averaged. These effects were measured for the components listed in Table 1.3 (a) – (d). The reactivity worth of the entire support structure is obtained by adding the worth of the three components of the support structure: annular diaphragm rings, stainless steel diaphragm, and low-mass support stand. Multiple measurements for the reactivity effects of the support structure were unavailable. The measured worth of the diaphragm includes the separation distance between the two halves of the experiments.[a]

The effective delayed-neutron fraction, $\beta_{eff}$, reported for a similar experiment in the series (HEU-MET-FAST-069) is 0.0066±0.00033 (±5 %), and can also be applied to these four experiments. For the 13″ OD – 7″ ID, the full assembly was 1.79¢ below delayed critical ($k_{eff}$ of 0.99988) and had an adjusted worth of 2.19¢ below delayed critical ($k_{eff}$ of 0.99986) with all the support structure removed. The 15″ OD – 7″ ID full assembly was 4.36¢ below delayed critical ($k_{eff}$ of 0.99971) and had an adjusted worth of 13.46¢ below delayed critical ($k_{eff}$ of 0.99911) when all the support structure was removed. The 15″ OD – 9″ ID assembly was 12.2¢ below delayed critical ($k_{eff}$ of 0.99919) and had an adjusted worth of 25.95¢ below delayed critical ($k_{eff}$ of 0.99829) when all the support structure was removed. The fourth experiment had multiple critical configurations. The best documented configuration was 7.2¢ below delayed critical ($k_{eff}$ of 0.99952). The lower support structure appears to be the only structure measured in this configuration and creates an adjusted worth of 15¢ below delayed critical ($k_{eff}$ of 0.99901).

The diaphragm bolts were not included in the experimental analysis of the support structure worth. The 304L stainless steel bolts are 0.5 inches (1.27 cm) in diameter and 1.5 inches (3.81 cm) long; their effective worth is believed to be negligible and within the measurement uncertainty of ±2¢, which is the reproducibility uncertainty for a given configuration.[a]

Table 1.3 (a). Reactivity Effects Measurements on Experiment 1 (7″ – 13″) in ¢.

| Measurement | Period | Channel A | Channel D | Reported Average | Calculated Average | Calculated Worth[a] |
|---|---|---|---|---|---|---|
| Critical Configuration | -1.88 | -1.85 | - | - | -1.865 | - |
| Diaphragm Support Rings | 3.97 | 3.97 / 3.7[e] | - | 3.88 | 3.88 | 3.88[b] |
| Low-Mass Support Structure | 15.4 | 15.4 | - | 15.4 | 15.4 | 15.4[b] |
| 10 mil Diaphragm Evaluation[c] | -1.42 | -1.5 | - | - | -1.46 | -16.86[c] |
| Recheck Critical | -1.74 | -1.67 | - | -1.79[d] | -1.785[d] | -1.79[d] |

[a] Personal communication between John Bess and John T. Mihalczo, February 2010.
[b] Personal communication between John Bess and John T. Mihalczo, June-July 2010.

| Configuration | | | | | | |
|---|---|---|---|---|---|---|

[a] Theses values were calculated by the evaluator and are found on page 92 of logbook 12R (East Cell – Logbook 1, E-19).
[b] The reactivity worth wasn't calculated by difference, as for all experiments for support and rings.
[c] Lower Support Structure is still on; worth of diaphragm includes diaphragm & low-mass support structure measurement.
[d] Average over all critical measurements.
[e] Two measurements were taken.

Table 1.3 (b). Reactivity Effects Measurements on Experiment 2 (7″ – 15″) in ¢.

| Measurement | Period | Channel A | Channel D | Reported Average | Calculated Average | Calculated Worth[a] |
|---|---|---|---|---|---|---|
| Critical Configuration | -3.72 | -4.5 | -4.85 | -4.36 | -4.357 | -4.36 |
| Diaphragm Support Rings | 4.75 | 4.75 | 5.28 | - | 4.75 | 4.22 |
| Low-Mass Support Structure | 18.1 | 17.2 | 19.8 | 17.65[b] | 17.65 | 22.01 |
| 10 mil Diaphragm Evaluation[c] | 0.59 | 0.47 | 0.63 | 0.52[b] | 0.563[d] | -17.12 |

[a] Values found on page 122 of logbook 12R (East Cell – Logbook 1, E-19).
[b] Experimenter had excluded the Channel D measurement from the average measured worth.
[c] Lower Support Structure is still on; worth of diaphragm includes diaphragm & low-mass support structure measurement.
[d] Average over all critical measurements.

Table 1.3 (c). Reactivity Effects Measurements on Experiment 3 (9″ – 15″) in ¢.

| Measurement | Period | Channel A | Channel D | Reported Average | Calculated Average | Calculated Worth[a] |
|---|---|---|---|---|---|---|
| Critical Configuration | -12.3 | -12.1 / -15.1 | -17.4 / -18.0 | - | -12.2 | -12.2 |
| Diaphragm Support Rings | 13.3 | 12.3 | 14.3 | - | 11.5 | 11.50 |
| Low-Mass Support Structure | 1.88 | 1.72 | 1.80 | - | 14.0 | 14.75 |
| 10 mil Diaphragm Evaluation[b] | 1.37 | 1.94 / 1.44 | 1.48 / 1.54 | - | -11.746 | -11.78 |
| Recheck Critical Configuration[c] | -15.4 | -12.8 / -8.68 | -14.6 | - | -12.87[d] | - |

[a] Values found on page 134 of logbook 12R (East Cell – Logbook 1, E-19).
[b] Lower Support Structure is still on; worth of diaphragm includes diaphragm & low-mass support structure measurement.
[c] Values found on page 268 of logbook 12R (East Cell – Logbook 1, E-19). A different arrangement of fuel annuli is used on the upper stacks to check the experimental worth but not for the measured corrections.
[d] Average over all critical measurements.

Table 1.3 (d). Reactivity Measurements on Experiment 4 ($7'' - 11''$) in ¢.

| Measurement | Period | Channel A | Channel D | Reported Average | Calculated Average | Calculated Worth[a] |
|---|---|---|---|---|---|---|
| Critical Configuration[b] | 16.2[b] | - | - | - | - | - |
| Diaphragm Support Rings[c] | - | - | - | - | - | 5.95 |
| 5 mil Diaphragm Evaluation | 10.5 | - | - | - | - | -5.7 |
| Clean Critical | -7.2[a] | | | | | |
| Low-Mass Support Structure | 7.8 | - | - | - | - | 15 |

[a] Values found on page 31 of logbook 12R (East Cell – Logbook 1, E-19).
[b] An early iteration in the $7'' - 11''$ construction was used to evaluate the diaphragm worth. Value reported on page 25 of logbook 12R (East Cell – Logbook 1, E-19).
[c] The rings were not measured for this experiment. The value reported comes from a similar experiment for an $11''$ OD cylinder that was performed after the $7'' - 11''$ case. Value found on page 46 of logbook 12R (East Cell – Logbook 1, E-19).

### 1.2.5 Uranium Components

The average dimensions and masses of the uranium metal parts for these experiments are given in Table 1.4 and come from Y-12 inspection reports; the dimensions are traditionally reported as having been measured to within $1\times10^{-4}$ inches ($2.54\times10^{-4}$ cm) with an uncertainty of $5\times10^{-5}$ inches ($1.27\times10^{-4}$ cm) and the masses of the parts are accurate to within 0.5 grams. All dimensional measurements for the parts were measured at 70° F (21.1° C) at the Y-12 Plant. The readout of the measuring device was calibrated to 0.0001 in. (0.000254 cm) using standards traceable back to the National Bureau of Standards (now NIST). An average of more than one measurement could result in the recording of a fifth digit.[a]

The density of each part can be calculated by dividing the reported mass of the part by its corresponding volume, which is calculated using the values provided in Table 1.4

The average gaps between uranium metal annular parts were obtained by subtracting the sum of the heights of the individual parts in a given stack from the measured stack height and then dividing this value by the number of parts in the stack minus one. This was not done with the annular cylinders in the $7'' - 11''$ experiment that were located above the diaphragm but below the 11 in. plate. The gaps varied below the 11 in. plate such that all parts rested evenly upon the plate.

Table 1.4. Measured Properties of Uranium Metal Annuli and Disks.

| **Part Number** | **Mass (g)** | **Height (in.)** | **Inner Diameter (in.)** | **Outer Diameter (in.)** |
|---|---|---|---|---|

[a] Personal communication between John Bess and John T. Mihalczo, March 2010.

| | | | | |
|---|---|---|---|---|
| 2728 | 4435 | 0.376 | - | 6.9944 |
| 2729 | 4440 | 0.3757 | - | 6.99595 |
| 2730 | 6646 | 0.562 | - | 6.996 |
| 2731 | 11841 | 1.0027 | - | 6.9965 |
| 2732 | 11814 | 1.00125 | - | 6.996 |
| 2735 | 13409 | 0.9985 | 13.002 | 14.9935 |
| 2736 | 2895 | 0.37635 | 7.0026 | 8.996 |
| 2737 | 4336 | 0.5625 | 7.0015 | 8.9965 |
| 2738 | 7710 | 1.0012 | 7.00375 | 8.99575 |
| 2739 | 13461 | 0.9945 | 13.0027 | 14.9955 |
| 2740 | 11568 | 1.5 | 7.0025 | 8.99625 |
| 2741 | 11568 | 1.5003 | 7.0025 | 8.9965 |
| 2742 | 3617 | 0.3751 | 9.0015 | 10.99675 |
| 2743 | 3621 | 0.374 | 9.0025 | 10.9965 |
| 2744 | 1223 | 0.12675 | 9.0065 | 10.99675 |
| 2745 | 9634 | 0.999 | 9.001 | 10.9965 |
| 2746 | 1238 | 0.12865 | 9.00175 | 10.9965 |
| 2747 | 14436 | 1.4999 | 9.002 | 10.99675 |
| 2748 | 14462 | 1.5 | 9.0025 | 10.9975 |
| 2749 | 4360 | 0.3774 | 11.003 | 12.9955 |
| 2750 | 4336 | 0.37545 | 11.0015 | 12.9945 |
| 2751 | 5822 | 0.50355 | 11.0015 | 12.99575 |
| 2752 | 5811 | 0.50325 | 11.0025 | 12.9955 |
| 2753 | 5782 | 0.5013 | 11.003 | 12.99675 |
| 2754 | 5826 | 0.5036 | 11.004 | 12.9953 |
| 2755 | 6514 | 0.5635 | 11.003 | 12.99595 |
| 2756 | 11567 | 1.0002 | 11.0036 | 12.9967 |
| 2757 | 11575 | 1.00155 | 11.0025 | 12.996 |
| 2758 | 1685 | 0.1245 | 12.9965 | 14.99665 |
| 2760 | 6743 | 0.5 | 13.002 | 14.995 |
| 2761 | 1706 | 0.1265 | 13.001 | 14.99475 |
| 2762 | 7703 | 0.99925 | 7.00375 | 8.99625 |
| 2763 | 953 | 0.1243 | 7.0038 | 8.9958 |
| 2766 | 7605 | 0.563 | 13.001 | 14.9965 |

| | | | | |
|---|---|---|---|---|
| 2767 | 5410 | 0.562 | 9.001 | 10.996 |
| 2768 | 1481 | 0.125 | - | 6.9965 |
| 2769 | 1495 | 0.1265 | - | 6.9965 |
| 2770 | 2955 | 0.25025 | - | 6.9957 |
| 2771 | 2916 | 0.24805 | - | 6.9966 |
| 2773 | 962 | 0.1260 | 7.0015 | 8.99700 |
| 2774 | 1930 | 0.2500 | 7.0030 | 8.99650 |
| 2775 | 1917 | 0.2485 | 7.0040 | 8.99675 |
| 2776 | 9644 | 1.0015 | 9.0015 | 10.9965 |
| 2778 | 2411 | 0.2510 | 9.0020 | 10.9965 |
| 2779 | 2417 | 0.251 | 9.0015 | 10.9970 |
| 2780 | 1440 | 0.12485 | 11.002 | 12.99605 |
| 2782 | 2914 | 0.25175 | 11.0035 | 12.9956 |
| 2783 | 2888 | 0.25075 | 11.003 | 12.9956 |
| 2784 | 5039 | 0.3725 | 13.0015 | 14.9945 |
| 2785 | 5043 | 0.3747 | 13.00285 | 14.99575 |
| 2786 | 6717 | 0.49465 | 13.0025 | 14.9950 |
| 2787 | 6788 | 0.5044 | 13.0015 | 14.995 |
| 2803 | 7220 | 0.24725 | - | 10.9965 |
| 2829 | 2895 | 0.37625 | 7.00315 | 8.99625 |
| 2848 | 6748 | 0.5019 | 13.0031 | 14.9964 |
| 2885 | 3415 | 0.25365 | 13.0032 | 14.9963 |
| 2886 | 3384 | 0.25145 | 13.0025 | 14.9966 |

## 1.3 Description of Material Data

The density of the annular right circular cylindrical assembly of uranium metal was reported to be 18.76 g/cm$^3$. The average isotopics of the uranium metal in weight percent were $^{234}$U = 0.97, $^{235}$U = 93.15, $^{236}$U = 0.24, and $^{238}$U = 5.64. The uranium material contained 0.9995 g of uranium per gram of material with negligible impurities, mainly consisting of bismuth, copper, manganese, sodium, nickel, oxygen, and nitrogen.

The uranium metal parts for these critical experiments were carefully cast and machined at the Oak Ridge Y-12 Plant in the early 1960s. Each uranium metal part was a separate casting which was then machined. Dimensions, masses, uranium isotopic, and impurity content were measured after machining. Uranium part masses and dimensions can be found in Table 1.4.

The uranium isotopic content obtained from Y-12 spectrographic analyses are given in Table 1.5. The uncertainty in the measured values for $^{234}U$, $^{235}U$, and $^{236}U$ are traditionally reported as $5\times10^{-3}$ wt.%. The $^{238}U$ values were obtained by subtracting the sum of the other three from 100 %.

The impurities from the 11 spectrographic analyses performed are given in Table 1.6 for uranium parts; only average and variation information were initially recorded.[a] These 11 randomly sampled uranium parts include discs and annular parts (from the series of oralloy experiments and not solely from this HEU experiment). As such, the information presented is a representative average of the impurity content in all uranium parts. These values are consistent with the nominal impurity content of highly enriched uranium metal at the Oak Ridge Y-12 Plant at the time the parts were made (i.e., 99.95 g of U per l00 g of material). Oxygen and nitrogen content was assumed by the experimentalist to be 20 and 30 ppm, respectively, consistent with highly enriched uranium produced at the time of these experiments.[b]

The HEU parts were coated annually in a very thin film of lightweight fluorocarbon oil to decrease mass loss due to oxidation. This oil has negligible effect upon the experiment conditions. After oiling, the parts were wiped with a dry rag to remove most of the oil. The oralloy parts were then handled using leather gloves, which further reduced the oil on the surface.[c]

Table 1.5. Uranium Disc Isotopic Content.[a]

| Part Number | $^{234}U$ (wt.%) | $^{235}U$ (wt.%) | $^{236}U$ (wt.%) | $^{238}U$ (wt.%)[b] |
|---|---|---|---|---|
| 2728 | 0.97 | 93.17 | 0.24 | 5.62 |
| 2729 | 0.99 | 93.15 | 0.26 | 5.60 |
| 2730 | 0.97 | 93.14 | 0.25 | 5.64 |
| 2731 | 0.97 | 93.13 | 0.22 | 5.68 |
| 2732 | 0.95 | 93.17 | 0.21 | 5.67 |
| 2735 | 0.98 | 93.12 | 0.25 | 5.65 |
| 2736 | 1.01 | 93.17 | 0.21 | 5.61 |
| 2737 | 0.99 | 93.08 | 0.29 | 5.64 |
| 2738 | 0.98 | 93.15 | 0.24 | 5.63 |
| 2739 | 0.96 | 93.16 | 0.25 | 5.63 |
| 2740 | 0.97 | 93.17 | 0.24 | 5.62 |
| 2741 | 0.96 | 93.18 | 0.25 | 5.61 |
| 2742 | 0.98 | 93.14 | 0.23 | 5.65 |
| 2743 | 0.98 | 93.14 | 0.23 | 5.65 |
| 2744 | 0.98 | 93.14 | 0.23 | 5.65 |
| 2745 | 0.96 | 93.2 | 0.22 | 5.62 |

[a] J. T. Mihalczo, "Graphite and Polyethylene Reflected Uranium-Metal Cylinders and Annuli," Union Carbide Corporation Nuclear Division, Oak Ridge Y-12 Plant, Y-DR-81 (1972).
[b] HEU-MET-FAST-076 in the ICSBEP Handbook.
[c] Personal communication between John D. Bess and John T. Mihalczo, June – July 2010.

| | | | | |
|---|---|---|---|---|
| 2746 | 1.0 | 93.09 | 0.22 | 5.69 |
| 2747 | 0.98 | 93.16 | 0.19 | 5.67 |
| 2748 | 1.0 | 93.09 | 0.22 | 5.69 |
| 2749 | 0.98 | 93.19 | 0.25 | 5.58 |
| 2750 | 0.95 | 93.12 | 0.25 | 5.68 |
| 2751 | 0.98 | 93.13 | 0.24 | 5.65 |
| 2752 | 0.98 | 93.13 | 0.24 | 5.65 |
| 2753 | 0.95 | 93.12 | 0.25 | 5.68 |
| 2754 | 0.96 | 93.1 | 0.28 | 5.66 |
| 2755 | 0.96 | 93.1 | 0.28 | 5.66 |
| 2756 | 0.93 | 93.18 | 0.25 | 5.64 |
| 2757 | 0.96 | 93.2 | 0.23 | 5.61 |
| 2758 | 0.98 | 93.16 | 0.27 | 5.59 |
| 2760 | 0.99 | 93.13 | 0.24 | 5.64 |
| 2761 | 0.96 | 93.12 | 0.27 | 5.65 |
| 2762 | 0.97 | 93.13 | 0.27 | 5.63 |
| 2763 | 0.96 | 93.18 | 0.25 | 5.61 |
| 2766 | 0.98 | 93.16 | 0.27 | 5.59 |
| 2767 | 0.96 | 93.14 | 0.26 | 5.64 |
| 2768 | 0.92 | 93.14 | 0.26 | 5.68 |
| 2769 | 0.97 | 93.15 | 0.25 | 5.63 |
| 2770 | 0.99 | 93.13 | 0.26 | 5.62 |
| 2771 | 0.97 | 93.14 | 0.25 | 5.64 |
| 2773 | 0.97 | 93.17 | 0.24 | 5.62 |
| 2774 | 0.99 | 93.08 | 0.29 | 5.64 |
| 2775 | 0.98 | 93.15 | 0.24 | 5.63 |
| 2776 | 0.96 | 93.16 | 0.23 | 5.65 |
| 2778 | 0.96 | 93.16 | 0.23 | 5.65 |
| 2779 | 0.96 | 93.16 | 0.23 | 5.65 |
| 2780 | 0.98 | 93.13 | 0.25 | 5.64 |
| 2782 | 0.96 | 93.2 | 0.23 | 5.61 |
| 2783 | 0.93 | 93.18 | 0.25 | 5.64 |
| 2784 | 0.99 | 93.11 | 0.24 | 5.64 |
| 2785 | 0.98 | 93.14 | 0.24 | 5.64 |

| | | | | |
|---|---|---|---|---|
| 2786 | 0.98 | 93.14 | 0.24 | 5.64 |
| 2787 | 0.98 | 93.14 | 0.24 | 5.64 |
| 2803 | 1.0 | 93.14 | 0.23 | 5.63 |
| 2829 | 0.99 | 93.1 | 0.24 | 5.67 |
| 2848 | 0.99 | 93.18 | 0.24 | 5.59 |
| 2885 | 0.99 | 93.11 | 0.26 | 5.64 |
| 2886 | 0.99 | 93.11 | 0.26 | 5.64 |

[a] Mass spectrographic analysis.
[b] By difference from 100 % pure uranium.

Table 1.6. Measured Impurity Content of Uranium Annuli and Disks.

| **Element[(a)]** | **Parts per Million by Weight (ppm) [(b)]** | **Variation (ppm)** | **Standard Deviation (ppm) [(c)]** |
|---|---|---|---|
| Ag | 8 | 3-25 | 5.6 |
| Ba | < 0.01 [(d)] | - | 0.005 |
| Bi | 164 | 81-311 | 32.8 |
| C | < 10 | - | 3.5 |
| Ca | 0.1 | - | 0.07 |
| Cd | < 1 | - | 0.5 |
| Co | 5 | 2-15 | 3.5 |
| Cr | 7 | 4-12 | 4.9 |
| Cu | 25 | 10-40 | 5 |
| K | < 0.2 | 0.2-0.8 | 0.1 |
| Li | < 2 | - | 1 |
| Mg | 3 | 2-3 | 2.1 |
| Mn | 56 | 25-89 | 11.2 |
| Mo | < 1 | < 1 | 0.5 |
| Na | 27 | 15-50 | 5.4 |
| Ni | 100 | - | 20 |
| Sb | 38 | 10-80 | 7.6 |
| Ti | 1 | - | 0.7 |
| N | 30 | - | 6 |
| O | 20 | - | 4 |

[a] Mass spectrographic analysis except for oxygen and nitrogen using data in J. T. Mihalczo, "Graphite and Polyethylene Reflected Uranium-Metal Cylinders and Annuli," Union Carbide Corporation Nuclear Division, Oak Ridge Y-12 Plant, Y-

DR-81 (April 28, 1972). Oxygen and nitrogen content was assumed by the principal experimentalist to be 20 and 30 ppm, respectively, consistent with highly enriched uranium produced at the time of these experiments. Total impurity content is consistent with stated values at that time of 500 ppm which gives 99.95 grams of U per 100 grams of material. Minor differences in the impurities exist between values listed in Table 8 and the impurity values provided in HEU-MET-FAST-051 in the ICSBEP Handbook.

[b] Except for the values shown as less than the detection limit, impurity data are average values from 11 randomly sampled uranium parts.

[c] Personal communication, J. A. Mullens to John Mihalczo in HEU-MET-FAST-076 in the ICSBEP Handbook, June 2004.

[d] Less than (<) indicates lower detection limit and not necessarily that the impurity is present.

## 1.4 Temperature

Room and assembly temperature measurements were not recorded during the course of the experiments. The ORCEF operated in a controlled environment.[a] The fission rate in the measurements corresponded to usually much less than 0.01 watts, so there was no appreciable heating of the experiment components. The dimensions of the uranium were measured at 70 ºF (21.1 ºC) and the experiments were generally performed at the ORCEF room temperature of 72 ºF (22.2 ºC). The reactivity coefficient for a temperature change for these assemblies is approximately -0.3¢/ºC.[b]

## 1.5 Supplemental Experimental Measurements

The following additional information comes from Reference 1. These measurements, although not all addressed in this benchmark, were taken of the different critical configurations examined and are included for succinctness.

Table 1.7. Additional experimental measurements from tables in Reference 1.

| Diameter (in.) | Height of Radial Increment (in.)[(a)] | | | | Average Uranium Density (g/cc) | Reactivity[(b)] (cents) | Mass (kg of U) |
|---|---|---|---|---|---|---|---|
| | 3.5 – 4.5 | 4.5 – 5.5 | 5.5 – 6.5 | 6.5 – 7.5 | | | |
| 12.996 OD 7.003 ID | 5.817 | 5.694 | 5.705 | - | 18.705 | - 4.2 | 165.571 |
| 14.996 OD 7.003 ID | 4.195 | 4.255 | 4.265 | 4.199 | 18.693 | - 13.5 | 178.992 |
| 14.996 OD 9.002 ID | - | 5.881 | 5.957 | 5.961 | 18.705 | - 26.7 | 205.571 |
| | Neutron Multiplication Constant | | Prompt-Neutron Decay Constant[(d)], $a$ ($10^6$ $sec^{-1}$) | | $\beta_{eff}$ | Prompt-Neutron Lifetime[(e)], $l$ (nsec) | |

[a] Personal communication between John D. Bess and John T. Mihalczo, February 2010.
[b] Personal communication betweee John D. Bess and John T. Mihalczo, March 2010.

| | Measured | Calculated[c] | | | |
|---|---|---|---|---|---|
| 12.996 OD<br>7.003 ID | 1.000 | 1.001 | 0.883 ± 0.009 | 0.00672 | 7.61 ± 0.08 |
| 14.996 OD<br>7.003 ID | 0.999 | 0.998 | 0.950 ± 0.010 | 0.00673 | 7.08 ± 0.07 |
| 14.996 OD<br>9.002 ID | 0.998 | 1.003 | 0.840 ± 0.008 | 0.00672 | 8.00 ± 0.07 |

| Diameter (cm) | Height (cm) | Correction to Experimental Mass[f] (g of U) | Corrected Mass (kg of U) |
|---|---|---|---|
| 33.010 OD<br>17.787 ID | 14.608 | + 366 | 165.937 |
| 38.088 OD<br>17.787 ID | 10.779 | + 517 | 179.509 |
| 38.088 OD<br>22.864 ID | 15.158 | + 1064 | 206.635 |

[a] These dimensions, for a particular diameter, show the unevenness in the upper surface of the assembly.
[b] Experimentally corrected for effect of lower support stand, aluminum clamp ring and stainless-steel diaphragm. Uncorrected reactivities were… -1.8, -4.4, -12.2, respectively.
[c] $S_8$ calculations; convergence criterion = $10^{-5}$.
[d] At delayed critical, $a = \beta_{eff} / l$.
[e] Error indicated is the standard deviation from a least-squares analysis of the data obtained in the measurement.
[f] Mass increments necessary to adjust the assemblies given (in this table) to uniform heights, and to make $k_{eff} = 1$.

# 2.0 EVALUATION OF EXPERIMENTAL DATA

Monte Carlo n-Particle (MCNP) version 6.1 calculations were utilized to estimate the biases and uncertainties associated with the experimental results in this evaluation. MCNP is a general-purpose, continuous-energy, generalized-geometry, time-dependent, coupled n-particle Monte Carlo transport code.[a] The Evaluated Neutron Data File library, ENDF/B-VII.1,[b] was utilized in analysis of the experiment and benchmark model biases and uncertainties. The statistical uncertainty in the calculated $k_{eff}$ is 0.00002 for the $13'' - 7''$, $15'' - 7''$, $15'' - 9''$, and $7'' - 11''$ experiments (to be referred to as Experiments 1 – 4, respectively, here on out). Calculations were performed with 1,050 generations with 1,000,000 neutrons per generation. The $k_{eff}$ estimates did not include the first 50 generations and are the result of 1,000,000,000 neutron histories.

Elemental data such as molecular weights and isotopic abundances were taken from the 17th edition of the Chart of the Nuclides.[c]

Room return effects with its associated uncertainty are addressed in Section 3.1.1.3.

## 2.1 Evaluation of Critical and / or Subcritical Experiment Data

Variations of the benchmark models provided in Section 3 were utilized with perturbations of the model parameters to estimate uncertainties in $k_{eff}$ due to uncertainties in values defining the benchmark experiment. Where applicable, comparison of the upper and lower perturbation $k_{eff}$ values to evaluate the uncertainty in the eigenvalue were utilized to minimize correlation effects, if any, induced by comparing all perturbations to the original benchmark model configuration, as discussed elsewhere.[d]

Unless specifically stated otherwise, all uncertainty values in this section correspond to $1\sigma$. When the change in $k_{eff}$ between the base case and the perturbed model (single-sided perturbation), or two perturbed models (double-sided perturbation directly comparing an upper and a lower perturbation from the base case), is less than the statistical uncertainty of the Monte Carlo results, the changes in the variable are amplified, if possible, and the calculations repeated. The resulting calculated change is then scaled to a value corresponding to the given uncertainty using a scaling factor (SF), assuming linearity, which should be adequate for these small changes in $k_{eff}$. Throughout Section 2, the difference in eigenvalues computed using the perturbation method described is denoted with $\Delta k_p$; the scaled $1\sigma$ uncertainty is denoted as $\Delta k_{eff}$. All $\Delta k_{eff}$ uncertainties are considered to be absolute values whose magnitude applies both positively and negatively to the experimental $k_{eff}$, as shown in tables 2.10 – 2.12. Negative signs are retained in other tables in Section 2, where the effective uncertainty is reported for a given uncertainty perturbation to demonstrate whether the effect in $k_{eff}$ was directly or indirectly proportional to the uncertainty.

When evaluating parameters such as measured diameters, heights, and mass, all parts of a given type are perturbed at the same time: e.g., the uranium mass in all annuli is simultaneously increased or decreased. The

[a] J. T. Goorley, et al., "Initial MCNP6 Release Overview – MCNP6 version 1.0," LA-UR-13-22934, Los Alamos National Laboratory (2013).
[b] M. B. Chadwick, et al., "ENDF/B-VII.1: Nuclear Data for Science and Technology: Cross Sections, Covariances, Fission Product Yields and Decay Data," *Nucl. Data Sheets*, **112**: 2887-2996 (2011).
[c] E. M. Baum, M. C. Ernesti, H. D. Knox, T. R. Miller, and A. M. Watson, *Nuclides and Isotopes, Chart of the Nuclides: 17th Edition,* Knolls Atomic Power Laboratory (2009).
[d] D. Mennerdahl, "Statistical Noise for Nuclear Criticality Safety Specialists," *Trans. Am. Nucl. Soc.*, **101**: 465-466 (2009).

calculated uncertainty is then reduced by the square root of the number of components perturbed, representative of a random uncertainty. When appropriate, a systematic component of the evaluated uncertainty is retained, which is considered to not be impacted by the perturbation of the number of parts perturbed for its assessment. It should be noted, however, that typically when parameters of multiple parts are evaluated, the parts are nearly identical in every aspect. The uranium annuli utilized in this experiment vary in mass and dimensions; as such, the relative importance of the annuli varies throughout the assembly. In general, perturbation of many components of varying dimensions and mass would not be appropriate and should be replaced instead with multiple individualized perturbation analyses. In the case of the precisely-measured annuli for these experiments, perturbation of individual component parameters without their respective uncertainties would produce negligible results. Simultaneous perturbation of the various parameters for all annuli parts is performed, even though the parts are not identical, to demonstrate that the combined effect of the uncertainties is still negligible.

Uncertainties less than 0.00003 $\Delta k_{eff}$ are treated as negligible. When calculated uncertainties in $\Delta k_{eff}$ are less than or equal to their statistical uncertainties, and an increased parameter scaling cannot be performed, the statistical uncertainties are added to the calculated uncertainty to assess the magnitude of the total uncertainty; however, the absolute magnitude of any uncertainty combined in this way is less than 0.00003 $\Delta k_{eff}$, therefore they are treated as negligible.

The total evaluated uncertainty in $k_{eff}$ for these experiments is provided in Section 2.1.4; the square root of the sum of the squares of all the individual uncertainties assessed in this section is used to obtain the total uncertainty for each experimental $k_{eff}$.

### 2.1.1 Experimental Measurements

#### *2.1.1.1 Temperature*

These experiments were performed at a room temperature of ~295 K. Measurements of the component parts were performed at a room temperature of ~294 K. The uncertainty in each of these two temperatures is ± 0.5 degrees. Any variations in temperature for the experiments and room environment were small. Heating effects in the experiment components were negligible. The temperature reactivity coefficient is approximately -0.3 ¢/ºC. It is assumed that a temperature variation of 2 ºC (1σ) adequately describes the temperature uncertainty. A temperature uncertainty of ±2 ºC in $k_{eff}$ results in a $\Delta k_{eff}$ of ±0.00004 for all experiments.

#### *2.1.1.2 Experiment Reproducibility and Measurement*

The experimenter indicated that to completely dismantle a system and reassemble it on a different day led to reactivity differences that were ~2 ¢ or less; measurements repeated on the same day exhibited much less of a difference.[a] The experimenter indicated that reproducibility of experiments performed with the vertical lift was even better. The corresponding uncertainty of ±0.00013 $\Delta k_{eff}$ is treated as a 1σ value for all experiments.

The uncertainty in the actual measurement of the reactivity, which was determined by positive period measurements, is considered very accurate. There is some uncertainty in fitting data and evaluation of the period. Careful measurements and rigorous fitting procedures can yield estimate uncertainties of ~0.2 pcm,

[a] Personal communication between John D. Bess and John T. Mihalczo, July 2014.

which is negligible.[a] It is assumed that uncertainty in the actual measurement of the reactivity is already included in the reproducibility uncertainty already discussed in the previous paragraph. The uncertainty of the effective delayed neutron fraction, which is required to get reactivity in cents from the period, is discussed below.

#### *2.1.1.3 Measured Reactivity of Support Structure Removal*

Reactivity values for the worth of the support structure are given in Table 1.2(a)-(d). Multiple measurements to assess the uncertainty in the support structure worth were not performed. Prior benchmarks in this experimental series (HEU-MET-FAST-051, HEU-MET-FAST-071, and HEU-MET-FAST-076 in the ICSBEP Handbook) assumed a 1σ standard deviation of 10 % of each measured value of the support structure worth and the delayed critical measurement worth was sufficient. A slightly more rigorous approach is utilized in this evaluation.

The individual worth measurements were obtained using modified experiments from the clean critical experimental configuration. Each of these configurations would have a repeatability uncertainty of, at most, ~2 ¢ if the assembly had been completely disassembled between measurements (as discussed in the previous section). Therefore the uncertainty in the adjustment for the removal of the assembly support structure from the experiment configuration would be obtained by taking the square root of the number of measured worths, multiplied by the square root of the number of experiment configurations needed to evaluate a given measured worth, and multiplied by the reproducibility uncertainty for a single configuration. A total of four experimental configurations were needed to obtain three worth measurement corrections to represent the removal of the support structure from each configuration: $\sqrt{4}\times\sqrt{3}\times 2$ ¢. The uncertainty in the repeatability of the clean critical experiments is already discussed in the previous section.

The calculated uncertainty associated with the uncertainty in the measured reactivity for support structure removal is ±0.00046 $\Delta k_{eff}$ for all experiments.

#### *2.1.1.4 Effective Delayed Neutron Fraction, $\beta_{eff}$*

A typical effective delayed neutron fraction for bare HEU metal systems is 0.0066 (see HEU-MET-FAST-051 in the ICSBEP Handbook). Typically the uncertainty in $\beta_{eff}$ is around 5 %, which, when propagated, results in a $\Delta k_{eff}$ of approximately ± 0.00001, ± 0.00004, ± 0.00009, and ± 0.00007 for configurations 1 – 4, respectively, which is considered negligible ($\Delta k_{eff} < 0.00003$) for Experiment 1 (7″ – 13″). This uncertainty was obtained by taking the difference between the experimental eigenvalue calculated for the actual experiment using the reported delayed neutron fraction, and an eigenvalue calculated using the delayed neutron fraction perturbed by ±5 %.

### 2.1.2 Geometrical Properties

#### *2.1.2.1 Uranium Annuli*

Traditionally, the uncertainties in the ORCEF oralloy experiments have been as follows in regards to geometrical properties. The measurement uncertainties in the stack heights can be calculated using the standard deviation of the average from multiple measurements, which are typically about ±0.001 inches

[a] Personal communication between John D. Bess and Dick McKnight, July 2010.

(±0.00254 cm). The manufacturing tolerances of the Y-12 HEU parts are ±0.0001 inches (±0.000254 cm). When multiple measurements of the dimensions of a part were taken, the average was typically within ±0.00005 inches (±0.000127 cm) of all the individual measurements.[a]

More recently a document has been prepared to examine the uncertainties pertaining to critical experiments performed at ORCEF using HEU metal components.[b] This document will be the basis for the uncertainty analysis in this evaluation; however, the results for many of the calculations are negligible, which is what would be expected if the traditional approach to calculate the geometrical uncertainties were implemented.

There may be effects on the system $k_{eff}$ values associated with correlations between uncertainties in stack heights, gap thicknesses, and the height of the individual parts in an assembly. However, except for the $k_{eff}$ uncertainty associated with the uranium stack height uncertainties, the individual evaluated uncertainties in $k_{eff}$ are negligible. Therefore, a possible increase in the uncertainty in $k_{eff}$ due to correlation, if any, between the individual uncertainties is considered negligible.

There are a total of 23, 28, 31, and 27 individual uranium annuli and disks in Experiments 1 – 4, respectively. When evaluating the uncertainty for a given parameter, all uranium components are simultaneously modified. The calculated change in the eigenvalue for the perturbation of a given parameter is scaled by the square root of the number of annuli, N, to represent the randomness of the actual variation amongst the individual pieces.

**Diameter**

The diameters of each uranium annulus was measured after machining at the Y-12 Plant and reported to an accuracy of 0.0001 inches (0.000254 cm) at several locations (~8) and then averaged. All dimensional measurements were at 70° Fahrenheit (21.1 ºC) and are traceable back to the National Bureau of Standards (i.e. measurement systems were calibrated with standards produced by the NBS). While these measurements were performed using a Moore machine (high-performance ultra-precision manufacturing equipment, typically a jig borer or jig grinder with accompanying high-accuracy measurement capability)[c] accurate to this quantity, other sources have since indicated that the accuracy of the Moore machine utilized at that time was between 0.0003 and 0.0005 in. (0.000762 to 0.00127 cm).[d] The maximum value is taken to represent the accuracy of the measurement of the diameter for the oralloy parts instead of the average. Additionally, the uncertainty in the reported diameter of each annulus included a rounding uncertainty of ±0.00005 inches (±0.000127 cm). These two uncertainties are both considered to represent bounding uncertainties with uniform probability distribution and are combined in quadrature to obtain a total bounding uncertainty of ±0.0005025 in. (±0.001276 cm).

To find the effect of this diametral uncertainty on the $k_{eff}$ value, the diameters of the annuli (Table 1.1) were adjusted by a factor of 5 times the bounding uncertainty. In order to keep the uranium mass of each experiment constant, the density of each of the uranium parts was adjusted accordingly. Effectively the entire uranium volume in the system was expanded and contracted while maintaining the total uranium mass constant. Outer and inner diameters were simultaneously increased to find an upper perturbation $k_p$ value and then simultaneously decreased to find a lower perturbation $k_p$ value. Half of the difference between the upper and lower perturbation $k_p$ values was used to represent the variation in $k_p$ due to perturbing the annuli

[a] Personal communication between John D. Bess and John T. Mihalczo, March 2010.
[b] J. T. Mihalczo and T. Gregory Schaaff, "Uncertainties in Masses, Dimensions, Impurities, and Isotopics of HEU Metal Used in Critical Experiments at ORCEF," ORNL/TM-2012/32, Oak Ridge National Laboratory (2012).
[c] Moore Precision Tools, http://mooretool.com/, Moore Tool Company, Bridgeport, CT, USA (last accessed September 18, 2014).
[d] Personal communication between John D. Bess and John T. Mihalczo, March 2010.

diameters. The 1σ uncertainty in $k_{eff}$ associated with the uncertainty in the diameter of the uranium annuli is found from the following formula, where $\Delta k_p$ is one-half the difference between the upper and lower perturbation $k_p$ values, SF is the scaling factor, N is the number of uranium annuli in each Experiment (which for these experiments is 23, 28, 31, and 27, respectively), and the factor of square root of two is present because the inner and outer diameters were simultaneously perturbed:

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF} + \frac{\Delta k_p}{SF * \sqrt{2} * \sqrt{N}}$$

In the above equation the systematic ($\gamma_{sys}$) and random ($\gamma_{ran}$) components (the 1st and 2nd terms on the left hand side of the equation respectively) are summed to account for the total uncertainty in $k_{eff}$ due to the uncertainty in the oralloy part diameters. Both of these uncertainties are treated as 100% rather than each accounting for a fraction of the total uncertainty. Results are provided in Table 2.1, and are considered negligible for any experiment if $\Delta k_{eff} < 0.00003$. The uncertainty in $\Delta k_{eff}$ is determined by the following equation:

$$\sigma_{\Delta keff} = \frac{\sqrt{\sigma^2_{kp+SF\sigma_p} + \sigma^2_{kp-SF\sigma_p}} * \sqrt{\gamma^2_{sys} + (\frac{\gamma_{ran}}{\sqrt{2} * \sqrt{N}})^2}}{2\ SF}$$

Table 2.1. Effect of Uncertainty in Uranium Annuli and Disks Diameters.

| Experiment | Deviation (cm) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ± 0.006382 | -0.00043 ± 0.0002 | $5\sqrt{3}$ | 0.00006 ± <0.00001 |
| 2 | ± 0.006382 | -0.00038 ± 0.0002 | $5\sqrt{3}$ | 0.00005 ± <0.00001 |
| 3 | ± 0.006382 | -0.00035 ± 0.0002 | $5\sqrt{3}$ | 0.00005 ± <0.00001 |
| 4 | ± 0.006382 | -0.00051 ± 0.0002 | $5\sqrt{3}$ | 0.00007 ± <0.00001 |

**Height**

The height of each uranium annulus was measured, after machining the uranium parts at the Y-12 Plant, to an accuracy of 0.0001 inches (0.000254 cm) at several radial locations (~8) and then averaged. The same detailed discussion of measurement uncertainties and the method of analysis provided regarding the analysis of the diameters of the uranium annuli in the previous subsection also apply to the uranium heights. An additional uncertainty related to the height though is the uncertatinty related to the part flatness when measuring. Small HEU plates analysed in HEU-MET-FAST-007 were manufactured to a tolerance in flatness of ± 0.002 inches. For the most conservative treatment for the uncertainty in height of the individual parts the two uncertainties are combined in quadrature to obtain a total bounding uncertainty of ± 0.005086 cm.

To find the effect of this uncertainty on the $k_{eff}$ value, the heights of the annuli (Table 1.1) were adjusted by a factor of 0.7529 times the bounding uncertainty, while reducing the effective gap thicknesses between each component. The measured stack height, where possible, was conserved. When the increase in the combined heights of the individual parts was greater than the stack height, the parts were modeled in contact, with no gaps, and the effective stack height was increased. In order to keep the uranium mass of each experiment constant, the density of each of the uranium parts was adjusted accordingly. Effectively, the entire uranium volume in the system was expanded and contracted while maintaining the total uranium mass constant. Heights were simultaneously increased to find an upper perturbation $k_p$ value and then simultaneously

decreased to find a lower perturbation $k_p$ value. Half of the difference between the upper and lower perturbation $k_p$ values was used to represent the variation in $k_p$ due to perturbing the annuli heights. The 1σ uncertainty in $k_{eff}$ associated with the uncertainty in the heights of the uranium annuli is found from the formula below, and the results are provided in Table 2.2 and are considered negligible if $\Delta k_{eff} < 0.00003$.

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF} + \frac{\Delta k_p}{SF * \sqrt{N}}$$

Table 2.2. Effect of uncertainty on Uranium Annuli and Disk Heights

| Experiment | Deviation (cm) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ± 0.003829 | -0.00005 ± 0.00003 | 0.7529√3 | -0.00005 ± <0.00001 |
| 2 | ± 0.003829 | -0.00006 ± 0.00003 | 0.7529√3 | -0.00006 ± <0.00001 |
| 3 | ± 0.003829 | -0.00007 ± 0.00003 | 0.7529√3 | -0.00006 ± <0.00001 |
| 4 | ± 0.003829 | -0.00007 ± 0.00003 | 0.7529√3 | -0.00006 ± <0.00001 |

**Stack Height**

The stack heights of the uranium annuli placed above and below the stainless steel diaphragm for the four experiments were measured with a standard deviation of the average of approximately ±0.002 in. (±0.00508 cm), ± 0.001 in. (±0.00254 cm), ± 0.001 in. (±0.00254 cm), and ± 0.003 in. (± 0.00762 cm), respectively. Additionally, the uncertainty in the reported stack height included a rounding uncertainty of ±0.0005 inches (±0.00127 cm), which is considered to represent a bounding uncertainty with uniform probability distribution (i.e. ÷√3). These two uncertainty components are combined in quadrature to obtain a total 1σ uncertainty of ± 0.002021 in. (0.005133 cm) for Experiment 1, ± 0.001041 in. (±0.002644 cm) for Experiments 2 and 3, and ±0.003014 in. (0.007655 cm) for Experiment 4.

To find the effect of this uncertainty on the $k_{eff}$ value, the stack height of these annuli (Tables 1.1-2 and 2.1-10) was adjusted by increasing the effective gap thicknesses between each component. The stack height was increased by a factor of 10 times the 1σ uncertainty to find an upper perturbation $k_p$ value. The difference between the upper perturbation $k_p$ value and the unperturbed model $k_{eff}$ value was used to represent the variation in $k_p$ due to perturbing the annuli stack heights. The 1σ uncertainty in $k_{eff}$ associated with the uncertainty in the measured stack heights of the uranium annuli is found from the following formula, where $\Delta k_p$ is the difference between the upper perturbation and unperturbed model $k_{eff}$ values, and N is the number of uranium annuli stacks in each experiment.

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF} + \frac{\Delta k_p}{SF * \sqrt{N}}$$

.

Both the systematic and random uncertainties are treated as 100%. Results are provided in Table 2.3.

Table 2.3. Effect of Uncertainty in Uranium Stack Heights

| Experiment | Deviation (cm) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | + 0.05133 | -0.0013 ± 0.00003 | 10 | -0.00016 ± <0.00001 |
| 2 | + 0.02644 | -0.0009 ± 0.00003 | 10 | -0.00011 ± <0.00001 |

| | | | | |
|---|---|---|---|---|
| 3 | + 0.02644 | -0.0008 ± 0.00003 | 10 | -0.00009 ± <0.00001 |
| 4 | + 0.07655 | -0.0003 ± 0.00003 | 10 | -0.00004 ± <0.00001 |

#### *2.1.2.2 Lateral Alignment*

Lateral alignment measurements were made to within ±0.005 inches (±0.0127 cm). To find the effect of this uncertainty on the $k_{eff}$ value, the lower half of each configuration was moved laterally (in a model) by a factor of 10 times this reported uncertainty to find a perturbed $k_{eff}$ value. The difference between the perturbed $k_p$ value and the unperturbed model $k_{eff}$ value was used to represent the variation in $k_{eff}$ due to perturbing the lateral assembly alignment. The 1σ uncertainty associated with the uncertainty in the lateral alignment is found from the following formula, where $\Delta k_p$ is the difference between the upper perturbation and unperturbed model $k_{eff}$ values, and SF is the parameter scaling factor:

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF}.$$

This uncertainty is treated as a one-sided bounding uncertainty with uniform probability distribution (i.e. ÷2√3). Furthermore, this uncertainty is treated as 100 % systematic with no random uncertainty component. Results are provided in Table 2.4, and are considered negligible ($\Delta k_{eff}$ < 0.00003) for all experiments.

Table 2.4. Effect of Uncertainty in Assembly Lateral Alignment.

| **Experiment** | **Deviation (cm)** | $\Delta k_p \pm \sigma_{\Delta kp}$ | **SF** | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | + 0.127 | -0.00003 ± 0.00003 | 10×2√3 | < 0.00001 ± <0.00001 |
| 2 | + 0.127 | -0.00007 ± 0.00003 | 10×2√3 | < 0.00001 ± <0.00001 |
| 3 | + 0.127 | -0.00005 ± 0.00003 | 10×2√3 | < 0.00001 ± <0.00001 |
| 4 | + 0.127 | -0.00002 ± 0.00003 | 10×2√3 | < 0.00001 ± <0.00001 |

#### *2.1.2.3 Vertical Assembly Alignment*

The uncertainty of axial symmetry was not considered in this evaluation since it is embedded within the uranium diameter uncertainties.

#### *2.1.2.4 Gaps Between Parts*

The uncertainty in gap heights was not considered in this evaluation since it is embedded within the uranium stack height and diameter uncertainties.

The total height of the gaps between the stacks of uranium annuli was obtained by taking the difference between the measured stack height and the summation of the heights of the individual uranium annuli in each stack. The total gap height was then divided by the number of annuli minus one, to represent the number of gaps between the uranium annuli. The gap heights for Experiments 1 through 4 can be seen in Figures 3.2, 3.4, 3.6, and 3.8.
The tallest stack of uranium annuli in the lower section was modeled "in contact with" the bottom of the stainless steel diaphragm. The gaps between the diaphragm and the remaining stacks were adjusted such that the bottoms of all the lower stacks were collocated on the same plane. This effectively models each of these

stacks as having been "raised" as a single configuration on a planar surface (as was performed in the actual experiment).

The measured worth of the diaphragm includes the separation distance between the two halves of the experiment. Therefore, when the diaphragm is removed from the model, the parts adjacent to the diaphragm are brought closer together and the separation distance of 0.010 in. (0.0254 cm) that represents the diaphragm thickness would be eliminated.[a]

#### *2.1.2.5 Assembly Separation*

The uncertainty for the separation of the upper and lower assemblies is based upon the accuracy of vertical placement measurement when bringing the two experiment halves into contact, ±0.001 in. (±0.00254 cm). This uncertainty, however, would be included within the measurement uncertainty of the worth of the stainless steel diaphragm.

### 2.1.3 Compositional Variations

#### *2.1.3.1 Uranium Annuli*

Traditionally, the uncertainties in the ORCEF oralloy experiments have been as follows in regards to material properties. The uranium mass of each part measured at the Y-12 Plant is traceable back to the Bureau of Standards to less than 0.5 gram accuracy and then rounded to the nearest gram yielding a mass uncertainty for each uranium annulus of ±0.5 g. Based on the accuracy of isotopic ratios from the mass spectrometry laboratory at the Y-12 Plant, uncertainty for the uranium isotopic content is ±0.005 wt.% for $^{234}$U, $^{235}$U, and $^{236}$U. The $^{238}$U content was obtained by subtracting the sum of the $^{234}$U, $^{235}$U, and $^{236}$U contents from one.

**Mass**

The uranium mass of each part measured at the Y-12 Plant is traceable back to the Bureau of Standards to less than 0.5 gram accuracy and then rounded to the nearest gram, thus the uncertainty for the mass of each uranium annulus is ±0.5 g. Additionally, the scale in the metrology laboratory of the Y-12 Plant had a mass accuracy of 0.089 g in 1960 for 20 kg calibration measurements.[b] These two uncertainties are both considered to represent bounding uncertainties with uniform probability distribution and are combined in quadrature to obtain a total bounding uncertainty of ±0.508 g. A mass measurement of multiple uranium annuli was not performed.

To find the effect of this uncertainty on the $k_{eff}$ value, the masses of the annuli (Table 1.1-4) were adjusted by a factor of 10 times the bounding uncertainty. In order to keep the uranium volume of the experiment constant, the density of each of the uranium annuli was adjusted accordingly. Uranium masses were simultaneously increased to find an upper perturbation $k_p$ value and then simultaneously decreased to find a lower perturbation $k_p$ value. Half of the difference between the upper and lower perturbation $k_p$ values was used to represent the variation in $k_p$ due to perturbing the annuli masses. The 1σ uncertainty in $k_{eff}$ associated with the uncertainty in the mass of the uranium annuli is found from the following formula, where $\Delta k_p$ is

[a] Personal communication between John D. Bess and John T. Mihalczo, February 2010.
[b] J. T. Mihalczo and T. Gregory Schaaff, "Uncertainties in Masses, Dimensions, Impurities, and Isotopics of HEU Metal Used in Critical Experiments at ORCEF," ORNL/TM-2012/32, Oak Ridge National Laboratory (2012).

one-half the difference between the upper and lower perturbation $k_{eff}$ values, N is the number of uranium annuli in each experiment, and SF is the parameter scaling factor:

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF} + \frac{\Delta k_p}{SF * \sqrt{N}}.$$

Both random and systematic uncertainties are treated as 100%. Results are provided in Table 2.5, and are considered negligible ($\Delta k_{eff} < 0.00003$) for all experiments.

Table 2.5. Effect of Uncertainty in Uranium Mass.

| Experiment | Deviation (g) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ±5.08 × 23 | -0.00049 ± 0.00003 | 10×2√3 | 0.00002 ± <0.00001 |
| 2 | ±5.08 × 28 | -0.00075 ± 0.00003 | 10×2√3 | 0.00003 ± <0.00001 |
| 3 | ±5.08 × 31 | -0.00054 ± 0.00003 | 10×2√3 | 0.00002 ± <0.00001 |
| 4 | ±5.08 × 27 | -0.00058 ± 0.00003 | 10×2√3 | 0.00002 ± <0.00001 |

**Isotopic Content**

Based on the accuracy of isotopic ratios from the mass spectrometry laboratory at the Y-12 Plant, uncertainty for the uranium isotopic content is ±0.005 wt.% for $^{234}U$, $^{235}U$, and $^{236}U$, which represents a rounding uncertainty that can also be considered a bounding uncertainty with uniform probability distribution (i.e. ÷√3). The $^{238}U$ content was obtained by subtracting the sum of the $^{234}U$, $^{235}U$, and $^{236}U$ contents from one. The weight percent uncertainty in isotopic content of the oralloy for measurement using a standard traceable back to the Bureau of Standards and the standard deviation of the mean for these parts were assessed.[a] The individual contributors to the total uncertainty in the uranium isotopic content are summarized in Table 2.6.

Table 2.6. Weight Percent (wt.%) Uncertainty (1σ) in Oralloy Isotopic Content.

| Isotope | Uncertainty in Traceable Standard Measurement[(a)] | Standard Deviation of the Mean for As-Measured Parts[(a)] | Rounding | Total Uncertainty |
|---|---|---|---|---|
| $^{234}U$ | 0.0017 | 0.00203 | 0.005/√3 | 0.003917 |
| $^{235}U$ | 0.0177 | 0.00346 | 0.005/√3 | 0.018265 |
| $^{236}U$ | 0.0130 | 0.00218 | 0.005/√3 | 0.013494 |

[a] J. T. Mihalczo and T. Gregory Schaaff, "Uncertainties in Masses, Dimensions, Impurities, and Isotopics of HEU Metal Used in Critical Experiments at ORCEF," ORNL/TM-2012/32, Oak Ridge National Laboratory (2012).

To find the effect of this uncertainty on the $k_{eff}$ value, the isotopic contents of the annuli (Table 1.5) were adjusted by a factor of 10 times the 1σ uncertainty. An upper perturbation $k_p$ value was found by simultaneously increasing the isotopic contents of $^{234}U$, $^{235}U$, or $^{236}U$ and adjusting the $^{238}U$ isotopic content accordingly. The isotopic contents of $^{234}U$, $^{235}U$, or $^{236}U$ were then simultaneously decreased, again with the $^{238}U$ content adjusted, to find the lower perturbation $k_p$ value. Typically, the isotopic content of all

[a] J. T. Mihalczo and T. Gregory Schaaff, "Uncertainties in Masses, Dimensions, Impurities, and Isotopics of HEU Metal Used in Critical Experiments at ORCEF," ORNL/TM-2012/32, Oak Ridge National Laboratory (2012).

components in a system would be varied individually so as to isolate any parts with significant merit. As this is a small system and relatively large perturbations of the combined isotopic content yield a negligible change in $k_{eff}$, all oralloy isotopic contents for a given isotope ($^{234}U$, $^{235}U$, or $^{236}U$) were adjusted simultaneously in all uranium parts. Half of the difference between the upper and lower perturbation $k_p$ values was used to represent the variation in $k_p$ due to perturbing the isotopic content. The 1σ uncertainty in $k_{eff}$ associated with the uncertainty in the isotopic content of the uranium annuli is found from the following formula, where $\Delta k_p$ is one-half the difference between the upper and lower perturbation $k_p$ values and SF is the parameter scaling factor:

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF}.$$

This uncertainty is treated as 100 % systematic with no random uncertainty component because the impact due to the variability in measurement of multiple oralloy components was already accounted for in the derivation of the standard deviation of the mean reported in Table 2.6. Results are provided in Tables 2.7 (a) – (c) for the uncertainties in uranium isotopics.

Table 2.7(a). Effect of Uncertainty in $^{234}U$ Isotopic Content.

| Experiment | Deviation (wt.%) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ±0.039172 | -0.00021 ± 0.00003 | 10 | -0.00002 ± <0.00001 |
| 2 | ±0.039172 | -0.00014 ± 0.00003 | 10 | -0.00001 ± <0.00001 |
| 3 | ±0.039172 | -0.00014 ± 0.00003 | 10 | -0.00001 ± <0.00001 |
| 4 | ±0.039172 | -0.00018 ± 0.00003 | 10 | -0.00002 ± <0.00001 |

Table 2.7(b). Effect of Uncertainty in $^{235}U$ Isotopic Content.

| Experiment | Deviation (wt.%) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ±0.0182646 | -0.00095 ± 0.00003 | 10 | -0.00010 ± <0.00001 |
| 2 | ±0.0182646 | -0.00095 ± 0.00003 | 10 | -0.00010 ± <0.00001 |
| 3 | ±0.0182646 | -0.0010 ± 0.00003 | 10 | -0.00010 ± <0.00001 |
| 4 | ±0.0182646 | -0.00098 ± 0.00003 | 10 | -0.00010 ± <0.00001 |

Table 2.7(c). Effect of Uncertainty in $^{236}U$ Isotopic Content.

| Experiment | Deviation (wt.%) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ±0.134939 | -0.00015 ± 0.00003 | 10 | -0.00001 ± <0.00001 |
| 2 | ±0.134939 | -0.00015 ± 0.00003 | 10 | -0.00001 ± <0.00001 |
| 3 | ±0.134939 | -0.00015 ± 0.00003 | 10 | -0.00001 ± <0.00001 |
| 4 | ±0.134939 | -0.00015 ± 0.00003 | 10 | -0.00001 ± <0.00001 |

**Impurities**

The uranium impurities listed in Table 1.5 are given as the average of a spectrographic analysis from randomly sampled components for each impurity (assuming the values to be normally distributed) or listed as less than a minimum value. In the latter case, they are less than the detectable limit. The impurity content, as specified in Table 1.5, is accepted as the nominal composition for the oralloy parts utilized at ORCEF. The

oxygen and nitrogen content was included at the experimentalist-specified quantities of 20 and 30 ppm, respectively. For impurities below a detectable limit, the content is selected as half the detectable limit and the detection limit as a bounding uncertainty. The concentration of metallic impurities in the oralloy was determined by DC-Arc emission spectroscopy, and the concentration of "gas" species was determined by combustion analyses, similar to modern LECO-type measurements. It was established that the uncertainty in these methods was 70 % for values measured below 10 µg/g-U and 20 % for values measured above 10 µg/g-U. However, for the measurement of oralloy materials, the uncertainty was about 20 % and 6 %, respectively.[a] The mean impurity content and revised uncertainty assessment are provided in Table 2.8.

Table 2.8. Impurity Content of Uranium Metal Annuli.

| Element | Impurity Content (ppm) | 1σ Uncertainty (ppm) |
|---|---|---|
| Ag | 8 | 1.6 |
| Ba | 0.005 | 0.005/√3 |
| Bi | 164 | 9.84 |
| C | 5 | 5/√3 |
| Ca | 0.1 | 0.02 |
| Cd | 0.5 | 0.5/√3 |
| Co | 5 | 1 |
| Cr | 7 | 1.4 |
| Cu | 25 | 1.5 |
| K | 0.1 | 0.1/√3 |
| Li | 1 | 1/√3 |
| Mg | 3 | 0.6 |
| Mn | 56 | 3.36 |
| Mo | 0.5 | 0.5/√3 |
| Na | 27 | 1.62 |
| Ni | 100 | 6 |
| Sb | 38 | 2.28 |
| Ti | 1 | 0.2 |
| O | 20 | 1.8 |
| N | 30 | 1.2 |
| Total | 491.205 | ~35 |

To find the effect of this uncertainty on the $k_{eff}$ value, the impurities were all simultaneously increased by 3σ to find an upper perturbation $k_p$ value and then all simultaneously decreased to find a lower perturbation $k_p$ value. Perturbation of the content of individual impurities was not performed as their content and the uncertainty in the content is already quite small; furthermore, the primary effect of this uncertainty would be the impact of adjusting the total uranium content in the oralloy metal. The weight fraction of the uranium metal was adjusted, as appropriate, to compensate for the adjustments in impurity content. Half of the difference between the upper and lower perturbation $k_p$ values was used to represent the variation in $k_p$ due to perturbing the uranium impurity content. The 1σ uncertainty in $k_{eff}$ associated with the impurity content of

[a] J. T. Mihalczo and T. Gregory Schaaff, "Uncertainties in Masses, Dimensions, Impurities, and Isotopics of HEU Metal Used in Critical Experiments at ORCEF," ORNL/TM-2012/32, Oak Ridge National Laboratory (2012).

the uranium annuli is found from the following formula, where $\Delta k_p$ is one-half the difference between the upper and lower perturbation $k_p$ values and SF is the parameter scaling factor:

$$\Delta k_{eff}(1\sigma) = \frac{\Delta k_p}{SF}.$$

This uncertainty is treated as 100 % systematic with no random uncertainty component because there is insufficient information to assess any randomness in the impurity content between manufactured oralloy components. Results are provided in Table 2.9, and are considered negligible ($\Delta k_{eff} < 0.00003$) for all experiments.

Table 2.9. Effect of Uncertainty in Uranium Impurity Content.

| Experiment | Deviation (ppm) | $\Delta k_p \pm \sigma_{\Delta kp}$ | SF | $\Delta k_{eff}(1\sigma) \pm \sigma_{\Delta keff}$ |
|---|---|---|---|---|
| 1 | ±3σ (see Table 2.8) | -0.00004 ± 0.00003 | 3 | -0.00001 ± <0.00001 |
| 2 | ±3σ (see Table 2.8) | -0.00004 ± 0.00003 | 3 | -0.00001 ± <0.00001 |
| 3 | ±3σ (see Table 2.8) | -0.00005 ± 0.00003 | 3 | -0.00002 ± <0.00001 |
| 4 | ±3σ (see Table 2.8) | -0.00004 ± 0.00003 | 3 | -0.00001 ± <0.00001 |

### 2.1.4 Total Experimental Uncertainty

The total $k_{eff}$ uncertainty for each experiment was calculated by taking the square root of the sum of the squares of all the individual uncertainties discussed in this section[a]; they are summarized in Tables 2.10, 2.11, 2.12, and 2.13 for Experiments 1 through 4, respectively; these are acceptable benchmark experiments. Uncertainties < 0.00003 $\Delta k_{eff}$ are reported as negligible (neg).

Table 2.10. Total Experimental Uncertainty for Experiment 1 (7″ – 13″).

| Perturbed Parameter | Parameter Value | 1σ Uncertainty | $\Delta k_{eff}$ |
|---|---|---|---|
| Temperature (K) | 294 | ±2 | 0.00004 |
| Experiment reproducibility (¢) | -- | ±2 | 0.00013 |
| Measured reactivity worth (¢) | -- | ±√4×√3×2 | 0.00046 |
| $\beta_{eff}$ | 0.0066 | ±5 % | neg |
| Uranium diameter (cm) | Table 2.1 | ±0.001276/√3 | 0.00006 |
| Uranium height (cm) | Table 2.2 | ±0.001276/√3 | 0.00005 |
| Uranium stack height (cm) | Table 2.3 | ±0.005133 | 0.00016 |
| Lateral assembly alignment (cm) | 0 | ±0.0127/2√3 | neg |
| Uranium mass (g) | Table 1.4 | ±0.508/√3 | neg |
| $^{234}$U content (wt. %) | Table 1.5 | ±0.039172 | neg |
| $^{235}$U content (wt. %) | Table 1.5 | ±0.182646 | 0.00010 |
| $^{236}$U content (wt. %) | Table 1.5 | ±0.134939 | neg |
| Uranium impurities (ppm) | Table 2.8 | | neg |
| **Total Experimental Uncertainty** | **--** | **--** | **0.00052** |

[a] Vertical assembly alignment, gaps between parts, and assembly separation uncertainties are discussed in section 2.1.2 and are not applicable here.

Table 2.11. Total Experimental Uncertainty for Experiment 2 ($7'' - 15''$).

| **Perturbed Parameter** | **Parameter Value** | **1σ Uncertainty** | **$\Delta k_{eff}$** |
|---|---|---|---|
| Temperature (K) | 294 | ±2 | 0.00004 |
| Experiment reproducibility (¢) | -- | ±2 | 0.00013 |
| Measured reactivity worth (¢) | -- | $\pm\sqrt{3}\times\sqrt{2}\times 2$ | 0.00046 |
| $\beta_{eff}$ | 0.0066 | ±5 % | 0.00004 |
| Uranium diameter (cm) | Table 2.1 | $\pm 0.001276/\sqrt{3}$ | 0.00005 |
| Uranium height (cm) | Table 2.2 | $\pm 0.001276/\sqrt{3}$ | 0.00006 |
| Uranium stack height (cm) | Table 2.3 | ±0.002644 | 0.00011 |
| Lateral assembly alignment (cm) | 0 | $\pm 0.0127/2\sqrt{3}$ | neg |
| Uranium mass (g) | Table 1.4 | $\pm 0.508/\sqrt{3}$ | 0.00003 |
| $^{234}$U content (wt. %) | Table 1.5 | ±0.039172 | neg |
| $^{235}$U content (wt. %) | Table 1.5 | ±0.182646 | 0.00010 |
| $^{236}$U content (wt. %) | Table 1.5 | ±0.134939 | neg |
| Uranium impurities (ppm) | Table 2.8 | | neg |
| **Total Experimental Uncertainty** | **--** | **--** | **0.00051** |

Table 2.12. Total Experimental Uncertainty for Experiment 3 ($9'' - 15''$).

| **Perturbed Parameter** | **Parameter Value** | **1σ Uncertainty** | **$\Delta k_{eff}$** |
|---|---|---|---|
| Temperature (K) | 294 | ±2 | 0.00004 |
| Experiment reproducibility (¢) | -- | ±2 | 0.00013 |
| Measured reactivity worth (¢) | -- | $\pm\sqrt{3}\times\sqrt{2}\times 2$ | 0.00046 |
| $\beta_{eff}$ | 0.0066 | ±5 % | 0.00009 |
| Uranium diameter (cm) | Table 2.1 | $\pm 0.001276/\sqrt{3}$ | 0.00005 |
| Uranium height (cm) | Table 2.2 | $\pm 0.001276/\sqrt{3}$ | 0.00006 |
| Uranium stack height (cm) | Table 2.3 | ±0.002644 | 0.00009 |
| Lateral assembly alignment (cm) | 0 | $\pm 0.0127/2\sqrt{3}$ | neg |
| Uranium mass (g) | Table 1.4 | $\pm 0.508/\sqrt{3}$ | neg |
| $^{234}$U content (wt. %) | Table 1.5 | ±0.039172 | neg |
| $^{235}$U content (wt. %) | Table 1.5 | ±0.182646 | 0.00010 |
| $^{236}$U content (wt. %) | Table 1.5 | ±0.134939 | neg |
| Uranium impurities (ppm) | Table 2.8 | | neg |
| **Total Experimental Uncertainty** | **--** | **--** | **0.00051** |

Table 2.13. Total Experimental Uncertainty for Experiment 4 ($7'' - 11''$).

| **Perturbed Parameter** | **Parameter Value** | **1σ Uncertainty** | **$\Delta k_{eff}$** |
|---|---|---|---|
| Temperature (K) | 294 | ±2 | 0.00004 |
| Experiment reproducibility (¢) | -- | ±2 | 0.00013 |
| Measured reactivity worth (¢) | -- | $\pm\sqrt{3}\times\sqrt{2}\times 2$ | 0.00046 |
| $\beta_{eff}$ | 0.0066 | ±5 % | 0.00007 |

| | | | |
|---|---|---|---|
| Uranium diameter (cm) | Table 2.1 | ±0.001276/√3 | 0.00007 |
| Uranium height (cm) | Table 2.2 | ±0.001276/√3 | 0.00006 |
| Uranium stack height (cm) | Table 2.3 | ±0.007655 | 0.00004 |
| Lateral assembly alignment (cm) | 0 | ±0.0127/2√3 | neg |
| Uranium mass (g) | Table 1.4 | ±0.508/√3 | neg |
| $^{234}$U content (wt. %) | Table 1.5 | ±0.039172 | neg |
| $^{235}$U content (wt. %) | Table 1.5 | ±0.182646 | 0.00010 |
| $^{236}$U content (wt. %) | Table 1.5 | ±0.134939 | neg |
| Uranium impurities (ppm) | Table 2.8 | | neg |
| **Total Experimental Uncertainty** | **--** | **--** | **0.00051** |

# 3.0 BENCHMARK SPECIFICATIONS

## 3.1 Benchmark-Model Specifications for Critical and / or Subcritical Measurements

One detailed model and one simple model were developed to represent each experiment. Part 2746 is listed twice in Experiment 4, but the detailed benchmark models represent, as much as possible, the experiments described in Section 1. Some approximation is necessary to estimate the height of gaps between the individual components of the experiments and reproduce the measured stack heights; however, any uncertainty in the gap height would be negligible compared with the total experimental uncertainty. The simple benchmark models reduce the experiments to a basic cylindrical structure comprised of a solid HEU material.

The experimental assembly, including the stainless steel diaphragm and the room itself, are not included in the benchmark models.

Experiment 4 contains part 2746 twice, which appears to be a misprint in logbook 12R page 22 (East Cell – Logbook 1, E-19). This part has nominal inner and outer diameters of 9 and 11 inches (22.86 and 27.94 cm), respectively, and a height of 0.125 inches (0.321945 cm). The mislabeled part is represented in the models as part 2744, which is the only other part with the same nominal dimensions as part 2746.

These four near-critical experiments have been evaluated as acceptable benchmark experiments. Experiments 1 through 4 are hereafter designated as Cases 1 through 4 in this evaluation.

### 3.1.1 Description of the Benchmark Model Simplifications

#### *3.1.1.1 Detailed Model*

The detailed benchmark model is comprised of stacks of uranium metal annuli. There are three sets of rings in Cases 1 and 3, four sets of rings in Case 2, and two sets of rings in Case 4 (along with disks). Small gaps exist between some adjacent components of the experiment and each component has unique dimensions and composition that reproduce, as closely as possible, the actual component dimensions and compositions (see Figures 3.1 – 3.8).

Very small gaps exist between the components of the experiment, as the top and bottom surfaces of the discs are not perfectly smooth. However, it is not easy to exactly model the imperfect surfaces of the experiment components. The measured stack height and individual heights of each part are preserved in the detailed benchmark model. To preserve the stack height, small gaps must be placed between the discs. These gap heights are exaggerated in Figures 3.2, 3.4, 3.6, and 3.8. The effect of eliminating the gaps between parts is quite small compared to effects such as adjusting the overall stacked height dimension of the experiment, which is then, much less than the uncertainty in the measurements of system reactivity and corrections for removal of experiment support structure (see section 2.1.4).

#### *3.1.1.2 Simple Model*

The simple benchmark models consist of a single piece of HEU metal for all cases. Cases 1 to 4 have inner radii of 8.89 cm, 8.89 cm 11.43 cm, and 8.89 cm and outer radii of 16.51 cm, 19.05 cm, 19.05 cm, and 13.97 cm, respectively. Their respective heights are 14.576213 cm, 10.742295 cm, 15.06982 cm, and 18.58518 cm. In Case 4, the upper and lower 7″ internal diameter (nominal) disks have heights of 3.17246 cm and 3.5052

cm. There are no gaps present between the uranium components. The total mass for the uranium is conserved in the simple model, and the model dimensions correspond to the nominal experimental dimensions.

### *3.1.1.3 Evaluation of Benchmark Model Biases*

A discussion of the individual benchmark model biases is provided below with a summary of the evaluated results in Table 3.1.

**Room Return**

The properties and dimensions of the room in which the experiment was performed were not provided in Reference 1, but they are well known and available from other ORCEF East Cell experiment reports. The dimensions were obtained from a similar benchmark report: HEU-MET-FAST-076 (in the ICSBEP Handbook). Room return effects were estimated using the room and experiment placement dimensions provided in Section 1.2 and assuming that the other concrete wall, floor, and ceiling thicknesses are 2 feet (61 cm). The concrete was modeled as Oak Ridge Concrete with a density of 2.3 g/cm$^3$ and the room containing air with a density of 1.2 kg/m$^3$. The use of either Oak Ridge Concrete or Magnuson Concrete was previously demonstrated to provide similar results as shown in HEU-MET-FAST-076. Both concretes were prepared using crushed limestone instead of sand due to the unavailability of sand at the time.[a]

**Support Structure Removal**

The benchmark models do not include the support structure of the experimental assembly or the stainless steel diaphragm. Removal of the support structure materials was included in the experimental assessment of the reported eigenvalue and the uncertainty in their worth is discussed in Section 2.1.

The diaphragm bolts were not included in the experimental analysis of the support structure worth.[b] A calculation was performed previously in HEU-MET-FAST-069 of the ICSBEP Handbook to evaluate a "ring" of steel material where the bolts would have been located in the actual experiment. The calculated bias in that benchmark evaluation was negligible and is also assumed to have a negligible effect upon this set of experiments.

**Temperature**

The temperature reactivity coefficient is reported by the experimenter to be approximately -0.3¢/ºC. The parts were measured at ~294 K and the original experiments were performed at ~295 K. The uncertainty in either of these two temperatures is unknown. The benchmark models use dimensions as measured at room temperature conditions, ~294 K, and ENDF/B-VII.1 cross sections evaluated at 293.6 K. No bias for temperature effects was included in the benchmark model, however an uncertainty in the temperature of the experiments and evaluation are provided in Section 2.1.

**Model Simplifications**

Additional simplifications were performed to facilitate the application of a simple model in place of the detailed model. Simplifications include the removal of impurities from the uranium annuli and disks and

[a] Personal communication between John D. Bess and John T. Mihalczo, February 2010.
[b] Personal communication between John D. Bess and John T. Mihalczo, June 2010.

development of a uranium solid with uniform material properties. There are no gaps between the individual annuli in a stack, as they are modeled as a single homogenous annulus. These adjustments in dimensions were performed to match the approximate measurement descriptions for the experiment. The density of the individual stacks was computed using the total measured mass divided by the total adjusted volume. The mass densities for the simple models are provided in Table 3.3. These densities are less than those for the individual parts due to the absorption of gaps into the total volume. The weight fraction of isotopes in the uranium annulus was obtained by taking the weight-averaged isotopic contents of the individual annuli. The mass of the uranium annulus was also reduced by replacing the impurities with void (uranium weight fraction of 0.9995088). Results for these simplifications are shown in Table 3.1. MCNP6.1 and ENDF/B-VII.1 was utilized to estimate the biases, with a statistical uncertainty in $\Delta k_{eff}$ of 0.00003.

**Total Bias Adjustment**

The total bias for the detailed benchmark model includes room return effects and experimentally measured corrections for the removal of support structure.

The total bias for the simple benchmark model includes those for the detailed benchmark model as well as the model simplifications discussed earlier in this section for homogenization, impurity removal, and implementing standard material densities.

A list of the individually evaluated biases, with their respective bias uncertainties, and the total bias for both detailed and simple benchmark models are provided in Table 3.1.

Table 3.1. Calculated Biases ($\Delta k_{eff}$) for Benchmark Model Simplifications.

| **Bias/*Correction*** | **Case 1** | **Case 2** |
|---|---|---|
| 1. Room Return Effects | -0.00110 ± 0.00003 | -0.00120 ± 0.00003 |
| *2. Removal of Stainless Steel Diaphragm* | 0.00111 --[(d)] | 0.00113 --[(d)] |
| *3. Removal of Diaphragm Support Rings* | -0.00038 --[(d)] | -0.00028 --[(d)] |
| *4. Removal of Support Structure* | -0.00076 --[(d)] | -0.00145 --[(d)] |
| 5. Temperature | -- | -- |
| **Total Bias for Detailed Model[(a)]** | **-0.00113 ± 0.00003** | **-0.00180 ± 0.00003** |
| 6. Removal of HEU Impurities | 0.00018 ± 0.00003 | 0.00020 ± 0.00003 |
| 7. Removal of HEU Impurities with Homogenization of HEU Annuli[(b)] | -0.00058 ± 0.00003 | -0.0011 ± 0.00003 |
| **Total Bias for Simplified Model[(c)]** | **-0.00171 ± 0.00004** | **-0.00290 ± 0.00004** |

| **Bias/*Correction*** | **Case 3** | **Case 4** |
|---|---|---|
| 1. Room Return Effects | -0.00130 ± 0.00003 | -0.00100 ± 0.00003 |
| *2. Removal of Stainless Steel Diaphragm* | 0.00078 --[(d)] | 0.00038 --[(d)] |
| *3. Removal of Diaphragm Support Rings* | -0.00076 --[(d)] | -0.00039 --[(d)] |
| *4. Removal of Support Structure* | -0.00092 --[(d)] | -0.00099 --[(d)] |
| 5. Temperature | -- | -- |
| **Total Bias for Detailed Model[(a)]** | **-0.00220 ± 0.00003** | **-0.00200 ± 0.00003** |
| 6. Removal of HEU Impurities | 0.00025 ± 0.00003 | -0.00002 ± 0.00003 |
| 7. Removal of HEU Impurities with | -0.00033 ± 0.00003 | -0.00027 ± 0.00003 |

| | | |
|---|---|---|
| Homogenization of HEU Annuli[(b)] | | |
| **Total Bias for Simplified Model[(c)]** | **-0.00253 ± 0.00004** | **-0.00227 ± 0.00004** |

[a] Bias is the arithmetic sum of Items 1 through 5; bias uncertainty is the square root of the sum of the squares of each uncertainty for items 1 through 5.
[b] Bias is the difference between calculated $k_{eff}$ of the detailed model and the simplified model (Items 6 and 7; bias uncertainty is the statistical uncertainty associated with the Monte Carlo calculations × √2.
[c] Bias is the arithmetic sum of the total bias of the detailed model and the calculated simplification bias; bias uncertainty is the square root of the sum of the squares of the uncertainty in the bias for the detailed model and the uncertainty in the calculated simplification bias. Since the bias of item 6 is included in item 7, item 6 values are not included in the calculations of the totals.
[d] The uncertainties in the measured corrections are already accounted for in evaluation of the total experimental uncertainty (see Section 2.1.1.3).

## 3.2 Dimensions

### *3.2.1 Detailed Models*

The detailed benchmark models are shown in Figures 3.1 through 3.8 for the both the part dimensions and gaps between the HEU parts. They are labeled with part identifiers and dimensions. Part dimensions for the HEU annuli are also summarized in Table 3.2[a].

[a] The number of significant figures given for the parts is greater than that measured in order to conserve the original measurement, which was in inches. Personal communication with John T. Mihalczo, March 2015.

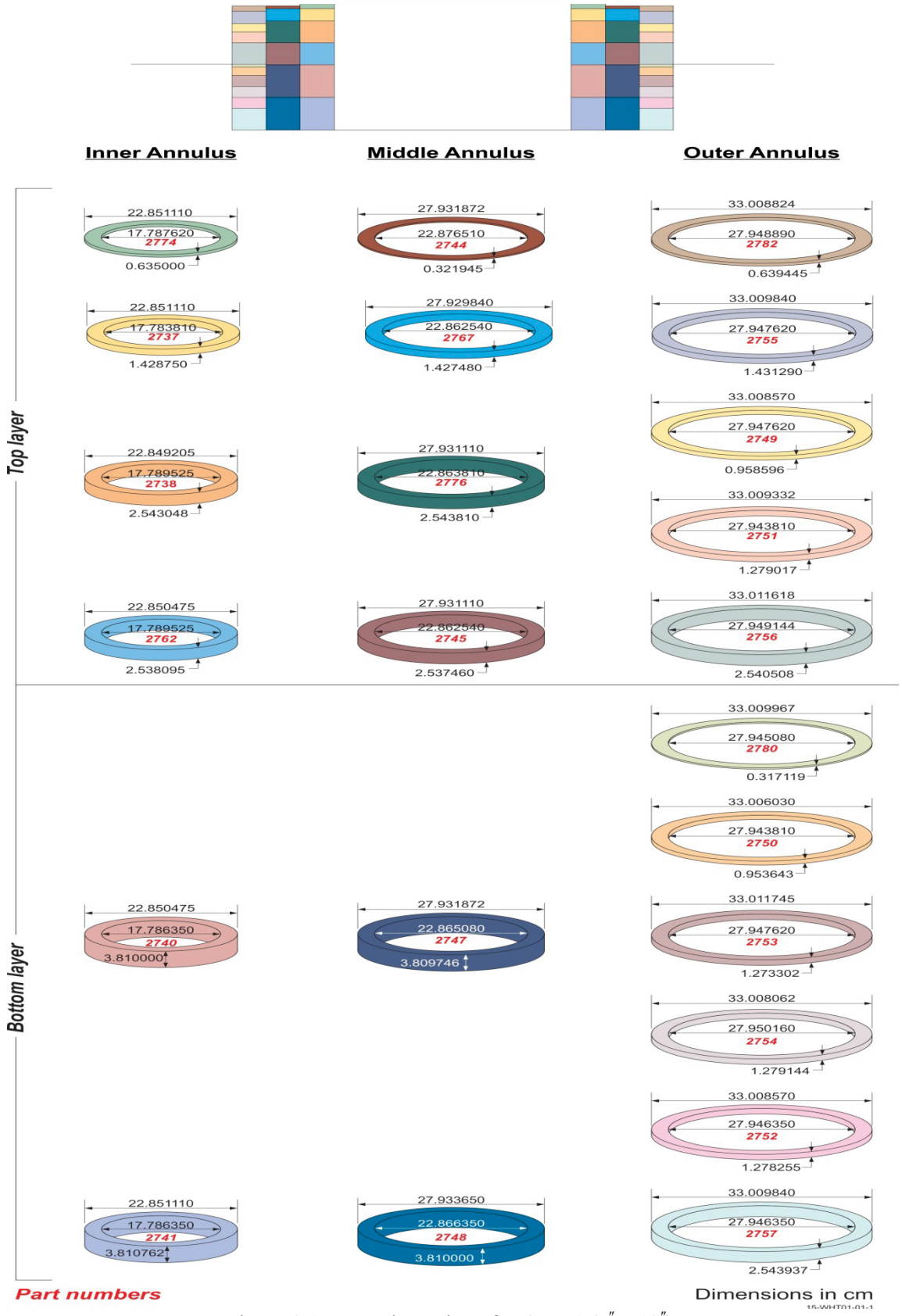


Figure 3.1. Part Dimensions for Case 1 (7″ – 13″).

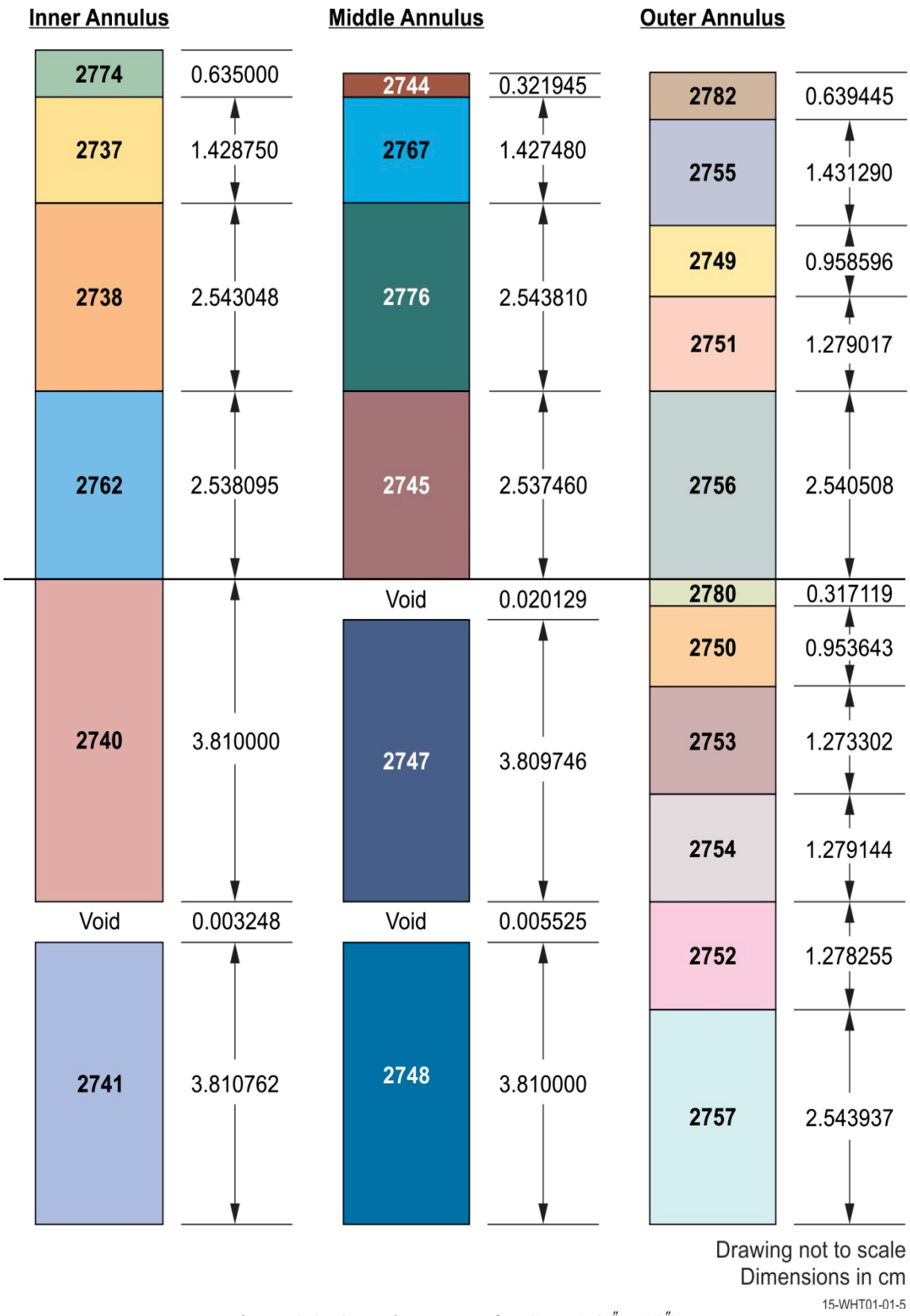


Figure 3.2. Gap Placements for Case 1 (7″ – 13″).


Figure 3.3. Part Dimensions for Case 2 (7″ – 15″).

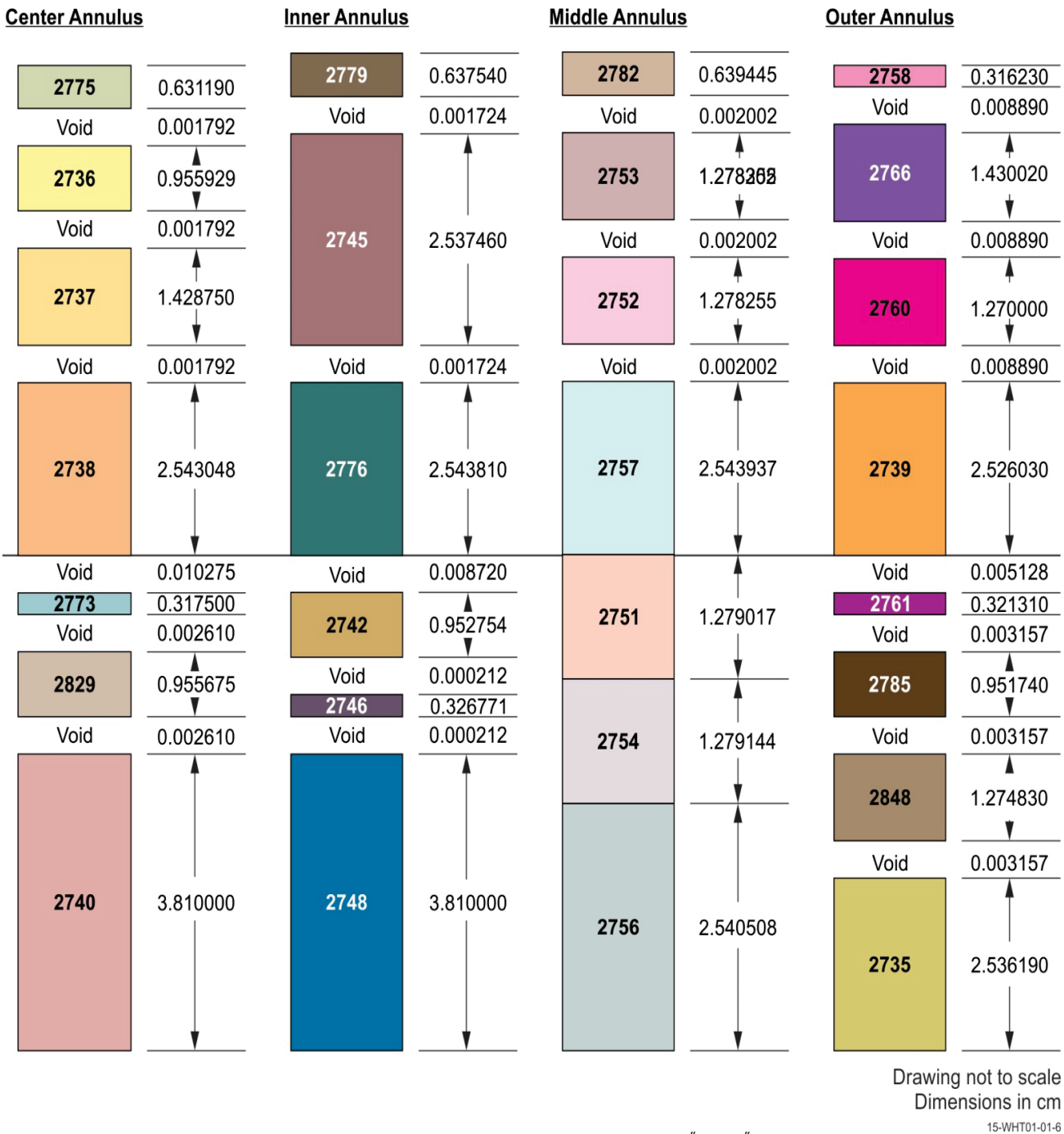


Figure 3.4. Gap Placements for Case 2 (7″ – 15″).

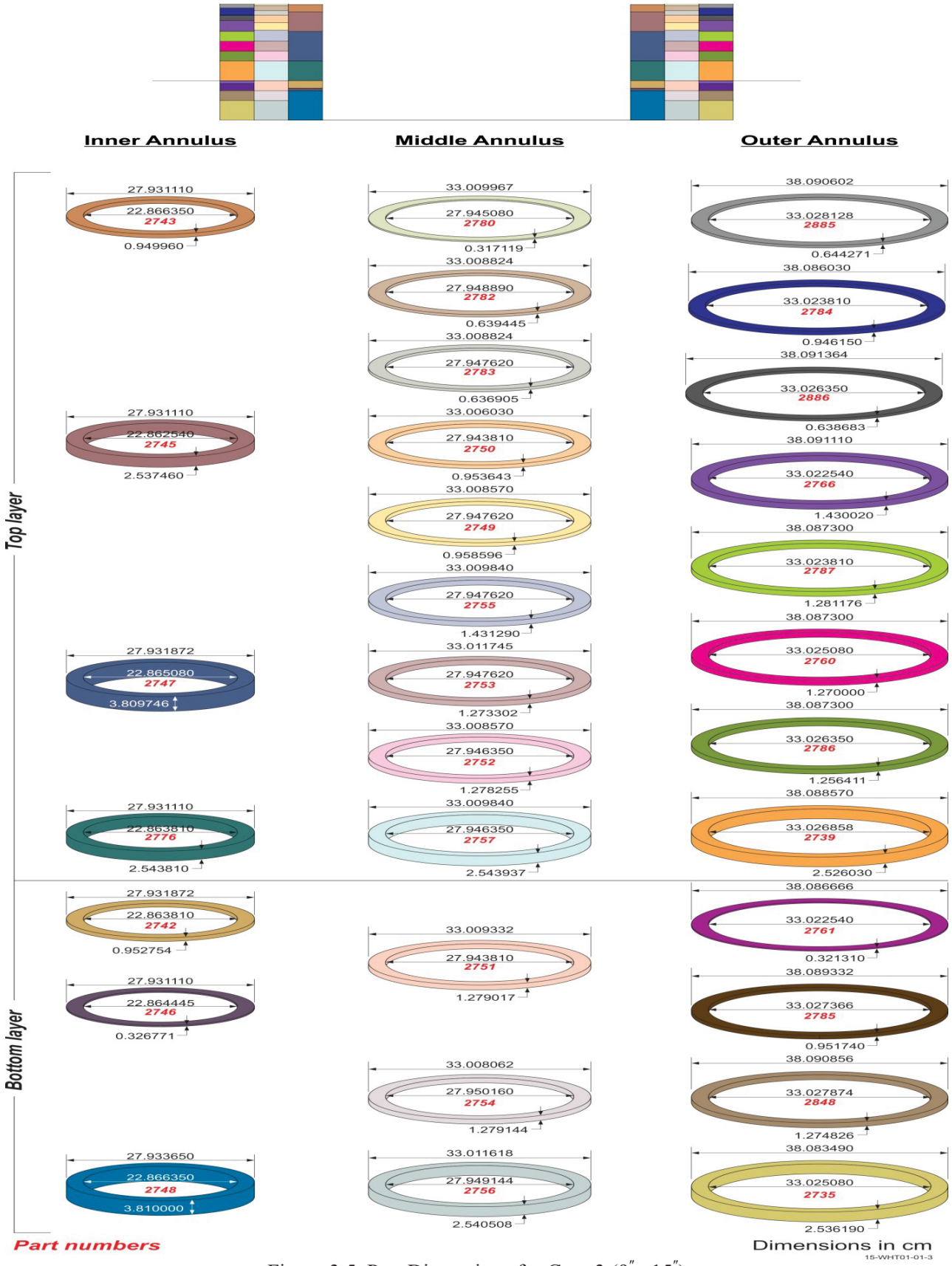


Figure 3.5. Part Dimensions for Case 3 (9″ – 15″)

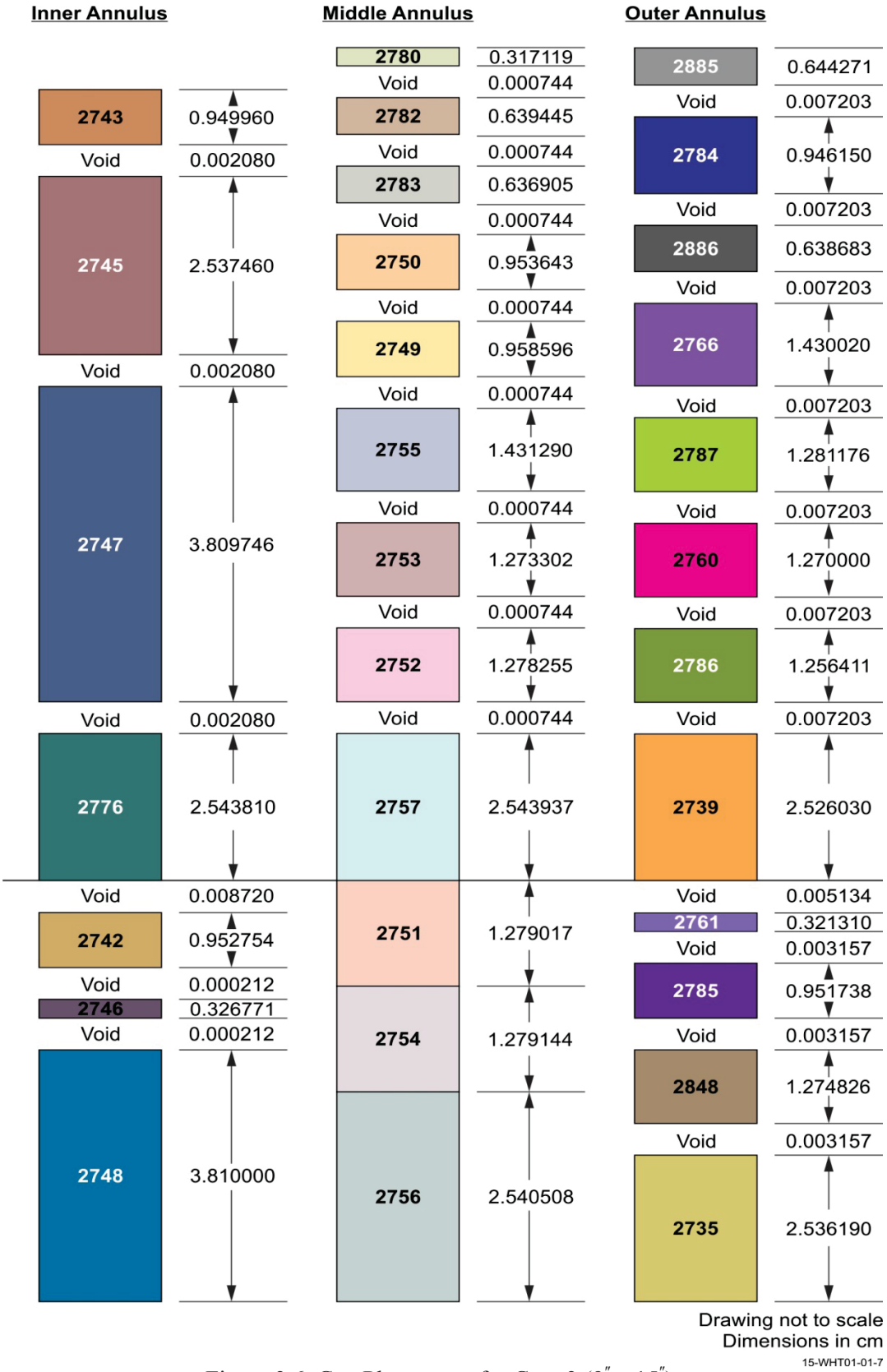


Figure 3.6. Gap Placements for Case 3 (9″ – 15″).

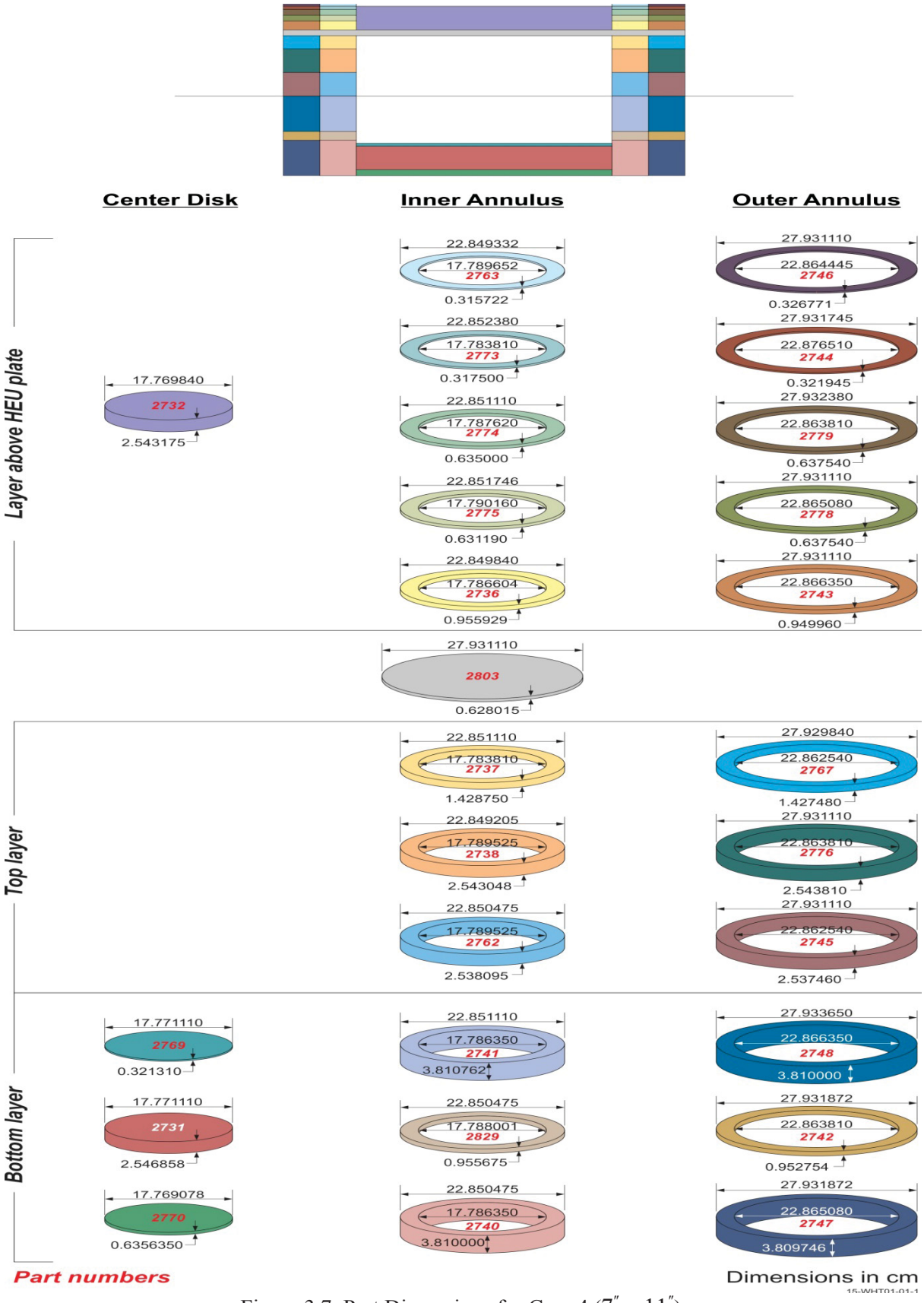


Figure 3.7. Part Dimensions for Case 4 (7″ – 11″).

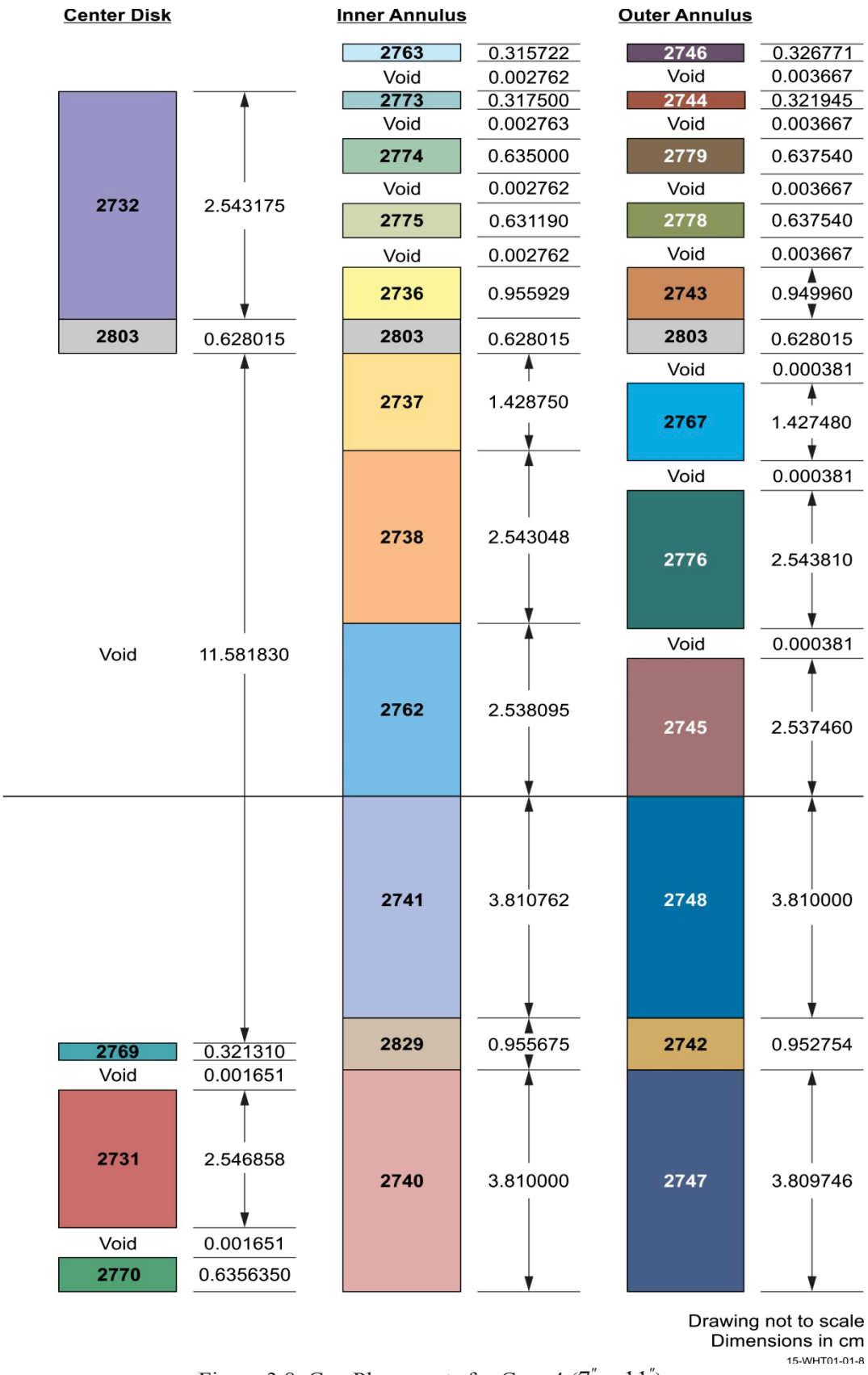


Figure 3.8. Gap Placements for Case 4 (7″ – 11″).

Table 3.2. Properties of Detailed Benchmark HEU Annuli and Disks.

| Part Number | Mass (g) | Height (cm) | Inner Diameter (cm) | Outer Diameter (cm) |
|---|---|---|---|---|
| 2728 | 4435 | 0.95504 | - | 8.882888 |
| 2729 | 4440 | 0.954278 | - | 8.8848565 |
| 2730 | 6646 | 1.42748 | - | 8.88492 |
| 2731 | 11841 | 2.546858 | - | 8.885555 |
| 2732 | 11814 | 2.543175 | - | 8.88492 |
| 2735 | 13409 | 2.53619 | 16.51254 | 19.041745 |
| 2736 | 2895 | 0.955929 | 8.893302 | 11.42492 |
| 2737 | 4336 | 1.42875 | 8.891905 | 11.425555 |
| 2738 | 7710 | 2.543048 | 8.8947625 | 11.4246025 |
| 2739 | 13461 | 2.52603 | 16.513429 | 19.044285 |
| 2740 | 11568 | 3.81 | 8.893175 | 11.4252375 |
| 2741 | 11568 | 3.810762 | 8.893175 | 11.425555 |
| 2742 | 3617 | 0.952754 | 11.431905 | 13.9658725 |
| 2743 | 3621 | 0.94996 | 11.433175 | 13.965555 |
| 2744 | 1223 | 0.321945 | 11.438255 | 13.9658725 |
| 2745 | 9634 | 2.53746 | 11.43127 | 13.965555 |
| 2746 | 1238 | 0.326771 | 11.4322225 | 13.965555 |
| 2747 | 14436 | 3.809746 | 11.43254 | 13.9658725 |
| 2748 | 14462 | 3.81 | 11.433175 | 13.966825 |
| 2749 | 4360 | 0.958596 | 13.97381 | 16.504285 |
| 2750 | 4336 | 0.953643 | 13.971905 | 16.503015 |
| 2751 | 5822 | 1.279017 | 13.971905 | 16.5046025 |
| 2752 | 5811 | 1.278255 | 13.973175 | 16.504285 |
| 2753 | 5782 | 1.273302 | 13.97381 | 16.5058725 |
| 2754 | 5826 | 1.279144 | 13.97508 | 16.504031 |
| 2755 | 6514 | 1.43129 | 13.97381 | 16.5048565 |
| 2756 | 11567 | 2.540508 | 13.974572 | 16.505809 |
| 2757 | 11575 | 2.543937 | 13.973175 | 16.50492 |
| 2758 | 1685 | 0.31623 | 16.505555 | 19.0457455 |
| 2760 | 6743 | 1.27 | 16.51254 | 19.04365 |
| 2761 | 1706 | 0.32131 | 16.51127 | 19.0433325 |
| 2762 | 7703 | 2.538095 | 8.8947625 | 11.4252375 |
| 2763 | 953 | 0.315722 | 8.894826 | 11.424666 |

| | | | | |
|---|---|---|---|---|
| 2766 | 7605 | 1.43002 | 16.51127 | 19.045555 |
| 2767 | 5410 | 1.42748 | 11.43127 | 13.96492 |
| 2768 | 1481 | 0.3175 | - | 8.885555 |
| 2769 | 1495 | 0.32131 | - | 8.885555 |
| 2770 | 2955 | 0.635635 | - | 8.884539 |
| 2771 | 2916 | 0.630047 | - | 8.885682 |
| 2773 | 962 | 0.32004 | 8.891905 | 11.42619 |
| 2774 | 1930 | 0.635 | 8.89381 | 11.425555 |
| 2775 | 1917 | 0.63119 | 8.89508 | 11.4258725 |
| 2776 | 9644 | 2.54381 | 11.431905 | 13.965555 |
| 2778 | 2411 | 0.63754 | 11.43254 | 13.965555 |
| 2779 | 2417 | 0.63754 | 11.431905 | 13.96619 |
| 2780 | 1440 | 0.317119 | 13.97254 | 16.5049835 |
| 2782 | 2914 | 0.639445 | 13.974445 | 16.504412 |
| 2783 | 2888 | 0.636905 | 13.97381 | 16.504412 |
| 2784 | 5039 | 0.94615 | 16.511905 | 19.043015 |
| 2785 | 5043 | 0.951738 | 16.5136195 | 19.0446025 |
| 2786 | 6717 | 1.256411 | 16.513175 | 19.04365 |
| 2787 | 6788 | 1.281176 | 16.511905 | 19.04365 |
| 2803 | 7220 | 0.628015 | | 13.965555 |
| 2829 | 2895 | 0.955675 | 8.8940005 | 11.4252375 |
| 2848 | 6748 | 1.274826 | 16.513937 | 19.045428 |
| 2885 | 3415 | 0.644271 | 16.514064 | 19.045301 |
| 2886 | 3384 | 0.638683 | 16.513175 | 19.045682 |

### *3.2.2 Simple Models*

For the simple benchmark models the nominal inner and outer radii and average measured stack heights were used. Cases 1 – 4 have inner radii of 8.89 cm, 8.89 cm 11.43 cm, and 8.89 cm and outer radii of 16.51 cm, 19.05 cm, 19.05 cm, and 13.97 cm, respectively. Their respective heights are 14.576213 cm, 10.742295 cm, 15.069820 cm, and 18.58518 cm. In Case 4, the upper 7″ and 11″ disks have a height of 3.17246 cm, and the lower 7″ diameter disks have a height of 3.5052 cm. Schematics of the simple models are shown in Figures 3.9 – 3.12.

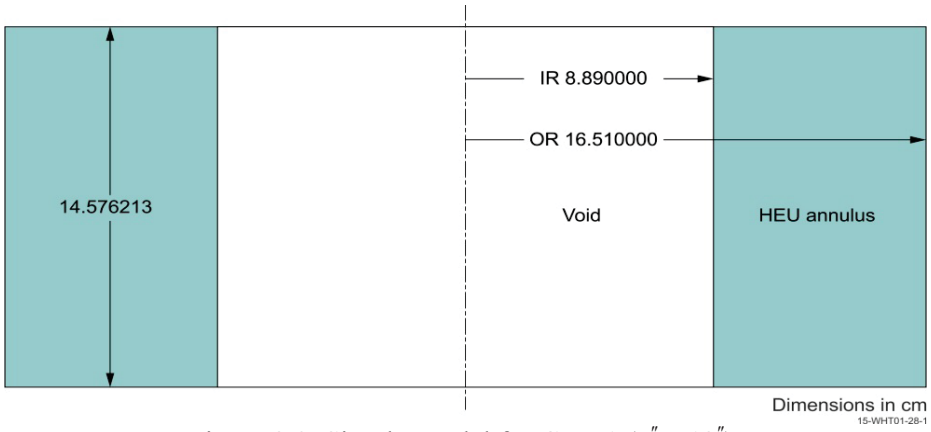


Figure 3.9. Simple Model for Case 1 (7″ – 13″).

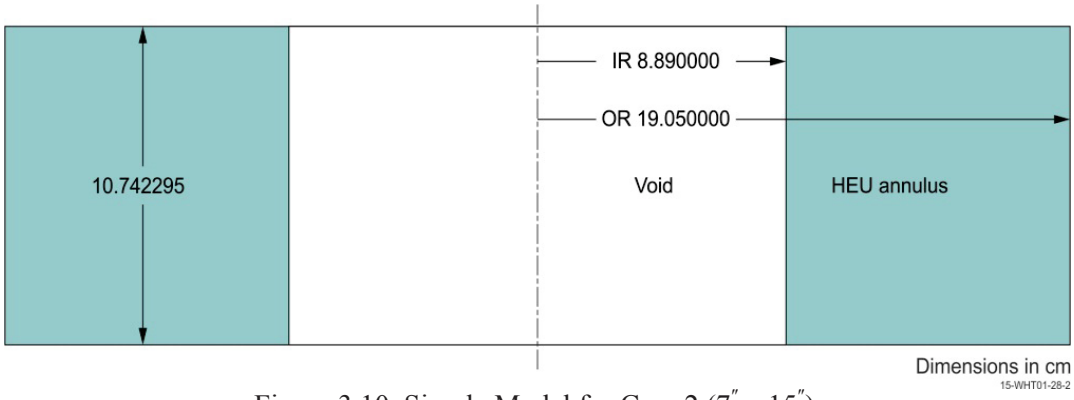


Figure 3.10. Simple Model for Case 2 (7″ – 15″).

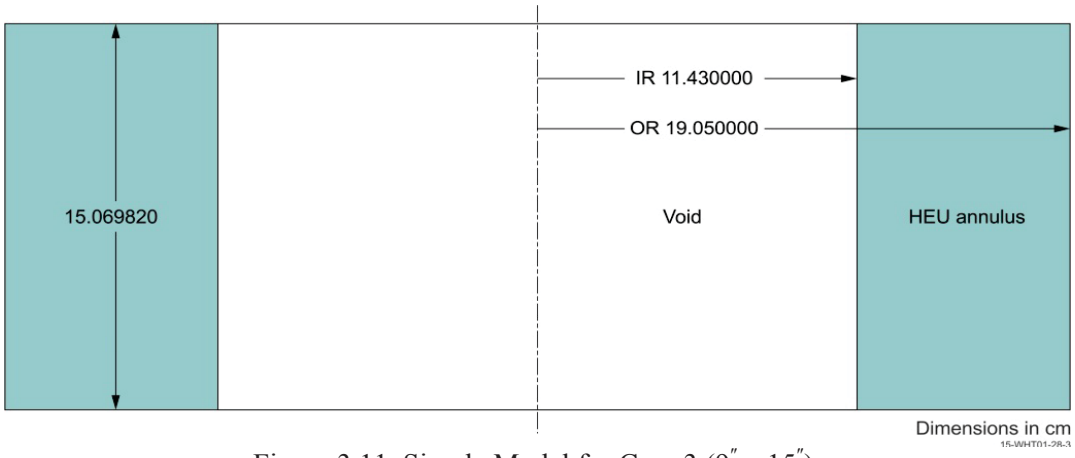


Figure 3.11. Simple Model for Case 3 (9″ – 15″).

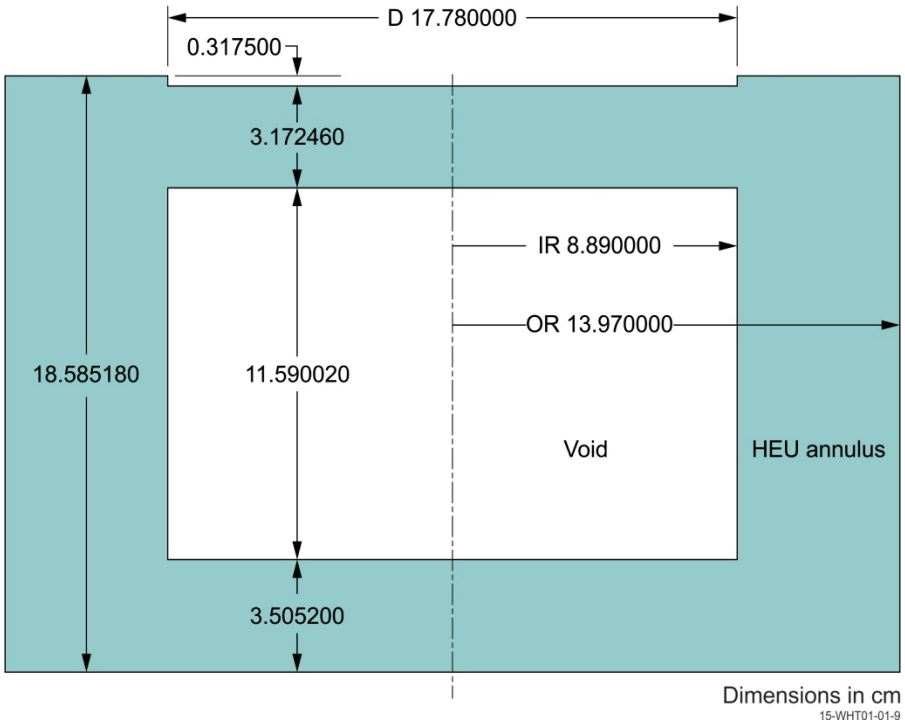


Figure 3.12. Simple Model for Case 4 ($7^{\prime\prime} - 11^{\prime\prime}$).

## 3.3 Material Data

### *3.3.1*

The atom densities of the various uranium annuli and disks are given in Table 3.3, where part identifiers match the identifiers shown in Figures 3.1 – 3.8 and Table 3.2.

Table 3.3. Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| Part Number | 2728 | 2729 | 2730 | 2731 | 2732 | 2735 |
|---|---|---|---|---|---|---|
| $^{234}$U | 4.6733E-04 | 4.7768E-04 | 4.6833E-04 | 4.6760E-04 | 4.5765E-04 | 4.9551E-04 |
| $^{235}$U | 4.4697E-02 | 4.4753E-02 | 4.4777E-02 | 4.4703E-02 | 4.4692E-02 | 4.4631E-02 |
| $^{236}$U | 1.1465E-04 | 1.2439E-04 | 1.1968E-04 | 1.0515E-04 | 1.0030E-04 | 1.4310E-04 |
| $^{238}$U | 2.6620E-03 | 2.6565E-03 | 2.6772E-03 | 2.6920E-03 | 2.6854E-03 | 2.6014E-03 |
| Ag | 8.3668E-07 | 8.3792E-07 | 8.3845E-07 | 8.3716E-07 | 8.3658E-07 | 8.3545E-07 |
| Ba | 4.1075E-10 | 4.1136E-10 | 4.1162E-10 | 4.1099E-10 | 4.1070E-10 | 4.1014E-10 |
| Bi | 8.8532E-06 | 8.8663E-06 | 8.8720E-06 | 8.8583E-06 | 8.8522E-06 | 8.8402E-06 |
| C | 4.6964E-06 | 4.7034E-06 | 4.7063E-06 | 4.6991E-06 | 4.6958E-06 | 4.6895E-06 |
| Ca | 2.8149E-08 | 2.8190E-08 | 2.8208E-08 | 2.8165E-08 | 2.8145E-08 | 2.8107E-08 |
| Cd | 5.0179E-08 | 5.0254E-08 | 5.0285E-08 | 5.0208E-08 | 5.0173E-08 | 5.0105E-08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Co** | 9.5713E-07 | 9.5855E-07 | 9.5916E-07 | 9.5768E-07 | 9.5702E-07 | 9.5573E-07 |
| **Cr** | 1.5188E-06 | 1.5210E-06 | 1.5220E-06 | 1.5196E-06 | 1.5186E-06 | 1.5165E-06 |
| **Cu** | 4.4383E-06 | 4.4449E-06 | 4.4477E-06 | 4.4408E-06 | 4.4378E-06 | 4.4317E-06 |
| **K** | 2.8854E-08 | 2.8897E-08 | 2.8915E-08 | 2.8871E-08 | 2.8851E-08 | 2.8811E-08 |
| **Li** | 1.6253E-06 | 1.6277E-06 | 1.6288E-06 | 1.6263E-06 | 1.6251E-06 | 1.6229E-06 |
| **Mg** | 1.3925E-06 | 1.3945E-06 | 1.3954E-06 | 1.3933E-06 | 1.3923E-06 | 1.3904E-06 |
| **Mn** | 1.1499E-05 | 1.1517E-05 | 1.1524E-05 | 1.1506E-05 | 1.1498E-05 | 1.1483E-05 |
| **Mo** | 5.8817E-08 | 5.8905E-08 | 5.8942E-08 | 5.8851E-08 | 5.8811E-08 | 5.8731E-08 |
| **Na** | 1.3249E-05 | 1.3269E-05 | 1.3277E-05 | 1.3257E-05 | 1.3248E-05 | 1.3230E-05 |
| **Ni** | 1.9221E-05 | 1.9249E-05 | 1.9262E-05 | 1.9232E-05 | 1.9219E-05 | 1.9193E-05 |
| **Sb** | 3.5208E-06 | 3.5260E-06 | 3.5283E-06 | 3.5228E-06 | 3.5204E-06 | 3.5156E-06 |
| **Ti** | 2.3568E-07 | 2.3603E-07 | 2.3618E-07 | 2.3582E-07 | 2.3565E-07 | 2.3534E-07 |
| **O** | 1.4102E-05 | 1.4123E-05 | 1.4132E-05 | 1.4110E-05 | 1.4101E-05 | 1.4082E-05 |
| **N** | 2.4163E-05 | 2.4199E-05 | 2.4214E-05 | 2.4177E-05 | 2.4160E-05 | 2.4127E-05 |
| **Total** | 4.8051E-02 | 4.8122E-02 | 4.8153E-02 | 4.8079E-02 | 4.8045E-02 | 4.7981E-02 |
| **Mass Density ($g/cm^3$)** | 18.7425213 | 18.77034 | 18.782241 | 18.75332664 | 18.7403202 | 18.7242123 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| Part Number | 2736 | 2737 | 2738 | 2739 | 2740 | 2741 |
|---|---|---|---|---|---|---|
| $^{234}U$ | 4.8680E-04 | 4.7780E-04 | 4.7317E-04 | 4.6537E-04 | 4.6863E-04 | 4.6364E-04 |
| $^{235}U$ | 4.4715E-02 | 4.4731E-02 | 4.4783E-02 | 4.4968E-02 | 4.4821E-02 | 4.4810E-02 |
| $^{236}U$ | 1.0036E-04 | 1.3877E-04 | 1.1489E-04 | 1.2016E-04 | 1.1497E-04 | 1.1972E-04 |
| $^{238}U$ | 2.6584E-03 | 2.6762E-03 | 2.6725E-03 | 2.6832E-03 | 2.6694E-03 | 2.6638E-03 |
| **Ag** | 8.3702E-07 | 8.3813E-07 | 8.3848E-07 | 8.4185E-07 | 8.3900E-07 | 8.3872E-07 |
| **Ba** | 4.1091E-10 | 4.1146E-10 | 4.1163E-10 | 4.1329E-10 | 4.1189E-10 | 4.1175E-10 |
| **Bi** | 8.8568E-06 | 8.8686E-06 | 8.8722E-06 | 8.9079E-06 | 8.8778E-06 | 8.8748E-06 |
| **C** | 4.6983E-06 | 4.7045E-06 | 4.7065E-06 | 4.7254E-06 | 4.7094E-06 | 4.7078E-06 |
| **Ca** | 2.8160E-08 | 2.8197E-08 | 2.8209E-08 | 2.8322E-08 | 2.8227E-08 | 2.8217E-08 |
| **Cd** | 5.0199E-08 | 5.0266E-08 | 5.0287E-08 | 5.0489E-08 | 5.0319E-08 | 5.0301E-08 |
| **Co** | 9.5752E-07 | 9.5879E-07 | 9.5919E-07 | 9.6304E-07 | 9.5979E-07 | 9.5946E-07 |
| **Cr** | 1.5194E-06 | 1.5214E-06 | 1.5220E-06 | 1.5281E-06 | 1.5230E-06 | 1.5225E-06 |
| **Cu** | 4.4401E-06 | 4.4460E-06 | 4.4478E-06 | 4.4657E-06 | 4.4506E-06 | 4.4491E-06 |
| **K** | 2.8866E-08 | 2.8904E-08 | 2.8916E-08 | 2.9032E-08 | 2.8934E-08 | 2.8924E-08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Li** | 1.6260E-06 | 1.6281E-06 | 1.6288E-06 | 1.6354E-06 | 1.6298E-06 | 1.6293E-06 |
| **Mg** | 1.3930E-06 | 1.3949E-06 | 1.3955E-06 | 1.4011E-06 | 1.3963E-06 | 1.3959E-06 |
| **Mn** | 1.1504E-05 | 1.1519E-05 | 1.1524E-05 | 1.1570E-05 | 1.1531E-05 | 1.1527E-05 |
| **Mo** | 5.8841E-08 | 5.8920E-08 | 5.8944E-08 | 5.9181E-08 | 5.8981E-08 | 5.8961E-08 |
| **Na** | 1.3255E-05 | 1.3272E-05 | 1.3278E-05 | 1.3331E-05 | 1.3286E-05 | 1.3282E-05 |
| **Ni** | 1.9229E-05 | 1.9254E-05 | 1.9262E-05 | 1.9340E-05 | 1.9274E-05 | 1.9268E-05 |
| **Sb** | 3.5222E-06 | 3.5269E-06 | 3.5284E-06 | 3.5425E-06 | 3.5306E-06 | 3.5294E-06 |
| **Ti** | 2.3578E-07 | 2.3609E-07 | 2.3619E-07 | 2.3714E-07 | 2.3634E-07 | 2.3626E-07 |
| **O** | 1.4108E-05 | 1.4127E-05 | 1.4133E-05 | 1.4189E-05 | 1.4141E-05 | 1.4137E-05 |
| **N** | 2.4173E-05 | 2.4205E-05 | 2.4215E-05 | 2.4312E-05 | 2.4230E-05 | 2.4222E-05 |
| **Total** | 4.8071E-02 | 4.8134E-02 | 4.8154E-02 | 4.8348E-02 | 4.8185E-02 | 4.8168E-02 |
| **Mass Density ($g/cm^3$)** | 18.750025 | 18.77504 | 18.782841 | 18.85827827 | 18.7945469 | 18.7881438 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| **Part Number** | 2742 | 2743 | 2744 | 2745 | 2746 | 2747 |
|---|---|---|---|---|---|---|
| **$^{234}U$** | 4.7324E-04 | 4.7545E-04 | 4.7461E-04 | 4.6359E-04 | 4.8204E-04 | 4.7245E-04 |
| **$^{235}U$** | 4.4785E-02 | 4.4994E-02 | 4.4915E-02 | 4.4815E-02 | 4.4682E-02 | 4.4720E-02 |
| **$^{236}U$** | 1.1012E-04 | 1.1064E-04 | 1.1044E-04 | 1.0534E-04 | 1.0515E-04 | 9.0820E-05 |
| **$^{238}U$** | 2.6824E-03 | 2.6949E-03 | 2.6902E-03 | 2.6682E-03 | 2.6966E-03 | 2.6874E-03 |
| **Ag** | 8.3860E-07 | 8.4251E-07 | 8.4103E-07 | 8.3862E-07 | 8.3711E-07 | 8.3721E-07 |
| **Ba** | 4.1169E-10 | 4.1361E-10 | 4.1289E-10 | 4.1170E-10 | 4.1096E-10 | 4.1101E-10 |
| **Bi** | 8.8735E-06 | 8.9149E-06 | 8.8993E-06 | 8.8738E-06 | 8.8578E-06 | 8.8588E-06 |
| **C** | 4.7072E-06 | 4.7291E-06 | 4.7208E-06 | 4.7073E-06 | 4.6988E-06 | 4.6994E-06 |
| **Ca** | 2.8213E-08 | 2.8345E-08 | 2.8295E-08 | 2.8214E-08 | 2.8163E-08 | 2.8166E-08 |
| **Cd** | 5.0294E-08 | 5.0529E-08 | 5.0440E-08 | 5.0296E-08 | 5.0205E-08 | 5.0211E-08 |
| **Co** | 9.5933E-07 | 9.6381E-07 | 9.6211E-07 | 9.5936E-07 | 9.5763E-07 | 9.5774E-07 |
| **Cr** | 1.5222E-06 | 1.5294E-06 | 1.5267E-06 | 1.5223E-06 | 1.5195E-06 | 1.5197E-06 |
| **Cu** | 4.4485E-06 | 4.4692E-06 | 4.4614E-06 | 4.4486E-06 | 4.4406E-06 | 4.4411E-06 |
| **K** | 2.8920E-08 | 2.9055E-08 | 2.9004E-08 | 2.8921E-08 | 2.8869E-08 | 2.8872E-08 |
| **Li** | 1.6291E-06 | 1.6367E-06 | 1.6338E-06 | 1.6291E-06 | 1.6262E-06 | 1.6264E-06 |
| **Mg** | 1.3957E-06 | 1.4022E-06 | 1.3997E-06 | 1.3957E-06 | 1.3932E-06 | 1.3934E-06 |
| **Mn** | 1.1526E-05 | 1.1580E-05 | 1.1559E-05 | 1.1526E-05 | 1.1505E-05 | 1.1507E-05 |
| **Mo** | 5.8952E-08 | 5.9228E-08 | 5.9123E-08 | 5.8954E-08 | 5.8848E-08 | 5.8855E-08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Na** | 1.3280E-05 | 1.3342E-05 | 1.3318E-05 | 1.3280E-05 | 1.3256E-05 | 1.3258E-05 |
| **Ni** | 1.9265E-05 | 1.9355E-05 | 1.9321E-05 | 1.9266E-05 | 1.9231E-05 | 1.9233E-05 |
| **Sb** | 3.5289E-06 | 3.5454E-06 | 3.5391E-06 | 3.5290E-06 | 3.5226E-06 | 3.5230E-06 |
| **Ti** | 2.3622E-07 | 2.3733E-07 | 2.3691E-07 | 2.3623E-07 | 2.3580E-07 | 2.3583E-07 |
| **O** | 1.4135E-05 | 1.4201E-05 | 1.4176E-05 | 1.4135E-05 | 1.4110E-05 | 1.4111E-05 |
| **N** | 2.4218E-05 | 2.4331E-05 | 2.4288E-05 | 2.4219E-05 | 2.4175E-05 | 2.4178E-05 |
| **Total** | 4.8161E-02 | 4.8386E-02 | 4.8301E-02 | 4.8163E-02 | 4.8076E-02 | 4.8082E-02 |
| **Mass Density ($g/cm^3$)** | 18.7855425 | 18.87319 | 18.839969 | 18.78604273 | 18.7522261 | 18.7544272 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| **Part Number** | 2748 | 2749 | 2750 | 2751 | 2752 | 2753 |
|---|---|---|---|---|---|---|
| **$^{234}U$** | 4.8285E-04 | 4.7313E-04 | 4.5842E-04 | 4.7310E-04 | 4.7278E-04 | 4.5759E-04 |
| **$^{235}U$** | 4.4757E-02 | 4.4799E-02 | 4.4743E-02 | 4.4767E-02 | 4.4737E-02 | 4.4662E-02 |
| **$^{236}U$** | 1.0533E-04 | 1.1967E-04 | 1.1961E-04 | 1.1488E-04 | 1.1480E-04 | 1.1940E-04 |
| **$^{238}U$** | 2.7012E-03 | 2.6486E-03 | 2.6947E-03 | 2.6816E-03 | 2.6798E-03 | 2.6898E-03 |
| **Ag** | 8.3853E-07 | 8.3841E-07 | 8.3800E-07 | 8.3836E-07 | 8.3780E-07 | 8.3648E-07 |
| **Ba** | 4.1166E-10 | 4.1160E-10 | 4.1140E-10 | 4.1157E-10 | 4.1130E-10 | 4.1065E-10 |
| **Bi** | 8.8728E-06 | 8.8715E-06 | 8.8672E-06 | 8.8710E-06 | 8.8650E-06 | 8.8511E-06 |
| **C** | 4.7068E-06 | 4.7061E-06 | 4.7038E-06 | 4.7058E-06 | 4.7027E-06 | 4.6953E-06 |
| **Ca** | 2.8211E-08 | 2.8207E-08 | 2.8193E-08 | 2.8205E-08 | 2.8186E-08 | 2.8142E-08 |
| **Cd** | 5.0290E-08 | 5.0283E-08 | 5.0258E-08 | 5.0280E-08 | 5.0246E-08 | 5.0167E-08 |
| **Co** | 9.5925E-07 | 9.5911E-07 | 9.5865E-07 | 9.5906E-07 | 9.5841E-07 | 9.5691E-07 |
| **Cr** | 1.5221E-06 | 1.5219E-06 | 1.5212E-06 | 1.5218E-06 | 1.5208E-06 | 1.5184E-06 |
| **Cu** | 4.4481E-06 | 4.4474E-06 | 4.4453E-06 | 4.4472E-06 | 4.4442E-06 | 4.4372E-06 |
| **K** | 2.8918E-08 | 2.8914E-08 | 2.8899E-08 | 2.8912E-08 | 2.8892E-08 | 2.8847E-08 |
| **Li** | 1.6289E-06 | 1.6287E-06 | 1.6279E-06 | 1.6286E-06 | 1.6275E-06 | 1.6249E-06 |
| **Mg** | 1.3956E-06 | 1.3954E-06 | 1.3947E-06 | 1.3953E-06 | 1.3943E-06 | 1.3921E-06 |
| **Mn** | 1.1525E-05 | 1.1523E-05 | 1.1518E-05 | 1.1523E-05 | 1.1515E-05 | 1.1497E-05 |
| **Mo** | 5.8947E-08 | 5.8939E-08 | 5.8910E-08 | 5.8936E-08 | 5.8896E-08 | 5.8804E-08 |
| **Na** | 1.3279E-05 | 1.3277E-05 | 1.3270E-05 | 1.3276E-05 | 1.3267E-05 | 1.3246E-05 |
| **Ni** | 1.9263E-05 | 1.9261E-05 | 1.9251E-05 | 1.9259E-05 | 1.9247E-05 | 1.9216E-05 |
| **Sb** | 3.5286E-06 | 3.5281E-06 | 3.5264E-06 | 3.5279E-06 | 3.5255E-06 | 3.5200E-06 |
| **Ti** | 2.3620E-07 | 2.3617E-07 | 2.3605E-07 | 2.3616E-07 | 2.3600E-07 | 2.3563E-07 |
| **O** | 1.4133E-05 | 1.4131E-05 | 1.4125E-05 | 1.4131E-05 | 1.4121E-05 | 1.4099E-05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **N** | 2.4216E-05 | 2.4213E-05 | 2.4201E-05 | 2.4211E-05 | 2.4195E-05 | 2.4157E-05 |
| **Total** | 4.8157E-02 | 4.8151E-02 | 4.8127E-02 | 4.8148E-02 | 4.8115E-02 | 4.8040E-02 |
| **Mass Density ($g/cm^3$)** | 18.7839417 | 18.78124 | 18.772136 | 18.78013983 | 18.7675336 | 18.7381192 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| **Part Number** | 2754 | 2755 | 2756 | 2757 | 2758 | 2760 |
|---|---|---|---|---|---|---|
| **$^{234}U$** | 4.6438E-04 | 4.6364E-04 | 4.4929E-04 | 4.6342E-04 | 4.9751E-04 | 4.7814E-04 |
| **$^{235}U$** | 4.4843E-02 | 4.4771E-02 | 4.4823E-02 | 4.4779E-02 | 4.4830E-02 | 4.4787E-02 |
| **$^{236}U$** | 1.3429E-04 | 1.3408E-04 | 1.1975E-04 | 1.2923E-04 | 1.5325E-04 | 1.1493E-04 |
| **$^{238}U$** | 2.6918E-03 | 2.6875E-03 | 2.6788E-03 | 2.6625E-03 | 2.5834E-03 | 2.6780E-03 |
| **Ag** | 8.4005E-07 | 8.3870E-07 | 8.3896E-07 | 8.3830E-07 | 8.3882E-07 | 8.3872E-07 |
| **Ba** | 4.1240E-10 | 4.1174E-10 | 4.1187E-10 | 4.1155E-10 | 4.1180E-10 | 4.1175E-10 |
| **Bi** | 8.8888E-06 | 8.8746E-06 | 8.8774E-06 | 8.8704E-06 | 8.8759E-06 | 8.8748E-06 |
| **C** | 4.7153E-06 | 4.7077E-06 | 4.7092E-06 | 4.7055E-06 | 4.7084E-06 | 4.7079E-06 |
| **Ca** | 2.8262E-08 | 2.8217E-08 | 2.8225E-08 | 2.8203E-08 | 2.8221E-08 | 2.8217E-08 |
| **Cd** | 5.0381E-08 | 5.0300E-08 | 5.0316E-08 | 5.0277E-08 | 5.0308E-08 | 5.0302E-08 |
| **Co** | 9.6098E-07 | 9.5945E-07 | 9.5974E-07 | 9.5899E-07 | 9.5958E-07 | 9.5947E-07 |
| **Cr** | 1.5249E-06 | 1.5224E-06 | 1.5229E-06 | 1.5217E-06 | 1.5227E-06 | 1.5225E-06 |
| **Cu** | 4.4561E-06 | 4.4490E-06 | 4.4504E-06 | 4.4469E-06 | 4.4496E-06 | 4.4491E-06 |
| **K** | 2.8970E-08 | 2.8924E-08 | 2.8933E-08 | 2.8910E-08 | 2.8928E-08 | 2.8924E-08 |
| **Li** | 1.6319E-06 | 1.6293E-06 | 1.6298E-06 | 1.6285E-06 | 1.6295E-06 | 1.6293E-06 |
| **Mg** | 1.3981E-06 | 1.3958E-06 | 1.3963E-06 | 1.3952E-06 | 1.3960E-06 | 1.3959E-06 |
| **Mn** | 1.1546E-05 | 1.1527E-05 | 1.1531E-05 | 1.1522E-05 | 1.1529E-05 | 1.1528E-05 |
| **Mo** | 5.9054E-08 | 5.8960E-08 | 5.8978E-08 | 5.8932E-08 | 5.8968E-08 | 5.8961E-08 |
| **Na** | 1.3303E-05 | 1.3281E-05 | 1.3285E-05 | 1.3275E-05 | 1.3283E-05 | 1.3282E-05 |
| **Ni** | 1.9298E-05 | 1.9267E-05 | 1.9273E-05 | 1.9258E-05 | 1.9270E-05 | 1.9268E-05 |
| **Sb** | 3.5350E-06 | 3.5293E-06 | 3.5304E-06 | 3.5276E-06 | 3.5298E-06 | 3.5294E-06 |
| **Ti** | 2.3663E-07 | 2.3625E-07 | 2.3632E-07 | 2.3614E-07 | 2.3629E-07 | 2.3626E-07 |
| **O** | 1.4159E-05 | 1.4136E-05 | 1.4141E-05 | 1.4130E-05 | 1.4138E-05 | 1.4137E-05 |
| **N** | 2.4260E-05 | 2.4221E-05 | 2.4229E-05 | 2.4210E-05 | 2.4225E-05 | 2.4222E-05 |
| **Total** | 4.8244E-02 | 4.8167E-02 | 4.8182E-02 | 4.8145E-02 | 4.8175E-02 | 4.8168E-02 |
| **Mass Density ($g/cm^3$)** | 18.8179584 | 18.78784 | 18.793646 | 18.77893924 | 18.7905449 | 18.7882438 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| Part Number | 2761 | 2762 | 2763 | 2766 | 2767 | 2768 |
|---|---|---|---|---|---|---|
| $^{234}$U | 4.6350E-04 | 4.6870E-04 | 4.6147E-04 | 4.7348E-04 | 4.6289E-04 | 4.4496E-04 |
| $^{235}$U | 4.4768E-02 | 4.4808E-02 | 4.4601E-02 | 4.4817E-02 | 4.4718E-02 | 4.4855E-02 |
| $^{236}$U | 1.2925E-04 | 1.2935E-04 | 1.1915E-04 | 1.2934E-04 | 1.2430E-04 | 1.2468E-04 |
| $^{238}$U | 2.6819E-03 | 2.6745E-03 | 2.6513E-03 | 2.6553E-03 | 2.6737E-03 | 2.7009E-03 |
| Ag | 8.3845E-07 | 8.3911E-07 | 8.3479E-07 | 8.3902E-07 | 8.3735E-07 | 8.3992E-07 |
| Ba | 4.1162E-10 | 4.1194E-10 | 4.0982E-10 | 4.1190E-10 | 4.1108E-10 | 4.1234E-10 |
| Bi | 8.8720E-06 | 8.8790E-06 | 8.8332E-06 | 8.8780E-06 | 8.8603E-06 | 8.8875E-06 |
| C | 4.7064E-06 | 4.7101E-06 | 4.6858E-06 | 4.7095E-06 | 4.7002E-06 | 4.7146E-06 |
| Ca | 2.8208E-08 | 2.8230E-08 | 2.8085E-08 | 2.8227E-08 | 2.8171E-08 | 2.8258E-08 |
| Cd | 5.0286E-08 | 5.0325E-08 | 5.0066E-08 | 5.0320E-08 | 5.0219E-08 | 5.0373E-08 |
| Co | 9.5916E-07 | 9.5992E-07 | 9.5497E-07 | 9.5981E-07 | 9.5790E-07 | 9.6084E-07 |
| Cr | 1.5220E-06 | 1.5232E-06 | 1.5153E-06 | 1.5230E-06 | 1.5200E-06 | 1.5246E-06 |
| Cu | 4.4477E-06 | 4.4512E-06 | 4.4282E-06 | 4.4507E-06 | 4.4418E-06 | 4.4555E-06 |
| K | 2.8915E-08 | 2.8938E-08 | 2.8789E-08 | 2.8935E-08 | 2.8877E-08 | 2.8966E-08 |
| Li | 1.6288E-06 | 1.6301E-06 | 1.6217E-06 | 1.6299E-06 | 1.6266E-06 | 1.6316E-06 |
| Mg | 1.3954E-06 | 1.3965E-06 | 1.3893E-06 | 1.3964E-06 | 1.3936E-06 | 1.3979E-06 |
| Mn | 1.1524E-05 | 1.1533E-05 | 1.1473E-05 | 1.1532E-05 | 1.1509E-05 | 1.1544E-05 |
| Mo | 5.8942E-08 | 5.8989E-08 | 5.8685E-08 | 5.8982E-08 | 5.8865E-08 | 5.9045E-08 |
| Na | 1.3277E-05 | 1.3288E-05 | 1.3219E-05 | 1.3286E-05 | 1.3260E-05 | 1.3301E-05 |
| Ni | 1.9262E-05 | 1.9277E-05 | 1.9177E-05 | 1.9275E-05 | 1.9236E-05 | 1.9295E-05 |
| Sb | 3.5283E-06 | 3.5310E-06 | 3.5128E-06 | 3.5307E-06 | 3.5236E-06 | 3.5344E-06 |
| Ti | 2.3618E-07 | 2.3637E-07 | 2.3515E-07 | 2.3634E-07 | 2.3587E-07 | 2.3659E-07 |
| O | 1.4132E-05 | 1.4143E-05 | 1.4070E-05 | 1.4142E-05 | 1.4114E-05 | 1.4157E-05 |
| N | 2.4214E-05 | 2.4233E-05 | 2.4108E-05 | 2.4230E-05 | 2.4182E-05 | 2.4256E-05 |
| Total | 4.8153E-02 | 4.8191E-02 | 4.7943E-02 | 4.8186E-02 | 4.8090E-02 | 4.8237E-02 |
| Mass Density (g/cm$^3$) | 18.7822409 | 18.79705 | 18.7002 | 18.79504716 | 18.7575287 | 18.815057 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| Part Number | 2769 | 2770 | 2771 | 2773 | 2774 | 2775 |
|---|---|---|---|---|---|---|
| $^{234}$U | 4.6796E-04 | 4.7732E-04 | 4.6548E-04 | 4.6726E-04 | 4.7883E-04 | 4.7378E-04 |
| $^{235}$U | 4.4747E-02 | 4.4710E-02 | 4.4505E-02 | 4.4689E-02 | 4.4828E-02 | 4.4841E-02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $^{236}$U | 1.1958E-04 | 1.2429E-04 | 1.1895E-04 | 1.1463E-04 | 1.3907E-04 | 1.1504E-04 |
| $^{238}$U | 2.6704E-03 | 2.6640E-03 | 2.6609E-03 | 2.6616E-03 | 2.6819E-03 | 2.6760E-03 |
| Ag | 8.3780E-07 | 8.3729E-07 | 8.3335E-07 | 8.3654E-07 | 8.3994E-07 | 8.3957E-07 |
| Ba | 4.1130E-10 | 4.1105E-10 | 4.0911E-10 | 4.1068E-10 | 4.1235E-10 | 4.1217E-10 |
| Bi | 8.8651E-06 | 8.8596E-06 | 8.8180E-06 | 8.8518E-06 | 8.8877E-06 | 8.8838E-06 |
| C | 4.7027E-06 | 4.6998E-06 | 4.6777E-06 | 4.6956E-06 | 4.7147E-06 | 4.7126E-06 |
| Ca | 2.8186E-08 | 2.8169E-08 | 2.8037E-08 | 2.8144E-08 | 2.8258E-08 | 2.8246E-08 |
| Cd | 5.0247E-08 | 5.0216E-08 | 4.9980E-08 | 5.0171E-08 | 5.0375E-08 | 5.0352E-08 |
| Co | 9.5842E-07 | 9.5783E-07 | 9.5333E-07 | 9.5698E-07 | 9.6086E-07 | 9.6044E-07 |
| Cr | 1.5208E-06 | 1.5199E-06 | 1.5127E-06 | 1.5185E-06 | 1.5247E-06 | 1.5240E-06 |
| Cu | 4.4442E-06 | 4.4415E-06 | 4.4206E-06 | 4.4375E-06 | 4.4556E-06 | 4.4536E-06 |
| K | 2.8893E-08 | 2.8875E-08 | 2.8739E-08 | 2.8849E-08 | 2.8966E-08 | 2.8954E-08 |
| Li | 1.6275E-06 | 1.6265E-06 | 1.6189E-06 | 1.6251E-06 | 1.6317E-06 | 1.6309E-06 |
| Mg | 1.3943E-06 | 1.3935E-06 | 1.3869E-06 | 1.3922E-06 | 1.3979E-06 | 1.3973E-06 |
| Mn | 1.1515E-05 | 1.1508E-05 | 1.1454E-05 | 1.1498E-05 | 1.1544E-05 | 1.1539E-05 |
| Mo | 5.8897E-08 | 5.8860E-08 | 5.8583E-08 | 5.8808E-08 | 5.9047E-08 | 5.9021E-08 |
| Na | 1.3267E-05 | 1.3259E-05 | 1.3197E-05 | 1.3247E-05 | 1.3301E-05 | 1.3295E-05 |
| Ni | 1.9247E-05 | 1.9235E-05 | 1.9144E-05 | 1.9218E-05 | 1.9296E-05 | 1.9287E-05 |
| Sb | 3.5255E-06 | 3.5234E-06 | 3.5068E-06 | 3.5202E-06 | 3.5345E-06 | 3.5330E-06 |
| Ti | 2.3600E-07 | 2.3585E-07 | 2.3474E-07 | 2.3564E-07 | 2.3660E-07 | 2.3650E-07 |
| O | 1.4121E-05 | 1.4113E-05 | 1.4046E-05 | 1.4100E-05 | 1.4157E-05 | 1.4151E-05 |
| N | 2.4195E-05 | 2.4180E-05 | 2.4067E-05 | 2.4159E-05 | 2.4257E-05 | 2.4246E-05 |
| **Total** | 4.8116E-02 | 4.8086E-02 | 4.7860E-02 | 4.8043E-02 | 4.8238E-02 | 4.8217E-02 |
| **Mass Density (g/cm$^3$)** | 18.7677337 | 18.75613 | 18.667985 | 18.73941979 | 18.8155573 | 18.8072532 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| Part Number | 2776 | 2778 | 2779 | 2780 | 2782 | 2783 |
|---|---|---|---|---|---|---|
| $^{234}$U | 4.6302E-04 | 4.6197E-04 | 4.6289E-04 | 4.7200E-04 | 4.6445E-04 | 4.7590E-04 |
| $^{235}$U | 4.4740E-02 | 4.4639E-02 | 4.4728E-02 | 4.4663E-02 | 4.4898E-02 | 4.4654E-02 |
| $^{236}$U | 1.0999E-04 | 1.0974E-04 | 1.0996E-04 | 1.1938E-04 | 1.1033E-04 | 1.1930E-04 |
| $^{238}$U | 2.6792E-03 | 2.6731E-03 | 2.6784E-03 | 2.6706E-03 | 2.6684E-03 | 2.6687E-03 |
| Ag | 8.3759E-07 | 8.3569E-07 | 8.3735E-07 | 8.3640E-07 | 8.4017E-07 | 8.3580E-07 |
| Ba | 4.1119E-10 | 4.1026E-10 | 4.1108E-10 | 4.1061E-10 | 4.1246E-10 | 4.1032E-10 |
| Bi | 8.8628E-06 | 8.8427E-06 | 8.8603E-06 | 8.8503E-06 | 8.8902E-06 | 8.8439E-06 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **C** | 4.7015E-06 | 4.6908E-06 | 4.7002E-06 | 4.6948E-06 | 4.7160E-06 | 4.6915E-06 |
| **Ca** | 2.8179E-08 | 2.8115E-08 | 2.8171E-08 | 2.8139E-08 | 2.8266E-08 | 2.8119E-08 |
| **Cd** | 5.0234E-08 | 5.0120E-08 | 5.0219E-08 | 5.0163E-08 | 5.0389E-08 | 5.0127E-08 |
| **Co** | 9.5817E-07 | 9.5600E-07 | 9.5790E-07 | 9.5682E-07 | 9.6113E-07 | 9.5613E-07 |
| **Cr** | 1.5204E-06 | 1.5170E-06 | 1.5200E-06 | 1.5183E-06 | 1.5251E-06 | 1.5172E-06 |
| **Cu** | 4.4431E-06 | 4.4330E-06 | 4.4418E-06 | 4.4368E-06 | 4.4568E-06 | 4.4336E-06 |
| **K** | 2.8885E-08 | 2.8820E-08 | 2.8877E-08 | 2.8844E-08 | 2.8974E-08 | 2.8824E-08 |
| **Li** | 1.6271E-06 | 1.6234E-06 | 1.6266E-06 | 1.6248E-06 | 1.6321E-06 | 1.6236E-06 |
| **Mg** | 1.3940E-06 | 1.3908E-06 | 1.3936E-06 | 1.3920E-06 | 1.3983E-06 | 1.3910E-06 |
| **Mn** | 1.1512E-05 | 1.1486E-05 | 1.1509E-05 | 1.1496E-05 | 1.1547E-05 | 1.1487E-05 |
| **Mo** | 5.8881E-08 | 5.8748E-08 | 5.8865E-08 | 5.8798E-08 | 5.9063E-08 | 5.8756E-08 |
| **Na** | 1.3264E-05 | 1.3234E-05 | 1.3260E-05 | 1.3245E-05 | 1.3305E-05 | 1.3235E-05 |
| **Ni** | 1.9242E-05 | 1.9198E-05 | 1.9236E-05 | 1.9215E-05 | 1.9301E-05 | 1.9201E-05 |
| **Sb** | 3.5246E-06 | 3.5166E-06 | 3.5236E-06 | 3.5196E-06 | 3.5355E-06 | 3.5171E-06 |
| **Ti** | 2.3594E-07 | 2.3540E-07 | 2.3587E-07 | 2.3560E-07 | 2.3667E-07 | 2.3543E-07 |
| **O** | 1.4118E-05 | 1.4086E-05 | 1.4114E-05 | 1.4098E-05 | 1.4161E-05 | 1.4087E-05 |
| **N** | 2.4189E-05 | 2.4134E-05 | 2.4182E-05 | 2.4155E-05 | 2.4264E-05 | 2.4138E-05 |
| **Total** | 4.8103E-02 | 4.7994E-02 | 4.8090E-02 | 4.8035E-02 | 4.8252E-02 | 4.8028E-02 |
| **Mass Density ($g/cm^3$)** | 18.7628313 | 18.72041 | 18.757529 | 18.73631827 | 18.8207598 | 18.7229117 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| **Part Number** | 2784 | 2785 | 2786 | 2787 | 2803 | 2829 |
|---|---|---|---|---|---|---|
| **$^{234}U$** | 4.7962E-04 | 4.7235E-04 | 4.7669E-04 | 4.7220E-04 | 4.8255E-04 | 4.7734E-04 |
| **$^{235}U$** | 4.4926E-02 | 4.4686E-02 | 4.5112E-02 | 4.4687E-02 | 4.4753E-02 | 4.4698E-02 |
| **$^{236}U$** | 1.1528E-04 | 1.2425E-04 | 1.1575E-04 | 1.1466E-04 | 1.1004E-04 | 1.1474E-04 |
| **$^{238}U$** | 2.6864E-03 | 2.6773E-03 | 2.6972E-03 | 2.6718E-03 | 2.6710E-03 | 2.6878E-03 |
| **Ag** | 8.3702E-07 | 8.3702E-07 | 8.4472E-07 | 8.3676E-07 | 8.3800E-07 | 8.3732E-07 |
| **Ba** | 4.1092E-10 | 4.1092E-10 | 4.1470E-10 | 4.1079E-10 | 4.1140E-10 | 4.1106E-10 |
| **Bi** | 8.8568E-06 | 8.8568E-06 | 8.9383E-06 | 8.8541E-06 | 8.8672E-06 | 8.8600E-06 |
| **C** | 4.6983E-06 | 4.6983E-06 | 4.7415E-06 | 4.6968E-06 | 4.7038E-06 | 4.7000E-06 |
| **Ca** | 2.8160E-08 | 2.8160E-08 | 2.8419E-08 | 2.8151E-08 | 2.8193E-08 | 2.8170E-08 |
| **Cd** | 5.0200E-08 | 5.0200E-08 | 5.0661E-08 | 5.0184E-08 | 5.0259E-08 | 5.0218E-08 |
| **Co** | 9.5752E-07 | 9.5752E-07 | 9.6633E-07 | 9.5722E-07 | 9.5865E-07 | 9.5787E-07 |
| **Cr** | 1.5194E-06 | 1.5194E-06 | 1.5334E-06 | 1.5189E-06 | 1.5212E-06 | 1.5199E-06 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Cu** | 4.4401E-06 | 4.4401E-06 | 4.4809E-06 | 4.4387E-06 | 4.4453E-06 | 4.4417E-06 |
| **K** | 2.8866E-08 | 2.8866E-08 | 2.9131E-08 | 2.8857E-08 | 2.8900E-08 | 2.8876E-08 |
| **Li** | 1.6260E-06 | 1.6260E-06 | 1.6409E-06 | 1.6255E-06 | 1.6279E-06 | 1.6266E-06 |
| **Mg** | 1.3930E-06 | 1.3930E-06 | 1.4059E-06 | 1.3926E-06 | 1.3947E-06 | 1.3935E-06 |
| **Mn** | 1.1504E-05 | 1.1504E-05 | 1.1610E-05 | 1.1501E-05 | 1.1518E-05 | 1.1508E-05 |
| **Mo** | 5.8841E-08 | 5.8841E-08 | 5.9383E-08 | 5.8823E-08 | 5.8911E-08 | 5.8863E-08 |
| **Na** | 1.3255E-05 | 1.3255E-05 | 1.3377E-05 | 1.3251E-05 | 1.3270E-05 | 1.3259E-05 |
| **Ni** | 1.9229E-05 | 1.9229E-05 | 1.9406E-05 | 1.9223E-05 | 1.9251E-05 | 1.9236E-05 |
| **Sb** | 3.5222E-06 | 3.5222E-06 | 3.5546E-06 | 3.5211E-06 | 3.5264E-06 | 3.5235E-06 |
| **Ti** | 2.3578E-07 | 2.3578E-07 | 2.3795E-07 | 2.3570E-07 | 2.3605E-07 | 2.3586E-07 |
| **O** | 1.4108E-05 | 1.4108E-05 | 1.4238E-05 | 1.4104E-05 | 1.4125E-05 | 1.4113E-05 |
| **N** | 2.4173E-05 | 2.4173E-05 | 2.4395E-05 | 2.4165E-05 | 2.4201E-05 | 2.4181E-05 |
| **Total** | 4.8318E-02 | 4.8071E-02 | 4.8513E-02 | 4.8056E-02 | 4.8127E-02 | 4.8088E-02 |
| **Mass Density ($g/cm^3$)** | 18.7501251 | 18.75013 | 18.92271 | 18.74432221 | 18.7721359 | 18.7569284 |

Table 3.3 (Continued). Uranium Annuli Atom Densities (atoms/barns-cm) for Detailed Benchmark Model.

| **Part Number** | 2848 | 2885 | 2886 |
|---|---|---|---|
| **$^{234}U$** | 4.6733E-04 | 4.7727E-04 | 4.7684E-04 |
| **$^{235}U$** | 4.4697E-02 | 4.4696E-02 | 4.4656E-02 |
| **$^{236}U$** | 1.1465E-04 | 1.2428E-04 | 1.2417E-04 |
| **$^{238}U$** | 2.6620E-03 | 2.6732E-03 | 2.6708E-03 |
| **Ag** | 8.3668E-07 | 8.3720E-07 | 8.3645E-07 |
| **Ba** | 4.1075E-10 | 4.1101E-10 | 4.1064E-10 |
| **Bi** | 8.8532E-06 | 8.8587E-06 | 8.8508E-06 |
| **C** | 4.6964E-06 | 4.6993E-06 | 4.6951E-06 |
| **Ca** | 2.8149E-08 | 2.8166E-08 | 2.8141E-08 |
| **Cd** | 5.0179E-08 | 5.0211E-08 | 5.0166E-08 |
| **Co** | 9.5713E-07 | 9.5773E-07 | 9.5687E-07 |
| **Cr** | 1.5188E-06 | 1.5197E-06 | 1.5184E-06 |
| **Cu** | 4.4383E-06 | 4.4410E-06 | 4.4371E-06 |
| **K** | 2.8854E-08 | 2.8872E-08 | 2.8846E-08 |
| **Li** | 1.6253E-06 | 1.6263E-06 | 1.6249E-06 |
| **Mg** | 1.3925E-06 | 1.3933E-06 | 1.3921E-06 |

| | | | |
|---|---|---|---|
| **Mn** | 1.1499E-05 | 1.1507E-05 | 1.1496E-05 |
| **Mo** | 5.8817E-08 | 5.8854E-08 | 5.8802E-08 |
| **Na** | 1.3249E-05 | 1.3258E-05 | 1.3246E-05 |
| **Ni** | 1.9221E-05 | 1.9233E-05 | 1.9216E-05 |
| **Sb** | 3.5208E-06 | 3.5230E-06 | 3.5198E-06 |
| **Ti** | 2.3568E-07 | 2.3583E-07 | 2.3562E-07 |
| **O** | 1.4102E-05 | 1.4111E-05 | 1.4098E-05 |
| **N** | 2.4163E-05 | 2.4178E-05 | 2.4156E-05 |
| **Total** | 4.8051E-02 | 4.8081E-02 | 4.8038E-02 |
| **Mass Density ($g/cm^3$)** | 18.7425213 | 18.75423 | 18.737419 |

### *3.3.2 Simple Models*

Material mass densities were obtained by taking the total mass of the uranium components and dividing by the total volume they occupy in the simple benchmark model.

The atom densities of the uranium annulus are in Table 3.4 (a) – (d). The density of the uranium annulus in the simple cases is obtained by dividing the total uranium mass by the volume of the modeled annulus; the density is then multiplied by the factor 0.9995088 to account for the removal of impurities (Table 2.8). The isotopic content of the simple cases is obtained by taking the weight averaged isotopic content of the individual HEU parts.

Table 3.4(a). Uranium Annulus Composition for Case 1.

| Isotope | Content (wt.%) | Atom Density (atoms/barns-cm) |
|---|---|---|
| $^{234}$**U** | 0.968015 | 4.6508E-04 |
| $^{235}$**U** | 93.149022 | 4.4562E-02 |
| $^{236}$**U** | 0.240480 | 1.1456E-04 |
| $^{238}$**U** | 5.6424836 | 2.6652E-03 |
| **Total** | 100 | 4.7807E-02 |
| **Mass Density ($g/cm^3$)** | | 18.681053 |

Table 3.4(b) Uranium Annulus Composition for Case 2.

| Isotope | Content (wt.%) | Atom Density (atoms/barns-cm) |
|---|---|---|
| $^{234}$**U** | 0.972108 | 4.6712E-04 |
| $^{235}$**U** | 93.148042 | 4.4568E-02 |
| $^{236}$**U** | 0.241825 | 1.1521E-04 |
| $^{238}$**U** | 5.638024 | 2.6635E-03 |
| **Total** | 100 | 4.7814E-02 |
| **Mass Density ($g/cm^3$)** | | 18.683873 |

Table 3.4(c) Uranium Annulus Composition for Case 3.

| Isotope | Content (wt.%) | Atom Density (atoms/barns-cm) |
|---|---|---|
| $^{234}$U | 0.971805 | 4.6720E-04 |
| $^{235}$U | 93.145744 | 4.4589E-02 |
| $^{236}$U | 0.239704 | 1.1426E-04 |
| $^{238}$U | 5.642747 | 2.6671E-03 |
| **Total** | 100 | 4.7838E-02 |
| **Mass Density (g/cm$^3$)** | | 18.693017 |

Table 3.4(d) Uranium Annulus Composition for Case 4.

| Isotope | Content (wt.%) | Atom Density (atoms/barns-cm) |
|---|---|---|
| $^{234}$U | 0.974525 | 4.6877E-04 |
| $^{235}$U | 93.146864 | 4.4615E-02 |
| $^{236}$U | 0.231409 | 1.1037E-04 |
| $^{238}$U | 5.647512 | 2.6709E-03 |
| **Total** | 100 | 4.7865E-02 |
| **Mass Density (g/cm$^3$)** | | 18.703760 |

## 3.4 Temperature Data

The temperature of all benchmark models is at room temperature, ~ 295 K. The temperature reactivity coefficient is approximately -0.3 ¢/ºC. Is is assumed that a temperature variation of 2 ºC (1σ) adequately describes the temperature uncertainty.

## 3.5 Experimental and Benchmark Model $k_{eff}$

The experimental $k_{eff}$ for the cases was approximately at unity, maintained near delayed critical with the 1σ uncertainty summarized in Section 2.1.4. Measured corrections and simplification biases, with their associated bias uncertainties, are discussed in Section 3.1.1 and applied to the benchmark models. The benchmark $k_{eff}$ is provided in Tables 3.5 and 3.6 for detailed and simple benchmark model, respectively, for all cases. The uncertainty in the benchmark $k_{eff}$ value is obtained by summing under quadrature the total experimental uncertainty (Tables 2.10 - 2.13) and the total bias uncertainty (Table 3.1).

Table 3.5. Experimental and Benchmark Eigenvalues, Biases, and Uncertainties for Detailed Benchmark Model.

| Case | Experimental | | | Bias | | | Benchmark Experiment | | |
|---|---|---|---|---|---|---|---|---|---|
| | $k_{eff}$ | ± | σ | Δk | ± | σ | $k_{eff}$ | ± | σ |
| 1 | 0.99988 | ± | 0.00052 | -0.00113 | ± | 0.00003 | 0.9988 | ± | 0.0005 |
| 2 | 0.99971 | ± | 0.00051 | -0.00180 | ± | 0.00003 | 0.9979 | ± | 0.0005 |
| 3 | 0.99919 | ± | 0.00051 | -0.00220 | ± | 0.00003 | 0.9970 | ± | 0.0005 |
| 4 | 0.99952 | ± | 0.00051 | -0.00200 | ± | 0.00003 | 0.9975 | ± | 0.0005 |

Table 3.6. Experimental and Benchmark Eigenvalues, Biases, and Uncertainties for Simple Benchmark Model.

| Case | Experimental | | | Bias | | | Benchmark Experiment | | |
|---|---|---|---|---|---|---|---|---|---|
| | $k_{eff}$ | ± | σ | Δk | ± | σ | $k_{eff}$ | ± | σ |
| 1 | 0.99988 | ± | 0.00052 | -0.00171 | ± | 0.00004 | 0.9982 | ± | 0.0005 |
| 2 | 0.99971 | ± | 0.00051 | -0.00290 | ± | 0.00004 | 0.9968 | ± | 0.0005 |
| 3 | 0.99919 | ± | 0.00051 | -0.00253 | ± | 0.00004 | 0.9967 | ± | 0.0005 |
| 4 | 0.99952 | ± | 0.00051 | -0.00227 | ± | 0.00004 | 0.9973 | ± | 0.0005 |

## 4.0 RESULTS OF SAMPLE CALCULATIONS

Results were calculated using MCNP6.1 with the ENDF/B-VII.1 neutron cross section library with the input deck and specifications provided in Appendix A. The cross section data for $^{16}O$ is used for $^{18}O$ in the input decks. Calculations were performed with 1,050 generations with 1,000,000 neutrons per generation. The $k_{eff}$ estimates did not include the first 50 generations and are the result of 1,000,000,000 neutron histories. Isotopic abundances were taken from the 17th edition of the Chart of the Nuclides.[a]

### 4.1 Results of Calculations of the Critical or Subcritical Experiments

### 4.1.1 Detailed Benchmark Model

The calculated results for the detailed benchmark models are reported in Table 4.1 for all cases.

Table 4.1. Detailed Benchmark and Calculated Eigenvalues.

| Case | Calculated | | | Benchmark Experiment | | | $\frac{C-E}{E}$% | | |
|---|---|---|---|---|---|---|---|---|---|
| | $k_{eff}$ | ± | σ | $k_{eff}$ | ± | σ | | | |
| 1 | 0.99640 | ± | 0.00002 | 0.9988 | ± | 0.0005 | -0.24 | ± | 0.05 |
| 2 | 0.99629 | ± | 0.00002 | 0.9979 | ± | 0.0005 | -0.16 | ± | 0.05 |
| 3 | 0.99471 | ± | 0.00002 | 0.9970 | ± | 0.0005 | -0.23 | ± | 0.05 |
| 4 | 0.99593 | ± | 0.00002 | 0.9975 | ± | 0.0005 | -0.16 | ± | 0.05 |

### 4.1.2 Simple Benchmark Model

The calculated results for the simple benchmark models are reported in Table 4.2 for all cases.

Table 4.2. Simple Benchmark and Calculated Eigenvalues.

| Case | Calculated | | | Benchmark Experiment | | | $\frac{C-E}{E}$% | | |
|---|---|---|---|---|---|---|---|---|---|
| | $k_{eff}$ | ± | σ | $k_{eff}$ | ± | σ | | | |
| 1 | 0.99536 | ± | 0.00002 | 0.9982 | ± | 0.0005 | -0.28 | ± | 0.05 |
| 2 | 0.99516 | ± | 0.00002 | 0.9968 | ± | 0.0005 | -0.16 | ± | 0.05 |
| 3 | 0.99504 | ± | 0.00002 | 0.9967 | ± | 0.0005 | -0.17 | ± | 0.05 |
| 4 | 0.99566 | ± | 0.00002 | 0.9973 | ± | 0.0005 | -0.16 | ± | 0.05 |

[a] E. M. Baum, M. C. Ernesti, H. D. Knox, T. R. Miller, and A. M. Watson, *Nuclides and Isotopes, Chart of the Nuclides: 17th Edition*, Knolls Atomic Power Laboratory (2009).

## 5.0 REFERENCES

1. J. T. Mihalczo, "Prompt-Neutron Lifetime in Critical Enriched-Uranium Metal Cylinders and Annuli," *Nuclear Sceince and Engineering*, **20**, 60-65 (1964).

# APPENDIX A: TYPICAL INPUT LISTINGS

The MCNP6.1 calculations were performed, using the continuous energy, ENDF/B-VII.1 neutron cross section data, with 1,050 generations with 1,000,000 neutrons per generation. The $k_{eff}$ estimates did not include the first 50 generations and are the result of 1,000,000,000 neutron histories.

## A.1 Code Input Listings

```
HEU Cylinders-------- 7″ - 13″ bare annuli (CONFIGURATION 1 – DETAILED MODEL)
c
c ----------Cell Cards---------------------------
c
c     7″ - 9″ annulus above diaphragm
1     1   4.8238E-02    8  -9  10 -16   imp:n=1 $ part 2774
2     2   4.8134E-02    7  -8  11 -17   imp:n=1 $ part 2737
3     3   4.8154E-02    6  -7  12 -18   imp:n=1 $ part 2738
4     4   4.8191E-02    5  -6  13 -19   imp:n=1 $ part 2762
c     7″ - 9″ annulus below diaphragm
5     5   4.8185E-02    3  -4  14 -20   imp:n=1 $ part 2740
6     6   4.8168E-02    1  -2  15 -21   imp:n=1 $ part 2741
c     9″ - 11″ annulus above diaphragm
7     7   4.8301E-02    47 -48 49 -55   imp:n=1 $ part 2744
8     8   4.8090E-02    46 -47 50 -56   imp:n=1 $ part 2767
9     9   4.8103E-02    45 -46 51 -57   imp:n=1 $ part 2776
10    10  4.8163E-02    44 -45 52 -58   imp:n=1 $ part 2745
c     9″ - 11″ annulus below diaphragm
11    11  4.8082E-02    42 -43 53 -59   imp:n=1 $ part 2747
12    12  4.8157E-02    40 -41 54 -60   imp:n=1 $ part 2748
c     11″ - 13 ″ above diaphragm
13    13  4.8252E-02    90 -91 92 -103  imp:n=1 $ part 2782
14    14  4.8167E-02    89 -90 93 -104  imp:n=1 $ part 2755
15    15  4.8151E-02    88 -89 94 -105  imp:n=1 $ part 2749
16    16  4.8148E-02    87 -88 95 -106  imp:n=1 $ part 2751
17    17  4.8182E-02    86 -87 96 -107  imp:n=1 $ part 2756
c     11″ - 13 ″ below diaphragm
18    18  4.8035E-02    85 -86 97  -108 imp:n=1 $ part 2780
19    19  4.8127E-02    84 -85 98  -109 imp:n=1 $ part 2750
20    20  4.8040E-02    83 -84 99  -110 imp:n=1 $ part 2753
21    21  4.8244E-02    82 -83 100 -111 imp:n=1 $ part 2754
22    22  4.8115E-02    81 -82 101 -112 imp:n=1 $ part 2752
23    23  4.8145E-02    80 -81 102 -113 imp:n=1 $ part 2757
c
c        VOID SPACES and Gaps
24    0  151  -152  -150 #1  #2 #3 #4 $ lesser void
        #5 #6  #7 #8 #9 #10 #11
        #12 #13 #14 #15 #16 #17
        #18 #19 #20 #21 #22 #23 imp:n=1
25    0  -151:152:150  imp:n=0              $ greater void

c  ------------Surface Cards (cm)----------------------------------
c
c     7″ - 9″ BARE ANNULUS
c    PLANES
1     pz  -7.6454    $ bottom (And Bottom Most Plane)
```

```
2    pz  -3.834638  $ part 2741
3    pz  -3.83139   $ gap
4    pz  -0.02139   $ part 2740
5    pz   0.0000    $ gap (diaphragm)
6    pz   2.538095  $ part 2762
7    pz   5.081143  $ part 2738
8    pz   6.509893  $ part 2737
9    pz   7.144893  $ part 2774  TOP (And Top Most Plane)
c    INNER RADII
10   cz   8.89381   $ Part 2774
11   cz   8.891905  $ Part 2737
12   cz   8.894763  $ Part 2738
13   cz   8.894763  $ Part 2762
14   cz   8.893175  $ Part 2740
15   cz   8.893175  $ Part 2741
c    OUTER RADII
16   cz   11.425555 $ Part 2774
17   cz   11.425555 $ Part 2737
18   cz   11.424603 $ Part 2738
19   cz   11.425238 $ Part 2762
20   cz   11.425238 $ Part 2740
21   cz   11.425555 $ Part 2741
c
c    9″ - 11″ BARE ANNULUS
c    PLANES
40   pz   -7.6454   $ bottom
41   pz   -3.8354   $ part 2748
42   pz   -3.829875 $ gap
43   pz   -0.020129 $ part 2747
44   pz    0.0000   $ gap (diaphragm)
45   pz    2.53746  $ part 2745
46   pz    5.08127  $ part 2776
47   pz    6.50875  $ part 2767
48   pz    6.830695 $ part 2744  TOP
c    INNER RADII
49   cz   11.438255 $ Part 2744
50   cz   11.43127  $ Part 2767
51   cz   11.431905 $ Part 2776
52   cz   11.431270 $ Part 2745
53   cz   11.432540 $ Part 2747
54   cz   11.433175 $ Part 2748
c    OUTER RADII
55   cz   13.965873 $ Part 2744
56   cz   13.96492  $ Part 2767
57   cz   13.965555 $ Part 2776
58   cz   13.965555 $ Part 2745
59   cz   13.965873 $ Part 2747
60   cz   13.966825 $ Part 2748
c
c    11″ - 13 ″ BARE ANNULUS
c    PLANES
80   pz   -7.6454   $ bottom
81   pz   -5.101463 $ part 2757
82   pz   -3.823208 $ part 2752
83   pz   -2.544064 $ part 2754
84   pz   -1.270762 $ part 2753
```

```
85   pz   -0.317119 $ part 2750
86   pz    0.0000   $ part 2780 (diaphragm)
87   pz    2.540508 $ part 2756
88   pz    3.819525 $ part 2751
89   pz    4.778121 $ part 2749
90   pz    6.209411 $ part 2755
91   pz    6.848856 $ part 2782 TOP
c    INNER RADII
92   cz   13.974445 $ Part 2782
93   cz   13.97381  $ Part 2755
94   cz   13.973810 $ Part 2749
95   cz   13.971905 $ Part 2751
96   cz   13.974572 $ Part 2756
97   cz   13.972540 $ Part 2780
98   cz   13.971905 $ Part 2750
99   cz   13.973810 $ Part 2753
100  cz   13.975080 $ Part 2754
101  cz   13.973175 $ Part 2752
102  cz   13.973175 $ Part 2757
c    OUTER RADII
103  cz   16.504412 $ Part 2782
104  cz   16.504857 $ Part 2755
105  cz   16.504285 $ Part 2749
106  cz   16.504603 $ Part 2751
107  cz   16.505809 $ Part 2756
108  cz   16.504984 $ Part 2780
109  cz   16.503015 $ Part 2750
110  cz   16.505873 $ Part 2753
111  cz   16.504031 $ Part 2754
112  cz   16.504285 $ Part 2752
113  cz   16.504920 $ Part 2757
c
150  cz   16.51 $----------Problem Boundary
151  pz   -7.65
152  pz    7.15 $--------------------------------

c  ------------Data Cards-----------------------------------------
c  ------ 7″-9″ HEU Annulus ------
c  --------- Part 2774 ---------
m1    92234.80c 4.7883E-04 92235.80c 4.4828E-02 92236.80c 1.3907E-04
      92238.80c 2.6819E-03 47107.80c 4.3542E-07 47109.80c 4.0452E-07
      56130.80c 4.3709E-13 56132.80c 4.1647E-13 56134.80c 9.9665E-12
      56135.80c 2.7182E-11 56136.80c 3.2386E-11 56137.80c 4.6315E-11
      56138.80c 2.9565E-10 83209.80c 8.8877E-06 06000.80c 4.7146E-06
      20040.80c 2.7394E-08 20042.80c 1.8283E-10 20043.80c 3.8149E-11
      20044.80c 5.8947E-10 20046.80c 1.1303E-12 20048.80c 5.2843E-11
      48106.80c 6.2969E-10 48108.80c 4.4834E-10 48110.80c 6.2919E-09
      48111.80c 6.4480E-09 48112.80c 1.2156E-08 48113.80c 6.1558E-09
      48114.80c 1.4473E-08 48116.80c 3.7731E-09 27059.80c 9.6086E-07
      24050.80c 6.6247E-08 24052.80c 1.2775E-06 24053.80c 1.4486E-07
      24054.80c 3.6059E-08 29063.80c 3.0819E-06 29065.80c 1.3737E-06
      19039.80c 2.7013E-08 19040.80c 3.3891E-12 19041.80c 1.9495E-09
      03006.80c 1.2384E-07 03007.80c 1.5078E-06 12024.80c 1.1042E-06
      12025.80c 1.3979E-07 12026.80c 1.5391E-07 25055.80c 1.1544E-05
      42092.80c 8.7590E-09 42094.80c 5.4596E-09 42095.80c 9.3965E-09
      42096.80c 9.8450E-09 42097.80c 5.6367E-09 42098.80c 1.4242E-08
```

```
     42100.80c 5.6839E-09 11023.80c 1.3301E-05 28058.80c 1.3137E-05
     28060.80c 5.0602E-06 28061.80c 2.1997E-07 28062.80c 7.0135E-07
     28064.80c 1.7861E-07 51121.80c 2.0223E-06 51123.80c 1.5125E-06
     22046.80c 1.9514E-08 22047.80c 1.7598E-08 22048.80c 1.7437E-07
     22049.80c 1.2797E-08 22050.80c 1.2253E-08 08016.80c 1.4152E-05
     08017.80c 5.3797E-09 07014.80c 2.4168E-05 07015.80c 8.9266E-08
c  Total 4.8238E-02
c
c  --------- Part 2737 ---------
m2    92234.80c 4.7780E-04 92235.80c 4.4731E-02 92236.80c 1.3877E-04
     92238.80c 2.6762E-03 47107.80c 4.3448E-07 47109.80c 4.0365E-07
     56130.80c 4.3615E-13 56132.80c 4.1558E-13 56134.80c 9.9450E-12
     56135.80c 2.7124E-11 56136.80c 3.2316E-11 56137.80c 4.6215E-11
     56138.80c 2.9501E-10 83209.80c 8.8686E-06 06000.80c 4.7044E-06
     20040.80c 2.7335E-08 20042.80c 1.8244E-10 20043.80c 3.8066E-11
     20044.80c 5.8820E-10 20046.80c 1.1279E-12 20048.80c 5.2729E-11
     48106.80c 6.2833E-10 48108.80c 4.4737E-10 48110.80c 6.2783E-09
     48111.80c 6.4341E-09 48112.80c 1.2129E-08 48113.80c 6.1426E-09
     48114.80c 1.4442E-08 48116.80c 3.7650E-09 27059.80c 9.5879E-07
     24050.80c 6.6105E-08 24052.80c 1.2748E-06 24053.80c 1.4455E-07
     24054.80c 3.5981E-08 29063.80c 3.0753E-06 29065.80c 1.3707E-06
     19039.80c 2.6955E-08 19040.80c 3.3818E-12 19041.80c 1.9453E-09
     03006.80c 1.2358E-07 03007.80c 1.5046E-06 12024.80c 1.1018E-06
     12025.80c 1.3949E-07 12026.80c 1.5358E-07 25055.80c 1.1519E-05
     42092.80c 8.7402E-09 42094.80c 5.4479E-09 42095.80c 9.3762E-09
     42096.80c 9.8238E-09 42097.80c 5.6246E-09 42098.80c 1.4212E-08
     42100.80c 5.6717E-09 11023.80c 1.3272E-05 28058.80c 1.3108E-05
     28060.80c 5.0493E-06 28061.80c 2.1949E-07 28062.80c 6.9983E-07
     28064.80c 1.7823E-07 51121.80c 2.0179E-06 51123.80c 1.5093E-06
     22046.80c 1.9472E-08 22047.80c 1.7560E-08 22048.80c 1.7400E-07
     22049.80c 1.2769E-08 22050.80c 1.2226E-08 08016.80c 1.4121E-05
     08017.80c 5.3682E-09 07014.80c 2.4116E-05 07015.80c 8.9073E-08
c  Total 4.8134E-02
c
c  --------- Part 2738 ---------
m3    92234.80c 4.7317E-04 92235.80c 4.4783E-02 92236.80c 1.1489E-04
     92238.80c 2.6725E-03 47107.80c 4.3466E-07 47109.80c 4.0382E-07
     56130.80c 4.3633E-13 56132.80c 4.1575E-13 56134.80c 9.9491E-12
     56135.80c 2.7135E-11 56136.80c 3.2330E-11 56137.80c 4.6234E-11
     56138.80c 2.9513E-10 83209.80c 8.8722E-06 06000.80c 4.7064E-06
     20040.80c 2.7346E-08 20042.80c 1.8251E-10 20043.80c 3.8082E-11
     20044.80c 5.8844E-10 20046.80c 1.1284E-12 20048.80c 5.2751E-11
     48106.80c 6.2859E-10 48108.80c 4.4756E-10 48110.80c 6.2809E-09
     48111.80c 6.4368E-09 48112.80c 1.2134E-08 48113.80c 6.1451E-09
     48114.80c 1.4448E-08 48116.80c 3.7665E-09 27059.80c 9.5919E-07
     24050.80c 6.6132E-08 24052.80c 1.2753E-06 24053.80c 1.4461E-07
     24054.80c 3.5996E-08 29063.80c 3.0766E-06 29065.80c 1.3713E-06
     19039.80c 2.6966E-08 19040.80c 3.3832E-12 19041.80c 1.9461E-09
     03006.80c 1.2363E-07 03007.80c 1.5052E-06 12024.80c 1.1023E-06
     12025.80c 1.3955E-07 12026.80c 1.5364E-07 25055.80c 1.1524E-05
     42092.80c 8.7438E-09 42094.80c 5.4501E-09 42095.80c 9.3801E-09
     42096.80c 9.8279E-09 42097.80c 5.6269E-09 42098.80c 1.4217E-08
     42100.80c 5.6740E-09 11023.80c 1.3278E-05 28058.80c 1.3114E-05
     28060.80c 5.0514E-06 28061.80c 2.1958E-07 28062.80c 7.0012E-07
     28064.80c 1.7830E-07 51121.80c 2.0187E-06 51123.80c 1.5099E-06
     22046.80c 1.9480E-08 22047.80c 1.7568E-08 22048.80c 1.7407E-07
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     22049.80c 1.2774E-08 22050.80c 1.2231E-08 08016.80c 1.4127E-05
     08017.80c 5.3704E-09 07014.80c 2.4126E-05 07015.80c 8.9110E-08
c  Total 4.8155E-02
c
c  --------- Part 2762 ---------
m4    92234.80c 4.6870E-04 92235.80c 4.4808E-02 92236.80c 1.2935E-04
     92238.80c 2.6745E-03 47107.80c 4.3499E-07 47109.80c 4.0413E-07
     56130.80c 4.3666E-13 56132.80c 4.1606E-13 56134.80c 9.9567E-12
     56135.80c 2.7155E-11 56136.80c 3.2354E-11 56137.80c 4.6270E-11
     56138.80c 2.9536E-10 83209.80c 8.8790E-06 06000.80c 4.7099E-06
     20040.80c 2.7367E-08 20042.80c 1.8265E-10 20043.80c 3.8111E-11
     20044.80c 5.8889E-10 20046.80c 1.1292E-12 20048.80c 5.2791E-11
     48106.80c 6.2907E-10 48108.80c 4.4790E-10 48110.80c 6.2857E-09
     48111.80c 6.4417E-09 48112.80c 1.2144E-08 48113.80c 6.1498E-09
     48114.80c 1.4459E-08 48116.80c 3.7694E-09 27059.80c 9.5992E-07
     24050.80c 6.6182E-08 24052.80c 1.2763E-06 24053.80c 1.4472E-07
     24054.80c 3.6023E-08 29063.80c 3.0789E-06 29065.80c 1.3723E-06
     19039.80c 2.6987E-08 19040.80c 3.3857E-12 19041.80c 1.9476E-09
     03006.80c 1.2372E-07 03007.80c 1.5063E-06 12024.80c 1.1031E-06
     12025.80c 1.3965E-07 12026.80c 1.5376E-07 25055.80c 1.1533E-05
     42092.80c 8.7504E-09 42094.80c 5.4543E-09 42095.80c 9.3872E-09
     42096.80c 9.8354E-09 42097.80c 5.6312E-09 42098.80c 1.4228E-08
     42100.80c 5.6783E-09 11023.80c 1.3288E-05 28058.80c 1.3124E-05
     28060.80c 5.0553E-06 28061.80c 2.1975E-07 28062.80c 7.0066E-07
     28064.80c 1.7844E-07 51121.80c 2.0203E-06 51123.80c 1.5111E-06
     22046.80c 1.9495E-08 22047.80c 1.7581E-08 22048.80c 1.7420E-07
     22049.80c 1.2784E-08 22050.80c 1.2241E-08 08016.80c 1.4138E-05
     08017.80c 5.3745E-09 07014.80c 2.4144E-05 07015.80c 8.9178E-08
c  Total 4.8191E-02
c
c  --------- Part 2740 ---------
m5    92234.80c 4.6863E-04 92235.80c 4.4821E-02 92236.80c 1.1497E-04
     92238.80c 2.6694E-03 47107.80c 4.3493E-07 47109.80c 4.0407E-07
     56130.80c 4.3660E-13 56132.80c 4.1601E-13 56134.80c 9.9554E-12
     56135.80c 2.7152E-11 56136.80c 3.2350E-11 56137.80c 4.6263E-11
     56138.80c 2.9532E-10 83209.80c 8.8778E-06 06000.80c 4.7093E-06
     20040.80c 2.7363E-08 20042.80c 1.8263E-10 20043.80c 3.8106E-11
     20044.80c 5.8881E-10 20046.80c 1.1291E-12 20048.80c 5.2784E-11
     48106.80c 6.2899E-10 48108.80c 4.4784E-10 48110.80c 6.2848E-09
     48111.80c 6.4408E-09 48112.80c 1.2142E-08 48113.80c 6.1490E-09
     48114.80c 1.4457E-08 48116.80c 3.7689E-09 27059.80c 9.5979E-07
     24050.80c 6.6174E-08 24052.80c 1.2761E-06 24053.80c 1.4470E-07
     24054.80c 3.6019E-08 29063.80c 3.0785E-06 29065.80c 1.3721E-06
     19039.80c 2.6983E-08 19040.80c 3.3853E-12 19041.80c 1.9473E-09
     03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1030E-06
     12025.80c 1.3963E-07 12026.80c 1.5374E-07 25055.80c 1.1531E-05
     42092.80c 8.7493E-09 42094.80c 5.4535E-09 42095.80c 9.3860E-09
     42096.80c 9.8341E-09 42097.80c 5.6304E-09 42098.80c 1.4226E-08
     42100.80c 5.6776E-09 11023.80c 1.3286E-05 28058.80c 1.3122E-05
     28060.80c 5.0546E-06 28061.80c 2.1972E-07 28062.80c 7.0056E-07
     28064.80c 1.7841E-07 51121.80c 2.0200E-06 51123.80c 1.5109E-06
     22046.80c 1.9492E-08 22047.80c 1.7579E-08 22048.80c 1.7418E-07
     22049.80c 1.2782E-08 22050.80c 1.2239E-08 08016.80c 1.4136E-05
     08017.80c 5.3737E-09 07014.80c 2.4141E-05 07015.80c 8.9166E-08
c  Total 4.8185E-02
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c  ------------ part 2741---------
m6    92234.80c 4.6364E-04 92235.80c 4.4810E-02 92236.80c 1.1972E-04
      92238.80c 2.6638E-03 47107.80c 4.3478E-07 47109.80c 4.0393E-07
      56130.80c 4.3645E-13 56132.80c 4.1587E-13 56134.80c 9.9520E-12
      56135.80c 2.7143E-11 56136.80c 3.2339E-11 56137.80c 4.6248E-11
      56138.80c 2.9522E-10 83209.80c 8.8748E-06 06000.80c 4.7078E-06
      20040.80c 2.7354E-08 20042.80c 1.8256E-10 20043.80c 3.8093E-11
      20044.80c 5.8861E-10 20046.80c 1.1287E-12 20048.80c 5.2766E-11
      48106.80c 6.2877E-10 48108.80c 4.4768E-10 48110.80c 6.2826E-09
      48111.80c 6.4386E-09 48112.80c 1.2138E-08 48113.80c 6.1468E-09
      48114.80c 1.4452E-08 48116.80c 3.7676E-09 27059.80c 9.5947E-07
      24050.80c 6.6151E-08 24052.80c 1.2757E-06 24053.80c 1.4465E-07
      24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3717E-06
      19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9467E-09
      03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
      12025.80c 1.3959E-07 12026.80c 1.5369E-07 25055.80c 1.1527E-05
      42092.80c 8.7463E-09 42094.80c 5.4517E-09 42095.80c 9.3828E-09
      42096.80c 9.8307E-09 42097.80c 5.6285E-09 42098.80c 1.4222E-08
      42100.80c 5.6992E-09 11023.80c 1.3282E-05 28058.80c 1.3117E-05
      28060.80c 5.0526E-06 28061.80c 2.1963E-07 28062.80c 7.0028E-07
      28064.80c 1.7834E-07 51121.80c 2.0192E-06 51123.80c 1.5102E-06
      22046.80c 1.9491E-08 22047.80c 1.7577E-08 22048.80c 1.7417E-07
      22049.80c 1.2781E-08 22050.80c 1.2238E-08 08016.80c 1.4131E-05
      08017.80c 5.3719E-09 07014.80c 2.4133E-05 07015.80c 8.9136E-08
c  Total 4.8168E-02
c
c  ------ 9″-11″ HEU Annulus ------
c  --------- Part 2744 ---------
m7     92234.80c 4.7461E-04 92235.80c 4.4915E-02 92236.80c 1.1044E-04
       92238.80c 2.6902E-03 47107.80c 4.3598E-07 47109.80c 4.0505E-07
       56130.80c 4.3766E-13 56132.80c 4.1701E-13 56134.80c 9.9794E-12
       56135.80c 2.7217E-11 56136.80c 3.2428E-11 56137.80c 4.6375E-11
       56138.80c 2.9603E-10 83209.80c 8.8993E-06 06000.80c 4.7207E-06
       20040.80c 2.7429E-08 20042.80c 1.8307E-10 20043.80c 3.8198E-11
       20044.80c 5.9023E-10 20046.80c 1.1318E-12 20048.80c 5.2912E-11
       48106.80c 6.3051E-10 48108.80c 4.4892E-10 48110.80c 6.3000E-09
       48111.80c 6.4564E-09 48112.80c 1.2171E-08 48113.80c 6.1638E-09
       48114.80c 1.4492E-08 48116.80c 3.7780E-09 27059.80c 9.6211E-07
       24050.80c 6.6334E-08 24052.80c 1.2792E-06 24053.80c 1.4505E-07
       24054.80c 3.6106E-08 29063.80c 3.0859E-06 29065.80c 1.3754E-06
       19039.80c 2.7049E-08 19040.80c 3.3935E-12 19041.80c 1.9520E-09
       03006.80c 1.2400E-07 03007.80c 1.5098E-06 12024.80c 1.1056E-06
       12025.80c 1.3997E-07 12026.80c 1.5411E-07 25055.80c 1.1559E-05
       42092.80c 8.7704E-09 42094.80c 5.4667E-09 42095.80c 9.4087E-09
       42096.80c 9.8578E-09 42097.80c 5.6440E-09 42098.80c 1.4261E-08
       42100.80c 5.6913E-09 11023.80c 1.3318E-05 28058.80c 1.3154E-05
       28060.80c 5.0668E-06 28061.80c 2.2025E-07 28062.80c 7.0226E-07
       28064.80c 1.7884E-07 51121.80c 2.0249E-06 51123.80c 1.5145E-06
       22046.80c 1.9540E-08 22047.80c 1.7621E-08 22048.80c 1.7460E-07
       22049.80c 1.2813E-08 22050.80c 1.2268E-08 08016.80c 1.4170E-05
       08017.80c 5.3867E-09 07014.80c 2.4199E-05 07015.80c 8.9382E-08
c  Total 4.8301E-02
c
c  ------------Part 2767---------
m8     92234.80c 4.6289E-04 92235.80c 4.4718E-02 92236.80c 1.2431E-04
       92238.80c 2.6737E-03 47107.80c 4.3407E-07 47109.80c 4.0328E-07
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      56130.80c 4.3574E-13 56132.80c 4.1519E-13 56134.80c 9.9358E-12
      56135.80c 2.7098E-11 56136.80c 3.2286E-11 56137.80c 4.6172E-11
      56138.80c 2.9473E-10 83209.80c 8.8603E-06 06000.80c 4.7002E-06
      20040.80c 2.7309E-08 20042.80c 1.8227E-10 20043.80c 3.8031E-11
      20044.80c 5.8765E-10 20046.80c 1.1268E-12 20048.80c 5.2680E-11
      48106.80c 6.2774E-10 48108.80c 4.4695E-10 48110.80c 6.2724E-09
      48111.80c 6.4281E-09 48112.80c 1.2118E-08 48113.80c 6.1368E-09
      48114.80c 1.4428E-08 48116.80c 3.7614E-09 27059.80c 9.5790E-07
      24050.80c 6.6043E-08 24052.80c 1.2736E-06 24053.80c 1.4441E-07
      24054.80c 3.5947E-08 29063.80c 3.0724E-06 29065.80c 1.3694E-06
      19039.80c 2.6930E-08 19040.80c 3.3786E-12 19041.80c 1.9435E-09
      03006.80c 1.2346E-07 03007.80c 1.5032E-06 12024.80c 1.1008E-06
      12025.80c 1.3936E-07 12026.80c 1.5343E-07 25055.80c 1.1509E-05
      42092.80c 8.7320E-09 42094.80c 5.4428E-09 42095.80c 9.3675E-09
      42096.80c 9.8147E-09 42097.80c 5.6193E-09 42098.80c 1.4198E-08
      42100.80c 5.6899E-09 11023.80c 1.3260E-05 28058.80c 1.3095E-05
      28060.80c 5.0443E-06 28061.80c 2.1927E-07 28062.80c 6.9914E-07
      28064.80c 1.7805E-07 51121.80c 2.0159E-06 51123.80c 1.5078E-06
      22046.80c 1.9459E-08 22047.80c 1.7549E-08 22048.80c 1.7388E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4108E-05
      08017.80c 5.3632E-09 07014.80c 2.4093E-05 07015.80c 8.8990E-08
c  Total 4.8090E-02
c
c  --------- Part 2776 ---------
m9     92234.80c 4.6302E-04 92235.80c 4.4740E-02 92236.80c 1.0999E-04
      92238.80c 2.6792E-03 47107.80c 4.3420E-07 47109.80c 4.0339E-07
      56130.80c 4.3587E-13 56132.80c 4.1531E-13 56134.80c 9.9386E-12
      56135.80c 2.7106E-11 56136.80c 3.2295E-11 56137.80c 4.6185E-11
      56138.80c 2.9482E-10 83209.80c 8.8628E-06 06000.80c 4.7014E-06
      20040.80c 2.7317E-08 20042.80c 1.8232E-10 20043.80c 3.8042E-11
      20044.80c 5.8782E-10 20046.80c 1.1272E-12 20048.80c 5.2695E-11
      48106.80c 6.2793E-10 48108.80c 4.4708E-10 48110.80c 6.2742E-09
      48111.80c 6.4300E-09 48112.80c 1.2121E-08 48113.80c 6.1386E-09
      48114.80c 1.4432E-08 48116.80c 3.7625E-09 27059.80c 9.5817E-07
      24050.80c 6.6062E-08 24052.80c 1.2739E-06 24053.80c 1.4445E-07
      24054.80c 3.5958E-08 29063.80c 3.0733E-06 29065.80c 1.3698E-06
      19039.80c 2.6938E-08 19040.80c 3.3796E-12 19041.80c 1.9440E-09
      03006.80c 1.2350E-07 03007.80c 1.5036E-06 12024.80c 1.1011E-06
      12025.80c 1.3940E-07 12026.80c 1.5348E-07 25055.80c 1.1512E-05
      42092.80c 8.7345E-09 42094.80c 5.4443E-09 42095.80c 9.3702E-09
      42096.80c 9.8175E-09 42097.80c 5.6209E-09 42098.80c 1.4202E-08
      42100.80c 5.6680E-09 11023.80c 1.3264E-05 28058.80c 1.3100E-05
      28060.80c 5.0461E-06 28061.80c 2.1935E-07 28062.80c 6.9938E-07
      28064.80c 1.7811E-07 51121.80c 2.0166E-06 51123.80c 1.5083E-06
      22046.80c 1.9460E-08 22047.80c 1.7549E-08 22048.80c 1.7389E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4112E-05
      08017.80c 5.3647E-09 07014.80c 2.4100E-05 07015.80c 8.9016E-08
c Total 4.8103E-02
c
c  --------- Part 2745 ---------
m10    92234.80c 4.6359E-04 92235.80c 4.4815E-02 92236.80c 1.0534E-04
      92238.80c 2.6682E-03 47107.80c 4.3473E-07 47109.80c 4.0389E-07
      56130.80c 4.3641E-13 56132.80c 4.1582E-13 56134.80c 9.9509E-12
      56135.80c 2.7140E-11 56136.80c 3.2335E-11 56137.80c 4.6243E-11
      56138.80c 2.9518E-10 83209.80c 8.8738E-06 06000.80c 4.7072E-06
      20040.80c 2.7351E-08 20042.80c 1.8254E-10 20043.80c 3.8089E-11
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      20044.80c 5.8854E-10 20046.80c 1.1286E-12 20048.80c 5.2760E-11
      48106.80c 6.2870E-10 48108.80c 4.4764E-10 48110.80c 6.2820E-09
      48111.80c 6.4379E-09 48112.80c 1.2136E-08 48113.80c 6.1462E-09
      48114.80c 1.4450E-08 48116.80c 3.7672E-09 27059.80c 9.5936E-07
      24050.80c 6.6144E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
      24054.80c 3.6002E-08 29063.80c 3.0771E-06 29065.80c 1.3715E-06
      19039.80c 2.6971E-08 19040.80c 3.3838E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5055E-06 12024.80c 1.1025E-06
      12025.80c 1.3957E-07 12026.80c 1.5367E-07 25055.80c 1.1526E-05
      42092.80c 8.7453E-09 42094.80c 5.4511E-09 42095.80c 9.3818E-09
      42096.80c 9.8296E-09 42097.80c 5.6279E-09 42098.80c 1.4220E-08
      42100.80c 5.6750E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
      28060.80c 5.0523E-06 28061.80c 2.1962E-07 28062.80c 7.0025E-07
      28064.80c 1.7833E-07 51121.80c 2.0191E-06 51123.80c 1.5102E-06
      22046.80c 1.9484E-08 22047.80c 1.7571E-08 22048.80c 1.7410E-07
      22049.80c 1.2777E-08 22050.80c 1.2233E-08 08016.80c 1.4130E-05
      08017.80c 5.3713E-09 07014.80c 2.4130E-05 07015.80c 8.9126E-08
c  Total 4.8163E-02
c
c  --------- Part 2747 ---------
m11    92234.80c 4.7245E-04 92235.80c 4.4720E-02 92236.80c 9.0820E-05
      92238.80c 2.6874E-03 47107.80c 4.3400E-07 47109.80c 4.0321E-07
      56130.80c 4.3567E-13 56132.80c 4.1512E-13 56134.80c 9.9341E-12
      56135.80c 2.7094E-11 56136.80c 3.2281E-11 56137.80c 4.6165E-11
      56138.80c 2.9469E-10 83209.80c 8.8588E-06 06000.80c 4.6993E-06
      20040.80c 2.7305E-08 20042.80c 1.8224E-10 20043.80c 3.8025E-11
      20044.80c 5.8755E-10 20046.80c 1.1267E-12 20048.80c 5.2671E-11
      48106.80c 6.2764E-10 48108.80c 4.4688E-10 48110.80c 6.2714E-09
      48111.80c 6.4270E-09 48112.80c 1.2116E-08 48113.80c 6.1358E-09
      48114.80c 1.4426E-08 48116.80c 3.7608E-09 27059.80c 9.5774E-07
      24050.80c 6.6032E-08 24052.80c 1.2734E-06 24053.80c 1.4439E-07
      24054.80c 3.5942E-08 29063.80c 3.0719E-06 29065.80c 1.3692E-06
      19039.80c 2.6926E-08 19040.80c 3.3781E-12 19041.80c 1.9432E-09
      03006.80c 1.2344E-07 03007.80c 1.5029E-06 12024.80c 1.1006E-06
      12025.80c 1.3934E-07 12026.80c 1.5341E-07 25055.80c 1.1507E-05
      42092.80c 8.7306E-09 42094.80c 5.4419E-09 42095.80c 9.3659E-09
      42096.80c 9.8131E-09 42097.80c 5.6184E-09 42098.80c 1.4196E-08
      42100.80c 5.6655E-09 11023.80c 1.3258E-05 28058.80c 1.3094E-05
      28060.80c 5.0438E-06 28061.80c 2.1925E-07 28062.80c 6.9907E-07
      28064.80c 1.7803E-07 51121.80c 2.0157E-06 51123.80c 1.5076E-06
      22046.80c 1.9451E-08 22047.80c 1.7541E-08 22048.80c 1.7381E-07
      22049.80c 1.2755E-08 22050.80c 1.2213E-08 08016.80c 1.4106E-05
      08017.80c 5.3623E-09 07014.80c 2.4089E-05 07015.80c 8.8976E-08
c  Total 4.8082E-02
c
c  --------- Part 2748 ---------
m12    92234.80c 4.8285E-04 92235.80c 4.4757E-02 92236.80c 1.0533E-04
      92238.80c 2.7012E-03 47107.80c 4.3468E-07 47109.80c 4.0384E-07
      56130.80c 4.3636E-13 56132.80c 4.1577E-13 56134.80c 9.9497E-12
      56135.80c 2.7136E-11 56136.80c 3.2332E-11 56137.80c 4.6237E-11
      56138.80c 2.9515E-10 83209.80c 8.8728E-06 06000.80c 4.7067E-06
      20040.80c 2.7348E-08 20042.80c 1.8252E-10 20043.80c 3.8085E-11
      20044.80c 5.8848E-10 20046.80c 1.1284E-12 20048.80c 5.2754E-11
      48106.80c 6.2863E-10 48108.80c 4.4759E-10 48110.80c 6.2813E-09
      48111.80c 6.4372E-09 48112.80c 1.2135E-08 48113.80c 6.1455E-09
      48114.80c 1.4448E-08 48116.80c 3.7668E-09 27059.80c 9.5925E-07
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      24050.80c 6.6136E-08 24052.80c 1.2754E-06 24053.80c 1.4462E-07
      24054.80c 3.5998E-08 29063.80c 3.0767E-06 29065.80c 1.3713E-06
      19039.80c 2.6968E-08 19040.80c 3.3834E-12 19041.80c 1.9462E-09
      03006.80c 1.2363E-07 03007.80c 1.5053E-06 12024.80c 1.1023E-06
      12025.80c 1.3956E-07 12026.80c 1.5365E-07 25055.80c 1.1525E-05
      42092.80c 8.7443E-09 42094.80c 5.4505E-09 42095.80c 9.3807E-09
      42096.80c 9.8285E-09 42097.80c 5.6272E-09 42098.80c 1.4218E-08
      42100.80c 5.6744E-09 11023.80c 1.3279E-05 28058.80c 1.3115E-05
      28060.80c 5.0517E-06 28061.80c 2.1960E-07 28062.80c 7.0017E-07
      28064.80c 1.7831E-07 51121.80c 2.0189E-06 51123.80c 1.5100E-06
      22046.80c 1.9481E-08 22047.80c 1.7569E-08 22048.80c 1.7408E-07
      22049.80c 1.2775E-08 22050.80c 1.2232E-08 08016.80c 1.4128E-05
      08017.80c 5.3707E-09 07014.80c 2.4127E-05 07015.80c 8.9116E-08
c Total 4.8157E-02
c
c  ------ 11″-13" HEU Annulus ------
c  ---------- Part 2782 ---------
m13    92234.80c 4.6445E-04 92235.80c 4.4898E-02 92236.80c 1.1033E-04
      92238.80c 2.6684E-03 47107.80c 4.3554E-07 47109.80c 4.0463E-07
            56130.80c 4.3721E-13 56132.80c 4.1659E-13 56134.80c 9.9692E-12
      56135.80c 2.7190E-11 56136.80c 3.2395E-11 56137.80c 4.6328E-11
      56138.80c 2.9573E-10 83209.80c 8.8902E-06 06000.80c 4.7160E-06
      20040.80c 2.7401E-08 20042.80c 1.8288E-10 20043.80c 3.8159E-11
            20044.80c 5.8963E-10 20046.80c 1.1306E-12 20048.80c 5.2857E-11
      48106.80c 6.2986E-10 48108.80c 4.4846E-10 48110.80c 6.2935E-09
      48111.80c 6.4497E-09 48112.80c 1.2159E-08 48113.80c 6.1575E-09
      48114.80c 1.4477E-08 48116.80c 3.7741E-09 27059.80c 9.6113E-07
      24050.80c 6.6266E-08 24052.80c 1.2779E-06 24053.80c 1.4490E-07
      24054.80c 3.6069E-08 29063.80c 3.0828E-06 29065.80c 1.3740E-06
      19039.80c 2.7021E-08 19040.80c 3.3900E-12 19041.80c 1.9500E-09
      03006.80c 1.2388E-07 03007.80c 1.5082E-06 12024.80c 1.1045E-06
      12025.80c 1.3983E-07 12026.80c 1.5395E-07 25055.80c 1.1547E-05
      42092.80c 8.7614E-09 42094.80c 5.4611E-09 42095.80c 9.3991E-09
            42096.80c 9.8478E-09 42097.80c 5.6383E-09 42098.80c 1.4246E-08
            42100.80c 5.7091E-09 11023.80c 1.3305E-05 28058.80c 1.3140E-05
      28060.80c 5.0613E-06 28061.80c 2.2001E-07 28062.80c 7.0150E-07
      28064.80c 1.7865E-07 51121.80c 2.0227E-06 51123.80c 1.5128E-06
      22046.80c 1.9525E-08 22047.80c 1.7608E-08 22048.80c 1.7447E-07
            22049.80c 1.2804E-08 22050.80c 1.2259E-08 08016.80c 1.4156E-05
            08017.80c 5.3812E-09 07014.80c 2.4174E-05 07015.80c 8.9290E-08
c Total 4.8252E-02
c
c  The parts below are listed in Hmf076.pdf-----------------------------
c
c    03007.80c 3.0260E-06
c    12000.80c 1.4027E-06
c    25055.80c 1.1584E-05
c    42000.80c 1.1845E-07
c    11023.80c 1.3347E-05
c    28058.80c 1.3182E-05
c    28060.80c 5.0776E-06
c    28061.80c 2.2072E-07
c    28062.80c 7.0376E-07
c    28064.80c 1.7923E-07
c    51000.80cc 3.5470E-06
c    22000.80c 2.3735E-07
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c    8016.80c 1.80c06E-05
c    7014.80c 2.4340E-05
c
c  Total 4.8222E-02
c
c  --------- Part 2755 ---------
m14    92234.80c 4.6364E-04 92235.80c 4.4771E-02 92236.80c 1.3408E-04
       92238.80c 2.6875E-03 47107.80c 4.3477E-07 47109.80c 4.0393E-07
       56130.80c 4.3645E-13 56132.80c 4.1586E-13 56134.80c 9.9518E-12
       56135.80c 2.7142E-11 56136.80c 3.2338E-11 56137.80c 4.6247E-11
       56138.80c 2.9521E-10 83209.80c 8.8746E-06 06000.80c 4.7076E-06
       20040.80c 2.7353E-08 20042.80c 1.8256E-10 20043.80c 3.8092E-11
       20044.80c 5.8860E-10 20046.80c 1.1287E-12 20048.80c 5.2765E-11
       48106.80c 6.2876E-10 48108.80c 4.4768E-10 48110.80c 6.2826E-09
       48111.80c 6.4385E-09 48112.80c 1.2138E-08 48113.80c 6.1468E-09
       48114.80c 1.4451E-08 48116.80c 3.7675E-09 27059.80c 9.5945E-07
       24050.80c 6.6150E-08 24052.80c 1.2756E-06 24053.80c 1.4465E-07
       24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3716E-06
       19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9466E-09
       03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
       12025.80c 1.3958E-07 12026.80c 1.5368E-07 25055.80c 1.1527E-05
       42092.80c 8.7461E-09 42094.80c 5.4516E-09 42095.80c 9.3826E-09
       42096.80c 9.8305E-09 42097.80c 5.6284E-09 42098.80c 1.4221E-08
       42100.80c 5.6755E-09 11023.80c 1.3281E-05 28058.80c 1.3117E-05
       28060.80c 5.0528E-06 28061.80c 2.1964E-07 28062.80c 7.0031E-07
       28064.80c 1.7835E-07 51121.80c 2.0193E-06 51123.80c 1.5103E-06
       22046.80c 1.9485E-08 22047.80c 1.7572E-08 22048.80c 1.7412E-07
       22049.80c 1.2778E-08 22050.80c 1.2234E-08 08016.80c 1.4131E-05
       08017.80c 5.3718E-09 07014.80c 2.4132E-05 07015.80c 8.9134E-08
c Total 4.8167E-02
c
c  --------- Part 2749 ---------
m15    92234.80c 4.7313E-04 92235.80c 4.4799E-02 92236.80c 1.1967E-04
       92238.80c 2.6486E-03 47107.80c 4.3462E-07 47109.80c 4.0379E-07
       56130.80c 4.3629E-13 56132.80c 4.1571E-13 56134.80c 9.9483E-12
       56135.80c 2.7133E-11 56136.80c 3.2327E-11 56137.80c 4.6231E-11
       56138.80c 2.9511E-10 83209.80c 8.8715E-06 06000.80c 4.7060E-06
       20040.80c 2.7344E-08 20042.80c 1.8250E-10 20043.80c 3.8079E-11
       20044.80c 5.8839E-10 20046.80c 1.1283E-12 20048.80c 5.2747E-11
       48106.80c 6.2854E-10 48108.80c 4.4752E-10 48110.80c 6.2804E-09
       48111.80c 6.4363E-09 48112.80c 1.2133E-08 48113.80c 6.1446E-09
       48114.80c 1.4446E-08 48116.80c 3.7662E-09 27059.80c 9.5911E-07
       24050.80c 6.6127E-08 24052.80c 1.2752E-06 24053.80c 1.4460E-07
       24054.80c 3.5993E-08 29063.80c 3.0763E-06 29065.80c 1.3711E-06
       19039.80c 2.6964E-08 19040.80c 3.3829E-12 19041.80c 1.9459E-09
       03006.80c 1.2362E-07 03007.80c 1.5051E-06 12024.80c 1.1022E-06
       12025.80c 1.3954E-07 12026.80c 1.5363E-07 25055.80c 1.1523E-05
       42092.80c 8.7431E-09 42094.80c 5.4497E-09 42095.80c 9.3793E-09
       42096.80c 9.8271E-09 42097.80c 5.6264E-09 42098.80c 1.4216E-08
       42100.80c 5.6736E-09 11023.80c 1.3277E-05 28058.80c 1.3113E-05
       28060.80c 5.0510E-06 28061.80c 2.1956E-07 28062.80c 7.0007E-07
       28064.80c 1.7829E-07 51121.80c 2.0186E-06 51123.80c 1.5098E-06
       22046.80c 1.9479E-08 22047.80c 1.7566E-08 22048.80c 1.7406E-07
       22049.80c 1.2773E-08 22050.80c 1.2230E-08 08016.80c 1.4126E-05
       08017.80c 5.3699E-09 07014.80c 2.4124E-05 07015.80c 8.9103E-08
c  Total 4.8151E-02
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c
c  --------- Part 2751 ---------
m16    92234.80c 4.7310E-04 92235.80c 4.4767E-02 92236.80c 1.1488E-04
       92238.80c 2.6816E-03 47107.80c 4.3460E-07 47109.80c 4.0376E-07
       56130.80c 4.3627E-13 56132.80c 4.1569E-13 56134.80c 9.9477E-12
       56135.80c 2.7131E-11 56136.80c 3.2325E-11 56137.80c 4.6228E-11
       56138.80c 2.9509E-10 83209.80c 8.8710E-06 06000.80c 4.7057E-06
       20040.80c 2.7342E-08 20042.80c 1.8249E-10 20043.80c 3.8077E-11
       20044.80c 5.8836E-10 20046.80c 1.1282E-12 20048.80c 5.2744E-11
       48106.80c 6.2850E-10 48108.80c 4.4750E-10 48110.80c 6.2800E-09
       48111.80c 6.4359E-09 48112.80c 1.2133E-08 48113.80c 6.1443E-09
       48114.80c 1.4446E-08 48116.80c 3.7660E-09 27059.80c 9.5906E-07
       24050.80c 6.6123E-08 24052.80c 1.2751E-06 24053.80c 1.4459E-07
       24054.80c 3.5991E-08 29063.80c 3.0761E-06 29065.80c 1.3711E-06
       19039.80c 2.6963E-08 19040.80c 3.3827E-12 19041.80c 1.9458E-09
       03006.80c 1.2361E-07 03007.80c 1.5050E-06 12024.80c 1.1021E-06
       12025.80c 1.3953E-07 12026.80c 1.5362E-07 25055.80c 1.1523E-05
       42092.80c 8.7425E-09 42094.80c 5.4494E-09 42095.80c 9.3788E-09
       42096.80c 9.8265E-09 42097.80c 5.6261E-09 42098.80c 1.4215E-08
       42100.80c 5.6732E-09 11023.80c 1.3276E-05 28058.80c 1.3112E-05
       28060.80c 5.0507E-06 28061.80c 2.1955E-07 28062.80c 7.0003E-07
       28064.80c 1.7828E-07 51121.80c 2.0185E-06 51123.80c 1.5097E-06
       22046.80c 1.9478E-08 22047.80c 1.7565E-08 22048.80c 1.7405E-07
       22049.80c 1.2773E-08 22050.80c 1.2230E-08 08016.80c 1.4125E-05
       08017.80c 5.3696E-09 07014.80c 2.4122E-05 07015.80c 8.9098E-08
c Total 4.8148E-02
c
c  --------- Part 2756 ---------
m17    92234.80c 4.4929E-04 92235.80c 4.4823E-02 92236.80c 1.1975E-04
       92238.80c 2.6788E-03 47107.80c 4.3491E-07 47109.80c 4.0405E-07
       56130.80c 4.3658E-13 56132.80c 4.1599E-13 56134.80c 9.9549E-12
       56135.80c 2.7150E-11 56136.80c 3.2348E-11 56137.80c 4.6261E-11
       56138.80c 2.9530E-10 83209.80c 8.8774E-06 06000.80c 4.7091E-06
       20040.80c 2.7362E-08 20042.80c 1.8262E-10 20043.80c 3.8104E-11
       20044.80c 5.8878E-10 20046.80c 1.1290E-12 20048.80c 5.2781E-11
       48106.80c 6.2896E-10 48108.80c 4.4782E-10 48110.80c 6.2845E-09
       48111.80c 6.4405E-09 48112.80c 1.2141E-08 48113.80c 6.1487E-09
       48114.80c 1.4456E-08 48116.80c 3.7687E-09 27059.80c 9.5974E-07
       24050.80c 6.6170E-08 24052.80c 1.2760E-06 24053.80c 1.4469E-07
       24054.80c 3.6017E-08 29063.80c 3.0783E-06 29065.80c 1.3721E-06
       19039.80c 2.6982E-08 19040.80c 3.3851E-12 19041.80c 1.9472E-09
       03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1029E-06
       12025.80c 1.3963E-07 12026.80c 1.5373E-07 25055.80c 1.1531E-05
       42092.80c 8.7488E-09 42094.80c 5.4533E-09 42095.80c 9.3855E-09
       42096.80c 9.8336E-09 42097.80c 5.6301E-09 42098.80c 1.4226E-08
       42100.80c 5.6773E-09 11023.80c 1.3285E-05 28058.80c 1.3121E-05
       28060.80c 5.0543E-06 28061.80c 2.1971E-07 28062.80c 7.0053E-07
       28064.80c 1.7840E-07 51121.80c 2.0199E-06 51123.80c 1.5108E-06
       22046.80c 1.9491E-08 22047.80c 1.7578E-08 22048.80c 1.7417E-07
       22049.80c 1.2782E-08 22050.80c 1.2238E-08 08016.80c 1.4135E-05
       08017.80c 5.3735E-09 07014.80c 2.4140E-05 07015.80c 8.9162E-08
c Total 4.8182E-02
c
c  --------- Part 2780 ---------
m18    92234.80c 4.7200E-04 92235.80c 4.4663E-02 92236.80c 1.1938E-04
       92238.80c 2.6706E-03 47107.80c 4.3358E-07 47109.80c 4.0282E-07
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      56130.80c 4.3525E-13 56132.80c 4.1472E-13 56134.80c 9.9245E-12
      56135.80c 2.7068E-11 56136.80c 3.2250E-11 56137.80c 4.6120E-11
      56138.80c 2.9440E-10 83209.80c 8.8503E-06 06000.80c 4.6947E-06
      20040.80c 2.7278E-08 20042.80c 1.8206E-10 20043.80c 3.7988E-11
      20044.80c 5.8699E-10 20046.80c 1.1256E-12 20048.80c 5.2620E-11
      48106.80c 6.2704E-10 48108.80c 4.4645E-10 48110.80c 6.2654E-09
      48111.80c 6.4208E-09 48112.80c 1.2104E-08 48113.80c 6.1299E-09
      48114.80c 1.4412E-08 48116.80c 3.7572E-09 27059.80c 9.5682E-07
      24050.80c 6.5969E-08 24052.80c 1.2721E-06 24053.80c 1.4425E-07
      24054.80c 3.5907E-08 29063.80c 3.0689E-06 29065.80c 1.3679E-06
      19039.80c 2.6900E-08 19040.80c 3.3748E-12 19041.80c 1.9413E-09
      03006.80c 1.2332E-07 03007.80c 1.5015E-06 12024.80c 1.0996E-06
      12025.80c 1.3920E-07 12026.80c 1.5326E-07 25055.80c 1.1496E-05
      42092.80c 8.7221E-09 42094.80c 5.4366E-09 42095.80c 9.3569E-09
      42096.80c 9.8036E-09 42097.80c 5.6130E-09 42098.80c 1.4182E-08
      42100.80c 5.6600E-09 11023.80c 1.3245E-05 28058.80c 1.3081E-05
      28060.80c 5.0389E-06 28061.80c 2.1904E-07 28062.80c 6.9839E-07
      28064.80c 1.7786E-07 51121.80c 2.0137E-06 51123.80c 1.5062E-06
      22046.80c 1.9432E-08 22047.80c 1.7524E-08 22048.80c 1.7364E-07
      22049.80c 1.2743E-08 22050.80c 1.2201E-08 08016.80c 1.4092E-05
      08017.80c 5.3571E-09 07014.80c 2.4066E-05 07015.80c 8.8890E-08
c  Total 4.8035E-02
c
c  --------- Part 2750 ---------
m19    92234.80c 4.5842E-04 92235.80c 4.4743E-02 92236.80c 1.1961E-04
      92238.80c 2.6947E-03 47107.80c 4.3441E-07 47109.80c 4.0359E-07
      56130.80c 4.3608E-13 56132.80c 4.1551E-13 56134.80c 9.9435E-12
      56135.80c 2.7119E-11 56136.80c 3.2311E-11 56137.80c 4.6208E-11
      56138.80c 2.9496E-10 83209.80c 8.8672E-06 06000.80c 4.7037E-06
      20040.80c 2.7331E-08 20042.80c 1.8241E-10 20043.80c 3.8061E-11
      20044.80c 5.8811E-10 20046.80c 1.1277E-12 20048.80c 5.2721E-11
      48106.80c 6.2824E-10 48108.80c 4.4730E-10 48110.80c 6.2773E-09
      48111.80c 6.4331E-09 48112.80c 1.2127E-08 48113.80c 6.1416E-09
      48114.80c 1.4439E-08 48116.80c 3.7644E-09 27059.80c 9.5865E-07
      24050.80c 6.6095E-08 24052.80c 1.2746E-06 24053.80c 1.4453E-07
      24054.80c 3.5976E-08 29063.80c 3.0748E-06 29065.80c 1.3705E-06
      19039.80c 2.6951E-08 19040.80c 3.3812E-12 19041.80c 1.9450E-09
      03006.80c 1.2356E-07 03007.80c 1.5043E-06 12024.80c 1.1017E-06
      12025.80c 1.3947E-07 12026.80c 1.5355E-07 25055.80c 1.1518E-05
      42092.80c 8.7388E-09 42094.80c 5.4470E-09 42095.80c 9.3748E-09
      42096.80c 9.8223E-09 42097.80c 5.6237E-09 42098.80c 1.4209E-08
      42100.80c 5.6708E-09 11023.80c 1.3270E-05 28058.80c 1.3106E-05
      28060.80c 5.0486E-06 28061.80c 2.1946E-07 28062.80c 6.9973E-07
      28064.80c 1.7820E-07 51121.80c 2.0176E-06 51123.80c 1.5091E-06
      22046.80c 1.9469E-08 22047.80c 1.7558E-08 22048.80c 1.7397E-07
      22049.80c 1.2767E-08 22050.80c 1.2224E-08 08016.80c 1.4119E-05
      08017.80c 5.3673E-09 07014.80c 2.4112E-05 07015.80c 8.9060E-08
c  Total 4.8127E-02
c
c  --------- Part 2753 ---------
m20    92234.80c 4.5759E-04 92235.80c 4.4662E-02 92236.80c 1.1940E-04
      92238.80c 2.6898E-03 47107.80c 4.3362E-07 47109.80c 4.0286E-07
      56130.80c 4.3529E-13 56132.80c 4.1476E-13 56134.80c 9.9255E-12
      56135.80c 2.7070E-11 56136.80c 3.2253E-11 56137.80c 4.6124E-11
      56138.80c 2.9443E-10 83209.80c 8.8511E-06 06000.80c 4.6952E-06
      20040.80c 2.7281E-08 20042.80c 1.8208E-10 20043.80c 3.7992E-11
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      20044.80c 5.8704E-10 20046.80c 1.1257E-12 20048.80c 5.2625E-11
      48106.80c 6.2710E-10 48108.80c 4.4649E-10 48110.80c 6.2660E-09
      48111.80c 6.4214E-09 48112.80c 1.2105E-08 48113.80c 6.1305E-09
      48114.80c 1.4413E-08 48116.80c 3.7576E-09 27059.80c 9.5691E-07
      24050.80c 6.5975E-08 24052.80c 1.2723E-06 24053.80c 1.4426E-07
      24054.80c 3.5910E-08 29063.80c 3.0692E-06 29065.80c 1.3680E-06
      19039.80c 2.6902E-08 19040.80c 3.3751E-12 19041.80c 1.9415E-09
      03006.80c 1.2333E-07 03007.80c 1.5016E-06 12024.80c 1.0997E-06
      12025.80c 1.3921E-07 12026.80c 1.5328E-07 25055.80c 1.1497E-05
      42092.80c 8.7230E-09 42094.80c 5.4372E-09 42095.80c 9.3578E-09
      42096.80c 9.8045E-09 42097.80c 5.6135E-09 42098.80c 1.4184E-08
      42100.80c 5.6605E-09 11023.80c 1.3246E-05 28058.80c 1.3083E-05
      28060.80c 5.0394E-06 28061.80c 2.1906E-07 28062.80c 6.9846E-07
      28064.80c 1.7788E-07 51121.80c 2.0139E-06 51123.80c 1.5063E-06
      22046.80c 1.9434E-08 22047.80c 1.7526E-08 22048.80c 1.7366E-07
      22049.80c 1.2744E-08 22050.80c 1.2202E-08 08016.80c 1.4094E-05
      08017.80c 5.3576E-09 07014.80c 2.4068E-05 07015.80c 8.8898E-08
c Total 4.8040E-02
c
c  --------- Part 2754 ---------
m21    92234.80c 4.6438E-04 92235.80c 4.4843E-02 92236.80c 1.3429E-04
      92238.80c 2.6918E-03 47107.80c 4.3547E-07 47109.80c 4.0457E-07
      56130.80c 4.3715E-13 56132.80c 4.1653E-13 56134.80c 9.9678E-12
      56135.80c 2.7186E-11 56136.80c 3.2390E-11 56137.80c 4.6321E-11
      56138.80c 2.9568E-10 83209.80c 8.8888E-06 06000.80c 4.7152E-06
      20040.80c 2.7397E-08 20042.80c 1.8285E-10 20043.80c 3.8153E-11
      20044.80c 5.8954E-10 20046.80c 1.1305E-12 20048.80c 5.2850E-11
      48106.80c 6.2977E-10 48108.80c 4.4840E-10 48110.80c 6.2927E-09
      48111.80c 6.4488E-09 48112.80c 1.2157E-08 48113.80c 6.1566E-09
      48114.80c 1.4475E-08 48116.80c 3.7736E-09 27059.80c 9.6098E-07
      24050.80c 6.6256E-08 24052.80c 1.2777E-06 24053.80c 1.4488E-07
      24054.80c 3.6063E-08 29063.80c 3.0823E-06 29065.80c 1.3738E-06
      19039.80c 2.7017E-08 19040.80c 3.3895E-12 19041.80c 1.9497E-09
      03006.80c 1.2386E-07 03007.80c 1.5080E-06 12024.80c 1.1043E-06
      12025.80c 1.3981E-07 12026.80c 1.5393E-07 25055.80c 1.1546E-05
      42092.80c 8.7601E-09 42094.80c 5.4603E-09 42095.80c 9.3977E-09
      42096.80c 9.8463E-09 42097.80c 5.6374E-09 42098.80c 1.4244E-08
      42100.80c 5.6846E-09 11023.80c 1.3303E-05 28058.80c 1.3138E-05
      28060.80c 5.0609E-06 28061.80c 2.1999E-07 28062.80c 7.0143E-07
      28064.80c 1.7863E-07 51121.80c 2.0225E-06 51123.80c 1.5127E-06
      22046.80c 1.9517E-08 22047.80c 1.7601E-08 22048.80c 1.7440E-07
      22049.80c 1.2798E-08 22050.80c 1.2254E-08 08016.80c 1.4154E-05
      08017.80c 5.3804E-09 07014.80c 2.4171E-05 07015.80c 8.9277E-08
c Total 4.8244E-02
c
c  --------- Part 2752 ---------
m22    92234.80c 4.7278E-04 92235.80c 4.4737E-02 92236.80c 1.1480E-04
      92238.80c 2.6798E-03 47107.80c 4.3431E-07 47109.80c 4.0349E-07
      56130.80c 4.3598E-13 56132.80c 4.1541E-13 56134.80c 9.9411E-12
      56135.80c 2.7113E-11 56136.80c 3.2303E-11 56137.80c 4.6197E-11
      56138.80c 2.9489E-10 83209.80c 8.8650E-06 06000.80c 4.7025E-06
      20040.80c 2.7324E-08 20042.80c 1.8236E-10 20043.80c 3.8051E-11
      20044.80c 5.8796E-10 20046.80c 1.1274E-12 20048.80c 5.2708E-11
      48106.80c 6.2808E-10 48108.80c 4.4719E-10 48110.80c 6.2758E-09
      48111.80c 6.4316E-09 48112.80c 1.2125E-08 48113.80c 6.1401E-09
      48114.80c 1.4436E-08 48116.80c 3.7635E-09 27059.80c 9.5841E-07
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      24050.80c 6.6078E-08 24052.80c 1.2743E-06 24053.80c 1.4449E-07
      24054.80c 3.5967E-08 29063.80c 3.0741E-06 29065.80c 1.3701E-06
      19039.80c 2.6945E-08 19040.80c 3.3804E-12 19041.80c 1.9445E-09
      03006.80c 1.2353E-07 03007.80c 1.5040E-06 12024.80c 1.1014E-06
      12025.80c 1.3943E-07 12026.80c 1.5352E-07 25055.80c 1.1515E-05
      42092.80c 8.7367E-09 42094.80c 5.4457E-09 42095.80c 9.3725E-09
      42096.80c 9.8199E-09 42097.80c 5.6223E-09 42098.80c 1.4206E-08
      42100.80c 5.6694E-09 11023.80c 1.3267E-05 28058.80c 1.3103E-05
      28060.80c 5.0473E-06 28061.80c 2.1940E-07 28062.80c 6.9956E-07
      28064.80c 1.7816E-07 51121.80c 2.0171E-06 51123.80c 1.5087E-06
      22046.80c 1.9464E-08 22047.80c 1.7553E-08 22048.80c 1.7393E-07
      22049.80c 1.2764E-08 22050.80c 1.2221E-08 08016.80c 1.4116E-05
      08017.80c 5.3660E-09 07014.80c 2.4106E-05 07015.80c 8.9038E-08
c Total 4.8115E-02
c
c  --------- Part 2757 ---------
m23    92234.80c 4.6342E-04 92235.80c 4.4798E-02 92236.80c 1.1008E-04
      92238.80c 2.6625E-03 47107.80c 4.3457E-07 47109.80c 4.0374E-07
      56130.80c 4.3624E-13 56132.80c 4.1566E-13 56134.80c 9.9471E-12
      56135.80c 2.7129E-11 56136.80c 3.2323E-11 56137.80c 4.6225E-11
      56138.80c 2.9507E-10 83209.80c 8.8704E-06 06000.80c 4.7054E-06
      20040.80c 2.7340E-08 20042.80c 1.8247E-10 20043.80c 3.8074E-11
      20044.80c 5.8832E-10 20046.80c 1.1281E-12 20048.80c 5.2740E-11
      48106.80c 6.2846E-10 48108.80c 4.4747E-10 48110.80c 6.2796E-09
      48111.80c 6.4355E-09 48112.80c 1.2132E-08 48113.80c 6.1439E-09
      48114.80c 1.4445E-08 48116.80c 3.7658E-09 27059.80c 9.5899E-07
      24050.80c 6.6118E-08 24052.80c 1.2750E-06 24053.80c 1.4458E-07
      24054.80c 3.5989E-08 29063.80c 3.0759E-06 29065.80c 1.3710E-06
      19039.80c 2.6961E-08 19040.80c 3.3825E-12 19041.80c 1.9457E-09
      03006.80c 1.2360E-07 03007.80c 1.5049E-06 12024.80c 1.1021E-06
      12025.80c 1.3952E-07 12026.80c 1.5361E-07 25055.80c 1.1522E-05
      42092.80c 8.7420E-09 42094.80c 5.4490E-09 42095.80c 9.3782E-09
      42096.80c 9.8259E-09 42097.80c 5.6257E-09 42098.80c 1.4215E-08
      42100.80c 5.6729E-09 11023.80c 1.3275E-05 28058.80c 1.3111E-05
      28060.80c 5.0504E-06 28061.80c 2.1954E-07 28062.80c 6.9998E-07
      28064.80c 1.7826E-07 51121.80c 2.0183E-06 51123.80c 1.5096E-06
      22046.80c 1.9476E-08 22047.80c 1.7564E-08 22048.80c 1.7403E-07
      22049.80c 1.2772E-08 22050.80c 1.2229E-08 08016.80c 1.4124E-05
      08017.80c 5.3693E-09 07014.80c 2.4121E-05 07015.80c 8.9092E-08
c Total 4.8145E-02
c
c
c  --- Control Cards ------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc 12.0 0.0 0.1   12.0 0.0 -0.1  12.0 0.0 1.0
     12.0 0.0 -1.0  12.0 0.0 2.0   12.0 0.0 -2.0
     -12.0 0.0 0.1  -12.0 0.0 1.0  -12.0 0.0 -1.0
     -12.0 0.0 2.0  -12.0 0.0 -2.0
c

*********************************************************************************************

HEU Cylinders-------- 7" - 13" bare annuli (CONFIGURATION 1 – SIMPLE MODEL)
c
c ----------Cell Cards---------------------------
```

```
c
c
1    1   4.7807E-02  1  -9 11 -19  imp:n=1  $
c
c        VOID SPACES and Gaps
24    0  151 -152 -150  #1 imp:n=1   $ inner void
25    0  -151:152:150      imp:n=0   $ greater void

c  ------------Surface Cards (cm)----------------------------------
c
c     7" - 9" BARE ANNULUS
c    PLANES
1    pz  0.0    $ bottom
9    pz  14.576213  $ top; 3 inch below diaphragm + 2.73 inches above diaphragm (top height was averaged)
11   cz  8.89       $ 3.5 inch inner diameter
19   cz  16.51      $ 6.5 inch outer diameter
c
150  cz   16.52 $----------------Problem Boundary
151  pz   -0.1
152  pz    14.58 $---------------------------------

c  ------------Data Cards-----------------------------------------
c
c  --------- simple model ---------
m1    92234.80c   4.6508E-04
      92235.80c   4.4562E-02
      92236.80c   1.1456E-04
      92238.80c   2.6652E-03
c total     4.7807E-02
c
c  --- Control Cards ------------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc 12.0 0.0 0.1   12.0 0.0 10.0  12.0 0.0 1.0
     12.0 0.0 10.0  12.0 0.0 2.0   12.0 0.0 10.0
     -12.0 0.0 0.1  -12.0 0.0 1.0  -12.0 0.0 -10.0
     -12.0 0.0 2.0  -12.0 0.0 10.0

*********************************************************************************
HEU Cylinders------   7" - 15" bare annuli  (CONFIGURATION 2 – DETAILED MODEL)
c
c ----------Cell Cards---------------------------
c
c     7" - 9" annulus above diaphragm
1     1   4.8217E-02  -14  13  15  -22  imp:n=1 $ part 2775
2     2   4.8071E-02  -12  11  16  -23  imp:n=1 $ part 2736
3     3   4.8134E-02  -10   9  17  -24  imp:n=1 $ part 2737
4     4   4.8154E-02   -8   7  18  -25  imp:n=1 $ part 2738
c     7" - 9" annulus below diaphragm
5     5   4.8043E-02   -6   5  19  -26  imp:n=1 $ part 2773
6     6   4.8088E-02   -4   3  20  -27  imp:n=1 $ part 2829
7     7   4.8185E-02   -2   1  21  -28  imp:n=1 $ part 2740
c     9" - 11" annulus above diaphragm
8     8   4.8090E-02  -51  50  52  -58  imp:n=1 $ part 2779
9     9   4.8163E-02  -49  48  53  -59  imp:n=1 $ part 2745
10    10  4.8103E-02  -47  46  54  -60  imp:n=1 $ part 2776
```

```
c     9" - 11" annulus below diaphragm
11    11  4.8161E-02  -45  44  55  -61  imp:n=1 $ part 2742
12    12  4.8076E-02  -43  42  56  -62  imp:n=1 $ part 2746
13    13  4.8157E-02  -41  40  57  -63  imp:n=1 $ part 2748
c     11" - 13" annulus above diaphragm
14    14  4.8252E-02  -90  89  91  -98  imp:n=1 $ part 2782
15    15  4.8040E-02  -88  87  92  -99  imp:n=1 $ part 2753
16    16  4.8115E-02  -86  85  93 -100  imp:n=1 $ part 2752
17    17  4.8145E-02  -84  83  94 -101  imp:n=1 $ part 2757
c     11" - 13" annulus below diaphragm
18    18  4.8148E-02  -83  82  95 -102  imp:n=1 $ part 2751
19    19  4.8244E-02  -82  81  96 -103  imp:n=1 $ part 2754
20    20  4.8182E-02  -81  80  97 -104  imp:n=1 $ part 2756
c     13" - 15" annulus above diaphragm
21    21  4.8341E-02 -125 124 126 -134  imp:n=1 $ part 2758
22    22  4.8186E-02 -123 122 127 -135  imp:n=1 $ part 2766
23    23  4.8168E-02 -121 120 128 -136  imp:n=1 $ part 2760
24    24  4.8348E-02 -119 118 129 -137  imp:n=1 $ part 2739
c     13" - 15" annulus below diaphragm
25    25  4.8153E-02 -117 116 130 -138  imp:n=1 $ part 2761
26    26  4.8071E-02 -115 114 131 -139  imp:n=1 $ part 2785
27    27  4.8010E-02 -113 112 132 -140  imp:n=1 $ part 2848
28    28  4.8004E-02 -111 110 133 -141  imp:n=1 $ part 2735
c
c        VOID SPACES and Gaps
29    0  151  -152  -150 #1  #2 #3 #4 $ lesser void
        #5 #6  #7 #8 #9 #10 #11
        #12 #13 #14 #15 #16 #17
        #18 #19 #20 #21 #22 #23
        #24 #25 #26 #27 #28       imp:n=1
30    0  -151:152:150             imp:n=0      $ greater void

c ------------Surface Cards (cm)----------------------------------
c
c      7" - 9" BARE ANNULUS
c    PLANES
1    pz   -5.098669   $ part 2740 (Bottom Most Plane)
2    pz   -1.28867    $ gap
3    pz   -1.28606    $ part 2829
4    pz   -0.330385   $ gap
5    pz   -0.327775   $ part 2773
6    pz   -0.010275   $ gap
7    pz    0.0000     $ diaphragm
8    pz    2.543048   $ part 2738
9    pz    2.54484    $ gap
10   pz    3.97359    $ part 2737
11   pz    3.975382   $ gap
12   pz    4.931311   $ part 2736
13   pz    4.933103   $ gap
14   pz    5.564293   $ part 2775
c    INNER RADII
15   cz    8.89508    $ part 2775
16   cz    8.893302   $ part 2736
17   cz    8.891905   $ part 2737
18   cz    8.894763   $ part 2738
19   cz    8.891905   $ part 2773
```

```
20   cz    8.894001   $ part 2829
21   cz    8.893175   $ part 2740
c    OUTER RADII
22   cz    11.425873  $ part 2775
23   cz    11.42492   $ part 2736
24   cz    11.425555  $ part 2737
25   cz    11.424603  $ part 2738
26   cz    11.42619   $ part 2773
27   cz    11.42238   $ part 2829
28   cz    11.425238  $ part 2740
c
c    9" - 11" BARE ANNULUS
c    PLANES
40   pz   -5.098669   $ part 2748 (Bottom Most Plane)
41   pz   -1.288669   $ gap
42   pz   -1.288457   $ part 2746
43   pz   -0.961686   $ gap
44   pz   -0.961474   $ part 2742
45   pz   -0.00872    $ gap
46   pz    0.0000     $ diaphragm
47   pz    2.54381    $ part 2776
48   pz    2.545534   $ gap
49   pz    5.082994   $ part 2745
50   pz    5.084718   $ gap
51   pz    5.722258   $ part 2779
c    INNER RADII
52   cz    11.431905  $ part 2779
53   cz    11.43127   $ part 2745
54   cz    11.431905  $ part 2776
55   cz    11.431905  $ part 2742
56   cz    11.432223  $ part 2746
57   cz    11.433175  $ part 2748
c    OUTER RADII
58   cz    13.96619   $ part 2779
59   cz    13.965555  $ part 2745
60   cz    13.965555  $ part 2776
61   cz    13.965936  $ part 2742
62   cz    13.965555  $ part 2746
63   cz    13.966825  $ part 2748
c
c    11" - 13" BARE ANNULUS
c    PLANES
80   pz   -5.098669 $ part 2756 (Bottom Most PLANE)
81   pz   -2.558161 $ part 2754
82   pz   -1.279017 $ part 2751
83   pz    0.0000   $ diaphragm
84   pz    2.543937 $ part 2757
85   pz    2.545939 $ gap
86   pz    3.824194 $ part 2752
87   pz    3.826196 $ gap
88   pz    5.099498 $ part 2753
89   pz    5.1015   $ gap
90   pz    5.740945 $ part 2782
c    INNER RADII
91   cz    13.974445 $ part 2782
92   cz    13.97381  $ part 2753
```

```
93   cz    13.973175 $ part 2752
94   cz    13.973175 $ part 2757
95   cz    13.971905 $ part 2751
96   cz    13.97508  $ part 2754
97   cz    13.974572 $ part 2756
c    OUTER RADII
98   cz    16.504412 $ part 2782
99   cz    16.505873 $ part 2753
100  cz    16.504285 $ part 2752
101  cz    16.50492  $ part 2757
102  cz    16.504666 $ part 2751
103  cz    16.504031 $ part 2754
104  cz    16.505809 $ part 2756
c
c    13" - 15" BARE ANNULUS
c    PLANES
110  pz   -5.098669 $ part 2735
111  pz   -2.562479 $ gap
112  pz   -2.559322 $ part 2848
113  pz   -1.284492 $ gap
114  pz   -1.281335 $ part 2785
115  pz   -0.329595 $ gap
116  pz   -0.326438 $ part 2761
117  pz   -0.005128 $ gap
118  pz    0.0000   $ diaphragm
119  pz    2.52603  $ part 2739
120  pz    2.53492  $ gap
121  pz    3.80492  $ part 2760
122  pz    3.81381  $ gap
123  pz    5.24383  $ part 2766
124  pz    5.25272  $ gap
125  pz    5.56895  $ part 2758
c    INNER RADII
126  cz    16.51254  $ part 2758
127  cz    16.51127  $ part 2766
128  cz    16.51254  $ part 2760
129  cz    16.513429 $ part 2739
130  cz    16.51127  $ part 2761
131  cz    16.513683 $ part 2785
132  cz    16.513937 $ part 2848
133  cz    16.51254  $ part 2735
c    OUTER RADII
134  cz    19.04365  $ part 2758
135  cz    19.045555 $ part 2766
136  cz    19.04365  $ part 2760
137  cz    19.044285 $ part 2739
138  cz    19.043333 $ part 2761
139  cz    19.044666 $ part 2785
140  cz    19.045428 $ part 2848
141  cz    19.041745 $ part 2735
c
150  cz   19.05 $----------Problem Boundary
151  pz   -5.1
152  pz    5.76 $-------------------------

c ------------Data Cards-----------------------------------------
```

```
c ------ 7"-9" HEU Annulus ------
c --------- Part 2775 ---------
m1     92234.80c 4.7378E-04 92235.80c 4.4841E-02 92236.80c 1.1504E-04
       92238.80c 2.6760E-03 47107.80c 4.3522E-07 47109.80c 4.0434E-07
       56130.80c 4.3690E-13 56132.80c 4.1629E-13 56134.80c 9.9621E-12
       56135.80c 2.7170E-11 56136.80c 3.2372E-11 56137.80c 4.6295E-11
       56138.80c 2.9552E-10 83209.80c 8.8838E-06 06000.80c 4.7125E-06
       20040.80c 2.7382E-08 20042.80c 1.8275E-10 20043.80c 3.8132E-11
       20044.80c 5.8921E-10 20046.80c 1.1298E-12 20048.80c 5.2820E-11
       48106.80c 6.2941E-10 48108.80c 4.4814E-10 48110.80c 6.2891E-09
       48111.80c 6.4452E-09 48112.80c 1.2150E-08 48113.80c 6.1531E-09
       48114.80c 1.4466E-08 48116.80c 3.7714E-09 27059.80c 9.6044E-07
       24050.80c 6.6218E-08 24052.80c 1.2770E-06 24053.80c 1.4480E-07
       24054.80c 3.6043E-08 29063.80c 3.0806E-06 29065.80c 1.3730E-06
       19039.80c 2.7002E-08 19040.80c 3.3876E-12 19041.80c 1.9486E-09
       03006.80c 1.2379E-07 03007.80c 1.5071E-06 12024.80c 1.1037E-06
       12025.80c 1.3973E-07 12026.80c 1.5384E-07 25055.80c 1.1539E-05
       42092.80c 8.7552E-09 42094.80c 5.4572E-09 42095.80c 9.3923E-09
       42096.80c 9.8407E-09 42097.80c 5.6342E-09 42098.80c 1.4236E-08
       42100.80c 5.6814E-09 11023.80c 1.3295E-05 28058.80c 1.3131E-05
       28060.80c 5.0580E-06 28061.80c 2.1987E-07 28062.80c 7.0104E-07
       28064.80c 1.7853E-07 51121.80c 2.0214E-06 51123.80c 1.5119E-06
       22046.80c 1.9506E-08 22047.80c 1.7591E-08 22048.80c 1.7430E-07
       22049.80c 1.2791E-08 22050.80c 1.2247E-08 08016.80c 1.4146E-05
       08017.80c 5.3774E-09 07014.80c 2.4157E-05 07015.80c 8.9226E-08
c Total 4.8217E-02
c
c --------- Part 2736 ---------
m2     92234.80c 4.8680E-04 92235.80c 4.4715E-02 92236.80c 1.0036E-04
       92238.80c 2.6584E-03 47107.80c 4.3390E-07 47109.80c 4.0312E-07
       56130.80c 4.3557E-13 56132.80c 4.1502E-13 56134.80c 9.9318E-12
       56135.80c 2.7087E-11 56136.80c 3.2273E-11 56137.80c 4.6154E-11
       56138.80c 2.9462E-10 83209.80c 8.8568E-06 06000.80c 4.6982E-06
       20040.80c 2.7298E-08 20042.80c 1.8219E-10 20043.80c 3.8016E-11
       20044.80c 5.8742E-10 20046.80c 1.1264E-12 20048.80c 5.2659E-11
       48106.80c 6.2750E-10 48108.80c 4.4678E-10 48110.80c 6.2700E-09
       48111.80c 6.4255E-09 48112.80c 1.2113E-08 48113.80c 6.1344E-09
       48114.80c 1.4422E-08 48116.80c 3.7600E-09 27059.80c 9.5752E-07
       24050.80c 6.6017E-08 24052.80c 1.2731E-06 24053.80c 1.4436E-07
       24054.80c 3.5933E-08 29063.80c 3.0712E-06 29065.80c 1.3689E-06
       19039.80c 2.6919E-08 19040.80c 3.3773E-12 19041.80c 1.9427E-09
       03006.80c 1.2341E-07 03007.80c 1.5026E-06 12024.80c 1.1004E-06
       12025.80c 1.3930E-07 12026.80c 1.5337E-07 25055.80c 1.1504E-05
       42092.80c 8.7285E-09 42094.80c 5.4406E-09 42095.80c 9.3638E-09
       42096.80c 9.8108E-09 42097.80c 5.6171E-09 42098.80c 1.4193E-08
       42100.80c 5.6641E-09 11023.80c 1.3255E-05 28058.80c 1.3091E-05
       28060.80c 5.0426E-06 28061.80c 2.1920E-07 28062.80c 6.9890E-07
       28064.80c 1.7799E-07 51121.80c 2.0152E-06 51123.80c 1.5073E-06
       22046.80c 1.9446E-08 22047.80c 1.7537E-08 22048.80c 1.7377E-07
       22049.80c 1.2752E-08 22050.80c 1.2210E-08 08016.80c 1.4103E-05
       08017.80c 5.3610E-09 07014.80c 2.4084E-05 07015.80c 8.8955E-08
c Total 4.8071E-02
c
c
c --------- Part 2737 ---------
m3     92234.80c 4.7780E-04 92235.80c 4.4731E-02 92236.80c 1.3877E-04
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     92238.80c 2.6762E-03 47107.80c 4.3448E-07 47109.80c 4.0365E-07
     56130.80c 4.3615E-13 56132.80c 4.1558E-13 56134.80c 9.9450E-12
     56135.80c 2.7124E-11 56136.80c 3.2316E-11 56137.80c 4.6215E-11
     56138.80c 2.9501E-10 83209.80c 8.8686E-06 06000.80c 4.7044E-06
     20040.80c 2.7335E-08 20042.80c 1.8244E-10 20043.80c 3.8066E-11
     20044.80c 5.8820E-10 20046.80c 1.1279E-12 20048.80c 5.2729E-11
     48106.80c 6.2833E-10 48108.80c 4.4737E-10 48110.80c 6.2783E-09
     48111.80c 6.4341E-09 48112.80c 1.2129E-08 48113.80c 6.1426E-09
     48114.80c 1.4442E-08 48116.80c 3.7650E-09 27059.80c 9.5879E-07
     24050.80c 6.6105E-08 24052.80c 1.2748E-06 24053.80c 1.4455E-07
     24054.80c 3.5981E-08 29063.80c 3.0753E-06 29065.80c 1.3707E-06
     19039.80c 2.6955E-08 19040.80c 3.3818E-12 19041.80c 1.9453E-09
     03006.80c 1.2358E-07 03007.80c 1.5046E-06 12024.80c 1.1018E-06
     12025.80c 1.3949E-07 12026.80c 1.5358E-07 25055.80c 1.1519E-05
     42092.80c 8.7402E-09 42094.80c 5.4479E-09 42095.80c 9.3762E-09
     42096.80c 9.8238E-09 42097.80c 5.6246E-09 42098.80c 1.4212E-08
     42100.80c 5.6717E-09 11023.80c 1.3272E-05 28058.80c 1.3108E-05
     28060.80c 5.0493E-06 28061.80c 2.1949E-07 28062.80c 6.9983E-07
     28064.80c 1.7823E-07 51121.80c 2.0179E-06 51123.80c 1.5093E-06
     22046.80c 1.9472E-08 22047.80c 1.7560E-08 22048.80c 1.7400E-07
     22049.80c 1.2769E-08 22050.80c 1.2226E-08 08016.80c 1.4121E-05
     08017.80c 5.3682E-09 07014.80c 2.4116E-05 07015.80c 8.9073E-08
c Total 4.8134E-02
c
c --------- Part 2738 ---------
m4    92234.80c 4.7317E-04 92235.80c 4.4783E-02 92236.80c 1.1489E-04
     92238.80c 2.6725E-03 47107.80c 4.3466E-07 47109.80c 4.0382E-07
     56130.80c 4.3633E-13 56132.80c 4.1575E-13 56134.80c 9.9491E-12
     56135.80c 2.7135E-11 56136.80c 3.2330E-11 56137.80c 4.6234E-11
     56138.80c 2.9513E-10 83209.80c 8.8722E-06 06000.80c 4.7064E-06
     20040.80c 2.7346E-08 20042.80c 1.8251E-10 20043.80c 3.8082E-11
     20044.80c 5.8844E-10 20046.80c 1.1284E-12 20048.80c 5.2751E-11
     48106.80c 6.2859E-10 48108.80c 4.4756E-10 48110.80c 6.2809E-09
     48111.80c 6.4368E-09 48112.80c 1.2134E-08 48113.80c 6.1451E-09
     48114.80c 1.4448E-08 48116.80c 3.7665E-09 27059.80c 9.5919E-07
     24050.80c 6.6132E-08 24052.80c 1.2753E-06 24053.80c 1.4461E-07
     24054.80c 3.5996E-08 29063.80c 3.0766E-06 29065.80c 1.3713E-06
     19039.80c 2.6966E-08 19040.80c 3.3832E-12 19041.80c 1.9461E-09
     03006.80c 1.2363E-07 03007.80c 1.5052E-06 12024.80c 1.1023E-06
     12025.80c 1.3955E-07 12026.80c 1.5364E-07 25055.80c 1.1524E-05
     42092.80c 8.7438E-09 42094.80c 5.4501E-09 42095.80c 9.3801E-09
     42096.80c 9.8279E-09 42097.80c 5.6269E-09 42098.80c 1.4217E-08
     42100.80c 5.6740E-09 11023.80c 1.3278E-05 28058.80c 1.3114E-05
     28060.80c 5.0514E-06 28061.80c 2.1958E-07 28062.80c 7.0012E-07
     28064.80c 1.7830E-07 51121.80c 2.0187E-06 51123.80c 1.5099E-06
     22046.80c 1.9480E-08 22047.80c 1.7568E-08 22048.80c 1.7407E-07
     22049.80c 1.2774E-08 22050.80c 1.2231E-08 08016.80c 1.4127E-05
     08017.80c 5.3704E-09 07014.80c 2.4126E-05 07015.80c 8.9110E-08
c Total 4.8155E-02
c
c --------- Part 2773 ---------
m5    92234.80c 4.6726E-04 92235.80c 4.4689E-02 92236.80c 1.1463E-04
     92238.80c 2.6616E-03 47107.80c 4.3365E-07 47109.80c 4.0289E-07
     56130.80c 4.3532E-13 56132.80c 4.1479E-13 56134.80c 9.9262E-12
     56135.80c 2.7072E-11 56136.80c 3.2255E-11 56137.80c 4.6128E-11
     56138.80c 2.9445E-10 83209.80c 8.8518E-06 06000.80c 4.6955E-06
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     20040.80c 2.7283E-08 20042.80c 1.8209E-10 20043.80c 3.7994E-11
     20044.80c 5.8708E-10 20046.80c 1.1258E-12 20048.80c 5.2629E-11
     48106.80c 6.2714E-10 48108.80c 4.4653E-10 48110.80c 6.2664E-09
     48111.80c 6.4219E-09 48112.80c 1.2106E-08 48113.80c 6.1309E-09
     48114.80c 1.4414E-08 48116.80c 3.7578E-09 27059.80c 9.5698E-07
     24050.80c 6.5979E-08 24052.80c 1.2723E-06 24053.80c 1.4427E-07
     24054.80c 3.5913E-08 29063.80c 3.0694E-06 29065.80c 1.3681E-06
     19039.80c 2.6904E-08 19040.80c 3.3754E-12 19041.80c 1.9416E-09
     03006.80c 1.2334E-07 03007.80c 1.5017E-06 12024.80c 1.0997E-06
     12025.80c 1.3922E-07 12026.80c 1.5329E-07 25055.80c 1.1498E-05
     42092.80c 8.7236E-09 42094.80c 5.4375E-09 42095.80c 9.3585E-09
     42096.80c 9.8052E-09 42097.80c 5.6139E-09 42098.80c 1.4185E-08
     42100.80c 5.6609E-09 11023.80c 1.3247E-05 28058.80c 1.3084E-05
     28060.80c 5.0398E-06 28061.80c 2.1908E-07 28062.80c 6.9851E-07
     28064.80c 1.7789E-07 51121.80c 2.0141E-06 51123.80c 1.5064E-06
     22046.80c 1.9435E-08 22047.80c 1.7527E-08 22048.80c 1.7367E-07
     22049.80c 1.2745E-08 22050.80c 1.2203E-08 08016.80c 1.4095E-05
     08017.80c 5.3580E-09 07014.80c 2.4070E-05 07015.80c 8.8905E-08
c Total 4.8043E-02
c
c --------- Part 2829 ---------
m6    92234.80c 4.7734E-04 92235.80c 4.4698E-02 92236.80c 1.1474E-04
     92238.80c 2.6878E-03 47107.80c 4.3406E-07 47109.80c 4.0326E-07
     56130.80c 4.3573E-13 56132.80c 4.1518E-13 56134.80c 9.9354E-12
     56135.80c 2.7097E-11 56136.80c 3.2285E-11 56137.80c 4.6171E-11
     56138.80c 2.9473E-10 83209.80c 8.8600E-06 06000.80c 4.6999E-06
     20040.80c 2.7308E-08 20042.80c 1.8226E-10 20043.80c 3.8030E-11
     20044.80c 5.8763E-10 20046.80c 1.1268E-12 20048.80c 5.2678E-11
     48106.80c 6.2773E-10 48108.80c 4.4694E-10 48110.80c 6.2723E-09
     48111.80c 6.4279E-09 48112.80c 1.2118E-08 48113.80c 6.1367E-09
     48114.80c 1.4428E-08 48116.80c 3.7613E-09 27059.80c 9.5787E-07
     24050.80c 6.6041E-08 24052.80c 1.2735E-06 24053.80c 1.4441E-07
     24054.80c 3.5946E-08 29063.80c 3.0723E-06 29065.80c 1.3694E-06
     19039.80c 2.6929E-08 19040.80c 3.3785E-12 19041.80c 1.9434E-09
     03006.80c 1.2346E-07 03007.80c 1.5031E-06 12024.80c 1.1008E-06
     12025.80c 1.3935E-07 12026.80c 1.5343E-07 25055.80c 1.1508E-05
     42092.80c 8.7317E-09 42094.80c 5.4426E-09 42095.80c 9.3672E-09
     42096.80c 9.8144E-09 42097.80c 5.6191E-09 42098.80c 1.4198E-08
     42100.80c 5.6662E-09 11023.80c 1.3259E-05 28058.80c 1.3096E-05
     28060.80c 5.0445E-06 28061.80c 2.1928E-07 28062.80c 6.9916E-07
     28064.80c 1.7806E-07 51121.80c 2.0160E-06 51123.80c 1.5078E-06
     22046.80c 1.9453E-08 22047.80c 1.7543E-08 22048.80c 1.7383E-07
     22049.80c 1.2757E-08 22050.80c 1.2214E-08 08016.80c 1.4108E-05
     08017.80c 5.3630E-09 07014.80c 2.4092E-05 07015.80c 8.8988E-08
c c Total 4.8088E-02
c
c --------- Part 2740 ---------
m7    92234.80c 4.6863E-04 92235.80c 4.4821E-02 92236.80c 1.1497E-04
     92238.80c 2.6694E-03 47107.80c 4.3493E-07 47109.80c 4.0407E-07
     56130.80c 4.3660E-13 56132.80c 4.1601E-13 56134.80c 9.9554E-12
     56135.80c 2.7152E-11 56136.80c 3.2350E-11 56137.80c 4.6263E-11
     56138.80c 2.9532E-10 83209.80c 8.8778E-06 06000.80c 4.7093E-06
     20040.80c 2.7363E-08 20042.80c 1.8263E-10 20043.80c 3.8106E-11
     20044.80c 5.8881E-10 20046.80c 1.1291E-12 20048.80c 5.2784E-11
     48106.80c 6.2899E-10 48108.80c 4.4784E-10 48110.80c 6.2848E-09
     48111.80c 6.4408E-09 48112.80c 1.2142E-08 48113.80c 6.1490E-09
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     48114.80c 1.4457E-08 48116.80c 3.7689E-09 27059.80c 9.5979E-07
     24050.80c 6.6174E-08 24052.80c 1.2761E-06 24053.80c 1.4470E-07
     24054.80c 3.6019E-08 29063.80c 3.0785E-06 29065.80c 1.3721E-06
     19039.80c 2.6983E-08 19040.80c 3.3853E-12 19041.80c 1.9473E-09
     03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1030E-06
     12025.80c 1.3963E-07 12026.80c 1.5374E-07 25055.80c 1.1531E-05
     42092.80c 8.7493E-09 42094.80c 5.4535E-09 42095.80c 9.3860E-09
     42096.80c 9.8341E-09 42097.80c 5.6304E-09 42098.80c 1.4226E-08
     42100.80c 5.6776E-09 11023.80c 1.3286E-05 28058.80c 1.3122E-05
     28060.80c 5.0546E-06 28061.80c 2.1972E-07 28062.80c 7.0056E-07
     28064.80c 1.7841E-07 51121.80c 2.0200E-06 51123.80c 1.5109E-06
     22046.80c 1.9492E-08 22047.80c 1.7579E-08 22048.80c 1.7418E-07
     22049.80c 1.2782E-08 22050.80c 1.2239E-08 08016.80c 1.4136E-05
     08017.80c 5.3737E-09 07014.80c 2.4141E-05 07015.80c 8.9166E-08
c Total 4.8185E-02
c
c ------ 9"-11" HEU Annulus ------
c --------- Part 2779 ---------
m8    92234.80c 4.6289E-04 92235.80c 4.4728E-02 92236.80c 1.0996E-04
      92238.80c 2.6784E-03 47107.80c 4.3407E-07 47109.80c 4.0328E-07
      56130.80c 4.3574E-13 56132.80c 4.1519E-13 56134.80c 9.9358E-12
      56135.80c 2.7098E-11 56136.80c 3.2286E-11 56137.80c 4.6172E-11
      56138.80c 2.9474E-10 83209.80c 8.8603E-06 06000.80c 4.7000E-06
      20040.80c 2.7309E-08 20042.80c 1.8227E-10 20043.80c 3.8031E-11
      20044.80c 5.8765E-10 20046.80c 1.1268E-12 20048.80c 5.2680E-11
      48106.80c 6.2775E-10 48108.80c 4.4696E-10 48110.80c 6.2725E-09
      48111.80c 6.4281E-09 48112.80c 1.2118E-08 48113.80c 6.1369E-09
      48114.80c 1.4428E-08 48116.80c 3.7615E-09 27059.80c 9.5790E-07
      24050.80c 6.6043E-08 24052.80c 1.2736E-06 24053.80c 1.4441E-07
      24054.80c 3.5948E-08 29063.80c 3.0724E-06 29065.80c 1.3694E-06
      19039.80c 2.6930E-08 19040.80c 3.3786E-12 19041.80c 1.9435E-09
      03006.80c 1.2346E-07 03007.80c 1.5032E-06 12024.80c 1.1008E-06
      12025.80c 1.3936E-07 12026.80c 1.5343E-07 25055.80c 1.1509E-05
      42092.80c 8.7320E-09 42094.80c 5.4428E-09 42095.80c 9.3675E-09
      42096.80c 9.8147E-09 42097.80c 5.6193E-09 42098.80c 1.4198E-08
      42100.80c 5.6664E-09 11023.80c 1.3260E-05 28058.80c 1.3096E-05
      28060.80c 5.0446E-06 28061.80c 2.1929E-07 28062.80c 6.9918E-07
      28064.80c 1.7806E-07 51121.80c 2.0160E-06 51123.80c 1.5079E-06
      22046.80c 1.9454E-08 22047.80c 1.7544E-08 22048.80c 1.7384E-07
      22049.80c 1.2757E-08 22050.80c 1.2215E-08 08016.80c 1.4108E-05
      08017.80c 5.3632E-09 07014.80c 2.4093E-05 07015.80c 8.8991E-08
c Total 4.8090E-02
c
c
c --------- Part 2745 ---------
m9    92234.80c 4.6359E-04 92235.80c 4.4815E-02 92236.80c 1.0534E-04
      92238.80c 2.6682E-03 47107.80c 4.3473E-07 47109.80c 4.0389E-07
      56130.80c 4.3641E-13 56132.80c 4.1582E-13 56134.80c 9.9509E-12
      56135.80c 2.7140E-11 56136.80c 3.2335E-11 56137.80c 4.6243E-11
      56138.80c 2.9518E-10 83209.80c 8.8738E-06 06000.80c 4.7072E-06
      20040.80c 2.7351E-08 20042.80c 1.8254E-10 20043.80c 3.8089E-11
      20044.80c 5.8854E-10 20046.80c 1.1286E-12 20048.80c 5.2760E-11
      48106.80c 6.2870E-10 48108.80c 4.4764E-10 48110.80c 6.2820E-09
      48111.80c 6.4379E-09 48112.80c 1.2136E-08 48113.80c 6.1462E-09
      48114.80c 1.4450E-08 48116.80c 3.7672E-09 27059.80c 9.5936E-07
      24050.80c 6.6144E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
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      24054.80c 3.6002E-08 29063.80c 3.0771E-06 29065.80c 1.3715E-06
      19039.80c 2.6971E-08 19040.80c 3.3838E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5055E-06 12024.80c 1.1025E-06
      12025.80c 1.3957E-07 12026.80c 1.5367E-07 25055.80c 1.1526E-05
      42092.80c 8.7453E-09 42094.80c 5.4511E-09 42095.80c 9.3818E-09
      42096.80c 9.8296E-09 42097.80c 5.6279E-09 42098.80c 1.4220E-08
      42100.80c 5.6750E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
      28060.80c 5.0523E-06 28061.80c 2.1962E-07 28062.80c 7.0025E-07
      28064.80c 1.7833E-07 51121.80c 2.0191E-06 51123.80c 1.5102E-06
      22046.80c 1.9484E-08 22047.80c 1.7571E-08 22048.80c 1.7410E-07
      22049.80c 1.2777E-08 22050.80c 1.2233E-08 08016.80c 1.4130E-05
      08017.80c 5.3713E-09 07014.80c 2.4130E-05 07015.80c 8.9126E-08
c Total 4.8163E-02
c
c --------- Part 2776 ---------
m10    92234.80c 4.6302E-04 92235.80c 4.4740E-02 92236.80c 1.0999E-04
      92238.80c 2.6792E-03 47107.80c 4.3420E-07 47109.80c 4.0339E-07
      56130.80c 4.3587E-13 56132.80c 4.1531E-13 56134.80c 9.9386E-12
      56135.80c 2.7106E-11 56136.80c 3.2295E-11 56137.80c 4.6185E-11
      56138.80c 2.9482E-10 83209.80c 8.8628E-06 06000.80c 4.7014E-06
      20040.80c 2.7317E-08 20042.80c 1.8232E-10 20043.80c 3.8042E-11
      20044.80c 5.8782E-10 20046.80c 1.1272E-12 20048.80c 5.2695E-11
      48106.80c 6.2793E-10 48108.80c 4.4708E-10 48110.80c 6.2742E-09
      48111.80c 6.4300E-09 48112.80c 1.2121E-08 48113.80c 6.1386E-09
      48114.80c 1.4432E-08 48116.80c 3.7625E-09 27059.80c 9.5817E-07
      24050.80c 6.6062E-08 24052.80c 1.2739E-06 24053.80c 1.4445E-07
      24054.80c 3.5958E-08 29063.80c 3.0733E-06 29065.80c 1.3698E-06
      19039.80c 2.6938E-08 19040.80c 3.3796E-12 19041.80c 1.9440E-09
      03006.80c 1.2350E-07 03007.80c 1.5036E-06 12024.80c 1.1011E-06
      12025.80c 1.3940E-07 12026.80c 1.5348E-07 25055.80c 1.1512E-05
      42092.80c 8.7345E-09 42094.80c 5.4443E-09 42095.80c 9.3702E-09
      42096.80c 9.8175E-09 42097.80c 5.6209E-09 42098.80c 1.4202E-08
      42100.80c 5.6680E-09 11023.80c 1.3264E-05 28058.80c 1.3100E-05
      28060.80c 5.0461E-06 28061.80c 2.1935E-07 28062.80c 6.9938E-07
      28064.80c 1.7811E-07 51121.80c 2.0166E-06 51123.80c 1.5083E-06
      22046.80c 1.9460E-08 22047.80c 1.7549E-08 22048.80c 1.7389E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4112E-05
      08017.80c 5.3647E-09 07014.80c 2.4100E-05 07015.80c 8.9016E-08
c Total 4.8103E-02
c
c --------- Part 2742 ---------
m11    92234.80c 4.7324E-04 92235.80c 4.4785E-02 92236.80c 1.1012E-04
      92238.80c 2.6824E-03 47107.80c 4.3472E-07 47109.80c 4.0388E-07
      56130.80c 4.3639E-13 56132.80c 4.1581E-13 56134.80c 9.9506E-12
      56135.80c 2.7139E-11 56136.80c 3.2334E-11 56137.80c 4.6241E-11
      56138.80c 2.9517E-10 83209.80c 8.8735E-06 06000.80c 4.7070E-06
      20040.80c 2.7350E-08 20042.80c 1.8254E-10 20043.80c 3.8088E-11
      20044.80c 5.8853E-10 20046.80c 1.1285E-12 20048.80c 5.2759E-11
      48106.80c 6.2868E-10 48108.80c 4.4762E-10 48110.80c 6.2818E-09
      48111.80c 6.4377E-09 48112.80c 1.2136E-08 48113.80c 6.1460E-09
      48114.80c 1.4450E-08 48116.80c 3.7671E-09 27059.80c 9.5933E-07
      24050.80c 6.6142E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
      24054.80c 3.6001E-08 29063.80c 3.0770E-06 29065.80c 1.3715E-06
      19039.80c 2.6970E-08 19040.80c 3.3836E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5054E-06 12024.80c 1.1024E-06
      12025.80c 1.3957E-07 12026.80c 1.5366E-07 25055.80c 1.1526E-05
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42092.80c 8.7450E-09 42094.80c 5.4509E-09 42095.80c 9.3815E-09
42096.80c 9.8293E-09 42097.80c 5.6277E-09 42098.80c 1.4220E-08
42100.80c 5.6748E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
28060.80c 5.0522E-06 28061.80c 2.1961E-07 28062.80c 7.0023E-07
28064.80c 1.7833E-07 51121.80c 2.0190E-06 51123.80c 1.5101E-06
22046.80c 1.9483E-08 22047.80c 1.7570E-08 22048.80c 1.7410E-07
22049.80c 1.2776E-08 22050.80c 1.2233E-08 08016.80c 1.4129E-05
08017.80c 5.3711E-09 07014.80c 2.4129E-05 07015.80c 8.9123E-08
c Total 4.8161E-02
c
c --------- Part 2746 ---------
m12 92234.80c 4.8204E-04 92235.80c 4.4682E-02 92236.80c 1.0515E-04
92238.80c 2.6966E-03 47107.80c 4.3395E-07 47109.80c 4.0316E-07
56130.80c 4.3562E-13 56132.80c 4.1507E-13 56134.80c 9.9329E-12
56135.80c 2.7091E-11 56136.80c 3.2277E-11 56137.80c 4.6159E-11
56138.80c 2.9465E-10 83209.80c 8.8578E-06 06000.80c 4.6987E-06
20040.80c 2.7302E-08 20042.80c 1.8222E-10 20043.80c 3.8020E-11
20044.80c 5.8748E-10 20046.80c 1.1265E-12 20048.80c 5.2665E-11
48106.80c 6.2757E-10 48108.80c 4.4683E-10 48110.80c 6.2707E-09
48111.80c 6.4263E-09 48112.80c 1.2115E-08 48113.80c 6.1351E-09
48114.80c 1.4424E-08 48116.80c 3.7604E-09 27059.80c 9.5763E-07
24050.80c 6.6025E-08 24052.80c 1.2732E-06 24053.80c 1.4437E-07
24054.80c 3.5937E-08 29063.80c 3.0715E-06 29065.80c 1.3690E-06
19039.80c 2.6923E-08 19040.80c 3.3777E-12 19041.80c 1.9429E-09
03006.80c 1.2343E-07 03007.80c 1.5027E-06 12024.80c 1.1005E-06
12025.80c 1.3932E-07 12026.80c 1.5339E-07 25055.80c 1.1505E-05
42092.80c 8.7295E-09 42094.80c 5.4413E-09 42095.80c 9.3648E-09
42096.80c 9.8119E-09 42097.80c 5.6177E-09 42098.80c 1.4194E-08
42100.80c 5.6648E-09 11023.80c 1.3256E-05 28058.80c 1.3093E-05
28060.80c 5.0432E-06 28061.80c 2.1922E-07 28062.80c 6.9899E-07
28064.80c 1.7801E-07 51121.80c 2.0155E-06 51123.80c 1.5075E-06
22046.80c 1.9449E-08 22047.80c 1.7539E-08 22048.80c 1.7379E-07
22049.80c 1.2754E-08 22050.80c 1.2211E-08 08016.80c 1.4104E-05
08017.80c 5.3616E-09 07014.80c 2.4086E-05 07015.80c 8.8965E-08
c Total 4.8076E-02
c --------- Part 2748 ---------
m13 92234.80c 4.8285E-04 92235.80c 4.4757E-02 92236.80c 1.0533E-04
92238.80c 2.7012E-03 47107.80c 4.3468E-07 47109.80c 4.0384E-07
56130.80c 4.3636E-13 56132.80c 4.1577E-13 56134.80c 9.9497E-12
56135.80c 2.7136E-11 56136.80c 3.2332E-11 56137.80c 4.6237E-11
56138.80c 2.9515E-10 83209.80c 8.8728E-06 06000.80c 4.7067E-06
20040.80c 2.7348E-08 20042.80c 1.8252E-10 20043.80c 3.8085E-11
20044.80c 5.8848E-10 20046.80c 1.1284E-12 20048.80c 5.2754E-11
48106.80c 6.2863E-10 48108.80c 4.4759E-10 48110.80c 6.2813E-09
48111.80c 6.4372E-09 48112.80c 1.2135E-08 48113.80c 6.1455E-09
48114.80c 1.4448E-08 48116.80c 3.7668E-09 27059.80c 9.5925E-07
24050.80c 6.6136E-08 24052.80c 1.2754E-06 24053.80c 1.4462E-07
24054.80c 3.5998E-08 29063.80c 3.0767E-06 29065.80c 1.3713E-06
19039.80c 2.6968E-08 19040.80c 3.3834E-12 19041.80c 1.9462E-09
03006.80c 1.2363E-07 03007.80c 1.5053E-06 12024.80c 1.1023E-06
12025.80c 1.3956E-07 12026.80c 1.5365E-07 25055.80c 1.1525E-05
42092.80c 8.7443E-09 42094.80c 5.4505E-09 42095.80c 9.3807E-09
42096.80c 9.8285E-09 42097.80c 5.6272E-09 42098.80c 1.4218E-08
42100.80c 5.6744E-09 11023.80c 1.3279E-05 28058.80c 1.3115E-05
28060.80c 5.0517E-06 28061.80c 2.1960E-07 28062.80c 7.0017E-07
28064.80c 1.7831E-07 51121.80c 2.0189E-06 51123.80c 1.5100E-06

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      22046.80c 1.9481E-08 22047.80c 1.7569E-08 22048.80c 1.7408E-07
      22049.80c 1.2775E-08 22050.80c 1.2232E-08 08016.80c 1.4128E-05
      08017.80c 5.3707E-09 07014.80c 2.4127E-05 07015.80c 8.9116E-08
c Total 4.8157E-02
c
c ------ 11"-13" HEU Annulus ------
c ---------- Part 2782 ---------
m14    92234.80c 4.6445E-04 92235.80c 4.4898E-02 92236.80c 1.1033E-04
      92238.80c 2.6684E-03 47107.80c 4.3554E-07 47109.80c 4.0463E-07
            56130.80c 4.3721E-13 56132.80c 4.1659E-13 56134.80c 9.9692E-12
      56135.80c 2.7190E-11 56136.80c 3.2395E-11 56137.80c 4.6328E-11
      56138.80c 2.9573E-10 83209.80c 8.8902E-06 06000.80c 4.7160E-06
      20040.80c 2.7401E-08 20042.80c 1.8288E-10 20043.80c 3.8159E-11
            20044.80c 5.8963E-10 20046.80c 1.1306E-12 20048.80c 5.2857E-11
      48106.80c 6.2986E-10 48108.80c 4.4846E-10 48110.80c 6.2935E-09
      48111.80c 6.4497E-09 48112.80c 1.2159E-08 48113.80c 6.1575E-09
      48114.80c 1.4477E-08 48116.80c 3.7741E-09 27059.80c 9.6113E-07
      24050.80c 6.6266E-08 24052.80c 1.2779E-06 24053.80c 1.4490E-07
      24054.80c 3.6069E-08 29063.80c 3.0828E-06 29065.80c 1.3740E-06
      19039.80c 2.7021E-08 19040.80c 3.3900E-12 19041.80c 1.9500E-09
      03006.80c 1.2388E-07 03007.80c 1.5082E-06 12024.80c 1.1045E-06
      12025.80c 1.3983E-07 12026.80c 1.5395E-07 25055.80c 1.1547E-05
      42092.80c 8.7614E-09 42094.80c 5.4611E-09 42095.80c 9.3991E-09
            42096.80c 9.8478E-09 42097.80c 5.6383E-09 42098.80c 1.4246E-08
            42100.80c 5.7091E-09 11023.80c 1.3305E-05 28058.80c 1.3140E-05
      28060.80c 5.0613E-06 28061.80c 2.2001E-07 28062.80c 7.0150E-07
      28064.80c 1.7865E-07 51121.80c 2.0227E-06 51123.80c 1.5128E-06
      22046.80c 1.9525E-08 22047.80c 1.7608E-08 22048.80c 1.7447E-07
            22049.80c 1.2804E-08 22050.80c 1.2259E-08 08016.80c 1.4156E-05
            08017.80c 5.3812E-09 07014.80c 2.4174E-05 07015.80c 8.9290E-08
c Total 4.8252E-02
C
c --------- Part 2753 ---------
m15    92234.80c 4.5759E-04 92235.80c 4.4662E-02 92236.80c 1.1940E-04
      92238.80c 2.6898E-03 47107.80c 4.3362E-07 47109.80c 4.0286E-07
      56130.80c 4.3529E-13 56132.80c 4.1476E-13 56134.80c 9.9255E-12
      56135.80c 2.7070E-11 56136.80c 3.2253E-11 56137.80c 4.6124E-11
      56138.80c 2.9443E-10 83209.80c 8.8511E-06 06000.80c 4.6952E-06
      20040.80c 2.7281E-08 20042.80c 1.8208E-10 20043.80c 3.7992E-11
      20044.80c 5.8704E-10 20046.80c 1.1257E-12 20048.80c 5.2625E-11
      48106.80c 6.2710E-10 48108.80c 4.4649E-10 48110.80c 6.2660E-09
      48111.80c 6.4215E-09 48112.80c 1.2105E-08 48113.80c 6.1305E-09
      48114.80c 1.4413E-08 48116.80c 3.7576E-09 27059.80c 9.5691E-07
      24050.80c 6.5975E-08 24052.80c 1.2723E-06 24053.80c 1.4426E-07
      24054.80c 3.5910E-08 29063.80c 3.0692E-06 29065.80c 1.3680E-06
      19039.80c 2.6902E-08 19040.80c 3.3751E-12 19041.80c 1.9415E-09
      03006.80c 1.2333E-07 03007.80c 1.5016E-06 12024.80c 1.0997E-06
      12025.80c 1.3921E-07 12026.80c 1.5328E-07 25055.80c 1.1497E-05
      42092.80c 8.7230E-09 42094.80c 5.4372E-09 42095.80c 9.3578E-09
      42096.80c 9.8045E-09 42097.80c 5.6135E-09 42098.80c 1.4184E-08
      42100.80c 5.6605E-09 11023.80c 1.3246E-05 28058.80c 1.3083E-05
      28060.80c 5.0394E-06 28061.80c 2.1906E-07 28062.80c 6.9846E-07
      28064.80c 1.7788E-07 51121.80c 2.0139E-06 51123.80c 1.5063E-06
      22046.80c 1.9434E-08 22047.80c 1.7526E-08 22048.80c 1.7366E-07
      22049.80c 1.2744E-08 22050.80c 1.2202E-08 08016.80c 1.4094E-05
      08017.80c 5.3576E-09 07014.80c 2.4068E-05 07015.80c 8.8898E-08
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c Total 4.8040E-02
c
c --------- Part 2752 ---------
m16    92234.80c 4.7278E-04 92235.80c 4.4737E-02 92236.80c 1.1480E-04
       92238.80c 2.6798E-03 47107.80c 4.3431E-07 47109.80c 4.0349E-07
       56130.80c 4.3598E-13 56132.80c 4.1541E-13 56134.80c 9.9411E-12
       56135.80c 2.7113E-11 56136.80c 3.2303E-11 56137.80c 4.6197E-11
       56138.80c 2.9489E-10 83209.80c 8.8650E-06 06000.80c 4.7025E-06
       20040.80c 2.7324E-08 20042.80c 1.8236E-10 20043.80c 3.8051E-11
       20044.80c 5.8796E-10 20046.80c 1.1274E-12 20048.80c 5.2708E-11
       48106.80c 6.2808E-10 48108.80c 4.4719E-10 48110.80c 6.2758E-09
       48111.80c 6.4316E-09 48112.80c 1.2125E-08 48113.80c 6.1401E-09
       48114.80c 1.4436E-08 48116.80c 3.7635E-09 27059.80c 9.5841E-07
       24050.80c 6.6078E-08 24052.80c 1.2743E-06 24053.80c 1.4449E-07
       24054.80c 3.5967E-08 29063.80c 3.0741E-06 29065.80c 1.3701E-06
       19039.80c 2.6945E-08 19040.80c 3.3804E-12 19041.80c 1.9445E-09
       03006.80c 1.2353E-07 03007.80c 1.5040E-06 12024.80c 1.1014E-06
       12025.80c 1.3943E-07 12026.80c 1.5352E-07 25055.80c 1.1515E-05
       42092.80c 8.7367E-09 42094.80c 5.4457E-09 42095.80c 9.3725E-09
       42096.80c 9.8199E-09 42097.80c 5.6223E-09 42098.80c 1.4206E-08
       42100.80c 5.6694E-09 11023.80c 1.3267E-05 28058.80c 1.3103E-05
       28060.80c 5.0473E-06 28061.80c 2.1940E-07 28062.80c 6.9956E-07
       28064.80c 1.7816E-07 51121.80c 2.0171E-06 51123.80c 1.5087E-06
       22046.80c 1.9464E-08 22047.80c 1.7553E-08 22048.80c 1.7393E-07
       22049.80c 1.2764E-08 22050.80c 1.2221E-08 08016.80c 1.4116E-05
       08017.80c 5.3660E-09 07014.80c 2.4106E-05 07015.80c 8.9038E-08
c Total 4.8115E-02
c
c --------- Part 2757 ---------
m17    92234.80c 4.6342E-04 92235.80c 4.4798E-02 92236.80c 1.1008E-04
       92238.80c 2.6625E-03 47107.80c 4.3457E-07 47109.80c 4.0374E-07
       56130.80c 4.3624E-13 56132.80c 4.1566E-13 56134.80c 9.9471E-12
       56135.80c 2.7129E-11 56136.80c 3.2323E-11 56137.80c 4.6225E-11
       56138.80c 2.9507E-10 83209.80c 8.8704E-06 06000.80c 4.7054E-06
       20040.80c 2.7340E-08 20042.80c 1.8247E-10 20043.80c 3.8074E-11
       20044.80c 5.8832E-10 20046.80c 1.1281E-12 20048.80c 5.2740E-11
       48106.80c 6.2846E-10 48108.80c 4.4747E-10 48110.80c 6.2796E-09
       48111.80c 6.4355E-09 48112.80c 1.2132E-08 48113.80c 6.1439E-09
       48114.80c 1.4445E-08 48116.80c 3.7658E-09 27059.80c 9.5899E-07
       24050.80c 6.6118E-08 24052.80c 1.2750E-06 24053.80c 1.4458E-07
       24054.80c 3.5989E-08 29063.80c 3.0759E-06 29065.80c 1.3710E-06
       19039.80c 2.6961E-08 19040.80c 3.3825E-12 19041.80c 1.9457E-09
       03006.80c 1.2360E-07 03007.80c 1.5049E-06 12024.80c 1.1021E-06
       12025.80c 1.3952E-07 12026.80c 1.5361E-07 25055.80c 1.1522E-05
       42092.80c 8.7420E-09 42094.80c 5.4490E-09 42095.80c 9.3782E-09
       42096.80c 9.8259E-09 42097.80c 5.6257E-09 42098.80c 1.4215E-08
       42100.80c 5.6729E-09 11023.80c 1.3275E-05 28058.80c 1.3111E-05
       28060.80c 5.0504E-06 28061.80c 2.1954E-07 28062.80c 6.9998E-07
       28064.80c 1.7826E-07 51121.80c 2.0183E-06 51123.80c 1.5096E-06
       22046.80c 1.9476E-08 22047.80c 1.7564E-08 22048.80c 1.7403E-07
       22049.80c 1.2772E-08 22050.80c 1.2229E-08 08016.80c 1.4124E-05
       08017.80c 5.3693E-09 07014.80c 2.4121E-05 07015.80c 8.9092E-08
c Total 4.8145E-02
c
c --------- Part 2751 ---------
m18    92234.80c 4.7310E-04 92235.80c 4.4767E-02 92236.80c 1.1488E-04
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     92238.80c 2.6816E-03 47107.80c 4.3460E-07 47109.80c 4.0376E-07
     56130.80c 4.3627E-13 56132.80c 4.1569E-13 56134.80c 9.9477E-12
     56135.80c 2.7131E-11 56136.80c 3.2325E-11 56137.80c 4.6228E-11
     56138.80c 2.9509E-10 83209.80c 8.8710E-06 06000.80c 4.7057E-06
     20040.80c 2.7342E-08 20042.80c 1.8249E-10 20043.80c 3.8077E-11
     20044.80c 5.8836E-10 20046.80c 1.1282E-12 20048.80c 5.2744E-11
     48106.80c 6.2850E-10 48108.80c 4.4750E-10 48110.80c 6.2800E-09
     48111.80c 6.4359E-09 48112.80c 1.2133E-08 48113.80c 6.1443E-09
     48114.80c 1.4446E-08 48116.80c 3.7660E-09 27059.80c 9.5906E-07
     24050.80c 6.6123E-08 24052.80c 1.2751E-06 24053.80c 1.4459E-07
     24054.80c 3.5991E-08 29063.80c 3.0761E-06 29065.80c 1.3711E-06
     19039.80c 2.6963E-08 19040.80c 3.3827E-12 19041.80c 1.9458E-09
     03006.80c 1.2361E-07 03007.80c 1.5050E-06 12024.80c 1.1021E-06
     12025.80c 1.3953E-07 12026.80c 1.5362E-07 25055.80c 1.1523E-05
     42092.80c 8.7425E-09 42094.80c 5.4494E-09 42095.80c 9.3788E-09
     42096.80c 9.8265E-09 42097.80c 5.6261E-09 42098.80c 1.4215E-08
     42100.80c 5.6732E-09 11023.80c 1.3276E-05 28058.80c 1.3112E-05
     28060.80c 5.0507E-06 28061.80c 2.1955E-07 28062.80c 7.0003E-07
     28064.80c 1.7828E-07 51121.80c 2.0185E-06 51123.80c 1.5097E-06
     22046.80c 1.9478E-08 22047.80c 1.7565E-08 22048.80c 1.7405E-07
     22049.80c 1.2773E-08 22050.80c 1.2230E-08 08016.80c 1.4125E-05
     08017.80c 5.3696E-09 07014.80c 2.4122E-05 07015.80c 8.9098E-08
c Total 4.8148E-02
c
c --------- Part 2754 ---------
m19    92234.80c 4.6438E-04 92235.80c 4.4843E-02 92236.80c 1.3429E-04
     92238.80c 2.6918E-03 47107.80c 4.3547E-07 47109.80c 4.0457E-07
     56130.80c 4.3715E-13 56132.80c 4.1653E-13 56134.80c 9.9678E-12
     56135.80c 2.7186E-11 56136.80c 3.2390E-11 56137.80c 4.6321E-11
     56138.80c 2.9568E-10 83209.80c 8.8888E-06 06000.80c 4.7152E-06
     20040.80c 2.7397E-08 20042.80c 1.8285E-10 20043.80c 3.8153E-11
     20044.80c 5.8954E-10 20046.80c 1.1305E-12 20048.80c 5.2850E-11
     48106.80c 6.2977E-10 48108.80c 4.4840E-10 48110.80c 6.2927E-09
     48111.80c 6.4488E-09 48112.80c 1.2157E-08 48113.80c 6.1566E-09
     48114.80c 1.4475E-08 48116.80c 3.7736E-09 27059.80c 9.6098E-07
     24050.80c 6.6256E-08 24052.80c 1.2777E-06 24053.80c 1.4488E-07
     24054.80c 3.6063E-08 29063.80c 3.0823E-06 29065.80c 1.3738E-06
     19039.80c 2.7017E-08 19040.80c 3.3895E-12 19041.80c 1.9497E-09
     03006.80c 1.2386E-07 03007.80c 1.5080E-06 12024.80c 1.1043E-06
     12025.80c 1.3981E-07 12026.80c 1.5393E-07 25055.80c 1.1546E-05
     42092.80c 8.7601E-09 42094.80c 5.4603E-09 42095.80c 9.3977E-09
     42096.80c 9.8463E-09 42097.80c 5.6374E-09 42098.80c 1.4244E-08
     42100.80c 5.6846E-09 11023.80c 1.3303E-05 28058.80c 1.3138E-05
     28060.80c 5.0609E-06 28061.80c 2.1999E-07 28062.80c 7.0143E-07
     28064.80c 1.7863E-07 51121.80c 2.0225E-06 51123.80c 1.5127E-06
     22046.80c 1.9517E-08 22047.80c 1.7601E-08 22048.80c 1.7440E-07
     22049.80c 1.2798E-08 22050.80c 1.2254E-08 08016.80c 1.4154E-05
     08017.80c 5.3804E-09 07014.80c 2.4171E-05 07015.80c 8.9277E-08
c Total 4.8244E-02
c
c --------- Part 2756 ---------
m20    92234.80c 4.4929E-04 92235.80c 4.4823E-02 92236.80c 1.1975E-04
     92238.80c 2.6788E-03 47107.80c 4.3491E-07 47109.80c 4.0405E-07
     56130.80c 4.3658E-13 56132.80c 4.1599E-13 56134.80c 9.9549E-12
     56135.80c 2.7150E-11 56136.80c 3.2348E-11 56137.80c 4.6261E-11
     56138.80c 2.9530E-10 83209.80c 8.8774E-06 06000.80c 4.7091E-06
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      20040.80c 2.7362E-08 20042.80c 1.8262E-10 20043.80c 3.8104E-11
      20044.80c 5.8878E-10 20046.80c 1.1290E-12 20048.80c 5.2781E-11
      48106.80c 6.2896E-10 48108.80c 4.4782E-10 48110.80c 6.2845E-09
      48111.80c 6.4405E-09 48112.80c 1.2141E-08 48113.80c 6.1487E-09
      48114.80c 1.4456E-08 48116.80c 3.7687E-09 27059.80c 9.5974E-07
      24050.80c 6.6170E-08 24052.80c 1.2760E-06 24053.80c 1.4469E-07
      24054.80c 3.6017E-08 29063.80c 3.0783E-06 29065.80c 1.3721E-06
      19039.80c 2.6982E-08 19040.80c 3.3851E-12 19041.80c 1.9472E-09
      03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1029E-06
      12025.80c 1.3963E-07 12026.80c 1.5373E-07 25055.80c 1.1531E-05
      42092.80c 8.7488E-09 42094.80c 5.4533E-09 42095.80c 9.3855E-09
      42096.80c 9.8336E-09 42097.80c 5.6301E-09 42098.80c 1.4226E-08
      42100.80c 5.6773E-09 11023.80c 1.3285E-05 28058.80c 1.3121E-05
      28060.80c 5.0543E-06 28061.80c 2.1971E-07 28062.80c 7.0053E-07
      28064.80c 1.7840E-07 51121.80c 2.0199E-06 51123.80c 1.5108E-06
      22046.80c 1.9491E-08 22047.80c 1.7578E-08 22048.80c 1.7417E-07
      22049.80c 1.2782E-08 22050.80c 1.2238E-08 08016.80c 1.4135E-05
      08017.80c 5.3735E-09 07014.80c 2.4140E-05 07015.80c 8.9162E-08
c Total 4.8182E-02
c
c ------ 13"-15" HEU Annulus ------
c
c --------- Part 2758 ---------
m21    92234.80c 4.7336E-04 92235.80c 4.4806E-02 92236.80c 1.2931E-04
      92238.80c 2.6546E-03 47107.80c 4.3484E-07 47109.80c 4.0399E-07
            56130.80c 4.3651E-13 56132.80c 4.1592E-13 56134.80c 9.9532E-12
            56135.80c 2.7146E-11 56136.80c 3.2343E-11 56137.80c 4.6253E-11
            56138.80c 2.9525E-10 83209.80c 8.8759E-06 06000.80c 4.7084E-06
            20040.80c 2.7357E-08 20042.80c 1.8259E-10 20043.80c 3.8098E-11
            20044.80c 5.8868E-10 20046.80c 1.1288E-12 20048.80c 5.2773E-11
            48106.80c 6.2885E-10 48108.80c 4.4774E-10 48110.80c 6.2834E-09
            48111.80c 6.4394E-09 48112.80c 1.2139E-08 48113.80c 6.1476E-09
            48114.80c 1.4453E-08 48116.80c 3.7680E-09 27059.80c 9.5958E-07
            24050.80c 6.6159E-08 24052.80c 1.2758E-06 24053.80c 1.4467E-07
            24054.80c 3.6011E-08 29063.80c 3.0778E-06 29065.80c 1.3718E-06
            19039.80c 2.6978E-08 19040.80c 3.3846E-12 19041.80c 1.9469E-09
            03006.80c 1.2368E-07 03007.80c 1.5058E-06 12024.80c 1.1027E-06
            12025.80c 1.3960E-07 12026.80c 1.5370E-07 25055.80c 1.1529E-05
            42092.80c 8.7474E-09 42094.80c 5.4524E-09 42095.80c 9.3840E-09
            42096.80c 9.8319E-09 42097.80c 5.6292E-09 42098.80c 1.4223E-08
            42100.80c 5.6999E-09 11023.80c 1.3283E-05 28058.80c 1.3118E-05
            28060.80c 5.0532E-06 28061.80c 2.1966E-07 28062.80c 7.0037E-07
            28064.80c 1.7836E-07 51121.80c 2.0194E-06 51123.80c 1.5104E-06
            22046.80c 1.9494E-08 22047.80c 1.7580E-08 22048.80c 1.7419E-07
            22049.80c 1.2783E-08 22050.80c 1.2240E-08 08016.80c 1.4133E-05
            08017.80c 5.3726E-09 07014.80c 2.4136E-05 07015.80c 8.9147E-08
c   TOTAL 4.8174E-02
c
c --------- Part 2766 ---------
m22    92234.80c 4.7348E-04 92235.80c 4.4817E-02 92236.80c 1.2934E-04
      92238.80c 2.6553E-03 47107.80c 4.3494E-07 47109.80c 4.0408E-07
      56130.80c 4.3661E-13 56132.80c 4.1602E-13 56134.80c 9.9556E-12
      56135.80c 2.7152E-11 56136.80c 3.2351E-11 56137.80c 4.6265E-11
      56138.80c 2.9532E-10 83209.80c 8.8780E-06 06000.80c 4.7094E-06
      20040.80c 2.7364E-08 20042.80c 1.8263E-10 20043.80c 3.8107E-11
      20044.80c 5.8882E-10 20046.80c 1.1291E-12 20048.80c 5.2785E-11
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      48106.80c 6.2900E-10 48108.80c 4.4785E-10 48110.80c 6.2850E-09
      48111.80c 6.4410E-09 48112.80c 1.2142E-08 48113.80c 6.1491E-09
      48114.80c 1.4457E-08 48116.80c 3.7690E-09 27059.80c 9.5981E-07
      24050.80c 6.6175E-08 24052.80c 1.2761E-06 24053.80c 1.4470E-07
      24054.80c 3.6019E-08 29063.80c 3.0786E-06 29065.80c 1.3722E-06
      19039.80c 2.6984E-08 19040.80c 3.3854E-12 19041.80c 1.9474E-09
      03006.80c 1.2371E-07 03007.80c 1.5062E-06 12024.80c 1.1030E-06
      12025.80c 1.3964E-07 12026.80c 1.5374E-07 25055.80c 1.1532E-05
      42092.80c 8.7495E-09 42094.80c 5.4537E-09 42095.80c 9.3862E-09
      42096.80c 9.8343E-09 42097.80c 5.6305E-09 42098.80c 1.4227E-08
      42100.80c 5.6777E-09 11023.80c 1.3286E-05 28058.80c 1.3122E-05
      28060.80c 5.0547E-06 28061.80c 2.1972E-07 28062.80c 7.0058E-07
      28064.80c 1.7842E-07 51121.80c 2.0201E-06 51123.80c 1.5109E-06
      22046.80c 1.9493E-08 22047.80c 1.7579E-08 22048.80c 1.7418E-07
      22049.80c 1.2783E-08 22050.80c 1.2239E-08 08016.80c 1.4136E-05
      08017.80c 5.3739E-09 07014.80c 2.4141E-05 07015.80c 8.9168E-08
c Total 4.8186E-02
c
c --------- Part 2760 ---------
m23    92234.80c 4.7814E-04 92235.80c 4.4787E-02 92236.80c 1.1493E-04
      92238.80c 2.6780E-03 47107.80c 4.3478E-07 47109.80c 4.0394E-07
            56130.80c 4.3646E-13 56132.80c 4.1587E-13 56134.80c 9.9520E-12
            56135.80c 2.7143E-11 56136.80c 3.2339E-11 56137.80c 4.6248E-11
            56138.80c 2.9522E-10 83209.80c 8.8748E-06 06000.80c 4.7079E-06
            20040.80c 2.7354E-08 20042.80c 1.8257E-10 20043.80c 3.8093E-11
            20044.80c 5.8861E-10 20046.80c 1.1287E-12 20048.80c 5.2766E-11
            48106.80c 6.2877E-10 48108.80c 4.4768E-10 48110.80c 6.2827E-09
            48111.80c 6.4386E-09 48112.80c 1.2138E-08 48113.80c 6.1469E-09
            48114.80c 1.4452E-08 48116.80c 3.7676E-09 27059.80c 9.5947E-07
            24050.80c 6.6151E-08 24052.80c 1.2757E-06 24053.80c 1.4465E-07
            24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3717E-06
            19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9467E-09
            03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
            12025.80c 1.3959E-07 12026.80c 1.5369E-07 25055.80c 1.1528E-05
            42092.80c 8.7463E-09 42094.80c 5.4517E-09 42095.80c 9.3828E-09
            42096.80c 9.8308E-09 42097.80c 5.6285E-09 42098.80c 1.4222E-08
            42100.80c 5.6993E-09 11023.80c 1.3282E-05 28058.80c 1.3117E-05
            28060.80c 5.0526E-06 28061.80c 2.1963E-07 28062.80c 7.0029E-07
            28064.80c 1.7834E-07 51121.80c 2.0192E-06 51123.80c 1.5102E-06
            22046.80c 1.9491E-08 22047.80c 1.7578E-08 22048.80c 1.7417E-07
            22049.80c 1.2782E-08 22050.80c 1.2238E-08 08016.80c 1.4131E-05
            08017.80c 5.3719E-09 07014.80c 2.4133E-05 07015.80c 8.9136E-08
c Total 4.8168E-02
c
c ------------ part 2739 -------------------
m24    92234.80c 4.6537E-04 92235.80c 4.4968E-02 92236.80c 1.2016E-04
      92238.80c 2.6832E-03 47107.80c 4.3640E-07 47109.80c 4.0544E-07
      56130.80c 4.3808E-13 56132.80c 4.1742E-13 56134.80c 9.9891E-12
      56135.80c 2.7244E-11 56136.80c 3.2459E-11 56137.80c 4.6420E-11
      56138.80c 2.9632E-10 83209.80c 8.9079E-06 06000.80c 4.7253E-06
      20040.80c 2.7456E-08 20042.80c 1.8325E-10 20043.80c 3.8235E-11
      20044.80c 5.9080E-10 20046.80c 1.1329E-12 20048.80c 5.2963E-11
      48106.80c 6.3112E-10 48108.80c 4.4936E-10 48110.80c 6.3061E-09
      48111.80c 6.4627E-09 48112.80c 1.2183E-08 48113.80c 6.1698E-09
      48114.80c 1.4506E-08 48116.80c 3.7817E-09 27059.80c 9.6304E-07
      24050.80c 6.6398E-08 24052.80c 1.2804E-06 24053.80c 1.4519E-07
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      24054.80c 3.6141E-08 29063.80c 3.0889E-06 29065.80c 1.3768E-06
      19039.80c 2.7075E-08 19040.80c 3.3968E-12 19041.80c 1.9539E-09
      03006.80c 1.2412E-07 03007.80c 1.5112E-06 12024.80c 1.1067E-06
      12025.80c 1.4011E-07 12026.80c 1.5426E-07 25055.80c 1.1570E-05
      42092.80c 8.7789E-09 42094.80c 5.4720E-09 42095.80c 9.4178E-09
      42096.80c 9.8674E-09 42097.80c 5.6495E-09 42098.80c 1.4275E-08
      42100.80c 5.6968E-09 11023.80c 1.3331E-05 28058.80c 1.3167E-05
      28060.80c 5.0717E-06 28061.80c 2.2046E-07 28062.80c 7.0294E-07
      28064.80c 1.7902E-07 51121.80c 2.0269E-06 51123.80c 1.5160E-06
      22046.80c 1.9558E-08 22047.80c 1.7638E-08 22048.80c 1.7477E-07
      22049.80c 1.2826E-08 22050.80c 1.2280E-08 08016.80c 1.4184E-05
      08017.80c 5.3919E-09 07014.80c 2.4223E-05 07015.80c 8.9468E-08
c  Total 4.8348E-02
c
c ------------ part 2761 -----------
m25    92234.80c 4.6350E-04 92235.80c 4.4768E-02 92236.80c 1.2925E-04
      92238.80c 2.6819E-03 47107.80c 4.3465E-07 47109.80c 4.0381E-07
      56130.80c 4.3632E-13 56132.80c 4.1574E-13 56134.80c 9.9489E-12
      56135.80c 2.7134E-11 56136.80c 3.2329E-11 56137.80c 4.6233E-11
      56138.80c 2.9512E-10 83209.80c 8.8720E-06 06000.80c 4.7062E-06
      20040.80c 2.7345E-08 20042.80c 1.8251E-10 20043.80c 3.8081E-11
      20044.80c 5.8842E-10 20046.80c 1.1283E-12 20048.80c 5.2749E-11
      48106.80c 6.2858E-10 48108.80c 4.4755E-10 48110.80c 6.2807E-09
      48111.80c 6.4366E-09 48112.80c 1.2134E-08 48113.80c 6.1450E-09
      48114.80c 1.4447E-08 48116.80c 3.7664E-09 27059.80c 9.5916E-07
      24050.80c 6.6130E-08 24052.80c 1.2753E-06 24053.80c 1.4460E-07
      24054.80c 3.5995E-08 29063.80c 3.0765E-06 29065.80c 1.3712E-06
      19039.80c 2.6966E-08 19040.80c 3.3831E-12 19041.80c 1.9460E-09
      03006.80c 1.2362E-07 03007.80c 1.5051E-06 12024.80c 1.1023E-06
      12025.80c 1.3954E-07 12026.80c 1.5364E-07 25055.80c 1.1524E-05
      42092.80c 8.7435E-09 42094.80c 5.4500E-09 42095.80c 9.3799E-09
      42096.80c 9.8276E-09 42097.80c 5.6267E-09 42098.80c 1.4217E-08
      42100.80c 5.6739E-09 11023.80c 1.3277E-05 28058.80c 1.3113E-05
      28060.80c 5.0513E-06 28061.80c 2.1958E-07 28062.80c 7.0011E-07
      28064.80c 1.7830E-07 51121.80c 2.0187E-06 51123.80c 1.5099E-06
      22046.80c 1.9480E-08 22047.80c 1.7567E-08 22048.80c 1.7407E-07
      22049.80c 1.2774E-08 22050.80c 1.2231E-08 08016.80c 1.4127E-05
      08017.80c 5.3702E-09 07014.80c 2.4125E-05 07015.80c 8.9108E-08
c  Total 4.8153E-02
c
c --------- Part 2785 ---------
m26     92234.80c 4.7235E-04 92235.80c 4.4701E-02 92236.80c 1.1469E-04
       92238.80c 2.6726E-03 47107.80c 4.3390E-07 47109.80c 4.0312E-07
       56130.80c 4.3557E-13 56132.80c 4.1503E-13 56134.80c 9.9318E-12
       56135.80c 2.7088E-11 56136.80c 3.2273E-11 56137.80c 4.6154E-11
       56138.80c 2.9462E-10 83209.80c 8.8568E-06 06000.80c 4.6982E-06
       20040.80c 2.7299E-08 20042.80c 1.8220E-10 20043.80c 3.8016E-11
       20044.80c 5.8742E-10 20046.80c 1.1264E-12 20048.80c 5.2659E-11
       48106.80c 6.2750E-10 48108.80c 4.4678E-10 48110.80c 6.2700E-09
       48111.80c 6.4256E-09 48112.80c 1.2113E-08 48113.80c 6.1344E-09
       48114.80c 1.4422E-08 48116.80c 3.7600E-09 27059.80c 9.5752E-07
       24050.80c 6.6017E-08 24052.80c 1.2731E-06 24053.80c 1.4436E-07
       24054.80c 3.5933E-08 29063.80c 3.0712E-06 29065.80c 1.3689E-06
       19039.80c 2.6920E-08 19040.80c 3.3773E-12 19041.80c 1.9427E-09
       03006.80c 1.2341E-07 03007.80c 1.5026E-06 12024.80c 1.1004E-06
       12025.80c 1.3930E-07 12026.80c 1.5337E-07 25055.80c 1.1504E-05
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42092.80c 8.7286E-09 42094.80c 5.4407E-09 42095.80c 9.3638E-09
42096.80c 9.8108E-09 42097.80c 5.6171E-09 42098.80c 1.4193E-08
42100.80c 5.6642E-09 11023.80c 1.3255E-05 28058.80c 1.3091E-05
28060.80c 5.0426E-06 28061.80c 2.1920E-07 28062.80c 6.9891E-07
28064.80c 1.7799E-07 51121.80c 2.0152E-06 51123.80c 1.5073E-06
22046.80c 1.9446E-08 22047.80c 1.7537E-08 22048.80c 1.7377E-07
22049.80c 1.2752E-08 22050.80c 1.2210E-08 08016.80c 1.4103E-05
08017.80c 5.3610E-09 07014.80c 2.4084E-05 07015.80c 8.8955E-08
c Total 4.8071E-02
c
c --------- Part 2848 ---------
m27 92234.80c 4.7656E-04 92235.80c 4.4663E-02 92236.80c 1.1455E-04
92238.80c 2.6456E-03 47107.80c 4.3336E-07 47109.80c 4.0261E-07
56130.80c 4.3502E-13 56132.80c 4.1450E-13 56134.80c 9.9193E-12
56135.80c 2.7053E-11 56136.80c 3.2233E-11 56137.80c 4.6096E-11
56138.80c 2.9425E-10 83209.80c 8.8457E-06 06000.80c 4.6923E-06
20040.80c 2.7264E-08 20042.80c 1.8197E-10 20043.80c 3.7968E-11
20044.80c 5.8668E-10 20046.80c 1.1250E-12 20048.80c 5.2593E-11
48106.80c 6.2671E-10 48108.80c 4.4622E-10 48110.80c 6.2621E-09
48111.80c 6.4175E-09 48112.80c 1.2098E-08 48113.80c 6.1267E-09
48114.80c 1.4404E-08 48116.80c 3.7552E-09 27059.80c 9.5632E-07
24050.80c 6.5934E-08 24052.80c 1.2715E-06 24053.80c 1.4417E-07
24054.80c 3.5888E-08 29063.80c 3.0673E-06 29065.80c 1.3672E-06
19039.80c 2.6886E-08 19040.80c 3.3730E-12 19041.80c 1.9403E-09
03006.80c 1.2326E-07 03007.80c 1.5007E-06 12024.80c 1.0990E-06
12025.80c 1.3913E-07 12026.80c 1.5318E-07 25055.80c 1.1490E-05
42092.80c 8.7176E-09 42094.80c 5.4338E-09 42095.80c 9.3520E-09
42096.80c 9.7985E-09 42097.80c 5.6100E-09 42098.80c 1.4175E-08
42100.80c 5.6570E-09 11023.80c 1.3238E-05 28058.80c 1.3075E-05
28060.80c 5.0363E-06 28061.80c 2.1892E-07 28062.80c 6.9803E-07
28064.80c 1.7777E-07 51121.80c 2.0127E-06 51123.80c 1.5054E-06
22046.80c 1.9422E-08 22047.80c 1.7515E-08 22048.80c 1.7355E-07
22049.80c 1.2736E-08 22050.80c 1.2195E-08 08016.80c 1.4085E-05
08017.80c 5.3543E-09 07014.80c 2.4053E-05 07015.80c 8.8843E-08
c Total 4.8011E-02
c
c --------- Part 2735 ---------
m28 92234.80c 4.7169E-04 92235.80c 4.4629E-02 92236.80c 1.1931E-04
92238.80c 2.6736E-03 47107.80c 4.3330E-07 47109.80c 4.0256E-07
56130.80c 4.3497E-13 56132.80c 4.1445E-13 56134.80c 9.9181E-12
56135.80c 2.7050E-11 56136.80c 3.2229E-11 56137.80c 4.6090E-11
56138.80c 2.9421E-10 83209.80c 8.8445E-06 06000.80c 4.6917E-06
20040.80c 2.7261E-08 20042.80c 1.8194E-10 20043.80c 3.7963E-11
20044.80c 5.8660E-10 20046.80c 1.1248E-12 20048.80c 5.2586E-11
48106.80c 6.2663E-10 48108.80c 4.4616E-10 48110.80c 6.2613E-09
48111.80c 6.4167E-09 48112.80c 1.2096E-08 48113.80c 6.1259E-09
48114.80c 1.4402E-08 48116.80c 3.7548E-09 27059.80c 9.5620E-07
24050.80c 6.5926E-08 24052.80c 1.2713E-06 24053.80c 1.4416E-07
24054.80c 3.5884E-08 29063.80c 3.0669E-06 29065.80c 1.3670E-06
19039.80c 2.6882E-08 19040.80c 3.3726E-12 19041.80c 1.9400E-09
03006.80c 1.2324E-07 03007.80c 1.5005E-06 12024.80c 1.0988E-06
12025.80c 1.3911E-07 12026.80c 1.5316E-07 25055.80c 1.1488E-05
42092.80c 8.7165E-09 42094.80c 5.4331E-09 42095.80c 9.3508E-09
42096.80c 9.7972E-09 42097.80c 5.6093E-09 42098.80c 1.4173E-08
42100.80c 5.6563E-09 11023.80c 1.3236E-05 28058.80c 1.3073E-05
28060.80c 5.0357E-06 28061.80c 2.1890E-07 28062.80c 6.9794E-07

```
      28064.80c 1.7774E-07 51121.80c 2.0124E-06 51123.80c 1.5052E-06
      22046.80c 1.9419E-08 22047.80c 1.7513E-08 22048.80c 1.7353E-07
      22049.80c 1.2734E-08 22050.80c 1.2193E-08 08016.80c 1.4083E-05
      08017.80c 5.3536E-09 07014.80c 2.4050E-05 07015.80c 8.8832E-08
c Total 4.8004E-02
c
c
c --- Control Cards ------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc 15.0 0.0 0.1   15.0 0.0 -0.1  15.0 0.0 1.0
    15.0 0.0 -1.0  15.0 0.0 2.0   15.0 0.0 -2.0
           -15.0 0.0 0.1   15.0 0.0 -0.1 -15.0 0.0 1.0
           -15.0 0.0 -1.0 -15.0 0.0 2.0  -15.0 0.0 -2.0

*********************************************************************************
HEU Cylinders------   7" - 15" bare annuli  (CONFIGURATION 2 – SIMPLE MODEL)
c
c ----------Cell Cards---------------------------
c
c
1    1   4.7814E-02  1  -9 11 -19  imp:n=1  $
c
c        VOID SPACES and Gaps
24    0  151 -152 -150  #1 imp:n=1   $ inner void
25    0  -151:152:150      imp:n=0   $ greater void

c  ------------Surface Cards (cm)---------------------------------
c
c   PLANES
1    pz  0.0       $ bottom
9    pz  10.74225  $ top; 2 inch below diaphragm + 2.2 inches above diaphragm (top height was averaged)
11   cz  8.89      $ 3.5 inch inner diameter
19   cz  19.05     $ 7.5 inch outer diameter
c
150  cz   19.06 $----------------Problem Boundary
151  pz   -0.1
152  pz    10.75 $--------------------------------

c  ------------Data Cards-----------------------------------------
c
c  --------- simple model ---------
m1    92234.80c   4.6712E-04
      92235.80c   4.4568E-02
      92236.80c   1.1521E-04
      92238.80c   2.6635E-03
c total    4.7814E-02
c
c  --- Control Cards ------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc 12.0 0.0 0.1   12.0 0.0 10.0  12.0 0.0 1.0
    12.0 0.0 10.0  12.0 0.0 2.0   12.0 0.0 10.0
    -12.0 0.0 0.1  -12.0 0.0 1.0  -12.0 0.0 -10.0
    -12.0 0.0 2.0  -12.0 0.0 10.0
```

```
**********************************************************************
HEU Cylinders-------   9" - 15" bare annuli  (CONFIGURATION 3 – DETAILED MODEL)
c
c  ----------Cell Cards---------------------------
c
c    9" - 11" annulus above diaphragm
1    1   4.8386E-02  -14  13  15  -22  imp:n=1 $ part 2743
2    2   4.8163E-02  -12  11  16  -23  imp:n=1 $ part 2745
3    3   4.8082E-02  -10   9  17  -24  imp:n=1 $ part 2747
4    4   4.8103E-02   -8   7  18  -25  imp:n=1 $ part 2776
c    9" - 11" annulus below diaphragm
5    5   4.8161E-02   -6   5  19  -26  imp:n=1 $ part 2742
6    6   4.8076E-02   -4   3  20  -27  imp:n=1 $ part 2746
7    7   4.8157E-02   -2   1  21  -28  imp:n=1 $ part 2748
c    11" - 13" annulus above diaphragm
8    8   4.8035E-02  -49  48  50  -62  imp:n=1 $ part 2780
9    9   4.8252E-02  -47  46  51  -63  imp:n=1 $ part 2782
10   10  4.8001E-02  -45  44  52  -64  imp:n=1 $ part 2783 --------------------------
11   11  4.8127E-02  -43  42  53  -65  imp:n=1 $ part 2750
12   12  4.8151E-02  -41  40  54  -66  imp:n=1 $ part 2749
13   13  4.8167E-02  -39  38  55  -67  imp:n=1 $ part 2755
14   14  4.8040E-02  -37  36  56  -68  imp:n=1 $ part 2753
15   15  4.8115E-02  -35  34  57  -69  imp:n=1 $ part 2752
16   16  4.8145E-02  -33  32  58  -70  imp:n=1 $ part 2757
c    11" - 13" annulus below diaphragm
17   17  4.8148E-02  -32  31  59  -71  imp:n=1 $ part 2751
18   18  4.8244E-02  -31  30  60  -72  imp:n=1 $ part 2754
19   19  4.8182E-02  -30  29  61  -73  imp:n=1 $ part 2756
c    13" - 15" annulus above diaphragm
20   20  4.8081E-02  -97  96  98 -110  imp:n=1 $ part 2885
21   21  4.8319E-02  -95  94  99 -111  imp:n=1 $ part 2784
22   22  4.8038E-02  -93  92 100 -112  imp:n=1 $ part 2886
23   23  4.8186E-02  -91  90 101 -113  imp:n=1 $ part 2766
24   24  4.8056E-02  -89  88 102 -114  imp:n=1 $ part 2787
25   25  4.8168E-02  -87  86 103 -115  imp:n=1 $ part 2760
26   26  4.8513E-02  -85  84 104 -116  imp:n=1 $ part 2786
27   27  4.8348E-02  -83  82 105 -117  imp:n=1 $ part 2739
c    13" - 15" annulus below diaphragm
28   28  4.8153E-02  -81  80 106 -118  imp:n=1 $ part 2761
29   29  4.8071E-02  -79  78 107 -119  imp:n=1 $ part 2785
30   30  4.8010E-02  -77  76 108 -120  imp:n=1 $ part 2848
31   31  4.8004E-02  -75  74 109 -121  imp:n=1 $ part 2735
c
c       VOID SPACES and Gaps
32   0  151  -152  -150 #1  #2 #3 #4 $ lesser void
     #5 #6  #7 #8 #9 #10 #11
     #12 #13 #14 #15 #16 #17
     #18 #19 #20 #21 #22 #23
     #24 #25 #26 #27 #28 #29
     #30 #31               imp:n=1
33   0  -151:152:150         imp:n=0  $ greater void

c  ------------Surface Cards (cm)----------------------------------
c
c
```

```
c   9" - 11" BARE ANNULUS
c   PLANES
1   pz   -5.098669 $ part 2748 (Bottom Most Plane)
2   pz   -1.288669 $ gap
3   pz   -1.288457 $ part 2746
4   pz   -0.961686 $ gap
5   pz   -0.961474 $ part 2742
6   pz   -0.00872  $ gap
7   pz    0.0000   $ diaphragm----------
8   pz    2.54381  $ part 2776
9   pz    2.54589  $ gap
10  pz    6.355636 $ part 2747
11  pz    6.357716 $ gap
12  pz    8.895176 $ part 2745
13  pz    8.897256 $ gap
14  pz    9.847216 $ part 2743
c   INNER RADII
15  cz    11.433175 $ part 2743
16  cz    11.43127  $ part 2745
17  cz    11.43254  $ part 2747
18  cz    11.431905 $ part 2776
19  cz    11.431905 $ part 2742
20  cz    11.432223 $ part 2746
21  cz    11.433175 $ part 2748
c   OUTER RADII
22  cz    13.965555 $ part 2743
23  cz    13.965555 $ part 2745
24  cz    13.965936 $ part 2747
25  cz    13.965555 $ part 2776
26  cz    13.965936 $ part 2742
27  cz    13.965555 $ part 2746
28  cz    13.966825 $ part 2748
c
c   11" - 13" BARE ANNULUS
c   PLANES
29  pz   -5.098669 $ part 2756 (Bottom Most PLANE)
30  pz   -2.558161 $ part 2754
31  pz   -1.279017 $ part 2751
32  pz    0.0000   $ diaphragm----------
33  pz    2.543937 $ part 2757
34  pz    2.544681 $ gap
35  pz    3.822936 $ part 2752
36  pz    3.82368  $ gap
37  pz    5.096982 $ part 2753
38  pz    5.097726 $ gap
39  pz    6.529016 $ part 2755
40  pz    6.52976  $ gap
41  pz    7.488356 $ part 2749
42  pz    7.4891   $ gap
43  pz    8.442743 $ part 2750
44  pz    8.443487 $ gap
45  pz    9.080392 $ part 2783
46  pz    9.081136 $ gap
47  pz    9.720581 $ part 2782
48  pz    9.721325 $ gap
49  pz   10.038444 $ part 2780
```

```
c   INNER RADII
50   cz   13.97254  $ part 2780
51   cz   13.974445 $ part 2782
52   cz   13.97381  $ part 2783
53   cz   13.971905 $ part 2750
54   cz   13.97381  $ part 2749
55   cz   13.97381  $ part 2755
56   cz   13.97381  $ part 2753
57   cz   13.973175 $ part 2752
58   cz   13.973175 $ part 2757
59   cz   13.971905 $ part 2751
60   cz   13.97508  $ part 2754
61   cz   13.974572 $ part 2756
c   OUTER RADII
62   cz   16.504984 $ part 2780
63   cz   16.504412 $ part 2782
64   cz   16.504412 $ part 2783
65   cz   16.503015 $ part 2750
66   cz   16.504285 $ part 2749
67   cz   16.50492  $ part 2755
68   cz   16.505873 $ part 2753
69   cz   16.504285 $ part 2752
70   cz   16.50492  $ part 2757
71   cz   16.504666 $ part 2751
72   cz   16.504031 $ part 2754
73   cz   16.505809 $ part 2756
c
c   13" - 15" BARE ANNULUS
c   PLANES
74   pz   -5.098669 $ part 2735
75   pz   -2.562479 $ gap
76   pz   -2.559322 $ part 2848
77   pz   -1.284496 $ gap
78   pz   -1.281339 $ part 2785
79   pz   -0.329601 $ gap
80   pz   -0.326444 $ part 2761
81   pz   -0.005134 $ gap
82   pz    0.0000   $ diaphragm----------
83   pz    2.52603  $ part 2739
84   pz    2.533233 $ gap
85   pz    3.789644 $ part 2786
86   pz    3.796847 $ gap
87   pz    5.066847 $ part 2760
88   pz    5.07405  $ gap
89   pz    6.355226 $ part 2787
90   pz    6.362429 $ gap
91   pz    7.792449 $ part 2766
92   pz    7.799652 $ gap
93   pz    8.438335 $ part 2886
94   pz    8.445538 $ gap
95   pz    9.391688 $ part 2784
96   pz    9.398891 $ gap
97   pz   10.043162 $ part 2885
c   INNER RADII
98   cz    16.514064 $ part 2885
99   cz    16.511905 $ part 2784
```

```
100  cz    16.513175 $ part 2886
101  cz    16.51127  $ part 2766
102  cz    16.511905 $ part 2787
103  cz    16.51254  $ part 2760
104  cz    16.513620 $ part 2786
105  cz    16.513429 $ part 2739
106  cz    16.51127  $ part 2761
107  cz    16.513683 $ part 2785
108  cz    16.513937 $ part 2848
109  cz    16.51254  $ part 2735
c    OUTER RADII
110  cz    19.045301 $ part 2885
111  cz    19.043015 $ part 2784
112  cz    19.045682 $ part 2886
113  cz    19.045555 $ part 2766
114  cz    19.04365  $ part 2787
115  cz    19.04365  $ part 2760
116  cz    19.044603 $ part 2786
117  cz    19.044285 $ part 2739
118  cz    19.043333 $ part 2761
119  cz    19.044666 $ part 2785
120  cz    19.045428 $ part 2848
121  cz    19.041745 $ part 2735
c
150  cz   19.05 $---------------Problem Boundary
151  pz   -5.1
152  pz   10.05 $-------------------------

c   ------------Data Cards-----------------------------------------
c   ------ 9" - 11" HEU Annulus ------
c  --------- Part 2743 ---------
m1      92234.80c 4.7545E-04 92235.80c 4.4994E-02 92236.80c 1.1064E-04
        92238.80c 2.6949E-03 47107.80c 4.3675E-07 47109.80c 4.0576E-07
        56130.80c 4.3843E-13 56132.80c 4.1775E-13 56134.80c 9.9970E-12
        56135.80c 2.7265E-11 56136.80c 3.2485E-11 56137.80c 4.6457E-11
        56138.80c 2.9655E-10 83209.80c 8.9149E-06 06000.80c 4.7290E-06
        20040.80c 2.7478E-08 20042.80c 1.8339E-10 20043.80c 3.8266E-11
        20044.80c 5.9127E-10 20046.80c 1.1338E-12 20048.80c 5.3005E-11
        48106.80c 6.3162E-10 48108.80c 4.4971E-10 48110.80c 6.3111E-09
        48111.80c 6.4678E-09 48112.80c 1.2193E-08 48113.80c 6.1747E-09
        48114.80c 1.4517E-08 48116.80c 3.7847E-09 27059.80c 9.6381E-07
        24050.80c 6.6451E-08 24052.80c 1.2814E-06 24053.80c 1.4530E-07
        24054.80c 3.6169E-08 29063.80c 3.0914E-06 29065.80c 1.3779E-06
        19039.80c 2.7096E-08 19040.80c 3.3994E-12 19041.80c 1.9555E-09
        03006.80c 1.2422E-07 03007.80c 1.5124E-06 12024.80c 1.1076E-06
        12025.80c 1.4022E-07 12026.80c 1.5438E-07 25055.80c 1.1580E-05
        42092.80c 8.7859E-09 42094.80c 5.4764E-09 42095.80c 9.4253E-09
        42096.80c 9.8752E-09 42097.80c 5.6540E-09 42098.80c 1.4286E-08
        42100.80c 5.7013E-09 11023.80c 1.3342E-05 28058.80c 1.3177E-05
        28060.80c 5.0758E-06 28061.80c 2.2064E-07 28062.80c 7.0349E-07
        28064.80c 1.7916E-07 51121.80c 2.0285E-06 51123.80c 1.5172E-06
        22046.80c 1.9574E-08 22047.80c 1.7652E-08 22048.80c 1.7491E-07
        22049.80c 1.2836E-08 22050.80c 1.2290E-08 08016.80c 1.4195E-05
        08017.80c 5.3962E-09 07014.80c 2.4242E-05 07015.80c 8.9539E-08
c  Total 4.8386E-02
c
```

```
c  --------- Part 2745 ---------
m2     92234.80c 4.6359E-04 92235.80c 4.4815E-02 92236.80c 1.0534E-04
       92238.80c 2.6682E-03 47107.80c 4.3473E-07 47109.80c 4.0389E-07
       56130.80c 4.3641E-13 56132.80c 4.1582E-13 56134.80c 9.9509E-12
       56135.80c 2.7140E-11 56136.80c 3.2335E-11 56137.80c 4.6243E-11
       56138.80c 2.9518E-10 83209.80c 8.8738E-06 06000.80c 4.7072E-06
       20040.80c 2.7351E-08 20042.80c 1.8254E-10 20043.80c 3.8089E-11
       20044.80c 5.8854E-10 20046.80c 1.1286E-12 20048.80c 5.2760E-11
       48106.80c 6.2870E-10 48108.80c 4.4764E-10 48110.80c 6.2820E-09
       48111.80c 6.4379E-09 48112.80c 1.2136E-08 48113.80c 6.1462E-09
       48114.80c 1.4450E-08 48116.80c 3.7672E-09 27059.80c 9.5936E-07
       24050.80c 6.6144E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
       24054.80c 3.6002E-08 29063.80c 3.0771E-06 29065.80c 1.3715E-06
       19039.80c 2.6971E-08 19040.80c 3.3838E-12 19041.80c 1.9464E-09
       03006.80c 1.2365E-07 03007.80c 1.5055E-06 12024.80c 1.1025E-06
       12025.80c 1.3957E-07 12026.80c 1.5367E-07 25055.80c 1.1526E-05
       42092.80c 8.7453E-09 42094.80c 5.4511E-09 42095.80c 9.3818E-09
       42096.80c 9.8296E-09 42097.80c 5.6279E-09 42098.80c 1.4220E-08
       42100.80c 5.6750E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
       28060.80c 5.0523E-06 28061.80c 2.1962E-07 28062.80c 7.0025E-07
       28064.80c 1.7833E-07 51121.80c 2.0191E-06 51123.80c 1.5102E-06
       22046.80c 1.9484E-08 22047.80c 1.7571E-08 22048.80c 1.7410E-07
       22049.80c 1.2777E-08 22050.80c 1.2233E-08 08016.80c 1.4130E-05
       08017.80c 5.3713E-09 07014.80c 2.4130E-05 07015.80c 8.9126E-08
c  Total 4.8163E-02
c
c  --------- Part 2747 ---------
m3     92234.80c 4.7245E-04 92235.80c 4.4720E-02 92236.80c 9.0820E-05
       92238.80c 2.6874E-03 47107.80c 4.3400E-07 47109.80c 4.0321E-07
       56130.80c 4.3567E-13 56132.80c 4.1512E-13 56134.80c 9.9341E-12
       56135.80c 2.7094E-11 56136.80c 3.2281E-11 56137.80c 4.6165E-11
       56138.80c 2.9469E-10 83209.80c 8.8588E-06 06000.80c 4.6993E-06
       20040.80c 2.7305E-08 20042.80c 1.8224E-10 20043.80c 3.8025E-11
       20044.80c 5.8755E-10 20046.80c 1.1267E-12 20048.80c 5.2671E-11
       48106.80c 6.2764E-10 48108.80c 4.4688E-10 48110.80c 6.2714E-09
       48111.80c 6.4270E-09 48112.80c 1.2116E-08 48113.80c 6.1358E-09
       48114.80c 1.4426E-08 48116.80c 3.7608E-09 27059.80c 9.5774E-07
       24050.80c 6.6032E-08 24052.80c 1.2734E-06 24053.80c 1.4439E-07
       24054.80c 3.5942E-08 29063.80c 3.0719E-06 29065.80c 1.3692E-06
       19039.80c 2.6926E-08 19040.80c 3.3781E-12 19041.80c 1.9432E-09
       03006.80c 1.2344E-07 03007.80c 1.5029E-06 12024.80c 1.1006E-06
       12025.80c 1.3934E-07 12026.80c 1.5341E-07 25055.80c 1.1507E-05
       42092.80c 8.7306E-09 42094.80c 5.4419E-09 42095.80c 9.3659E-09
       42096.80c 9.8131E-09 42097.80c 5.6184E-09 42098.80c 1.4196E-08
       42100.80c 5.6655E-09 11023.80c 1.3258E-05 28058.80c 1.3094E-05
       28060.80c 5.0438E-06 28061.80c 2.1925E-07 28062.80c 6.9907E-07
       28064.80c 1.7803E-07 51121.80c 2.0157E-06 51123.80c 1.5076E-06
       22046.80c 1.9451E-08 22047.80c 1.7541E-08 22048.80c 1.7381E-07
       22049.80c 1.2755E-08 22050.80c 1.2213E-08 08016.80c 1.4106E-05
       08017.80c 5.3623E-09 07014.80c 2.4089E-05 07015.80c 8.8976E-08
c  Total 4.8082E-02
c
c --------- Part 2776 ---------
m4     92234.80c 4.6302E-04 92235.80c 4.4740E-02 92236.80c 1.0999E-04
       92238.80c 2.6792E-03 47107.80c 4.3420E-07 47109.80c 4.0339E-07
       56130.80c 4.3587E-13 56132.80c 4.1531E-13 56134.80c 9.9386E-12
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      56135.80c 2.7106E-11 56136.80c 3.2295E-11 56137.80c 4.6185E-11
      56138.80c 2.9482E-10 83209.80c 8.8628E-06 06000.80c 4.7014E-06
      20040.80c 2.7317E-08 20042.80c 1.8232E-10 20043.80c 3.8042E-11
      20044.80c 5.8782E-10 20046.80c 1.1272E-12 20048.80c 5.2695E-11
      48106.80c 6.2793E-10 48108.80c 4.4708E-10 48110.80c 6.2742E-09
      48111.80c 6.4300E-09 48112.80c 1.2121E-08 48113.80c 6.1386E-09
      48114.80c 1.4432E-08 48116.80c 3.7625E-09 27059.80c 9.5817E-07
      24050.80c 6.6062E-08 24052.80c 1.2739E-06 24053.80c 1.4445E-07
      24054.80c 3.5958E-08 29063.80c 3.0733E-06 29065.80c 1.3698E-06
      19039.80c 2.6938E-08 19040.80c 3.3796E-12 19041.80c 1.9440E-09
      03006.80c 1.2350E-07 03007.80c 1.5036E-06 12024.80c 1.1011E-06
      12025.80c 1.3940E-07 12026.80c 1.5348E-07 25055.80c 1.1512E-05
      42092.80c 8.7345E-09 42094.80c 5.4443E-09 42095.80c 9.3702E-09
      42096.80c 9.8175E-09 42097.80c 5.6209E-09 42098.80c 1.4202E-08
      42100.80c 5.6680E-09 11023.80c 1.3264E-05 28058.80c 1.3100E-05
      28060.80c 5.0461E-06 28061.80c 2.1935E-07 28062.80c 6.9938E-07
      28064.80c 1.7811E-07 51121.80c 2.0166E-06 51123.80c 1.5083E-06
      22046.80c 1.9460E-08 22047.80c 1.7549E-08 22048.80c 1.7389E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4112E-05
      08017.80c 5.3647E-09 07014.80c 2.4100E-05 07015.80c 8.9016E-08
c Total 4.8103E-02
c
c --------- Part 2742 ---------
m5    92234.80c 4.7324E-04 92235.80c 4.4785E-02 92236.80c 1.1012E-04
      92238.80c 2.6824E-03 47107.80c 4.3472E-07 47109.80c 4.0388E-07
      56130.80c 4.3639E-13 56132.80c 4.1581E-13 56134.80c 9.9506E-12
      56135.80c 2.7139E-11 56136.80c 3.2334E-11 56137.80c 4.6241E-11
      56138.80c 2.9517E-10 83209.80c 8.8735E-06 06000.80c 4.7070E-06
      20040.80c 2.7350E-08 20042.80c 1.8254E-10 20043.80c 3.8088E-11
      20044.80c 5.8853E-10 20046.80c 1.1285E-12 20048.80c 5.2759E-11
      48106.80c 6.2868E-10 48108.80c 4.4762E-10 48110.80c 6.2818E-09
      48111.80c 6.4377E-09 48112.80c 1.2136E-08 48113.80c 6.1460E-09
      48114.80c 1.4450E-08 48116.80c 3.7671E-09 27059.80c 9.5933E-07
      24050.80c 6.6142E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
      24054.80c 3.6001E-08 29063.80c 3.0770E-06 29065.80c 1.3715E-06
      19039.80c 2.6970E-08 19040.80c 3.3836E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5054E-06 12024.80c 1.1024E-06
      12025.80c 1.3957E-07 12026.80c 1.5366E-07 25055.80c 1.1526E-05
      42092.80c 8.7450E-09 42094.80c 5.4509E-09 42095.80c 9.3815E-09
      42096.80c 9.8293E-09 42097.80c 5.6277E-09 42098.80c 1.4220E-08
      42100.80c 5.6748E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
      28060.80c 5.0522E-06 28061.80c 2.1961E-07 28062.80c 7.0023E-07
      28064.80c 1.7833E-07 51121.80c 2.0190E-06 51123.80c 1.5101E-06
      22046.80c 1.9483E-08 22047.80c 1.7570E-08 22048.80c 1.7410E-07
      22049.80c 1.2776E-08 22050.80c 1.2233E-08 08016.80c 1.4129E-05
      08017.80c 5.3711E-09 07014.80c 2.4129E-05 07015.80c 8.9123E-08
c Total 4.8161E-02
c
c --------- Part 2746 ---------
m6    92234.80c 4.8204E-04 92235.80c 4.4682E-02 92236.80c 1.0515E-04
      92238.80c 2.6966E-03 47107.80c 4.3395E-07 47109.80c 4.0316E-07
      56130.80c 4.3562E-13 56132.80c 4.1507E-13 56134.80c 9.9329E-12
      56135.80c 2.7091E-11 56136.80c 3.2277E-11 56137.80c 4.6159E-11
      56138.80c 2.9465E-10 83209.80c 8.8578E-06 06000.80c 4.6987E-06
      20040.80c 2.7302E-08 20042.80c 1.8222E-10 20043.80c 3.8020E-11
      20044.80c 5.8748E-10 20046.80c 1.1265E-12 20048.80c 5.2665E-11
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      48106.80c 6.2757E-10 48108.80c 4.4683E-10 48110.80c 6.2707E-09
      48111.80c 6.4263E-09 48112.80c 1.2115E-08 48113.80c 6.1351E-09
      48114.80c 1.4424E-08 48116.80c 3.7604E-09 27059.80c 9.5763E-07
      24050.80c 6.6025E-08 24052.80c 1.2732E-06 24053.80c 1.4437E-07
      24054.80c 3.5937E-08 29063.80c 3.0715E-06 29065.80c 1.3690E-06
      19039.80c 2.6923E-08 19040.80c 3.3777E-12 19041.80c 1.9429E-09
      03006.80c 1.2343E-07 03007.80c 1.5027E-06 12024.80c 1.1005E-06
      12025.80c 1.3932E-07 12026.80c 1.5339E-07 25055.80c 1.1505E-05
      42092.80c 8.7295E-09 42094.80c 5.4413E-09 42095.80c 9.3648E-09
      42096.80c 9.8119E-09 42097.80c 5.6177E-09 42098.80c 1.4194E-08
      42100.80c 5.6648E-09 11023.80c 1.3256E-05 28058.80c 1.3093E-05
      28060.80c 5.0432E-06 28061.80c 2.1922E-07 28062.80c 6.9899E-07
      28064.80c 1.7801E-07 51121.80c 2.0155E-06 51123.80c 1.5075E-06
      22046.80c 1.9449E-08 22047.80c 1.7539E-08 22048.80c 1.7379E-07
      22049.80c 1.2754E-08 22050.80c 1.2211E-08 08016.80c 1.4104E-05
      08017.80c 5.3616E-09 07014.80c 2.4086E-05 07015.80c 8.8965E-08
c Total 4.8076E-02
c
c --------- Part 2748 ---------
m7    92234.80c 4.8285E-04 92235.80c 4.4757E-02 92236.80c 1.0533E-04
      92238.80c 2.7012E-03 47107.80c 4.3468E-07 47109.80c 4.0384E-07
      56130.80c 4.3636E-13 56132.80c 4.1577E-13 56134.80c 9.9497E-12
      56135.80c 2.7136E-11 56136.80c 3.2332E-11 56137.80c 4.6237E-11
      56138.80c 2.9515E-10 83209.80c 8.8728E-06 06000.80c 4.7067E-06
      20040.80c 2.7348E-08 20042.80c 1.8252E-10 20043.80c 3.8085E-11
      20044.80c 5.8848E-10 20046.80c 1.1284E-12 20048.80c 5.2754E-11
      48106.80c 6.2863E-10 48108.80c 4.4759E-10 48110.80c 6.2813E-09
      48111.80c 6.4372E-09 48112.80c 1.2135E-08 48113.80c 6.1455E-09
      48114.80c 1.4448E-08 48116.80c 3.7668E-09 27059.80c 9.5925E-07
      24050.80c 6.6136E-08 24052.80c 1.2754E-06 24053.80c 1.4462E-07
      24054.80c 3.5998E-08 29063.80c 3.0767E-06 29065.80c 1.3713E-06
      19039.80c 2.6968E-08 19040.80c 3.3834E-12 19041.80c 1.9462E-09
      03006.80c 1.2363E-07 03007.80c 1.5053E-06 12024.80c 1.1023E-06
      12025.80c 1.3956E-07 12026.80c 1.5365E-07 25055.80c 1.1525E-05
      42092.80c 8.7443E-09 42094.80c 5.4505E-09 42095.80c 9.3807E-09
      42096.80c 9.8285E-09 42097.80c 5.6272E-09 42098.80c 1.4218E-08
      42100.80c 5.6744E-09 11023.80c 1.3279E-05 28058.80c 1.3115E-05
      28060.80c 5.0517E-06 28061.80c 2.1960E-07 28062.80c 7.0017E-07
      28064.80c 1.7831E-07 51121.80c 2.0189E-06 51123.80c 1.5100E-06
      22046.80c 1.9481E-08 22047.80c 1.7569E-08 22048.80c 1.7408E-07
      22049.80c 1.2775E-08 22050.80c 1.2232E-08 08016.80c 1.4128E-05
      08017.80c 5.3707E-09 07014.80c 2.4127E-05 07015.80c 8.9116E-08
c Total 4.8157E-02
c
c  ------ 11"-13" HEU Annulus ------
c  --------- Part 2780 ---------
m8    92234.80c 4.7200E-04 92235.80c 4.4663E-02 92236.80c 1.1938E-04
      92238.80c 2.6706E-03 47107.80c 4.3358E-07 47109.80c 4.0282E-07
      56130.80c 4.3525E-13 56132.80c 4.1472E-13 56134.80c 9.9245E-12
      56135.80c 2.7068E-11 56136.80c 3.2250E-11 56137.80c 4.6120E-11
      56138.80c 2.9440E-10 83209.80c 8.8503E-06 06000.80c 4.6947E-06
      20040.80c 2.7278E-08 20042.80c 1.8206E-10 20043.80c 3.7988E-11
      20044.80c 5.8699E-10 20046.80c 1.1256E-12 20048.80c 5.2620E-11
      48106.80c 6.2704E-10 48108.80c 4.4645E-10 48110.80c 6.2654E-09
      48111.80c 6.4208E-09 48112.80c 1.2104E-08 48113.80c 6.1299E-09
      48114.80c 1.4412E-08 48116.80c 3.7572E-09 27059.80c 9.5682E-07
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      24050.80c 6.5969E-08 24052.80c 1.2721E-06 24053.80c 1.4425E-07
      24054.80c 3.5907E-08 29063.80c 3.0689E-06 29065.80c 1.3679E-06
      19039.80c 2.6900E-08 19040.80c 3.3748E-12 19041.80c 1.9413E-09
      03006.80c 1.2332E-07 03007.80c 1.5015E-06 12024.80c 1.0996E-06
      12025.80c 1.3920E-07 12026.80c 1.5326E-07 25055.80c 1.1496E-05
      42092.80c 8.7221E-09 42094.80c 5.4366E-09 42095.80c 9.3569E-09
      42096.80c 9.8036E-09 42097.80c 5.6130E-09 42098.80c 1.4182E-08
      42100.80c 5.6600E-09 11023.80c 1.3245E-05 28058.80c 1.3081E-05
      28060.80c 5.0389E-06 28061.80c 2.1904E-07 28062.80c 6.9839E-07
      28064.80c 1.7786E-07 51121.80c 2.0137E-06 51123.80c 1.5062E-06
      22046.80c 1.9432E-08 22047.80c 1.7524E-08 22048.80c 1.7364E-07
      22049.80c 1.2743E-08 22050.80c 1.2201E-08 08016.80c 1.4092E-05
      08017.80c 5.3571E-09 07014.80c 2.4066E-05 07015.80c 8.8890E-08
c  Total 4.8035E-02
c
c  ---------- Part 2782 ---------
m9     92234.80c 4.6445E-04 92235.80c 4.4898E-02 92236.80c 1.1033E-04
      92238.80c 2.6684E-03 47107.80c 4.3554E-07 47109.80c 4.0463E-07
            56130.80c 4.3721E-13 56132.80c 4.1659E-13 56134.80c 9.9692E-12
      56135.80c 2.7190E-11 56136.80c 3.2395E-11 56137.80c 4.6328E-11
      56138.80c 2.9573E-10 83209.80c 8.8902E-06 06000.80c 4.7160E-06
      20040.80c 2.7401E-08 20042.80c 1.8288E-10 20043.80c 3.8159E-11
            20044.80c 5.8963E-10 20046.80c 1.1306E-12 20048.80c 5.2857E-11
      48106.80c 6.2986E-10 48108.80c 4.4846E-10 48110.80c 6.2935E-09
      48111.80c 6.4497E-09 48112.80c 1.2159E-08 48113.80c 6.1575E-09
      48114.80c 1.4477E-08 48116.80c 3.7741E-09 27059.80c 9.6113E-07
      24050.80c 6.6266E-08 24052.80c 1.2779E-06 24053.80c 1.4490E-07
      24054.80c 3.6069E-08 29063.80c 3.0828E-06 29065.80c 1.3740E-06
      19039.80c 2.7021E-08 19040.80c 3.3900E-12 19041.80c 1.9500E-09
      03006.80c 1.2388E-07 03007.80c 1.5082E-06 12024.80c 1.1045E-06
      12025.80c 1.3983E-07 12026.80c 1.5395E-07 25055.80c 1.1547E-05
      42092.80c 8.7614E-09 42094.80c 5.4611E-09 42095.80c 9.3991E-09
            42096.80c 9.8478E-09 42097.80c 5.6383E-09 42098.80c 1.4246E-08
            42100.80c 5.7091E-09 11023.80c 1.3305E-05 28058.80c 1.3140E-05
      28060.80c 5.0613E-06 28061.80c 2.2001E-07 28062.80c 7.0150E-07
      28064.80c 1.7865E-07 51121.80c 2.0227E-06 51123.80c 1.5128E-06
      22046.80c 1.9525E-08 22047.80c 1.7608E-08 22048.80c 1.7447E-07
            22049.80c 1.2804E-08 22050.80c 1.2259E-08 08016.80c 1.4156E-05
            08017.80c 5.3812E-09 07014.80c 2.4174E-05 07015.80c 8.9290E-08
c Total 4.8252E-02
c
c The parts below are listed in Hmf076.pdf-----------------------------
c
c    03007.80c 3.0260E-06
c    12000.80c 1.4027E-06
c    25055.80c 1.1584E-05
c    42000.80c 1.1845E-07
c    11023.80c 1.3347E-05
c    28058.80c 1.3182E-05
c    28060.80c 5.0776E-06
c    28061.80c 2.2072E-07
c    28062.80c 7.0376E-07
c    28064.80c 1.7923E-07
c    51000.80cc 3.5470E-06
c    22000.80c 2.3735E-07
c    8016.80c 1.80c06E-05
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c    7014.80c 2.4340E-05
c
c Total 4.8222E-02
c
c ---------- part 2783---------these isotopics were taken from Hmf071----------
m10    92234.80c 4.7590E-04
       92235.80c 4.4654E-02
       92236.80c 1.1930E-04
       92238.80c 2.6687E-03
       47107.80c 4.3327E-07
       47109.80c 4.0253E-07
       56130.80c 4.3494E-13
       56132.80c 4.1442E-13
       56134.80c 9.9174E-12
       56135.80c 2.7048E-11
       56136.80c 3.2226E-11
       56137.80c 4.6087E-11
       56138.80c 2.9419E-10
       83209.80c 8.8439E-06
       06000.80c 4.6915E-06
       20040.80c 2.7259E-08
       20042.80c 1.8193E-10
       20043.80c 3.7961E-11
       20044.80c 5.8656E-10
       20046.80c 1.1248E-12
       20048.80c 5.2583E-11
       48106.80c 6.2658E-10
       48108.80c 4.4613E-10
       48110.80c 6.2608E-09
       48111.80c 6.4162E-09
       48112.80c 1.2096E-08
       48113.80c 6.1255E-09
       48114.80c 1.4401E-08
       48116.80c 3.7545E-09
       27059.80c 9.5613E-07
       24050.80c 6.5921E-08
       24052.80c 1.2712E-06
       24053.80c 1.4415E-07
       24054.80c 3.5881E-08
       29063.80c 3.0667E-06
       29065.80c 1.3669E-06
       19039.80c 2.6880E-08
       19040.80c 3.3724E-12
       19041.80c 1.9399E-09
       03006.80c 1.2323E-07
       03007.80c 1.5004E-06
       12024.80c 1.0988E-06
       12025.80c 1.3910E-07
       12026.80c 1.5315E-07
       25055.80c 1.1487E-05
       42092.80c 8.7159E-09
       42094.80c 5.4327E-09
       42095.80c 9.3502E-09
       42096.80c 9.7966E-09
       42097.80c 5.6089E-09
       42098.80c 1.4172E-08
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      42100.80c 5.6794E-09
      11023.80c 1.3235E-05
      28058.80c 1.3071E-05
      28060.80c 5.0350E-06
      28061.80c 2.1887E-07
      28062.80c 6.9785E-07
      28064.80c 1.7772E-07
      51121.80c 2.0121E-06
      51123.80c 1.5050E-06
      22046.80c 1.9423E-08
      22047.80c 1.7516E-08
      22048.80c 1.7356E-07
      22049.80c 1.2737E-08
      22050.80c 1.2196E-08
      08016.80c 1.4082E-05
      08017.80c 5.3532E-09
      07014.80c 2.4049E-05
      07015.80c 8.8826E-08
c Total 4.8029E-02
c
c  --------- Part 2750 ---------
m11    92234.80c 4.5842E-04 92235.80c 4.4743E-02 92236.80c 1.1961E-04
      92238.80c 2.6947E-03 47107.80c 4.3441E-07 47109.80c 4.0359E-07
      56130.80c 4.3608E-13 56132.80c 4.1551E-13 56134.80c 9.9435E-12
      56135.80c 2.7119E-11 56136.80c 3.2311E-11 56137.80c 4.6208E-11
      56138.80c 2.9496E-10 83209.80c 8.8672E-06 06000.80c 4.7037E-06
      20040.80c 2.7331E-08 20042.80c 1.8241E-10 20043.80c 3.8061E-11
      20044.80c 5.8811E-10 20046.80c 1.1277E-12 20048.80c 5.2721E-11
      48106.80c 6.2824E-10 48108.80c 4.4730E-10 48110.80c 6.2773E-09
      48111.80c 6.4331E-09 48112.80c 1.2127E-08 48113.80c 6.1416E-09
      48114.80c 1.4439E-08 48116.80c 3.7644E-09 27059.80c 9.5865E-07
      24050.80c 6.6095E-08 24052.80c 1.2746E-06 24053.80c 1.4453E-07
      24054.80c 3.5976E-08 29063.80c 3.0748E-06 29065.80c 1.3705E-06
      19039.80c 2.6951E-08 19040.80c 3.3812E-12 19041.80c 1.9450E-09
      03006.80c 1.2356E-07 03007.80c 1.5043E-06 12024.80c 1.1017E-06
      12025.80c 1.3947E-07 12026.80c 1.5355E-07 25055.80c 1.1518E-05
      42092.80c 8.7388E-09 42094.80c 5.4470E-09 42095.80c 9.3748E-09
      42096.80c 9.8223E-09 42097.80c 5.6237E-09 42098.80c 1.4209E-08
      42100.80c 5.6708E-09 11023.80c 1.3270E-05 28058.80c 1.3106E-05
      28060.80c 5.0486E-06 28061.80c 2.1946E-07 28062.80c 6.9973E-07
      28064.80c 1.7820E-07 51121.80c 2.0176E-06 51123.80c 1.5091E-06
      22046.80c 1.9469E-08 22047.80c 1.7558E-08 22048.80c 1.7397E-07
      22049.80c 1.2767E-08 22050.80c 1.2224E-08 08016.80c 1.4119E-05
      08017.80c 5.3673E-09 07014.80c 2.4112E-05 07015.80c 8.9060E-08
c  Total 4.8127E-02
c
c  --------- Part 2749 ---------
m12    92234.80c 4.7313E-04 92235.80c 4.4799E-02 92236.80c 1.1967E-04
      92238.80c 2.6486E-03 47107.80c 4.3462E-07 47109.80c 4.0379E-07
      56130.80c 4.3629E-13 56132.80c 4.1571E-13 56134.80c 9.9483E-12
      56135.80c 2.7133E-11 56136.80c 3.2327E-11 56137.80c 4.6231E-11
      56138.80c 2.9511E-10 83209.80c 8.8715E-06 06000.80c 4.7060E-06
      20040.80c 2.7344E-08 20042.80c 1.8250E-10 20043.80c 3.8079E-11
      20044.80c 5.8839E-10 20046.80c 1.1283E-12 20048.80c 5.2747E-11
      48106.80c 6.2854E-10 48108.80c 4.4752E-10 48110.80c 6.2804E-09
      48111.80c 6.4363E-09 48112.80c 1.2133E-08 48113.80c 6.1446E-09
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      48114.80c 1.4446E-08 48116.80c 3.7662E-09 27059.80c 9.5911E-07
      24050.80c 6.6127E-08 24052.80c 1.2752E-06 24053.80c 1.4460E-07
      24054.80c 3.5993E-08 29063.80c 3.0763E-06 29065.80c 1.3711E-06
      19039.80c 2.6964E-08 19040.80c 3.3829E-12 19041.80c 1.9459E-09
      03006.80c 1.2362E-07 03007.80c 1.5051E-06 12024.80c 1.1022E-06
      12025.80c 1.3954E-07 12026.80c 1.5363E-07 25055.80c 1.1523E-05
      42092.80c 8.7431E-09 42094.80c 5.4497E-09 42095.80c 9.3793E-09
      42096.80c 9.8271E-09 42097.80c 5.6264E-09 42098.80c 1.4216E-08
      42100.80c 5.6736E-09 11023.80c 1.3277E-05 28058.80c 1.3113E-05
      28060.80c 5.0510E-06 28061.80c 2.1956E-07 28062.80c 7.0007E-07
      28064.80c 1.7829E-07 51121.80c 2.0186E-06 51123.80c 1.5098E-06
      22046.80c 1.9479E-08 22047.80c 1.7566E-08 22048.80c 1.7406E-07
      22049.80c 1.2773E-08 22050.80c 1.2230E-08 08016.80c 1.4126E-05
      08017.80c 5.3699E-09 07014.80c 2.4124E-05 07015.80c 8.9103E-08
c  Total 4.8151E-02
c
c --------- Part 2755 ---------
m13    92234.80c 4.6364E-04 92235.80c 4.4771E-02 92236.80c 1.3408E-04
      92238.80c 2.6875E-03 47107.80c 4.3477E-07 47109.80c 4.0393E-07
      56130.80c 4.3645E-13 56132.80c 4.1586E-13 56134.80c 9.9518E-12
      56135.80c 2.7142E-11 56136.80c 3.2338E-11 56137.80c 4.6247E-11
      56138.80c 2.9521E-10 83209.80c 8.8746E-06 06000.80c 4.7076E-06
      20040.80c 2.7353E-08 20042.80c 1.8256E-10 20043.80c 3.8092E-11
      20044.80c 5.8860E-10 20046.80c 1.1287E-12 20048.80c 5.2765E-11
      48106.80c 6.2876E-10 48108.80c 4.4768E-10 48110.80c 6.2826E-09
      48111.80c 6.4385E-09 48112.80c 1.2138E-08 48113.80c 6.1468E-09
      48114.80c 1.4451E-08 48116.80c 3.7675E-09 27059.80c 9.5945E-07
      24050.80c 6.6150E-08 24052.80c 1.2756E-06 24053.80c 1.4465E-07
      24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3716E-06
      19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9466E-09
      03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
      12025.80c 1.3958E-07 12026.80c 1.5368E-07 25055.80c 1.1527E-05
      42092.80c 8.7461E-09 42094.80c 5.4516E-09 42095.80c 9.3826E-09
      42096.80c 9.8305E-09 42097.80c 5.6284E-09 42098.80c 1.4221E-08
      42100.80c 5.6755E-09 11023.80c 1.3281E-05 28058.80c 1.3117E-05
      28060.80c 5.0528E-06 28061.80c 2.1964E-07 28062.80c 7.0031E-07
      28064.80c 1.7835E-07 51121.80c 2.0193E-06 51123.80c 1.5103E-06
      22046.80c 1.9485E-08 22047.80c 1.7572E-08 22048.80c 1.7412E-07
      22049.80c 1.2778E-08 22050.80c 1.2234E-08 08016.80c 1.4131E-05
      08017.80c 5.3718E-09 07014.80c 2.4132E-05 07015.80c 8.9134E-08
c Total 4.8167E-02
c
c --------- Part 2753 ---------
m14    92234.80c 4.5759E-04 92235.80c 4.4662E-02 92236.80c 1.1940E-04
      92238.80c 2.6898E-03 47107.80c 4.3362E-07 47109.80c 4.0286E-07
      56130.80c 4.3529E-13 56132.80c 4.1476E-13 56134.80c 9.9255E-12
      56135.80c 2.7070E-11 56136.80c 3.2253E-11 56137.80c 4.6124E-11
      56138.80c 2.9443E-10 83209.80c 8.8511E-06 06000.80c 4.6952E-06
      20040.80c 2.7281E-08 20042.80c 1.8208E-10 20043.80c 3.7992E-11
      20044.80c 5.8704E-10 20046.80c 1.1257E-12 20048.80c 5.2625E-11
      48106.80c 6.2710E-10 48108.80c 4.4649E-10 48110.80c 6.2660E-09
      48111.80c 6.4214E-09 48112.80c 1.2105E-08 48113.80c 6.1305E-09
      48114.80c 1.4413E-08 48116.80c 3.7576E-09 27059.80c 9.5691E-07
      24050.80c 6.5975E-08 24052.80c 1.2723E-06 24053.80c 1.4426E-07
      24054.80c 3.5910E-08 29063.80c 3.0692E-06 29065.80c 1.3680E-06
      19039.80c 2.6902E-08 19040.80c 3.3751E-12 19041.80c 1.9415E-09
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      03006.80c 1.2333E-07 03007.80c 1.5016E-06 12024.80c 1.0997E-06
      12025.80c 1.3921E-07 12026.80c 1.5328E-07 25055.80c 1.1497E-05
      42092.80c 8.7230E-09 42094.80c 5.4372E-09 42095.80c 9.3578E-09
      42096.80c 9.8045E-09 42097.80c 5.6135E-09 42098.80c 1.4184E-08
      42100.80c 5.6605E-09 11023.80c 1.3246E-05 28058.80c 1.3083E-05
      28060.80c 5.0394E-06 28061.80c 2.1906E-07 28062.80c 6.9846E-07
      28064.80c 1.7788E-07 51121.80c 2.0139E-06 51123.80c 1.5063E-06
      22046.80c 1.9434E-08 22047.80c 1.7526E-08 22048.80c 1.7366E-07
      22049.80c 1.2744E-08 22050.80c 1.2202E-08 08016.80c 1.4094E-05
      08017.80c 5.3576E-09 07014.80c 2.4068E-05 07015.80c 8.8898E-08
c Total 4.8040E-02
c
c --------- Part 2752 ---------
m15   92234.80c 4.7278E-04 92235.80c 4.4737E-02 92236.80c 1.1480E-04
      92238.80c 2.6798E-03 47107.80c 4.3431E-07 47109.80c 4.0349E-07
      56130.80c 4.3598E-13 56132.80c 4.1541E-13 56134.80c 9.9411E-12
      56135.80c 2.7113E-11 56136.80c 3.2303E-11 56137.80c 4.6197E-11
      56138.80c 2.9489E-10 83209.80c 8.8650E-06 06000.80c 4.7025E-06
      20040.80c 2.7324E-08 20042.80c 1.8236E-10 20043.80c 3.8051E-11
      20044.80c 5.8796E-10 20046.80c 1.1274E-12 20048.80c 5.2708E-11
      48106.80c 6.2808E-10 48108.80c 4.4719E-10 48110.80c 6.2758E-09
      48111.80c 6.4316E-09 48112.80c 1.2125E-08 48113.80c 6.1401E-09
      48114.80c 1.4436E-08 48116.80c 3.7635E-09 27059.80c 9.5841E-07
      24050.80c 6.6078E-08 24052.80c 1.2743E-06 24053.80c 1.4449E-07
      24054.80c 3.5967E-08 29063.80c 3.0741E-06 29065.80c 1.3701E-06
      19039.80c 2.6945E-08 19040.80c 3.3804E-12 19041.80c 1.9445E-09
      03006.80c 1.2353E-07 03007.80c 1.5040E-06 12024.80c 1.1014E-06
      12025.80c 1.3943E-07 12026.80c 1.5352E-07 25055.80c 1.1515E-05
      42092.80c 8.7367E-09 42094.80c 5.4457E-09 42095.80c 9.3725E-09
      42096.80c 9.8199E-09 42097.80c 5.6223E-09 42098.80c 1.4206E-08
      42100.80c 5.6694E-09 11023.80c 1.3267E-05 28058.80c 1.3103E-05
      28060.80c 5.0473E-06 28061.80c 2.1940E-07 28062.80c 6.9956E-07
      28064.80c 1.7816E-07 51121.80c 2.0171E-06 51123.80c 1.5087E-06
      22046.80c 1.9464E-08 22047.80c 1.7553E-08 22048.80c 1.7393E-07
      22049.80c 1.2764E-08 22050.80c 1.2221E-08 08016.80c 1.4116E-05
      08017.80c 5.3660E-09 07014.80c 2.4106E-05 07015.80c 8.9038E-08
c Total 4.8115E-02
c
c --------- Part 2757 ---------
m16   92234.80c 4.6342E-04 92235.80c 4.4798E-02 92236.80c 1.1008E-04
      92238.80c 2.6625E-03 47107.80c 4.3457E-07 47109.80c 4.0374E-07
      56130.80c 4.3624E-13 56132.80c 4.1566E-13 56134.80c 9.9471E-12
      56135.80c 2.7129E-11 56136.80c 3.2323E-11 56137.80c 4.6225E-11
      56138.80c 2.9507E-10 83209.80c 8.8704E-06 06000.80c 4.7054E-06
      20040.80c 2.7340E-08 20042.80c 1.8247E-10 20043.80c 3.8074E-11
      20044.80c 5.8832E-10 20046.80c 1.1281E-12 20048.80c 5.2740E-11
      48106.80c 6.2846E-10 48108.80c 4.4747E-10 48110.80c 6.2796E-09
      48111.80c 6.4355E-09 48112.80c 1.2132E-08 48113.80c 6.1439E-09
      48114.80c 1.4445E-08 48116.80c 3.7658E-09 27059.80c 9.5899E-07
      24050.80c 6.6118E-08 24052.80c 1.2750E-06 24053.80c 1.4458E-07
      24054.80c 3.5989E-08 29063.80c 3.0759E-06 29065.80c 1.3710E-06
      19039.80c 2.6961E-08 19040.80c 3.3825E-12 19041.80c 1.9457E-09
      03006.80c 1.2360E-07 03007.80c 1.5049E-06 12024.80c 1.1021E-06
      12025.80c 1.3952E-07 12026.80c 1.5361E-07 25055.80c 1.1522E-05
      42092.80c 8.7420E-09 42094.80c 5.4490E-09 42095.80c 9.3782E-09
      42096.80c 9.8259E-09 42097.80c 5.6257E-09 42098.80c 1.4215E-08
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      42100.80c 5.6729E-09 11023.80c 1.3275E-05 28058.80c 1.3111E-05
      28060.80c 5.0504E-06 28061.80c 2.1954E-07 28062.80c 6.9998E-07
      28064.80c 1.7826E-07 51121.80c 2.0183E-06 51123.80c 1.5096E-06
      22046.80c 1.9476E-08 22047.80c 1.7564E-08 22048.80c 1.7403E-07
      22049.80c 1.2772E-08 22050.80c 1.2229E-08 08016.80c 1.4124E-05
      08017.80c 5.3693E-09 07014.80c 2.4121E-05 07015.80c 8.9092E-08
c Total 4.8145E-02
c
c --------- Part 2751 ---------
m17   92234.80c 4.7310E-04 92235.80c 4.4767E-02 92236.80c 1.1488E-04
      92238.80c 2.6816E-03 47107.80c 4.3460E-07 47109.80c 4.0376E-07
      56130.80c 4.3627E-13 56132.80c 4.1569E-13 56134.80c 9.9477E-12
      56135.80c 2.7131E-11 56136.80c 3.2325E-11 56137.80c 4.6228E-11
      56138.80c 2.9509E-10 83209.80c 8.8710E-06 06000.80c 4.7057E-06
      20040.80c 2.7342E-08 20042.80c 1.8249E-10 20043.80c 3.8077E-11
      20044.80c 5.8836E-10 20046.80c 1.1282E-12 20048.80c 5.2744E-11
      48106.80c 6.2850E-10 48108.80c 4.4750E-10 48110.80c 6.2800E-09
      48111.80c 6.4359E-09 48112.80c 1.2133E-08 48113.80c 6.1443E-09
      48114.80c 1.4446E-08 48116.80c 3.7660E-09 27059.80c 9.5906E-07
      24050.80c 6.6123E-08 24052.80c 1.2751E-06 24053.80c 1.4459E-07
      24054.80c 3.5991E-08 29063.80c 3.0761E-06 29065.80c 1.3711E-06
      19039.80c 2.6963E-08 19040.80c 3.3827E-12 19041.80c 1.9458E-09
      03006.80c 1.2361E-07 03007.80c 1.5050E-06 12024.80c 1.1021E-06
      12025.80c 1.3953E-07 12026.80c 1.5362E-07 25055.80c 1.1523E-05
      42092.80c 8.7425E-09 42094.80c 5.4494E-09 42095.80c 9.3788E-09
      42096.80c 9.8265E-09 42097.80c 5.6261E-09 42098.80c 1.4215E-08
      42100.80c 5.6732E-09 11023.80c 1.3276E-05 28058.80c 1.3112E-05
      28060.80c 5.0507E-06 28061.80c 2.1955E-07 28062.80c 7.0003E-07
      28064.80c 1.7828E-07 51121.80c 2.0185E-06 51123.80c 1.5097E-06
      22046.80c 1.9478E-08 22047.80c 1.7565E-08 22048.80c 1.7405E-07
      22049.80c 1.2773E-08 22050.80c 1.2230E-08 08016.80c 1.4125E-05
      08017.80c 5.3696E-09 07014.80c 2.4122E-05 07015.80c 8.9098E-08
c Total 4.8148E-02
c
c --------- Part 2754 ---------
m18   92234.80c 4.6438E-04 92235.80c 4.4843E-02 92236.80c 1.3429E-04
      92238.80c 2.6918E-03 47107.80c 4.3547E-07 47109.80c 4.0457E-07
      56130.80c 4.3715E-13 56132.80c 4.1653E-13 56134.80c 9.9678E-12
      56135.80c 2.7186E-11 56136.80c 3.2390E-11 56137.80c 4.6321E-11
      56138.80c 2.9568E-10 83209.80c 8.8888E-06 06000.80c 4.7152E-06
      20040.80c 2.7397E-08 20042.80c 1.8285E-10 20043.80c 3.8153E-11
      20044.80c 5.8954E-10 20046.80c 1.1305E-12 20048.80c 5.2850E-11
      48106.80c 6.2977E-10 48108.80c 4.4840E-10 48110.80c 6.2927E-09
      48111.80c 6.4488E-09 48112.80c 1.2157E-08 48113.80c 6.1566E-09
      48114.80c 1.4475E-08 48116.80c 3.7736E-09 27059.80c 9.6098E-07
      24050.80c 6.6256E-08 24052.80c 1.2777E-06 24053.80c 1.4488E-07
      24054.80c 3.6063E-08 29063.80c 3.0823E-06 29065.80c 1.3738E-06
      19039.80c 2.7017E-08 19040.80c 3.3895E-12 19041.80c 1.9497E-09
      03006.80c 1.2386E-07 03007.80c 1.5080E-06 12024.80c 1.1043E-06
      12025.80c 1.3981E-07 12026.80c 1.5393E-07 25055.80c 1.1546E-05
      42092.80c 8.7601E-09 42094.80c 5.4603E-09 42095.80c 9.3977E-09
      42096.80c 9.8463E-09 42097.80c 5.6374E-09 42098.80c 1.4244E-08
      42100.80c 5.6846E-09 11023.80c 1.3303E-05 28058.80c 1.3138E-05
      28060.80c 5.0609E-06 28061.80c 2.1999E-07 28062.80c 7.0143E-07
      28064.80c 1.7863E-07 51121.80c 2.0225E-06 51123.80c 1.5127E-06
      22046.80c 1.9517E-08 22047.80c 1.7601E-08 22048.80c 1.7440E-07
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      22049.80c 1.2798E-08 22050.80c 1.2254E-08 08016.80c 1.4154E-05
      08017.80c 5.3804E-09 07014.80c 2.4171E-05 07015.80c 8.9277E-08
c Total 4.8244E-02
c
c --------- Part 2756 ---------
m19    92234.80c 4.4929E-04 92235.80c 4.4823E-02 92236.80c 1.1975E-04
      92238.80c 2.6788E-03 47107.80c 4.3491E-07 47109.80c 4.0405E-07
      56130.80c 4.3658E-13 56132.80c 4.1599E-13 56134.80c 9.9549E-12
      56135.80c 2.7150E-11 56136.80c 3.2348E-11 56137.80c 4.6261E-11
      56138.80c 2.9530E-10 83209.80c 8.8774E-06 06000.80c 4.7091E-06
      20040.80c 2.7362E-08 20042.80c 1.8262E-10 20043.80c 3.8104E-11
      20044.80c 5.8878E-10 20046.80c 1.1290E-12 20048.80c 5.2781E-11
      48106.80c 6.2896E-10 48108.80c 4.4782E-10 48110.80c 6.2845E-09
      48111.80c 6.4405E-09 48112.80c 1.2141E-08 48113.80c 6.1487E-09
      48114.80c 1.4456E-08 48116.80c 3.7687E-09 27059.80c 9.5974E-07
      24050.80c 6.6170E-08 24052.80c 1.2760E-06 24053.80c 1.4469E-07
      24054.80c 3.6017E-08 29063.80c 3.0783E-06 29065.80c 1.3721E-06
      19039.80c 2.6982E-08 19040.80c 3.3851E-12 19041.80c 1.9472E-09
      03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1029E-06
      12025.80c 1.3963E-07 12026.80c 1.5373E-07 25055.80c 1.1531E-05
      42092.80c 8.7488E-09 42094.80c 5.4533E-09 42095.80c 9.3855E-09
      42096.80c 9.8336E-09 42097.80c 5.6301E-09 42098.80c 1.4226E-08
      42100.80c 5.6773E-09 11023.80c 1.3285E-05 28058.80c 1.3121E-05
      28060.80c 5.0543E-06 28061.80c 2.1971E-07 28062.80c 7.0053E-07
      28064.80c 1.7840E-07 51121.80c 2.0199E-06 51123.80c 1.5108E-06
      22046.80c 1.9491E-08 22047.80c 1.7578E-08 22048.80c 1.7417E-07
      22049.80c 1.2782E-08 22050.80c 1.2238E-08 08016.80c 1.4135E-05
      08017.80c 5.3735E-09 07014.80c 2.4140E-05 07015.80c 8.9162E-08
c Total 4.8182E-02
c
c ------ 13"-15" HEU Annulus ------
c
c ------------ Part 2885 -------------------these isotopics were taken from Hmf071---------
M20    92234.80c 4.7727E-04 92235.80c 4.4696E-02 92236.80c 1.2428E-04
      92238.80c 2.6732E-03 47107.80c 4.3400E-07 47109.80c 4.0320E-07
      56130.80c 4.3567E-13 56132.80c 4.1512E-13 56134.80c 9.9340E-12
      56135.80c 2.7093E-11 56136.80c 3.2280E-11 56137.80c 4.6164E-11
      56138.80c 2.9468E-10 83209.80c 8.8587E-06 06000.80c 4.6993E-06
      20040.80c 2.7305E-08 20042.80c 1.8223E-10 20043.80c 3.8024E-11
      20044.80c 5.8755E-10 20046.80c 1.1266E-12 20048.80c 5.2671E-11
      48106.80c 6.2763E-10 48108.80c 4.4687E-10 48110.80c 6.2713E-09
      48111.80c 6.4269E-09 48112.80c 1.2116E-08 48113.80c 6.1357E-09
      48114.80c 1.4425E-08 48116.80c 3.7608E-09 27059.80c 9.5773E-07
      24050.80c 6.6031E-08 24052.80c 1.2733E-06 24053.80c 1.4439E-07
      24054.80c 3.5941E-08 29063.80c 3.0719E-06 29065.80c 1.3692E-06
      19039.80c 2.6925E-08 19040.80c 3.3780E-12 19041.80c 1.9431E-09
      03006.80c 1.2344E-07 03007.80c 1.5029E-06 12024.80c 1.1006E-06
      12025.80c 1.3933E-07 12026.80c 1.5341E-07 25055.80c 1.1507E-05
      42092.80c 8.7305E-09 42094.80c 5.4418E-09 42095.80c 9.3658E-09
      42096.80c 9.8130E-09 42097.80c 5.6183E-09 42098.80c 1.4196E-08
      42100.80c 5.6889E-09 11023.80c 1.3258E-05 28058.80c 1.3093E-05
      28060.80c 5.0435E-06 28061.80c 2.1924E-07 28062.80c 6.9902E-07
      28064.80c 1.7802E-07 51121.80c 2.0155E-06 51123.80c 1.5075E-06
      22046.80c 1.9456E-08 22047.80c 1.7546E-08 22048.80c 1.7385E-07
      22049.80c 1.2758E-08 22050.80c 1.2216E-08 08016.80c 1.4106E-05
      08017.80c 5.3622E-09 07014.80c 2.4089E-05 07015.80c 8.8975E-08
```

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c Total 4.8081
c
c
c ---------- Part 2784 -----------
m21    92234.80c 4.7962E-04 92235.80c 4.4916E-02 92236.80c 1.2489E-04
       92238.80c 2.6864E-03 47107.80c 4.3614E-07 47109.80c 4.0519E-07
       56130.80c 4.3782E-13 56132.80c 4.1716E-13 56134.80c 9.9830E-12
       56135.80c 2.7227E-11 56136.80c 3.2440E-11 56137.80c 4.6392E-11
       56138.80c 2.9614E-10 83209.80c 8.9025E-06 06000.80c 4.7224E-06
       20040.80c 2.7439E-08 20042.80c 1.8313E-10 20043.80c 3.8212E-11
       20044.80c 5.9045E-10 20046.80c 1.1322E-12 20048.80c 5.2931E-11
       48106.80c 6.3073E-10 48108.80c 4.4908E-10 48110.80c 6.3023E-09
       48111.80c 6.4587E-09 48112.80c 1.2176E-08 48113.80c 6.1661E-09
       48114.80c 1.4497E-08 48116.80c 3.7794E-09 27059.80c 9.6246E-07
       24050.80c 6.6357E-08 24052.80c 1.2796E-06 24053.80c 1.4510E-07
       24054.80c 3.6119E-08 29063.80c 3.0870E-06 29065.80c 1.3759E-06
       19039.80c 2.7058E-08 19040.80c 3.3947E-12 19041.80c 1.9527E-09
       03006.80c 1.2405E-07 03007.80c 1.5103E-06 12024.80c 1.1060E-06
       12025.80c 1.4002E-07 12026.80c 1.5416E-07 25055.80c 1.1563E-05
       42092.80c 8.7736E-09 42094.80c 5.4687E-09 42095.80c 9.4121E-09
       42096.80c 9.8614E-09 42097.80c 5.6461E-09 42098.80c 1.4266E-08
       42100.80c 5.6934E-09 11023.80c 1.3323E-05 28058.80c 1.3159E-05
       28060.80c 5.0686E-06 28061.80c 2.2033E-07 28062.80c 7.0251E-07
       28064.80c 1.7891E-07 51121.80c 2.0256E-06 51123.80c 1.5151E-06
       22046.80c 1.9547E-08 22047.80c 1.7627E-08 22048.80c 1.7466E-07
       22049.80c 1.2818E-08 22050.80c 1.2273E-08 08016.80c 1.4175E-05
       08017.80c 5.3887E-09 07014.80c 2.4208E-05 07015.80c 8.9414E-08
c  Total 4.8318E-02
c
c --------- Part 2886 ----------------these isotopics were taken from Hmf071----------
m22    92234.80c 4.7684E-04 92235.80c 4.4656E-02 92236.80c 1.2417E-04
       92238.80c 2.6708E-03 47107.80c 4.3361E-07 47109.80c 4.0284E-07
       56130.80c 4.3528E-13 56132.80c 4.1474E-13 56134.80c 9.9251E-12
       56135.80c 2.7069E-11 56136.80c 3.2251E-11 56137.80c 4.6123E-11
       56138.80c 2.9442E-10 83209.80c 8.8508E-06 06000.80c 4.6951E-06
       20040.80c 2.7280E-08 20042.80c 1.8207E-10 20043.80c 3.7990E-11
       20044.80c 5.8702E-10 20046.80c 1.1256E-12 20048.80c 5.2624E-11
       48106.80c 6.2707E-10 48108.80c 4.4647E-10 48110.80c 6.2657E-09
       48111.80c 6.4212E-09 48112.80c 1.2105E-08 48113.80c 6.1302E-09
       48114.80c 1.4413E-08 48116.80c 3.7574E-09 27059.80c 9.5687E-07
       24050.80c 6.5972E-08 24052.80c 1.2722E-06 24053.80c 1.4426E-07
       24054.80c 3.5909E-08 29063.80c 3.0691E-06 29065.80c 1.3679E-06
       19039.80c 2.6901E-08 19040.80c 3.3750E-12 19041.80c 1.9414E-09
       03006.80c 1.2333E-07 03007.80c 1.5016E-06 12024.80c 1.0996E-06
       12025.80c 1.3921E-07 12026.80c 1.5327E-07 25055.80c 1.1496E-05
       42092.80c 8.7227E-09 42094.80c 5.4370E-09 42095.80c 9.3575E-09
       42096.80c 9.8042E-09 42097.80c 5.6133E-09 42098.80c 1.4183E-08
       42100.80c 5.6838E-09 11023.80c 1.3246E-05 28058.80c 1.3081E-05
       28060.80c 5.0389E-06 28061.80c 2.1904E-07 28062.80c 6.9839E-07
       28064.80c 1.7786E-07 51121.80c 2.0137E-06 51123.80c 1.5061E-06
       22046.80c 1.9438E-08 22047.80c 1.7530E-08 22048.80c 1.7370E-07
       22049.80c 1.2747E-08 22050.80c 1.2205E-08 08016.80c 1.4093E-05
       08017.80c 5.3574E-09 07014.80c 2.4067E-05 07015.80c 8.8895E-08
c Part Total 4.8038E-02
c
c --------- Part 2766 ---------
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m23    92234.80c 4.7348E-04 92235.80c 4.4817E-02 92236.80c 1.2934E-04
       92238.80c 2.6553E-03 47107.80c 4.3494E-07 47109.80c 4.0408E-07
       56130.80c 4.3661E-13 56132.80c 4.1602E-13 56134.80c 9.9556E-12
       56135.80c 2.7152E-11 56136.80c 3.2351E-11 56137.80c 4.6265E-11
       56138.80c 2.9532E-10 83209.80c 8.8780E-06 06000.80c 4.7094E-06
       20040.80c 2.7364E-08 20042.80c 1.8263E-10 20043.80c 3.8107E-11
       20044.80c 5.8882E-10 20046.80c 1.1291E-12 20048.80c 5.2785E-11
       48106.80c 6.2900E-10 48108.80c 4.4785E-10 48110.80c 6.2850E-09
       48111.80c 6.4410E-09 48112.80c 1.2142E-08 48113.80c 6.1491E-09
       48114.80c 1.4457E-08 48116.80c 3.7690E-09 27059.80c 9.5981E-07
       24050.80c 6.6175E-08 24052.80c 1.2761E-06 24053.80c 1.4470E-07
       24054.80c 3.6019E-08 29063.80c 3.0786E-06 29065.80c 1.3722E-06
       19039.80c 2.6984E-08 19040.80c 3.3854E-12 19041.80c 1.9474E-09
       03006.80c 1.2371E-07 03007.80c 1.5062E-06 12024.80c 1.1030E-06
       12025.80c 1.3964E-07 12026.80c 1.5374E-07 25055.80c 1.1532E-05
       42092.80c 8.7495E-09 42094.80c 5.4537E-09 42095.80c 9.3862E-09
       42096.80c 9.8343E-09 42097.80c 5.6305E-09 42098.80c 1.4227E-08
       42100.80c 5.6777E-09 11023.80c 1.3286E-05 28058.80c 1.3122E-05
       28060.80c 5.0547E-06 28061.80c 2.1972E-07 28062.80c 7.0058E-07
       28064.80c 1.7842E-07 51121.80c 2.0201E-06 51123.80c 1.5109E-06
       22046.80c 1.9493E-08 22047.80c 1.7579E-08 22048.80c 1.7418E-07
       22049.80c 1.2783E-08 22050.80c 1.2239E-08 08016.80c 1.4136E-05
       08017.80c 5.3739E-09 07014.80c 2.4141E-05 07015.80c 8.9168E-08
c Total 4.8186E-02
c
c
c ----------part 2787 ------------------isotopics taken from Hmf071.pdf--------
m24    92234.80c 4.7220E-04 92235.80c 4.4687E-02 92236.80c 1.1466E-04
       92238.80c 2.6718E-03 47107.80c 4.3377E-07 47109.80c 4.0299E-07
       56130.80c 4.3544E-13 56132.80c 4.1490E-13 56134.80c 9.9287E-12
       56135.80c 2.7079E-11 56136.80c 3.2263E-11 56137.80c 4.6140E-11
       56138.80c 2.9453E-10 83209.80c 8.8541E-06 06000.80c 4.6968E-06
       20040.80c 2.7290E-08 20042.80c 1.8214E-10 20043.80c 3.8004E-11
       20044.80c 5.8724E-10 20046.80c 1.1260E-12 20048.80c 5.2643E-11
       48106.80c 6.2730E-10 48108.80c 4.4664E-10 48110.80c 6.2680E-09
       48111.80c 6.4235E-09 48112.80c 1.2109E-08 48113.80c 6.1325E-09
       48114.80c 1.4418E-08 48116.80c 3.7588E-09 27059.80c 9.5722E-07
       24050.80c 6.5996E-08 24052.80c 1.2727E-06 24053.80c 1.4431E-07
       24054.80c 3.5922E-08 29063.80c 3.0702E-06 29065.80c 1.3685E-06
       19039.80c 2.6911E-08 19040.80c 3.3762E-12 19041.80c 1.9421E-09
       03006.80c 1.2337E-07 03007.80c 1.5021E-06 12024.80c 1.1000E-06
       12025.80c 1.3926E-07 12026.80c 1.5333E-07 25055.80c 1.1501E-05
       42092.80c 8.7259E-09 42094.80c 5.4390E-09 42095.80c 9.3609E-09
       42096.80c 9.8078E-09 42097.80c 5.6154E-09 42098.80c 1.4188E-08
       42100.80c 5.6859E-09 11023.80c 1.3251E-05 28058.80c 1.3086E-05
       28060.80c 5.0408E-06 28061.80c 2.1912E-07 28062.80c 6.9865E-07
       28064.80c 1.7793E-07 51121.80c 2.0144E-06 51123.80c 1.5067E-06
       22046.80c 1.9446E-08 22047.80c 1.7536E-08 22048.80c 1.7376E-07
       22049.80c 1.2752E-08 22050.80c 1.2209E-08 08016.80c 1.4098E-05
       08017.80c 5.3594E-09 07014.80c 2.4076E-05 07015.80c 8.8928E-08
c Total 4.8067E-02
c
c
c --------- Part 2760 ---------
m25    92234.80c 4.7814E-04 92235.80c 4.4787E-02 92236.80c 1.1493E-04
       92238.80c 2.6780E-03 47107.80c 4.3478E-07 47109.80c 4.0394E-07
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          56130.80c 4.3646E-13 56132.80c 4.1587E-13 56134.80c 9.9520E-12
          56135.80c 2.7143E-11 56136.80c 3.2339E-11 56137.80c 4.6248E-11
          56138.80c 2.9522E-10 83209.80c 8.8748E-06 06000.80c 4.7079E-06
          20040.80c 2.7354E-08 20042.80c 1.8257E-10 20043.80c 3.8093E-11
          20044.80c 5.8861E-10 20046.80c 1.1287E-12 20048.80c 5.2766E-11
          48106.80c 6.2877E-10 48108.80c 4.4768E-10 48110.80c 6.2827E-09
          48111.80c 6.4386E-09 48112.80c 1.2138E-08 48113.80c 6.1469E-09
          48114.80c 1.4452E-08 48116.80c 3.7676E-09 27059.80c 9.5947E-07
          24050.80c 6.6151E-08 24052.80c 1.2757E-06 24053.80c 1.4465E-07
          24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3717E-06
          19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9467E-09
          03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
          12025.80c 1.3959E-07 12026.80c 1.5369E-07 25055.80c 1.1528E-05
          42092.80c 8.7463E-09 42094.80c 5.4517E-09 42095.80c 9.3828E-09
          42096.80c 9.8308E-09 42097.80c 5.6285E-09 42098.80c 1.4222E-08
          42100.80c 5.6993E-09 11023.80c 1.3282E-05 28058.80c 1.3117E-05
          28060.80c 5.0526E-06 28061.80c 2.1963E-07 28062.80c 7.0029E-07
          28064.80c 1.7834E-07 51121.80c 2.0192E-06 51123.80c 1.5102E-06
          22046.80c 1.9491E-08 22047.80c 1.7578E-08 22048.80c 1.7417E-07
          22049.80c 1.2782E-08 22050.80c 1.2238E-08 08016.80c 1.4131E-05
          08017.80c 5.3719E-09 07014.80c 2.4133E-05 07015.80c 8.9136E-08
c Total 4.8168E-02
c
c ------------part 2786 -----------
m26    92234.80c 4.7669E-04 92235.80c 4.5112E-02 92236.80c 1.1575E-04
       92238.80c 2.6972E-03 47107.80c 4.3789E-07 47109.80c 4.0683E-07
       56130.80c 4.3958E-13 56132.80c 4.1884E-13 56134.80c 1.0023E-11
       56135.80c 2.7337E-11 56136.80c 3.2570E-11 56137.80c 4.6579E-11
       56138.80c 2.9733E-10 83209.80c 8.9383E-06 06000.80c 4.7415E-06
       20040.80c 2.7550E-08 20042.80c 1.8387E-10 20043.80c 3.8366E-11
       20044.80c 5.9282E-10 20046.80c 1.1368E-12 20048.80c 5.3144E-11
       48106.80c 6.3327E-10 48108.80c 4.5089E-10 48110.80c 6.3276E-09
       48111.80c 6.4847E-09 48112.80c 1.2225E-08 48113.80c 6.1908E-09
       48114.80c 1.4555E-08 48116.80c 3.7945E-09 27059.80c 9.6633E-07
       24050.80c 6.6624E-08 24052.80c 1.2848E-06 24053.80c 1.4568E-07
       24054.80c 3.6264E-08 29063.80c 3.0995E-06 29065.80c 1.3815E-06
       19039.80c 2.7167E-08 19040.80c 3.4084E-12 19041.80c 1.9606E-09
       03006.80c 1.2455E-07 03007.80c 1.5164E-06 12024.80c 1.1105E-06
       12025.80c 1.4059E-07 12026.80c 1.5479E-07 25055.80c 1.1610E-05
       42092.80c 8.8089E-09 42094.80c 5.4907E-09 42095.80c 9.4500E-09
       42096.80c 9.9011E-09 42097.80c 5.6688E-09 42098.80c 1.4323E-08
       42100.80c 5.7400E-09 11023.80c 1.3377E-05 28058.80c 1.3211E-05
       28060.80c 5.0888E-06 28061.80c 2.2120E-07 28062.80c 7.0530E-07
       28064.80c 1.7962E-07 51121.80c 2.0336E-06 51123.80c 1.5210E-06
       22046.80c 1.9631E-08 22047.80c 1.7703E-08 22048.80c 1.7541E-07
       22049.80c 1.2873E-08 22050.80c 1.2326E-08 08016.80c 1.4232E-05
       08017.80c 5.4104E-09 07014.80c 2.4305E-05 07015.80c 8.9774E-08
c Total 4.8513E-02
c
c ------------ part 2739 ----------
m27    92234.80c 4.6537E-04 92235.80c 4.4968E-02 92236.80c 1.2016E-04
       92238.80c 2.6832E-03 47107.80c 4.3640E-07 47109.80c 4.0544E-07
       56130.80c 4.3808E-13 56132.80c 4.1742E-13 56134.80c 9.9891E-12
       56135.80c 2.7244E-11 56136.80c 3.2459E-11 56137.80c 4.6420E-11
       56138.80c 2.9632E-10 83209.80c 8.9079E-06 06000.80c 4.7253E-06
       20040.80c 2.7456E-08 20042.80c 1.8325E-10 20043.80c 3.8235E-11
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      20044.80c 5.9080E-10 20046.80c 1.1329E-12 20048.80c 5.2963E-11
      48106.80c 6.3112E-10 48108.80c 4.4936E-10 48110.80c 6.3061E-09
      48111.80c 6.4627E-09 48112.80c 1.2183E-08 48113.80c 6.1698E-09
      48114.80c 1.4506E-08 48116.80c 3.7817E-09 27059.80c 9.6304E-07
      24050.80c 6.6398E-08 24052.80c 1.2804E-06 24053.80c 1.4519E-07
      24054.80c 3.6141E-08 29063.80c 3.0889E-06 29065.80c 1.3768E-06
      19039.80c 2.7075E-08 19040.80c 3.3968E-12 19041.80c 1.9539E-09
      03006.80c 1.2412E-07 03007.80c 1.5112E-06 12024.80c 1.1067E-06
      12025.80c 1.4011E-07 12026.80c 1.5426E-07 25055.80c 1.1570E-05
      42092.80c 8.7789E-09 42094.80c 5.4720E-09 42095.80c 9.4178E-09
      42096.80c 9.8674E-09 42097.80c 5.6495E-09 42098.80c 1.4275E-08
      42100.80c 5.6968E-09 11023.80c 1.3331E-05 28058.80c 1.3167E-05
      28060.80c 5.0717E-06 28061.80c 2.2046E-07 28062.80c 7.0294E-07
      28064.80c 1.7902E-07 51121.80c 2.0269E-06 51123.80c 1.5160E-06
      22046.80c 1.9558E-08 22047.80c 1.7638E-08 22048.80c 1.7477E-07
      22049.80c 1.2826E-08 22050.80c 1.2280E-08 08016.80c 1.4184E-05
      08017.80c 5.3919E-09 07014.80c 2.4223E-05 07015.80c 8.9468E-08
c  Total 4.8348E-02
c
c ---------- part 2761 ----------
m28    92234.80c 4.6350E-04 92235.80c 4.4768E-02 92236.80c 1.2925E-04
      92238.80c 2.6819E-03 47107.80c 4.3465E-07 47109.80c 4.0381E-07
      56130.80c 4.3632E-13 56132.80c 4.1574E-13 56134.80c 9.9489E-12
      56135.80c 2.7134E-11 56136.80c 3.2329E-11 56137.80c 4.6233E-11
      56138.80c 2.9512E-10 83209.80c 8.8720E-06 06000.80c 4.7062E-06
      20040.80c 2.7345E-08 20042.80c 1.8251E-10 20043.80c 3.8081E-11
      20044.80c 5.8842E-10 20046.80c 1.1283E-12 20048.80c 5.2749E-11
      48106.80c 6.2858E-10 48108.80c 4.4755E-10 48110.80c 6.2807E-09
      48111.80c 6.4366E-09 48112.80c 1.2134E-08 48113.80c 6.1450E-09
      48114.80c 1.4447E-08 48116.80c 3.7664E-09 27059.80c 9.5916E-07
      24050.80c 6.6130E-08 24052.80c 1.2753E-06 24053.80c 1.4460E-07
      24054.80c 3.5995E-08 29063.80c 3.0765E-06 29065.80c 1.3712E-06
      19039.80c 2.6966E-08 19040.80c 3.3831E-12 19041.80c 1.9460E-09
      03006.80c 1.2362E-07 03007.80c 1.5051E-06 12024.80c 1.1023E-06
      12025.80c 1.3954E-07 12026.80c 1.5364E-07 25055.80c 1.1524E-05
      42092.80c 8.7435E-09 42094.80c 5.4500E-09 42095.80c 9.3799E-09
      42096.80c 9.8276E-09 42097.80c 5.6267E-09 42098.80c 1.4217E-08
      42100.80c 5.6739E-09 11023.80c 1.3277E-05 28058.80c 1.3113E-05
      28060.80c 5.0513E-06 28061.80c 2.1958E-07 28062.80c 7.0011E-07
      28064.80c 1.7830E-07 51121.80c 2.0187E-06 51123.80c 1.5099E-06
      22046.80c 1.9480E-08 22047.80c 1.7567E-08 22048.80c 1.7407E-07
      22049.80c 1.2774E-08 22050.80c 1.2231E-08 08016.80c 1.4127E-05
      08017.80c 5.3702E-09 07014.80c 2.4125E-05 07015.80c 8.9108E-08
c  Total 4.8153E-02
c
c ---------- part 2785 ----------
m29   92234.80c 4.7235E-04 92235.80c 4.4701E-02 92236.80c 1.1469E-04
      92238.80c 2.6726E-03 47107.80c 4.3390E-07 47109.80c 4.0312E-07
      56130.80c 4.3557E-13 56132.80c 4.1503E-13 56134.80c 9.9318E-12
      56135.80c 2.7088E-11 56136.80c 3.2273E-11 56137.80c 4.6154E-11
      56138.80c 2.9462E-10 83209.80c 8.8568E-06 06000.80c 4.6982E-06
      20040.80c 2.7299E-08 20042.80c 1.8220E-10 20043.80c 3.8016E-11
      20044.80c 5.8742E-10 20046.80c 1.1264E-12 20048.80c 5.2659E-11
      48106.80c 6.2750E-10 48108.80c 4.4678E-10 48110.80c 6.2700E-09
      48111.80c 6.4255E-09 48112.80c 1.2113E-08 48113.80c 6.1344E-09
      48114.80c 1.4422E-08 48116.80c 3.7600E-09 27059.80c 9.5752E-07
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      24050.80c 6.6017E-08 24052.80c 1.2731E-06 24053.80c 1.4436E-07
      24054.80c 3.5933E-08 29063.80c 3.0712E-06 29065.80c 1.3689E-06
      19039.80c 2.6920E-08 19040.80c 3.3773E-12 19041.80c 1.9427E-09
      03006.80c 1.2341E-07 03007.80c 1.5026E-06 12024.80c 1.1004E-06
      12025.80c 1.3930E-07 12026.80c 1.5337E-07 25055.80c 1.1504E-05
      42092.80c 8.7286E-09 42094.80c 5.4407E-09 42095.80c 9.3638E-09
      42096.80c 9.8108E-09 42097.80c 5.6171E-09 42098.80c 1.4193E-08
      42100.80c 5.6642E-09 11023.80c 1.3255E-05 28058.80c 1.3091E-05
      28060.80c 5.0426E-06 28061.80c 2.1920E-07 28062.80c 6.9891E-07
      28064.80c 1.7799E-07 51121.80c 2.0152E-06 51123.80c 1.5073E-06
      22046.80c 1.9446E-08 22047.80c 1.7537E-08 22048.80c 1.7377E-07
      22049.80c 1.2752E-08 22050.80c 1.2210E-08 08016.80c 1.4103E-05
      08017.80c 5.3610E-09 07014.80c 2.4084E-05 07015.80c 8.8955E-08
c  Total 4.8071E-02
c
c ---------- part 2848 ----------
m30    92234.80c 4.6734E-04 92235.80c 4.4697E-02 92236.80c 1.1465E-04
      92238.80c 2.6620E-03 47107.80c 4.3373E-07 47109.80c 4.0295E-07
      56130.80c 4.3539E-13 56132.80c 4.1486E-13 56134.80c 9.9278E-12
      56135.80c 2.7077E-11 56136.80c 3.2260E-11 56137.80c 4.6135E-11
      56138.80c 2.9450E-10 83209.80c 8.8532E-06 06000.80c 4.6964E-06
      20040.80c 2.7287E-08 20042.80c 1.8212E-10 20043.80c 3.8001E-11
      20044.80c 5.8718E-10 20046.80c 1.1259E-12 20048.80c 5.2638E-11
      48106.80c 6.2724E-10 48108.80c 4.4659E-10 48110.80c 6.2674E-09
      48111.80c 6.4229E-09 48112.80c 1.2108E-08 48113.80c 6.1319E-09
      48114.80c 1.4416E-08 48116.80c 3.7584E-09 27059.80c 9.5713E-07
      24050.80c 6.5990E-08 24052.80c 1.2726E-06 24053.80c 1.4430E-07
      24054.80c 3.5919E-08 29063.80c 3.0700E-06 29065.80c 1.3683E-06
      19039.80c 2.6909E-08 19040.80c 3.3759E-12 19041.80c 1.9419E-09
      03006.80c 1.2336E-07 03007.80c 1.5020E-06 12024.80c 1.0999E-06
      12025.80c 1.3925E-07 12026.80c 1.5331E-07 25055.80c 1.1499E-05
      42092.80c 8.7250E-09 42094.80c 5.4384E-09 42095.80c 9.3600E-09
      42096.80c 9.8068E-09 42097.80c 5.6148E-09 42098.80c 1.4187E-08
      42100.80c 5.6854E-09 11023.80c 1.3249E-05 28058.80c 1.3085E-05
      28060.80c 5.0403E-06 28061.80c 2.1910E-07 28062.80c 6.9858E-07
      28064.80c 1.7791E-07 51121.80c 2.0142E-06 51123.80c 1.5065E-06
      22046.80c 1.9444E-08 22047.80c 1.7535E-08 22048.80c 1.7374E-07
      22049.80c 1.2750E-08 22050.80c 1.2208E-08 08016.80c 1.4097E-05
      08017.80c 5.3589E-09 07014.80c 2.4074E-05 07015.80c 8.8919E-08
c Total 4.8051E-02
c
c ---------- part 2735 ----------
m31    92234.80c 4.7169E-04 92235.80c 4.4629E-02 92236.80c 1.1931E-04
      92238.80c 2.6736E-03 47107.80c 4.3330E-07 47109.80c 4.0256E-07
      56130.80c 4.3497E-13 56132.80c 4.1445E-13 56134.80c 9.9181E-12
      56135.80c 2.7050E-11 56136.80c 3.2229E-11 56137.80c 4.6090E-11
      56138.80c 2.9421E-10 83209.80c 8.8445E-06 06000.80c 4.6917E-06
      20040.80c 2.7261E-08 20042.80c 1.8194E-10 20043.80c 3.7963E-11
      20044.80c 5.8660E-10 20046.80c 1.1248E-12 20048.80c 5.2586E-11
      48106.80c 6.2663E-10 48108.80c 4.4616E-10 48110.80c 6.2613E-09
      48111.80c 6.4167E-09 48112.80c 1.2096E-08 48113.80c 6.1259E-09
      48114.80c 1.4402E-08 48116.80c 3.7548E-09 27059.80c 9.5620E-07
      24050.80c 6.5926E-08 24052.80c 1.2713E-06 24053.80c 1.4416E-07
      24054.80c 3.5884E-08 29063.80c 3.0669E-06 29065.80c 1.3670E-06
      19039.80c 2.6882E-08 19040.80c 3.3726E-12 19041.80c 1.9400E-09
      03006.80c 1.2324E-07 03007.80c 1.5005E-06 12024.80c 1.0988E-06
```

```
      12025.80c 1.3911E-07 12026.80c 1.5316E-07 25055.80c 1.1488E-05
      42092.80c 8.7165E-09 42094.80c 5.4331E-09 42095.80c 9.3508E-09
      42096.80c 9.7972E-09 42097.80c 5.6093E-09 42098.80c 1.4173E-08
      42100.80c 5.6563E-09 11023.80c 1.3236E-05 28058.80c 1.3073E-05
      28060.80c 5.0357E-06 28061.80c 2.1890E-07 28062.80c 6.9794E-07
      28064.80c 1.7774E-07 51121.80c 2.0124E-06 51123.80c 1.5052E-06
      22046.80c 1.9419E-08 22047.80c 1.7513E-08 22048.80c 1.7353E-07
      22049.80c 1.2734E-08 22050.80c 1.2193E-08 08016.80c 1.4083E-05
      08017.80c 5.3536E-09 07014.80c 2.4050E-05 07015.80c 8.8832E-08
c  Total 4.8004E-02
c
c
c --- Control Cards ------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc  15.0 0.0 0.1   15.0 0.0 -0.1   15.0 0.0 1.0
     15.0 0.0 -1.0  15.0 0.0 2.0    15.0 0.0 -2.0
    -15.0 0.0 0.1  -15.0 0.0 -1.0  -15.0 0.0 1.0
    -15.0 0.0 2.0  -15.0 0.0 -2.0
c
c
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

HEU Cylinders-------   9" - 15" bare annuli  (CONFIGURATION 3 – SIMPLE MODEL)
c
c  ----------Cell Cards---------------------------
c
1     1   4.7838E-02  1  -9 11 -19  imp:n=1  $
c
c         VOID SPACES and Gaps
24    0  151 -152 -150  #1 imp:n=1   $ inner void
25    0  -151:152:150      imp:n=0   $ greater void

c  ------------Surface Cards (cm)----------------------------------
c
c    PLANES
1    pz  0.0       $ bottom
9    pz  15.06982  $ top; 2 inch below diaphragm + 3.9 inches above diaphragm (top height was averaged)
11   cz  11.43     $ 4.5 inch inner diameter
19   cz  19.05     $ 7.5 inch outer diameter
c
150  cz   19.06 $---------------Problem Boundary
151  pz   -0.1
152  pz   15.1  $--------------------------------

c  ------------Data Cards-----------------------------------------
c
c  --------- simple model ---------
m1    92234.80c   4.6720E-04
      92235.80c   4.4589E-02
      92236.80c   1.1426E-04
      92238.80c   2.6671E-03
c total     4.7838E-02
c
c  --- Control Cards ------------------------------------------------------
mode n
```

```
kcode 1000000 1 50 1050
ksrc 12.0 0.0 0.1   12.0 0.0 10.0  12.0 0.0 1.0
     12.0 0.0 10.0  12.0 0.0 2.0   12.0 0.0 10.0
     -12.0 0.0 0.1  -12.0 0.0 1.0  -12.0 0.0 -10.0
     -12.0 0.0 2.0  -12.0 0.0 10.0
*********************************************************************************
HEU Cylinders-------- 7" - 11" (CONFIGURATION 4 – DETAILED MODEL)
c
c ----------Cell Cards---------------------------
c
c     7" disks above diaphragm
4     4   4.8045E-02   6   -7   -14     imp:n=1 $ part 2732
c     7" disks below diaphragm
3     3   4.8115E-02   205 -206 -11      imp:n=1 $ part 2769
5     5   4.8078E-02   3   -4   -16     imp:n=1 $ part 2731
6     6   4.8085E-02   1   -2   -12     imp:n=1 $ part 2770
c     7" - 9" annulus above diaphragm
7     7   4.7943E-02  72  -73    44   -55   imp:n=1 $ part 2763
8     8   4.8043E-02  70  -71    45   -56   imp:n=1 $ part 2773
9     9   4.8238E-02  41  -42    46   -57   imp:n=1 $ part 2774
10    10  4.8217E-02  39  -40    47   -58   imp:n=1 $ part 2775
11    11  4.8071E-02  37  -38    48   -59   imp:n=1 $ part 2736
12    12  4.8134E-02  35  -36    49   -60   imp:n=1 $ part 2737
13    13  4.8154E-02  34  -35    50   -61   imp:n=1 $ part 2738
14    14  4.8191E-02  33  -34    51   -62   imp:n=1 $ part 2762
c     7" - 9" annulus below diaphragm
15    15  4.8168E-02  32  -33    52   -63   imp:n=1 $ part 2741
16    16  4.8088E-02  31  -32    53   -64   imp:n=1 $ part 2829
17    17  4.8185E-02  30  -31    54   -65   imp:n=1 $ part 2740
c     9" - 11" annulus above diaphragm
18    18  4.8076E-02 130 -131    99  -110   imp:n=1 $ part 2746
19    19  4.8301E-02  97  -98   100  -111   imp:n=1 $ part 2744
20    20  4.8090E-02  95  -96   101  -112   imp:n=1 $ part 2779
21    21  4.7994E-02  93  -94   102  -113   imp:n=1 $ part 2778
22    22  4.8386E-02  91  -92   103  -114   imp:n=1 $ part 2743
23    23  4.8090E-02  88  -89   104  -115   imp:n=1 $ part 2767
24    24  4.8103E-02  86  -87   105  -116   imp:n=1 $ part 2776
25    25  4.8163E-02  84  -85   106  -117   imp:n=1 $ part 2745
c     9" - 11" annulus below diaphragm
26    26  4.8157E-02  82  -83   107  -118   imp:n=1 $ part 2748
27    27  4.8161E-02  81  -82   108  -119   imp:n=1 $ part 2742
28    28  4.8082E-02  80  -81   109  -120   imp:n=1 $ part 2747
c
c ---------------- plate --------------------
29    29  4.8127E-02    36  -37  -140    imp:n=1 $ part 2803
c        VOID SPACES and Gaps
30    0  151  -152  -150 #1  #2 #3 #4 $ lesser void
       #5 #6  #7 #8 #9 #10 #11
       #12 #13 #14 #15 #16 #17
       #18 #19 #20 #21 #22 #23
       #24 #25 #26 #27 #28 #29 imp:n=1
31    0  -151:152:150  imp:n=0              $ greater void

c  ------------Surface Cards (cm)----------------------------------
c
c     7" DISKS planes
```

```
1    pz  -8.576437  $ part 2770
2    pz  -7.940802  $ gap
3    pz  -7.939151  $ part 2731
4    pz  -5.392293  $ gap
205  pz  -5.390642  $ part 2769
206  pz  -5.069332  $ gap/void
5    pz   0.0000    $ diaphragm
6    pz   7.137908  $ top of part 2803 the metal 11" disk----------same height for all
7    pz   9.681083  $ top of part 2732
c     7" DISKS cylinders
11   cz   8.885555  $ part 2769
12   cz   8.884539  $ part 2770
14   cz   8.88492   $ part 2732
16   cz   8.885555  $ part 2731
c
c     7" - 9" BARE ANNULUS
c    PLANES
30   pz  -8.576437  $ part 2740
31   pz  -4.766437  $ part 2829
32   pz  -3.810762  $ part 2741
33   pz   0.0000    $ diaphragm
34   pz   2.538095  $ part 2762
35   pz   5.081143  $ part 2738
36   pz   6.509893  $ part 2737
37   pz   7.137908  $ top of part 2803 ---------- 11" metal disk
38   pz   8.093837  $ top of part 2736
39   pz   8.096599  $ top of gap
40   pz   8.727789  $ top of part 2775
41   pz   8.730551  $ top of gap
42   pz   9.365551  $ top of part 2774
70   pz   9.368314  $ top of gap
71   pz   9.685814  $ top of part 2773
72   pz   9.688576  $ top of gap
73   pz  10.004298  $ top of part 2763
c    INNER RADII
44   cz   8.894826  $ part 2763
45   cz   8.891905  $ part 2773
46   cz   8.89381   $ part 2774
47   cz   8.89508   $ part 2775
48   cz   8.893302  $ part 2736
49   cz   8.891905  $ part 2737
50   cz   8.894763  $ part 2738
51   cz   8.894763  $ part 2762
52   cz   8.893175  $ part 2741
53   cz   8.894001  $ part 2829
54   cz   8.893175  $ part 2740
c    OUTER RADII
55   cz   11.424666  $ part 2763
56   cz   11.42619   $ part 2773
57   cz   11.425555  $ part 2774
58   cz   11.425873  $ part 2775
59   cz   11.42492   $ part 2736
60   cz   11.425555  $ part 2737
61   cz   11.424603  $ part 2738
62   cz   11.425238  $ part 2762
63   cz   11.425555  $ part 2741
```

```
64   cz   11.425238  $ part 2829
65   cz   11.425238  $ part 2740
c
c    9" - 11" BARE ANNULUS
c    PLANES
80   pz  -8.576437  $ part 2747
81   pz  -4.766691  $ part 2742
82   pz  -3.813937  $ part 2748
83   pz  -0.003937  $ gap
84   pz   0.0000    $ diaphragm
85   pz   2.53746   $ top of part 2745
86   pz   2.537841  $ top of gap
87   pz   5.081651  $ top of part 2776
88   pz   5.082032  $ top of gap
89   pz   6.509512  $ top of part 2767
90   pz   6.509893  $ top of gap
91   pz   7.137908  $ top of part 2803 ----------metal 11" disk
92   pz   8.087868  $ top of part 2743
93   pz   8.091535  $ top of gap
94   pz   8.729075  $ top of part 2778
95   pz   8.732742  $ top of gap
96   pz   9.370282  $ top of part 2779
97   pz   9.373949  $ top of gap
98   pz   9.691449  $ top of part 2246
130  pz   9.695116  $ top of gap
131  pz  10.021887  $ top of part 2746
c    INNER RADII
99   cz  11.432223  $ part 2746
100  cz  11.438255  $ part 2744
101  cz  11.431905  $ part 2779
102  cz  11.43254   $ part 2778
103  cz  11.433175  $ part 2743
104  cz  11.43127   $ part 2767
105  cz  11.431905  $ part 2776
106  cz  11.43127   $ part 2745
107  cz  11.433175  $ part 2748
108  cz  11.431905  $ part 2742
109  cz  11.43254   $ part 2747
c    OUTER RADII
110  cz  13.965555  $ part 2746
111  cz  13.965936  $ part 2744
112  cz  13.96619   $ part 2779
113  cz  13.965555  $ part 2778
114  cz  13.965555  $ part 2743
115  cz  13.96492   $ part 2767
116  cz  13.965555  $ part 2776
117  cz  13.965555  $ part 2745
118  cz  13.966825  $ part 2748
119  cz  13.965873  $ part 2742
120  cz  13.965873  $ part 2747
c
140  cz  13.965555  $ part 2803
c
150  cz   13.97 $----------Problem Boundary
151  pz   -8.58
152  pz   10.03 $--------------------------------
```

```
c  ------------Data Cards-----------------------------------------
c ------- 7" DISKS ---------------
c
c
c ---------- part 2769 ---------
m3       92234.80c     4.4384E-04
     92235.80c     4.4723E-02
     92236.80c     9.5668E-05
     92238.80c     2.7415E-03
     47107.80c     4.3431E-07
     47109.80c     4.0349E-07
     56130.80c     4.3598E-13
     56132.80c     4.1541E-13
     56134.80c     9.9412E-12
     56135.80c     2.7113E-11
     56136.80c     3.2304E-11
     56137.80c     4.6197E-11
     56138.80c     2.9489E-10
     83209.80c     8.8651E-06
     6000.80c     4.7027E-06
     20040.80c     2.7324E-08
     20042.80c     1.8237E-10
     20043.80c     3.8052E-11
     20044.80c     5.8797E-10
     20046.80c     1.1275E-12
     20048.80c     5.2709E-11
     48106.80c     6.2808E-10
     48108.80c     4.4720E-10
     48110.80c     6.2758E-09
     48111.80c     6.4316E-09
     48112.80c     1.2125E-08
     48113.80c     6.1401E-09
     48114.80c     1.4436E-08
     48116.80c     3.7635E-09
     27059.80c     9.5842E-07
     24050.80c     6.6079E-08
     24052.80c     1.2743E-06
     24053.80c     1.4449E-07
     24054.80c     3.5967E-08
     29063.80c     3.0741E-06
     29065.80c     1.3702E-06
     19039.80c     2.6945E-08
     19040.80c     3.3804E-12
     19041.80c     1.9445E-09
     3006.80c     1.2353E-07
     3007.80c     1.5040E-06
     12024.80c     1.1014E-06
     12025.80c     1.3943E-07
     12026.80c     1.5352E-07
     25055.80c     1.1515E-05
     42092.80c     8.7368E-09
     42094.80c     5.4458E-09
     42095.80c     9.3726E-09
     42096.80c     9.8200E-09
     42097.80c     5.6224E-09
```

```
     42098.80c    1.4206E-08
     42100.80c    5.6930E-09
     11023.80c    1.3267E-05
     28058.80c    1.3103E-05
     28060.80c    5.0471E-06
     28061.80c    2.1939E-07
     28062.80c    6.9952E-07
     28064.80c    1.7815E-07
     51121.80c    2.0170E-06
     51123.80c    1.5086E-06
     22046.80c    1.9470E-08
     22047.80c    1.7558E-08
     22048.80c    1.7398E-07
     22049.80c    1.2768E-08
     22050.80c    1.2225E-08
     8016.80c    1.4116E-05
     8017.80c    5.3661E-09
     7014.80c    2.4106E-05
     7015.80c    8.9039E-08
c
c ------------------part 2732 ----
m4   92234.80c    4.5765E-04
     92235.80c    4.4692E-02
     92236.80c    1.0030E-04
     92238.80c    2.6854E-03
     47107.80c    4.3368E-07
     47109.80c    4.0291E-07
     56130.80c    4.3534E-13
     56132.80c    4.1481E-13
     56134.80c    9.9266E-12
     56135.80c    2.7073E-11
     56136.80c    3.2256E-11
     56137.80c    4.6130E-11
     56138.80c    2.9446E-10
     83209.80c    8.8522E-06
     6000.80c    4.6958E-06
     20040.80c    2.7284E-08
     20042.80c    1.8210E-10
     20043.80c    3.7996E-11
     20044.80c    5.8711E-10
     20046.80c    1.1258E-12
     20048.80c    5.2632E-11
     48106.80c    6.2717E-10
     48108.80c    4.4654E-10
     48110.80c    6.2666E-09
     48111.80c    6.4222E-09
     48112.80c    1.2107E-08
     48113.80c    6.1312E-09
     48114.80c    1.4415E-08
     48116.80c    3.7580E-09
     27059.80c    9.5702E-07
     24050.80c    6.5983E-08
     24052.80c    1.2724E-06
     24053.80c    1.4428E-07
     24054.80c    3.5915E-08
     29063.80c    3.0696E-06
```

```
     29065.80c    1.3682E-06
     19039.80c    2.6905E-08
     19040.80c    3.3755E-12
     19041.80c    1.9417E-09
     3006.80c    1.2335E-07
     3007.80c    1.5018E-06
     12024.80c    1.0998E-06
     12025.80c    1.3923E-07
     12026.80c    1.5329E-07
     25055.80c    1.1498E-05
     42092.80c    8.7240E-09
     42094.80c    5.4378E-09
     42095.80c    9.3589E-09
     42096.80c    9.8057E-09
     42097.80c    5.6142E-09
     42098.80c    1.4185E-08
     42100.80c    5.6847E-09
     11023.80c    1.3248E-05
     28058.80c    1.3083E-05
     28060.80c    5.0397E-06
     28061.80c    2.1907E-07
     28062.80c    6.9850E-07
     28064.80c    1.7789E-07
     51121.80c    2.0140E-06
     51123.80c    1.5064E-06
     22046.80c    1.9441E-08
     22047.80c    1.7533E-08
     22048.80c    1.7372E-07
     22049.80c    1.2749E-08
     22050.80c    1.2207E-08
     8016.80c    1.4095E-05
     8017.80c    5.3582E-09
     7014.80c    2.4071E-05
     7015.80c    8.8909E-08
c
c ---------- part 2731 ---------
m5        92234.80c    4.4350E-04
     92235.80c    4.4679E-02
     92236.80c    8.1255E-05
     92238.80c    2.7631E-03
     47107.80c    4.3398E-07
     47109.80c    4.0319E-07
     56130.80c    4.3564E-13
     56132.80c    4.1510E-13
     56134.80c    9.9335E-12
     56135.80c    2.7092E-11
     56136.80c    3.2279E-11
     56137.80c    4.6162E-11
     56138.80c    2.9467E-10
     83209.80c    8.8583E-06
     6000.80c    4.6991E-06
     20040.80c    2.7303E-08
     20042.80c    1.8223E-10
     20043.80c    3.8022E-11
     20044.80c    5.8752E-10
     20046.80c    1.1266E-12
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     20048.80c     5.2668E-11
     48106.80c     6.2760E-10
     48108.80c     4.4685E-10
     48110.80c     6.2710E-09
     48111.80c     6.4266E-09
     48112.80c     1.2115E-08
     48113.80c     6.1354E-09
     48114.80c     1.4425E-08
     48116.80c     3.7606E-09
     27059.80c     9.5768E-07
     24050.80c     6.6028E-08
     24052.80c     1.2733E-06
     24053.80c     1.4438E-07
     24054.80c     3.5939E-08
     29063.80c     3.0717E-06
     29065.80c     1.3691E-06
     19039.80c     2.6924E-08
     19040.80c     3.3779E-12
     19041.80c     1.9430E-09
     3006.80c     1.2343E-07
     3007.80c     1.5028E-06
     12024.80c     1.1006E-06
     12025.80c     1.3933E-07
     12026.80c     1.5340E-07
     25055.80c     1.1506E-05
     42092.80c     8.7301E-09
     42094.80c     5.4416E-09
     42095.80c     9.3654E-09
     42096.80c     9.8125E-09
     42097.80c     5.6181E-09
     42098.80c     1.4195E-08
     42100.80c     5.6887E-09
     11023.80c     1.3257E-05
     28058.80c     1.3093E-05
     28060.80c     5.0432E-06
     28061.80c     2.1923E-07
     28062.80c     6.9899E-07
     28064.80c     1.7801E-07
     51121.80c     2.0154E-06
     51123.80c     1.5074E-06
     22046.80c     1.9455E-08
     22047.80c     1.7545E-08
     22048.80c     1.7384E-07
     22049.80c     1.2758E-08
     22050.80c     1.2215E-08
     8016.80c     1.4105E-05
     8017.80c     5.3619E-09
     7014.80c     2.4088E-05
     7015.80c     8.8970E-08
c
c
c ---------- part 2770 ---------
m6         92234.80c     4.5321E-04
     92235.80c     4.4686E-02
     92236.80c     1.0039E-04
     92238.80c     2.7351E-03
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47107.80c 4.3404E-07
47109.80c 4.0325E-07
56130.80c 4.3571E-13
56132.80c 4.1516E-13
56134.80c 9.9350E-12
56135.80c 2.7096E-11
56136.80c 3.2284E-11
56137.80c 4.6169E-11
56138.80c 2.9471E-10
83209.80c 8.8596E-06
6000.80c 4.6998E-06
20040.80c 2.7307E-08
20042.80c 1.8225E-10
20043.80c 3.8028E-11
20044.80c 5.8761E-10
20046.80c 1.1268E-12
20048.80c 5.2676E-11
48106.80c 6.2770E-10
48108.80c 4.4692E-10
48110.80c 6.2719E-09
48111.80c 6.4276E-09
48112.80c 1.2117E-08
48113.80c 6.1364E-09
48114.80c 1.4427E-08
48116.80c 3.7612E-09
27059.80c 9.5783E-07
24050.80c 6.6038E-08
24052.80c 1.2735E-06
24053.80c 1.4440E-07
24054.80c 3.5945E-08
29063.80c 3.0722E-06
29065.80c 1.3693E-06
19039.80c 2.6928E-08
19040.80c 3.3784E-12
19041.80c 1.9433E-09
3006.80c 1.2345E-07
3007.80c 1.5031E-06
12024.80c 1.1007E-06
12025.80c 1.3935E-07
12026.80c 1.5342E-07
25055.80c 1.1508E-05
42092.80c 8.7314E-09
42094.80c 5.4424E-09
42095.80c 9.3668E-09
42096.80c 9.8140E-09
42097.80c 5.6189E-09
42098.80c 1.4197E-08
42100.80c 5.6895E-09
11023.80c 1.3259E-05
28058.80c 1.3094E-05
28060.80c 5.0440E-06
28061.80c 2.1926E-07
28062.80c 6.9909E-07
28064.80c 1.7804E-07
51121.80c 2.0157E-06
51123.80c 1.5076E-06

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     22046.80c     1.9458E-08
     22047.80c     1.7547E-08
     22048.80c     1.7387E-07
     22049.80c     1.2760E-08
     22050.80c     1.2217E-08
     8016.80c     1.4107E-05
     8017.80c     5.3628E-09
     7014.80c     2.4091E-05
     7015.80c     8.8984E-08
c
c ------ 7"-9" HEU Annulus ------
c  --------- Part 2763 ---------
m7      92234.80c 4.6147E-04 92235.80c 4.4601E-02 92236.80c 1.1915E-04
        92238.80c 2.6513E-03 47107.80c 4.3275E-07 47109.80c 4.0204E-07
        56130.80c 4.3441E-13 56132.80c 4.1392E-13 56134.80c 9.9054E-12
        56135.80c 2.7015E-11 56136.80c 3.2187E-11 56137.80c 4.6031E-11
        56138.80c 2.9383E-10 83209.80c 8.8332E-06 06000.80c 4.6857E-06
        20040.80c 2.7226E-08 20042.80c 1.8171E-10 20043.80c 3.7915E-11
        20044.80c 5.8585E-10 20046.80c 1.1234E-12 20048.80c 5.2519E-11
        48106.80c 6.2583E-10 48108.80c 4.4559E-10 48110.80c 6.2533E-09
        48111.80c 6.4085E-09 48112.80c 1.2081E-08 48113.80c 6.1181E-09
        48114.80c 1.4384E-08 48116.80c 3.7500E-09 27059.80c 9.5497E-07
        24050.80c 6.5841E-08 24052.80c 1.2697E-06 24053.80c 1.4397E-07
        24054.80c 3.5838E-08 29063.80c 3.0630E-06 29065.80c 1.3652E-06
        19039.80c 2.6848E-08 19040.80c 3.3683E-12 19041.80c 1.9375E-09
        03006.80c 1.2308E-07 03007.80c 1.4986E-06 12024.80c 1.0974E-06
        12025.80c 1.3893E-07 12026.80c 1.5297E-07 25055.80c 1.1473E-05
        42092.80c 8.7053E-09 42094.80c 5.4262E-09 42095.80c 9.3389E-09
        42096.80c 9.7847E-09 42097.80c 5.6021E-09 42098.80c 1.4155E-08
        42100.80c 5.6491E-09 11023.80c 1.3219E-05 28058.80c 1.3056E-05
        28060.80c 5.0292E-06 28061.80c 2.1862E-07 28062.80c 6.9704E-07
        28064.80c 1.7752E-07 51121.80c 2.0099E-06 51123.80c 1.5033E-06
        22046.80c 1.9395E-08 22047.80c 1.7490E-08 22048.80c 1.7331E-07
        22049.80c 1.2718E-08 22050.80c 1.2177E-08 08016.80c 1.4065E-05
        08017.80c 5.3468E-09 07014.80c 2.4020E-05 07015.80c 8.8718E-08
c  Total 4.7943E-02
c
c  --------- Part 2773 ---------
m8          92234.80c   4.6726E-04
     92235.80c   4.4689E-02
     92236.80c   1.1463E-04
     92238.80c   2.6616E-03
     47107.80c   4.3365E-07
     47109.80c   4.0289E-07
     56130.80c   4.3532E-13
     56132.80c   4.1479E-13
     56134.80c   9.9262E-12
     56135.80c   2.7072E-11
     56136.80c   3.2255E-11
     56137.80c   4.6128E-11
     56138.80c   2.9445E-10
     83209.80c   8.8518E-06
     6000.80c   4.6956E-06
     20040.80c   2.7283E-08
     20042.80c   1.8209E-10
     20043.80c   3.7994E-11
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     20044.80c   5.8708E-10
     20046.80c   1.1258E-12
     20048.80c   5.2629E-11
     48106.80c   6.2714E-10
     48108.80c   4.4652E-10
     48110.80c   6.2663E-09
     48111.80c   6.4219E-09
     48112.80c   1.2106E-08
     48113.80c   6.1309E-09
     48114.80c   1.4414E-08
     48116.80c   3.7578E-09
     27059.80c   9.5698E-07
     24050.80c   6.5979E-08
     24052.80c   1.2723E-06
     24053.80c   1.4427E-07
     24054.80c   3.5913E-08
     29063.80c   3.0694E-06
     29065.80c   1.3681E-06
     19039.80c   2.6904E-08
     19040.80c   3.3754E-12
     19041.80c   1.9416E-09
     3006.80c   1.2334E-07
     3007.80c   1.5017E-06
     12024.80c   1.0997E-06
     12025.80c   1.3922E-07
     12026.80c   1.5329E-07
     25055.80c   1.1498E-05
     42092.80c   8.7236E-09
     42094.80c   5.4375E-09
     42095.80c   9.3585E-09
     42096.80c   9.8052E-09
     42097.80c   5.6139E-09
     42098.80c   1.4185E-08
     42100.80c   5.6844E-09
     11023.80c   1.3247E-05
     28058.80c   1.3083E-05
     28060.80c   5.0395E-06
     28061.80c   2.1906E-07
     28062.80c   6.9847E-07
     28064.80c   1.7788E-07
     51121.80c   2.0139E-06
     51123.80c   1.5063E-06
     22046.80c   1.9441E-08
     22047.80c   1.7532E-08
     22048.80c   1.7372E-07
     22049.80c   1.2748E-08
     22050.80c   1.2206E-08
     8016.80c   1.4095E-05
     8017.80c   5.3580E-09
     7014.80c   2.4070E-05
     7015.80c   8.8905E-08
c
c  --------- Part 2774 ---------
m9        92234.80c   4.7883E-04
     92235.80c   4.4828E-02
     92236.80c   1.3907E-04
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92238.80c 2.6819E-03
47107.80c 4.3542E-07
47109.80c 4.0452E-07
56130.80c 4.3709E-13
56132.80c 4.1647E-13
56134.80c 9.9665E-12
56135.80c 2.7182E-11
56136.80c 3.2386E-11
56137.80c 4.6315E-11
56138.80c 2.9565E-10
83209.80c 8.8877E-06
6000.80c 4.7147E-06
20040.80c 2.7394E-08
20042.80c 1.8283E-10
20043.80c 3.8149E-11
20044.80c 5.8947E-10
20046.80c 1.1303E-12
20048.80c 5.2843E-11
48106.80c 6.2968E-10
48108.80c 4.4834E-10
48110.80c 6.2918E-09
48111.80c 6.4480E-09
48112.80c 1.2155E-08
48113.80c 6.1558E-09
48114.80c 1.4473E-08
48116.80c 3.7731E-09
27059.80c 9.6086E-07
24050.80c 6.6247E-08
24052.80c 1.2775E-06
24053.80c 1.4486E-07
24054.80c 3.6059E-08
29063.80c 3.0819E-06
29065.80c 1.3737E-06
19039.80c 2.7013E-08
19040.80c 3.3891E-12
19041.80c 1.9495E-09
3006.80c 1.2384E-07
3007.80c 1.5078E-06
12024.80c 1.1042E-06
12025.80c 1.3979E-07
12026.80c 1.5391E-07
25055.80c 1.1544E-05
42092.80c 8.7590E-09
42094.80c 5.4596E-09
42095.80c 9.3965E-09
42096.80c 9.8450E-09
42097.80c 5.6367E-09
42098.80c 1.4242E-08
42100.80c 5.7075E-09
11023.80c 1.3301E-05
28058.80c 1.3136E-05
28060.80c 5.0600E-06
28061.80c 2.1995E-07
28062.80c 7.0131E-07
28064.80c 1.7860E-07
51121.80c 2.0221E-06

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     51123.80c   1.5124E-06
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     22047.80c   1.7603E-08
     22048.80c   1.7442E-07
     22049.80c   1.2800E-08
     22050.80c   1.2256E-08
     8016.80c   1.4152E-05
     8017.80c   5.3797E-09
     7014.80c   2.4168E-05
     7015.80c   8.9266E-08
c
c  --------- Part 2775 ---------
m10        92234.80c     4.7378E-04
     92235.80c     4.4817E-02
     92236.80c     9.1076E-05
     92238.80c     2.7235E-03
     47107.80c     4.3522E-07
     47109.80c     4.0434E-07
     56130.80c     4.3690E-13
     56132.80c     4.1629E-13
     56134.80c     9.9621E-12
     56135.80c     2.7170E-11
     56136.80c     3.2372E-11
     56137.80c     4.6295E-11
     56138.80c     2.9552E-10
     83209.80c     8.8838E-06
     6000.80c     4.7126E-06
     20040.80c     2.7382E-08
     20042.80c     1.8275E-10
     20043.80c     3.8132E-11
     20044.80c     5.8921E-10
     20046.80c     1.1298E-12
     20048.80c     5.2820E-11
     48106.80c     6.2941E-10
     48108.80c     4.4814E-10
     48110.80c     6.2890E-09
     48111.80c     6.4451E-09
     48112.80c     1.2150E-08
     48113.80c     6.1531E-09
     48114.80c     1.4466E-08
     48116.80c     3.7714E-09
     27059.80c     9.6044E-07
     24050.80c     6.6218E-08
     24052.80c     1.2769E-06
     24053.80c     1.4480E-07
     24054.80c     3.6043E-08
     29063.80c     3.0806E-06
     29065.80c     1.3730E-06
     19039.80c     2.7002E-08
     19040.80c     3.3876E-12
     19041.80c     1.9486E-09
     3006.80c     1.2379E-07
     3007.80c     1.5071E-06
     12024.80c     1.1037E-06
     12025.80c     1.3973E-07
     12026.80c     1.5384E-07
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     42092.80c    8.7552E-09
     42094.80c    5.4572E-09
     42095.80c    9.3923E-09
     42096.80c    9.8407E-09
     42097.80c    5.6342E-09
     42098.80c    1.4236E-08
     42100.80c    5.7050E-09
     11023.80c    1.3295E-05
     28058.80c    1.3130E-05
     28060.80c    5.0577E-06
     28061.80c    2.1986E-07
     28062.80c    7.0099E-07
     28064.80c    1.7852E-07
     51121.80c    2.0212E-06
     51123.80c    1.5118E-06
     22046.80c    1.9511E-08
     22047.80c    1.7595E-08
     22048.80c    1.7434E-07
     22049.80c    1.2794E-08
     22050.80c    1.2250E-08
     8016.80c    1.4146E-05
     8017.80c    5.3774E-09
     7014.80c    2.4157E-05
     7015.80c    8.9226E-08
c
c  --------- Part 2736 ---------
m11     92234.80c 4.8680E-04 92235.80c 4.4715E-02 92236.80c 1.0036E-04
        92238.80c 2.6584E-03 47107.80c 4.3390E-07 47109.80c 4.0312E-07
        56130.80c 4.3557E-13 56132.80c 4.1502E-13 56134.80c 9.9318E-12
        56135.80c 2.7087E-11 56136.80c 3.2273E-11 56137.80c 4.6154E-11
        56138.80c 2.9462E-10 83209.80c 8.8568E-06 06000.80c 4.6982E-06
        20040.80c 2.7298E-08 20042.80c 1.8219E-10 20043.80c 3.8016E-11
        20044.80c 5.8742E-10 20046.80c 1.1264E-12 20048.80c 5.2659E-11
        48106.80c 6.2750E-10 48108.80c 4.4678E-10 48110.80c 6.2700E-09
        48111.80c 6.4255E-09 48112.80c 1.2113E-08 48113.80c 6.1344E-09
        48114.80c 1.4422E-08 48116.80c 3.7600E-09 27059.80c 9.5752E-07
        24050.80c 6.6017E-08 24052.80c 1.2731E-06 24053.80c 1.4436E-07
        24054.80c 3.5933E-08 29063.80c 3.0712E-06 29065.80c 1.3689E-06
        19039.80c 2.6919E-08 19040.80c 3.3773E-12 19041.80c 1.9427E-09
        03006.80c 1.2341E-07 03007.80c 1.5026E-06 12024.80c 1.1004E-06
        12025.80c 1.3930E-07 12026.80c 1.5337E-07 25055.80c 1.1504E-05
        42092.80c 8.7285E-09 42094.80c 5.4406E-09 42095.80c 9.3638E-09
        42096.80c 9.8108E-09 42097.80c 5.6171E-09 42098.80c 1.4193E-08
        42100.80c 5.6641E-09 11023.80c 1.3255E-05 28058.80c 1.3091E-05
        28060.80c 5.0426E-06 28061.80c 2.1920E-07 28062.80c 6.9890E-07
        28064.80c 1.7799E-07 51121.80c 2.0152E-06 51123.80c 1.5073E-06
        22046.80c 1.9446E-08 22047.80c 1.7537E-08 22048.80c 1.7377E-07
        22049.80c 1.2752E-08 22050.80c 1.2210E-08 08016.80c 1.4103E-05
        08017.80c 5.3610E-09 07014.80c 2.4084E-05 07015.80c 8.8955E-08
c Total 4.8071E-02
c
c  --------- Part 2737 ---------
m12     92234.80c 4.7780E-04 92235.80c 4.4731E-02 92236.80c 1.3877E-04
        92238.80c 2.6762E-03 47107.80c 4.3448E-07 47109.80c 4.0365E-07
        56130.80c 4.3615E-13 56132.80c 4.1558E-13 56134.80c 9.9450E-12
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      56135.80c 2.7124E-11 56136.80c 3.2316E-11 56137.80c 4.6215E-11
      56138.80c 2.9501E-10 83209.80c 8.8686E-06 06000.80c 4.7044E-06
      20040.80c 2.7335E-08 20042.80c 1.8244E-10 20043.80c 3.8066E-11
      20044.80c 5.8820E-10 20046.80c 1.1279E-12 20048.80c 5.2729E-11
      48106.80c 6.2833E-10 48108.80c 4.4737E-10 48110.80c 6.2783E-09
      48111.80c 6.4341E-09 48112.80c 1.2129E-08 48113.80c 6.1426E-09
      48114.80c 1.4442E-08 48116.80c 3.7650E-09 27059.80c 9.5879E-07
      24050.80c 6.6105E-08 24052.80c 1.2748E-06 24053.80c 1.4455E-07
      24054.80c 3.5981E-08 29063.80c 3.0753E-06 29065.80c 1.3707E-06
      19039.80c 2.6955E-08 19040.80c 3.3818E-12 19041.80c 1.9453E-09
      03006.80c 1.2358E-07 03007.80c 1.5046E-06 12024.80c 1.1018E-06
      12025.80c 1.3949E-07 12026.80c 1.5358E-07 25055.80c 1.1519E-05
      42092.80c 8.7402E-09 42094.80c 5.4479E-09 42095.80c 9.3762E-09
      42096.80c 9.8238E-09 42097.80c 5.6246E-09 42098.80c 1.4212E-08
      42100.80c 5.6717E-09 11023.80c 1.3272E-05 28058.80c 1.3108E-05
      28060.80c 5.0493E-06 28061.80c 2.1949E-07 28062.80c 6.9983E-07
      28064.80c 1.7823E-07 51121.80c 2.0179E-06 51123.80c 1.5093E-06
      22046.80c 1.9472E-08 22047.80c 1.7560E-08 22048.80c 1.7400E-07
      22049.80c 1.2769E-08 22050.80c 1.2226E-08 08016.80c 1.4121E-05
      08017.80c 5.3682E-09 07014.80c 2.4116E-05 07015.80c 8.9073E-08
c  Total 4.8134E-02
c
c  --------- Part 2738 ---------
m13     92234.80c 4.7317E-04 92235.80c 4.4783E-02 92236.80c 1.1489E-04
      92238.80c 2.6725E-03 47107.80c 4.3466E-07 47109.80c 4.0382E-07
      56130.80c 4.3633E-13 56132.80c 4.1575E-13 56134.80c 9.9491E-12
      56135.80c 2.7135E-11 56136.80c 3.2330E-11 56137.80c 4.6234E-11
      56138.80c 2.9513E-10 83209.80c 8.8722E-06 06000.80c 4.7064E-06
      20040.80c 2.7346E-08 20042.80c 1.8251E-10 20043.80c 3.8082E-11
      20044.80c 5.8844E-10 20046.80c 1.1284E-12 20048.80c 5.2751E-11
      48106.80c 6.2859E-10 48108.80c 4.4756E-10 48110.80c 6.2809E-09
      48111.80c 6.4368E-09 48112.80c 1.2134E-08 48113.80c 6.1451E-09
      48114.80c 1.4448E-08 48116.80c 3.7665E-09 27059.80c 9.5919E-07
      24050.80c 6.6132E-08 24052.80c 1.2753E-06 24053.80c 1.4461E-07
      24054.80c 3.5996E-08 29063.80c 3.0766E-06 29065.80c 1.3713E-06
      19039.80c 2.6966E-08 19040.80c 3.3832E-12 19041.80c 1.9461E-09
      03006.80c 1.2363E-07 03007.80c 1.5052E-06 12024.80c 1.1023E-06
      12025.80c 1.3955E-07 12026.80c 1.5364E-07 25055.80c 1.1524E-05
      42092.80c 8.7438E-09 42094.80c 5.4501E-09 42095.80c 9.3801E-09
      42096.80c 9.8279E-09 42097.80c 5.6269E-09 42098.80c 1.4217E-08
      42100.80c 5.6740E-09 11023.80c 1.3278E-05 28058.80c 1.3114E-05
      28060.80c 5.0514E-06 28061.80c 2.1958E-07 28062.80c 7.0012E-07
      28064.80c 1.7830E-07 51121.80c 2.0187E-06 51123.80c 1.5099E-06
      22046.80c 1.9480E-08 22047.80c 1.7568E-08 22048.80c 1.7407E-07
      22049.80c 1.2774E-08 22050.80c 1.2231E-08 08016.80c 1.4127E-05
      08017.80c 5.3704E-09 07014.80c 2.4126E-05 07015.80c 8.9110E-08
c  Total 4.8155E-02
c
c  --------- Part 2762 ---------
m14     92234.80c 4.6870E-04 92235.80c 4.4808E-02 92236.80c 1.2935E-04
      92238.80c 2.6745E-03 47107.80c 4.3499E-07 47109.80c 4.0413E-07
      56130.80c 4.3666E-13 56132.80c 4.1606E-13 56134.80c 9.9567E-12
      56135.80c 2.7155E-11 56136.80c 3.2354E-11 56137.80c 4.6270E-11
      56138.80c 2.9536E-10 83209.80c 8.8790E-06 06000.80c 4.7099E-06
      20040.80c 2.7367E-08 20042.80c 1.8265E-10 20043.80c 3.8111E-11
      20044.80c 5.8889E-10 20046.80c 1.1292E-12 20048.80c 5.2791E-11
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      48106.80c 6.2907E-10 48108.80c 4.4790E-10 48110.80c 6.2857E-09
      48111.80c 6.4417E-09 48112.80c 1.2144E-08 48113.80c 6.1498E-09
      48114.80c 1.4459E-08 48116.80c 3.7694E-09 27059.80c 9.5992E-07
      24050.80c 6.6182E-08 24052.80c 1.2763E-06 24053.80c 1.4472E-07
      24054.80c 3.6023E-08 29063.80c 3.0789E-06 29065.80c 1.3723E-06
      19039.80c 2.6987E-08 19040.80c 3.3857E-12 19041.80c 1.9476E-09
      03006.80c 1.2372E-07 03007.80c 1.5063E-06 12024.80c 1.1031E-06
      12025.80c 1.3965E-07 12026.80c 1.5376E-07 25055.80c 1.1533E-05
      42092.80c 8.7504E-09 42094.80c 5.4543E-09 42095.80c 9.3872E-09
      42096.80c 9.8354E-09 42097.80c 5.6312E-09 42098.80c 1.4228E-08
      42100.80c 5.6783E-09 11023.80c 1.3288E-05 28058.80c 1.3124E-05
      28060.80c 5.0553E-06 28061.80c 2.1975E-07 28062.80c 7.0066E-07
      28064.80c 1.7844E-07 51121.80c 2.0203E-06 51123.80c 1.5111E-06
      22046.80c 1.9495E-08 22047.80c 1.7581E-08 22048.80c 1.7420E-07
      22049.80c 1.2784E-08 22050.80c 1.2241E-08 08016.80c 1.4138E-05
      08017.80c 5.3745E-09 07014.80c 2.4144E-05 07015.80c 8.9178E-08
c  Total 4.8191E-02
c
c  ------------ part 2741---------
m15     92234.80c 4.6364E-04 92235.80c 4.4810E-02 92236.80c 1.1972E-04
      92238.80c 2.6638E-03 47107.80c 4.3478E-07 47109.80c 4.0393E-07
      56130.80c 4.3645E-13 56132.80c 4.1587E-13 56134.80c 9.9520E-12
      56135.80c 2.7143E-11 56136.80c 3.2339E-11 56137.80c 4.6248E-11
      56138.80c 2.9522E-10 83209.80c 8.8748E-06 06000.80c 4.7078E-06
      20040.80c 2.7354E-08 20042.80c 1.8256E-10 20043.80c 3.8093E-11
      20044.80c 5.8861E-10 20046.80c 1.1287E-12 20048.80c 5.2766E-11
      48106.80c 6.2877E-10 48108.80c 4.4768E-10 48110.80c 6.2826E-09
      48111.80c 6.4386E-09 48112.80c 1.2138E-08 48113.80c 6.1468E-09
      48114.80c 1.4452E-08 48116.80c 3.7676E-09 27059.80c 9.5947E-07
      24050.80c 6.6151E-08 24052.80c 1.2757E-06 24053.80c 1.4465E-07
      24054.80c 3.6006E-08 29063.80c 3.0774E-06 29065.80c 1.3717E-06
      19039.80c 2.6974E-08 19040.80c 3.3841E-12 19041.80c 1.9467E-09
      03006.80c 1.2366E-07 03007.80c 1.5056E-06 12024.80c 1.1026E-06
      12025.80c 1.3959E-07 12026.80c 1.5369E-07 25055.80c 1.1527E-05
      42092.80c 8.7463E-09 42094.80c 5.4517E-09 42095.80c 9.3828E-09
      42096.80c 9.8307E-09 42097.80c 5.6285E-09 42098.80c 1.4222E-08
      42100.80c 5.6992E-09 11023.80c 1.3282E-05 28058.80c 1.3117E-05
      28060.80c 5.0526E-06 28061.80c 2.1963E-07 28062.80c 7.0028E-07
      28064.80c 1.7834E-07 51121.80c 2.0192E-06 51123.80c 1.5102E-06
      22046.80c 1.9491E-08 22047.80c 1.7577E-08 22048.80c 1.7417E-07
      22049.80c 1.2781E-08 22050.80c 1.2238E-08 08016.80c 1.4131E-05
      08017.80c 5.3719E-09 07014.80c 2.4133E-05 07015.80c 8.9136E-08
c  Total 4.8168E-02
c
c  --------- Part 2829 ---------
m16     92234.80c 4.7734E-04 92235.80c 4.4698E-02 92236.80c 1.1474E-04
      92238.80c 2.6878E-03 47107.80c 4.3406E-07 47109.80c 4.0326E-07
      56130.80c 4.3573E-13 56132.80c 4.1518E-13 56134.80c 9.9354E-12
      56135.80c 2.7097E-11 56136.80c 3.2285E-11 56137.80c 4.6171E-11
      56138.80c 2.9473E-10 83209.80c 8.8600E-06 06000.80c 4.6999E-06
      20040.80c 2.7308E-08 20042.80c 1.8226E-10 20043.80c 3.8030E-11
      20044.80c 5.8763E-10 20046.80c 1.1268E-12 20048.80c 5.2678E-11
      48106.80c 6.2773E-10 48108.80c 4.4694E-10 48110.80c 6.2723E-09
      48111.80c 6.4279E-09 48112.80c 1.2118E-08 48113.80c 6.1367E-09
      48114.80c 1.4428E-08 48116.80c 3.7613E-09 27059.80c 9.5787E-07
      24050.80c 6.6041E-08 24052.80c 1.2735E-06 24053.80c 1.4441E-07
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      24054.80c 3.5946E-08 29063.80c 3.0723E-06 29065.80c 1.3694E-06
      19039.80c 2.6929E-08 19040.80c 3.3785E-12 19041.80c 1.9434E-09
      03006.80c 1.2346E-07 03007.80c 1.5031E-06 12024.80c 1.1008E-06
      12025.80c 1.3935E-07 12026.80c 1.5343E-07 25055.80c 1.1508E-05
      42092.80c 8.7317E-09 42094.80c 5.4426E-09 42095.80c 9.3672E-09
      42096.80c 9.8144E-09 42097.80c 5.6191E-09 42098.80c 1.4198E-08
      42100.80c 5.6662E-09 11023.80c 1.3259E-05 28058.80c 1.3096E-05
      28060.80c 5.0445E-06 28061.80c 2.1928E-07 28062.80c 6.9916E-07
      28064.80c 1.7806E-07 51121.80c 2.0160E-06 51123.80c 1.5078E-06
      22046.80c 1.9453E-08 22047.80c 1.7543E-08 22048.80c 1.7383E-07
      22049.80c 1.2757E-08 22050.80c 1.2214E-08 08016.80c 1.4108E-05
      08017.80c 5.3630E-09 07014.80c 2.4092E-05 07015.80c 8.8988E-08
c  c Total 4.8088E-02
c
c  --------- Part 2740 ---------
m17     92234.80c 4.6863E-04 92235.80c 4.4821E-02 92236.80c 1.1497E-04
      92238.80c 2.6694E-03 47107.80c 4.3493E-07 47109.80c 4.0407E-07
      56130.80c 4.3660E-13 56132.80c 4.1601E-13 56134.80c 9.9554E-12
      56135.80c 2.7152E-11 56136.80c 3.2350E-11 56137.80c 4.6263E-11
      56138.80c 2.9532E-10 83209.80c 8.8778E-06 06000.80c 4.7093E-06
      20040.80c 2.7363E-08 20042.80c 1.8263E-10 20043.80c 3.8106E-11
      20044.80c 5.8881E-10 20046.80c 1.1291E-12 20048.80c 5.2784E-11
      48106.80c 6.2899E-10 48108.80c 4.4784E-10 48110.80c 6.2848E-09
      48111.80c 6.4408E-09 48112.80c 1.2142E-08 48113.80c 6.1490E-09
      48114.80c 1.4457E-08 48116.80c 3.7689E-09 27059.80c 9.5979E-07
      24050.80c 6.6174E-08 24052.80c 1.2761E-06 24053.80c 1.4470E-07
      24054.80c 3.6019E-08 29063.80c 3.0785E-06 29065.80c 1.3721E-06
      19039.80c 2.6983E-08 19040.80c 3.3853E-12 19041.80c 1.9473E-09
      03006.80c 1.2370E-07 03007.80c 1.5061E-06 12024.80c 1.1030E-06
      12025.80c 1.3963E-07 12026.80c 1.5374E-07 25055.80c 1.1531E-05
      42092.80c 8.7493E-09 42094.80c 5.4535E-09 42095.80c 9.3860E-09
      42096.80c 9.8341E-09 42097.80c 5.6304E-09 42098.80c 1.4226E-08
      42100.80c 5.6776E-09 11023.80c 1.3286E-05 28058.80c 1.3122E-05
      28060.80c 5.0546E-06 28061.80c 2.1972E-07 28062.80c 7.0056E-07
      28064.80c 1.7841E-07 51121.80c 2.0200E-06 51123.80c 1.5109E-06
      22046.80c 1.9492E-08 22047.80c 1.7579E-08 22048.80c 1.7418E-07
      22049.80c 1.2782E-08 22050.80c 1.2239E-08 08016.80c 1.4136E-05
      08017.80c 5.3737E-09 07014.80c 2.4141E-05 07015.80c 8.9166E-08
c  Total 4.8185E-02
c
c
c  ------ 9"-11" HEU Annulus ------
c
c  --------- Part 2746 ---------
m18     92234.80c 4.8204E-04 92235.80c 4.4682E-02 92236.80c 1.0515E-04
      92238.80c 2.6966E-03 47107.80c 4.3395E-07 47109.80c 4.0316E-07
      56130.80c 4.3562E-13 56132.80c 4.1507E-13 56134.80c 9.9329E-12
      56135.80c 2.7091E-11 56136.80c 3.2277E-11 56137.80c 4.6159E-11
      56138.80c 2.9465E-10 83209.80c 8.8578E-06 06000.80c 4.6987E-06
      20040.80c 2.7302E-08 20042.80c 1.8222E-10 20043.80c 3.8020E-11
      20044.80c 5.8748E-10 20046.80c 1.1265E-12 20048.80c 5.2665E-11
      48106.80c 6.2757E-10 48108.80c 4.4683E-10 48110.80c 6.2707E-09
      48111.80c 6.4263E-09 48112.80c 1.2115E-08 48113.80c 6.1351E-09
      48114.80c 1.4424E-08 48116.80c 3.7604E-09 27059.80c 9.5763E-07
      24050.80c 6.6025E-08 24052.80c 1.2732E-06 24053.80c 1.4437E-07
      24054.80c 3.5937E-08 29063.80c 3.0715E-06 29065.80c 1.3690E-06
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      19039.80c 2.6923E-08 19040.80c 3.3777E-12 19041.80c 1.9429E-09
      03006.80c 1.2343E-07 03007.80c 1.5027E-06 12024.80c 1.1005E-06
      12025.80c 1.3932E-07 12026.80c 1.5339E-07 25055.80c 1.1505E-05
      42092.80c 8.7295E-09 42094.80c 5.4413E-09 42095.80c 9.3648E-09
      42096.80c 9.8119E-09 42097.80c 5.6177E-09 42098.80c 1.4194E-08
      42100.80c 5.6648E-09 11023.80c 1.3256E-05 28058.80c 1.3093E-05
      28060.80c 5.0432E-06 28061.80c 2.1922E-07 28062.80c 6.9899E-07
      28064.80c 1.7801E-07 51121.80c 2.0155E-06 51123.80c 1.5075E-06
      22046.80c 1.9449E-08 22047.80c 1.7539E-08 22048.80c 1.7379E-07
      22049.80c 1.2754E-08 22050.80c 1.2211E-08 08016.80c 1.4104E-05
      08017.80c 5.3616E-09 07014.80c 2.4086E-05 07015.80c 8.8965E-08
c Total 4.8076E-02
c
c  --------- Part 2744 ------------------------------------------------------------
m19   92234.80c   4.7883E-04
    92235.80c   4.4828E-02
    92236.80c   1.3907E-04
    92238.80c   2.6819E-03
    47107.80c   4.3542E-07
    47109.80c   4.0452E-07
    56130.80c   4.3709E-13
    56132.80c   4.1647E-13
    56134.80c   9.9665E-12
    56135.80c   2.7182E-11
    56136.80c   3.2386E-11
    56137.80c   4.6315E-11
    56138.80c   2.9565E-10
    83209.80c   8.8877E-06
    6000.80c   4.7147E-06
    20040.80c   2.7394E-08
    20042.80c   1.8283E-10
    20043.80c   3.8149E-11
    20044.80c   5.8947E-10
    20046.80c   1.1303E-12
    20048.80c   5.2843E-11
    48106.80c   6.2968E-10
    48108.80c   4.4834E-10
    48110.80c   6.2918E-09
    48111.80c   6.4480E-09
    48112.80c   1.2155E-08
    48113.80c   6.1558E-09
    48114.80c   1.4473E-08
    48116.80c   3.7731E-09
    27059.80c   9.6086E-07
    24050.80c   6.6247E-08
    24052.80c   1.2775E-06
    24053.80c   1.4486E-07
    24054.80c   3.6059E-08
    29063.80c   3.0819E-06
    29065.80c   1.3737E-06
    19039.80c   2.7013E-08
    19040.80c   3.3891E-12
    19041.80c   1.9495E-09
    3006.80c   1.2384E-07
    3007.80c   1.5078E-06
    12024.80c   1.1042E-06
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     12025.80c   1.3979E-07
     12026.80c   1.5391E-07
     25055.80c   1.1544E-05
     42092.80c   8.7590E-09
     42094.80c   5.4596E-09
     42095.80c   9.3965E-09
     42096.80c   9.8450E-09
     42097.80c   5.6367E-09
     42098.80c   1.4242E-08
     42100.80c   5.7075E-09
     11023.80c   1.3301E-05
     28058.80c   1.3136E-05
     28060.80c   5.0600E-06
     28061.80c   2.1995E-07
     28062.80c   7.0131E-07
     28064.80c   1.7860E-07
     51121.80c   2.0221E-06
     51123.80c   1.5124E-06
     22046.80c   1.9520E-08
     22047.80c   1.7603E-08
     22048.80c   1.7442E-07
     22049.80c   1.2800E-08
     22050.80c   1.2256E-08
     8016.80c   1.4152E-05
     8017.80c   5.3797E-09
     7014.80c   2.4168E-05
     7015.80c   8.9266E-08
c
c
c  --------- Part 2779 ---------
m20     92234.80c 4.6289E-04 92235.80c 4.4728E-02 92236.80c 1.0996E-04
        92238.80c 2.6784E-03 47107.80c 4.3407E-07 47109.80c 4.0328E-07
        56130.80c 4.3574E-13 56132.80c 4.1519E-13 56134.80c 9.9358E-12
        56135.80c 2.7098E-11 56136.80c 3.2286E-11 56137.80c 4.6172E-11
        56138.80c 2.9474E-10 83209.80c 8.8603E-06 06000.80c 4.7000E-06
        20040.80c 2.7309E-08 20042.80c 1.8227E-10 20043.80c 3.8031E-11
        20044.80c 5.8765E-10 20046.80c 1.1268E-12 20048.80c 5.2680E-11
        48106.80c 6.2775E-10 48108.80c 4.4696E-10 48110.80c 6.2725E-09
        48111.80c 6.4281E-09 48112.80c 1.2118E-08 48113.80c 6.1369E-09
        48114.80c 1.4428E-08 48116.80c 3.7615E-09 27059.80c 9.5790E-07
        24050.80c 6.6043E-08 24052.80c 1.2736E-06 24053.80c 1.4441E-07
        24054.80c 3.5948E-08 29063.80c 3.0724E-06 29065.80c 1.3694E-06
        19039.80c 2.6930E-08 19040.80c 3.3786E-12 19041.80c 1.9435E-09
        03006.80c 1.2346E-07 03007.80c 1.5032E-06 12024.80c 1.1008E-06
        12025.80c 1.3936E-07 12026.80c 1.5343E-07 25055.80c 1.1509E-05
        42092.80c 8.7320E-09 42094.80c 5.4428E-09 42095.80c 9.3675E-09
        42096.80c 9.8147E-09 42097.80c 5.6193E-09 42098.80c 1.4198E-08
        42100.80c 5.6664E-09 11023.80c 1.3260E-05 28058.80c 1.3096E-05
        28060.80c 5.0446E-06 28061.80c 2.1929E-07 28062.80c 6.9918E-07
        28064.80c 1.7806E-07 51121.80c 2.0160E-06 51123.80c 1.5079E-06
        22046.80c 1.9454E-08 22047.80c 1.7544E-08 22048.80c 1.7384E-07
        22049.80c 1.2757E-08 22050.80c 1.2215E-08 08016.80c 1.4108E-05
        08017.80c 5.3632E-09 07014.80c 2.4093E-05 07015.80c 8.8991E-08
c  Total 4.8090E-02
c
c  --------- Part 2778 ---------
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m21     92234.80c 4.6197E-04 92235.80c 4.4639E-02 92236.80c 1.0974E-04
        92238.80c 2.6731E-03 47107.80c 4.3321E-07 47109.80c 4.0248E-07
        56130.80c 4.3488E-13 56132.80c 4.1437E-13 56134.80c 9.9161E-12
        56135.80c 2.7045E-11 56136.80c 3.2222E-11 56137.80c 4.6081E-11
        56138.80c 2.9415E-10 83209.80c 8.8427E-06 06000.80c 4.6907E-06
        20040.80c 2.7255E-08 20042.80c 1.8191E-10 20043.80c 3.7956E-11
        20044.80c 5.8649E-10 20046.80c 1.1246E-12 20048.80c 5.2576E-11
        48106.80c 6.2650E-10 48108.80c 4.4607E-10 48110.80c 6.2600E-09
        48111.80c 6.4154E-09 48112.80c 1.2094E-08 48113.80c 6.1247E-09
        48114.80c 1.4400E-08 48116.80c 3.7540E-09 27059.80c 9.5600E-07
        24050.80c 6.5912E-08 24052.80c 1.2711E-06 24053.80c 1.4413E-07
        24054.80c 3.5876E-08 29063.80c 3.0663E-06 29065.80c 1.3667E-06
        19039.80c 2.6877E-08 19040.80c 3.3719E-12 19041.80c 1.9396E-09
        03006.80c 1.2322E-07 03007.80c 1.5002E-06 12024.80c 1.0986E-06
        12025.80c 1.3908E-07 12026.80c 1.5313E-07 25055.80c 1.1486E-05
        42092.80c 8.7147E-09 42094.80c 5.4320E-09 42095.80c 9.3489E-09
        42096.80c 9.7952E-09 42097.80c 5.6082E-09 42098.80c 1.4170E-08
        42100.80c 5.6552E-09 11023.80c 1.3234E-05 28058.80c 1.3070E-05
        28060.80c 5.0346E-06 28061.80c 2.1885E-07 28062.80c 6.9780E-07
        28064.80c 1.7771E-07 51121.80c 2.0120E-06 51123.80c 1.5049E-06
        22046.80c 1.9416E-08 22047.80c 1.7509E-08 22048.80c 1.7349E-07
        22049.80c 1.2732E-08 22050.80c 1.2191E-08 08016.80c 1.4080E-05
        08017.80c 5.3525E-09 07014.80c 2.4045E-05 07015.80c 8.8814E-08
c  Total 4.7994E-02
c
c  --------- Part 2743 ---------
m22     92234.80c 4.7545E-04 92235.80c 4.4994E-02 92236.80c 1.1064E-04
        92238.80c 2.6949E-03 47107.80c 4.3675E-07 47109.80c 4.0576E-07
        56130.80c 4.3843E-13 56132.80c 4.1775E-13 56134.80c 9.9970E-12
        56135.80c 2.7265E-11 56136.80c 3.2485E-11 56137.80c 4.6457E-11
        56138.80c 2.9655E-10 83209.80c 8.9149E-06 06000.80c 4.7290E-06
        20040.80c 2.7478E-08 20042.80c 1.8339E-10 20043.80c 3.8266E-11
        20044.80c 5.9127E-10 20046.80c 1.1338E-12 20048.80c 5.3005E-11
        48106.80c 6.3162E-10 48108.80c 4.4971E-10 48110.80c 6.3111E-09
        48111.80c 6.4678E-09 48112.80c 1.2193E-08 48113.80c 6.1747E-09
        48114.80c 1.4517E-08 48116.80c 3.7847E-09 27059.80c 9.6381E-07
        24050.80c 6.6451E-08 24052.80c 1.2814E-06 24053.80c 1.4530E-07
        24054.80c 3.6169E-08 29063.80c 3.0914E-06 29065.80c 1.3779E-06
        19039.80c 2.7096E-08 19040.80c 3.3994E-12 19041.80c 1.9555E-09
        03006.80c 1.2422E-07 03007.80c 1.5124E-06 12024.80c 1.1076E-06
        12025.80c 1.4022E-07 12026.80c 1.5438E-07 25055.80c 1.1580E-05
        42092.80c 8.7859E-09 42094.80c 5.4764E-09 42095.80c 9.4253E-09
        42096.80c 9.8752E-09 42097.80c 5.6540E-09 42098.80c 1.4286E-08
        42100.80c 5.7013E-09 11023.80c 1.3342E-05 28058.80c 1.3177E-05
        28060.80c 5.0758E-06 28061.80c 2.2064E-07 28062.80c 7.0349E-07
        28064.80c 1.7916E-07 51121.80c 2.0285E-06 51123.80c 1.5172E-06
        22046.80c 1.9574E-08 22047.80c 1.7652E-08 22048.80c 1.7491E-07
        22049.80c 1.2836E-08 22050.80c 1.2290E-08 08016.80c 1.4195E-05
        08017.80c 5.3962E-09 07014.80c 2.4242E-05 07015.80c 8.9539E-08
c  Total 4.8386E-02
c
c  ------------Part 2767---------
m23    92234.80c 4.6289E-04 92235.80c 4.4718E-02 92236.80c 1.2431E-04
       92238.80c 2.6737E-03 47107.80c 4.3407E-07 47109.80c 4.0328E-07
       56130.80c 4.3574E-13 56132.80c 4.1519E-13 56134.80c 9.9358E-12
       56135.80c 2.7098E-11 56136.80c 3.2286E-11 56137.80c 4.6172E-11
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      56138.80c 2.9473E-10 83209.80c 8.8603E-06 06000.80c 4.7002E-06
      20040.80c 2.7309E-08 20042.80c 1.8227E-10 20043.80c 3.8031E-11
      20044.80c 5.8765E-10 20046.80c 1.1268E-12 20048.80c 5.2680E-11
      48106.80c 6.2774E-10 48108.80c 4.4695E-10 48110.80c 6.2724E-09
      48111.80c 6.4281E-09 48112.80c 1.2118E-08 48113.80c 6.1368E-09
      48114.80c 1.4428E-08 48116.80c 3.7614E-09 27059.80c 9.5790E-07
      24050.80c 6.6043E-08 24052.80c 1.2736E-06 24053.80c 1.4441E-07
      24054.80c 3.5947E-08 29063.80c 3.0724E-06 29065.80c 1.3694E-06
      19039.80c 2.6930E-08 19040.80c 3.3786E-12 19041.80c 1.9435E-09
      03006.80c 1.2346E-07 03007.80c 1.5032E-06 12024.80c 1.1008E-06
      12025.80c 1.3936E-07 12026.80c 1.5343E-07 25055.80c 1.1509E-05
      42092.80c 8.7320E-09 42094.80c 5.4428E-09 42095.80c 9.3675E-09
      42096.80c 9.8147E-09 42097.80c 5.6193E-09 42098.80c 1.4198E-08
      42100.80c 5.6899E-09 11023.80c 1.3260E-05 28058.80c 1.3095E-05
      28060.80c 5.0443E-06 28061.80c 2.1927E-07 28062.80c 6.9914E-07
      28064.80c 1.7805E-07 51121.80c 2.0159E-06 51123.80c 1.5078E-06
      22046.80c 1.9459E-08 22047.80c 1.7549E-08 22048.80c 1.7388E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4108E-05
      08017.80c 5.3632E-09 07014.80c 2.4093E-05 07015.80c 8.8990E-08
c  Total 4.8090E-02
c
c  --------- Part 2776 ---------
m24    92234.80c 4.6302E-04 92235.80c 4.4740E-02 92236.80c 1.0999E-04
      92238.80c 2.6792E-03 47107.80c 4.3420E-07 47109.80c 4.0339E-07
      56130.80c 4.3587E-13 56132.80c 4.1531E-13 56134.80c 9.9386E-12
      56135.80c 2.7106E-11 56136.80c 3.2295E-11 56137.80c 4.6185E-11
      56138.80c 2.9482E-10 83209.80c 8.8628E-06 06000.80c 4.7014E-06
      20040.80c 2.7317E-08 20042.80c 1.8232E-10 20043.80c 3.8042E-11
      20044.80c 5.8782E-10 20046.80c 1.1272E-12 20048.80c 5.2695E-11
      48106.80c 6.2793E-10 48108.80c 4.4708E-10 48110.80c 6.2742E-09
      48111.80c 6.4300E-09 48112.80c 1.2121E-08 48113.80c 6.1386E-09
      48114.80c 1.4432E-08 48116.80c 3.7625E-09 27059.80c 9.5817E-07
      24050.80c 6.6062E-08 24052.80c 1.2739E-06 24053.80c 1.4445E-07
      24054.80c 3.5958E-08 29063.80c 3.0733E-06 29065.80c 1.3698E-06
      19039.80c 2.6938E-08 19040.80c 3.3796E-12 19041.80c 1.9440E-09
      03006.80c 1.2350E-07 03007.80c 1.5036E-06 12024.80c 1.1011E-06
      12025.80c 1.3940E-07 12026.80c 1.5348E-07 25055.80c 1.1512E-05
      42092.80c 8.7345E-09 42094.80c 5.4443E-09 42095.80c 9.3702E-09
      42096.80c 9.8175E-09 42097.80c 5.6209E-09 42098.80c 1.4202E-08
      42100.80c 5.6680E-09 11023.80c 1.3264E-05 28058.80c 1.3100E-05
      28060.80c 5.0461E-06 28061.80c 2.1935E-07 28062.80c 6.9938E-07
      28064.80c 1.7811E-07 51121.80c 2.0166E-06 51123.80c 1.5083E-06
      22046.80c 1.9460E-08 22047.80c 1.7549E-08 22048.80c 1.7389E-07
      22049.80c 1.2761E-08 22050.80c 1.2218E-08 08016.80c 1.4112E-05
      08017.80c 5.3647E-09 07014.80c 2.4100E-05 07015.80c 8.9016E-08
c Total 4.8103E-02
c
c  --------- Part 2745 ---------
m25    92234.80c 4.6359E-04 92235.80c 4.4815E-02 92236.80c 1.0534E-04
      92238.80c 2.6682E-03 47107.80c 4.3473E-07 47109.80c 4.0389E-07
      56130.80c 4.3641E-13 56132.80c 4.1582E-13 56134.80c 9.9509E-12
      56135.80c 2.7140E-11 56136.80c 3.2335E-11 56137.80c 4.6243E-11
      56138.80c 2.9518E-10 83209.80c 8.8738E-06 06000.80c 4.7072E-06
      20040.80c 2.7351E-08 20042.80c 1.8254E-10 20043.80c 3.8089E-11
      20044.80c 5.8854E-10 20046.80c 1.1286E-12 20048.80c 5.2760E-11
      48106.80c 6.2870E-10 48108.80c 4.4764E-10 48110.80c 6.2820E-09
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      48111.80c 6.4379E-09 48112.80c 1.2136E-08 48113.80c 6.1462E-09
      48114.80c 1.4450E-08 48116.80c 3.7672E-09 27059.80c 9.5936E-07
      24050.80c 6.6144E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
      24054.80c 3.6002E-08 29063.80c 3.0771E-06 29065.80c 1.3715E-06
      19039.80c 2.6971E-08 19040.80c 3.3838E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5055E-06 12024.80c 1.1025E-06
      12025.80c 1.3957E-07 12026.80c 1.5367E-07 25055.80c 1.1526E-05
      42092.80c 8.7453E-09 42094.80c 5.4511E-09 42095.80c 9.3818E-09
      42096.80c 9.8296E-09 42097.80c 5.6279E-09 42098.80c 1.4220E-08
      42100.80c 5.6750E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
      28060.80c 5.0523E-06 28061.80c 2.1962E-07 28062.80c 7.0025E-07
      28064.80c 1.7833E-07 51121.80c 2.0191E-06 51123.80c 1.5102E-06
      22046.80c 1.9484E-08 22047.80c 1.7571E-08 22048.80c 1.7410E-07
      22049.80c 1.2777E-08 22050.80c 1.2233E-08 08016.80c 1.4130E-05
      08017.80c 5.3713E-09 07014.80c 2.4130E-05 07015.80c 8.9126E-08
c  Total 4.8163E-02
c
c  --------- Part 2748 ---------
m26    92234.80c 4.8285E-04 92235.80c 4.4757E-02 92236.80c 1.0533E-04
      92238.80c 2.7012E-03 47107.80c 4.3468E-07 47109.80c 4.0384E-07
      56130.80c 4.3636E-13 56132.80c 4.1577E-13 56134.80c 9.9497E-12
      56135.80c 2.7136E-11 56136.80c 3.2332E-11 56137.80c 4.6237E-11
      56138.80c 2.9515E-10 83209.80c 8.8728E-06 06000.80c 4.7067E-06
      20040.80c 2.7348E-08 20042.80c 1.8252E-10 20043.80c 3.8085E-11
      20044.80c 5.8848E-10 20046.80c 1.1284E-12 20048.80c 5.2754E-11
      48106.80c 6.2863E-10 48108.80c 4.4759E-10 48110.80c 6.2813E-09
      48111.80c 6.4372E-09 48112.80c 1.2135E-08 48113.80c 6.1455E-09
      48114.80c 1.4448E-08 48116.80c 3.7668E-09 27059.80c 9.5925E-07
      24050.80c 6.6136E-08 24052.80c 1.2754E-06 24053.80c 1.4462E-07
      24054.80c 3.5998E-08 29063.80c 3.0767E-06 29065.80c 1.3713E-06
      19039.80c 2.6968E-08 19040.80c 3.3834E-12 19041.80c 1.9462E-09
      03006.80c 1.2363E-07 03007.80c 1.5053E-06 12024.80c 1.1023E-06
      12025.80c 1.3956E-07 12026.80c 1.5365E-07 25055.80c 1.1525E-05
      42092.80c 8.7443E-09 42094.80c 5.4505E-09 42095.80c 9.3807E-09
      42096.80c 9.8285E-09 42097.80c 5.6272E-09 42098.80c 1.4218E-08
      42100.80c 5.6744E-09 11023.80c 1.3279E-05 28058.80c 1.3115E-05
      28060.80c 5.0517E-06 28061.80c 2.1960E-07 28062.80c 7.0017E-07
      28064.80c 1.7831E-07 51121.80c 2.0189E-06 51123.80c 1.5100E-06
      22046.80c 1.9481E-08 22047.80c 1.7569E-08 22048.80c 1.7408E-07
      22049.80c 1.2775E-08 22050.80c 1.2232E-08 08016.80c 1.4128E-05
      08017.80c 5.3707E-09 07014.80c 2.4127E-05 07015.80c 8.9116E-08
c Total 4.8157E-02
c
c  --------- Part 2742 ---------
m27    92234.80c 4.7324E-04 92235.80c 4.4785E-02 92236.80c 1.1012E-04
      92238.80c 2.6824E-03 47107.80c 4.3472E-07 47109.80c 4.0388E-07
      56130.80c 4.3639E-13 56132.80c 4.1581E-13 56134.80c 9.9506E-12
      56135.80c 2.7139E-11 56136.80c 3.2334E-11 56137.80c 4.6241E-11
      56138.80c 2.9517E-10 83209.80c 8.8735E-06 06000.80c 4.7070E-06
      20040.80c 2.7350E-08 20042.80c 1.8254E-10 20043.80c 3.8088E-11
      20044.80c 5.8853E-10 20046.80c 1.1285E-12 20048.80c 5.2759E-11
      48106.80c 6.2868E-10 48108.80c 4.4762E-10 48110.80c 6.2818E-09
      48111.80c 6.4377E-09 48112.80c 1.2136E-08 48113.80c 6.1460E-09
      48114.80c 1.4450E-08 48116.80c 3.7671E-09 27059.80c 9.5933E-07
      24050.80c 6.6142E-08 24052.80c 1.2755E-06 24053.80c 1.4463E-07
      24054.80c 3.6001E-08 29063.80c 3.0770E-06 29065.80c 1.3715E-06
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      19039.80c 2.6970E-08 19040.80c 3.3836E-12 19041.80c 1.9464E-09
      03006.80c 1.2365E-07 03007.80c 1.5054E-06 12024.80c 1.1024E-06
      12025.80c 1.3957E-07 12026.80c 1.5366E-07 25055.80c 1.1526E-05
      42092.80c 8.7450E-09 42094.80c 5.4509E-09 42095.80c 9.3815E-09
      42096.80c 9.8293E-09 42097.80c 5.6277E-09 42098.80c 1.4220E-08
      42100.80c 5.6748E-09 11023.80c 1.3280E-05 28058.80c 1.3116E-05
      28060.80c 5.0522E-06 28061.80c 2.1961E-07 28062.80c 7.0023E-07
      28064.80c 1.7833E-07 51121.80c 2.0190E-06 51123.80c 1.5101E-06
      22046.80c 1.9483E-08 22047.80c 1.7570E-08 22048.80c 1.7410E-07
      22049.80c 1.2776E-08 22050.80c 1.2233E-08 08016.80c 1.4129E-05
      08017.80c 5.3711E-09 07014.80c 2.4129E-05 07015.80c 8.9123E-08
c Total 4.8161E-02
c
c  --------- Part 2747 ---------
m28    92234.80c 4.7245E-04 92235.80c 4.4720E-02 92236.80c 9.0820E-05
      92238.80c 2.6874E-03 47107.80c 4.3400E-07 47109.80c 4.0321E-07
      56130.80c 4.3567E-13 56132.80c 4.1512E-13 56134.80c 9.9341E-12
      56135.80c 2.7094E-11 56136.80c 3.2281E-11 56137.80c 4.6165E-11
      56138.80c 2.9469E-10 83209.80c 8.8588E-06 06000.80c 4.6993E-06
      20040.80c 2.7305E-08 20042.80c 1.8224E-10 20043.80c 3.8025E-11
      20044.80c 5.8755E-10 20046.80c 1.1267E-12 20048.80c 5.2671E-11
      48106.80c 6.2764E-10 48108.80c 4.4688E-10 48110.80c 6.2714E-09
      48111.80c 6.4270E-09 48112.80c 1.2116E-08 48113.80c 6.1358E-09
      48114.80c 1.4426E-08 48116.80c 3.7608E-09 27059.80c 9.5774E-07
      24050.80c 6.6032E-08 24052.80c 1.2734E-06 24053.80c 1.4439E-07
      24054.80c 3.5942E-08 29063.80c 3.0719E-06 29065.80c 1.3692E-06
      19039.80c 2.6926E-08 19040.80c 3.3781E-12 19041.80c 1.9432E-09
      03006.80c 1.2344E-07 03007.80c 1.5029E-06 12024.80c 1.1006E-06
      12025.80c 1.3934E-07 12026.80c 1.5341E-07 25055.80c 1.1507E-05
      42092.80c 8.7306E-09 42094.80c 5.4419E-09 42095.80c 9.3659E-09
      42096.80c 9.8131E-09 42097.80c 5.6184E-09 42098.80c 1.4196E-08
      42100.80c 5.6655E-09 11023.80c 1.3258E-05 28058.80c 1.3094E-05
      28060.80c 5.0438E-06 28061.80c 2.1925E-07 28062.80c 6.9907E-07
      28064.80c 1.7803E-07 51121.80c 2.0157E-06 51123.80c 1.5076E-06
      22046.80c 1.9451E-08 22047.80c 1.7541E-08 22048.80c 1.7381E-07
      22049.80c 1.2755E-08 22050.80c 1.2213E-08 08016.80c 1.4106E-05
      08017.80c 5.3623E-09 07014.80c 2.4089E-05 07015.80c 8.8976E-08
c  Total 4.8082E-02
c
c --------- part 2803 -----------
m29    92234.80c 4.8255E-04
       92235.80c 4.4753E-02
       92236.80c 1.1004E-04
       92238.80c 2.6710E-03
       47107.80c 4.3441E-07
       47109.80c 4.0359E-07
       56130.80c 4.3608E-13
       56132.80c 4.1551E-13
       56134.80c 9.9435E-12
       56135.80c 2.7119E-11
       56136.80c 3.2311E-11
       56137.80c 4.6208E-11
       56138.80c 2.9496E-10
       83209.80c 8.8672E-06
       06000.80c 4.7038E-06
       20040.80c 2.7331E-08
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     20044.80c 5.8811E-10
     20046.80c 1.1277E-12
     20048.80c 5.2721E-11
     48106.80c 6.2823E-10
     48108.80c 4.4730E-10
     48110.80c 6.2773E-09
     48111.80c 6.4331E-09
     48112.80c 1.2127E-08
     48113.80c 6.1416E-09
     48114.80c 1.4439E-08
     48116.80c 3.7644E-09
     27059.80c 9.5865E-07
     24050.80c 6.6095E-08
     24052.80c 1.2746E-06
     24053.80c 1.4453E-07
     24054.80c 3.5976E-08
     29063.80c 3.0748E-06
     29065.80c 1.3705E-06
     19039.80c 2.6951E-08
     19040.80c 3.3812E-12
     19041.80c 1.9450E-09
     03006.80c 1.2356E-07
     03007.80c 1.5043E-06
     12024.80c 1.1017E-06
     12025.80c 1.3947E-07
     12026.80c 1.5355E-07
     25055.80c 1.1518E-05
     42092.80c 8.7388E-09
     42094.80c 5.4470E-09
     42095.80c 9.3748E-09
     42096.80c 9.8223E-09
     42097.80c 5.6237E-09
     42098.80c 1.4209E-08
     42100.80c 5.6944E-09
     11023.80c 1.3270E-05
     28058.80c 1.3106E-05
     28060.80c 5.0483E-06
     28061.80c 2.1945E-07
     28062.80c 6.9969E-07
     28064.80c 1.7819E-07
     51121.80c 2.0174E-06
     51123.80c 1.5089E-06
     22046.80c 1.9475E-08
     22047.80c 1.7562E-08
     22048.80c 1.7402E-07
     22049.80c 1.2771E-08
     22050.80c 1.2228E-08
     08016.80c 1.4119E-05
     08017.80c 5.3673E-09
     07014.80c 2.4112E-05
     07015.80c 8.9060E-08
c
c  --- Control Cards ---------------------------------------------------------
mode n
```

```
kcode 1000000 1 50 1050
ksrc 10.32 0.0 0.1  10.32 0.0 1.0  10.32 0.0 -1.0
     10.32 0.0 2.0  10.32 0.0 -2.0 -10.32 0.0 0.1
     -10.32 0.0 1.0  -10.32 0.0 -1.0
     -10.32 0.0 2.0  -10.32 0.0 -2.0
c
c
*********************************************************************************************
HEU Cylinders-------- 7" - 11" (CONFIGURATION 4 – SIMPLE MODEL)
c
c ----------Cell Cards---------------------------
c
c
1     0   (2 -3 -11):(4 -9 -11)     imp:n=1
2     2   4.7865E-02  1 -9 -19 #1   imp:n=1  $
c 1     0   2 -3 4 -9 -11             imp:n=1
c 2     2   4.8013E-02  1 -9 -19 #1   imp:n=1  $
c
c         VOID SPACES and Gaps
24    0  151 -152 -150  #1 #2 imp:n=1   $ outside void
25    0  -151:152:150      imp:n=0   $ greater void

c  ------------Surface Cards (cm)---------------------------------
c
c      7" - 9" BARE ANNULUS
c    PLANES
1    pz  0.0       $ bottom
2    pz  3.5052    $ below diaphragm 7" disks height
3    pz  15.09522 $ bottom of upper 11" disk (part 2803)
4    pz  18.26768 $ top of upper 7" disks
9    pz  18.58518 $ top; 7.32" (both heights were averaged)
11   cz  8.89   $ 3.5 inch inner diameter
19   cz  13.97  $ 5.5 inch outer diameter
c
150  cz   14.0 $---------------Problem Boundary
151  pz   -0.1
152  pz    18.6 $---------------------------------

c  ------------Data Cards-----------------------------------------
c
c  --------- simple model ---------
m2    92234.80c   4.6877E-04
      92235.80c   4.4615E-02
      92236.80c   1.1037E-04
      92238.80c   2.6709E-03
c total 4.7865E-02
c
c  --- Control Cards ------------------------------------------------------------
mode n
kcode 1000000 1 50 1050
ksrc 12.0 0.0 0.1   12.0 0.0 10.0  12.0 0.0 1.0
     12.0 0.0 10.0  12.0 0.0 2.0   12.0 0.0 10.0
     -12.0 0.0 0.1  -12.0 0.0 1.0  -12.0 0.0 -10.0
     -12.0 0.0 2.0  -12.0 0.0 10.0
```

## APPENDIX B: Support Structure Assembly Schematics

These additional drawings were obtained (indirectly[a]) from the original experimenter in order to preserve the dimensions of the support structure immediately surrounding the experiment. Figure B.1 represents the diaphragm and rings with its support structure. Figure B.2 represents the low-mass support structure. Both of these structures can be seen in Figure 1.4. Although these support structures were used in many other critical experiments with oralloy at ORCEF, the drawings are first formerly documented previously in the HEU-MET-FAST-059 benchmark evaluation.

[a] Drawings obtained by John D. Bess from personal communication with John T. Mihalczo, February 2010.

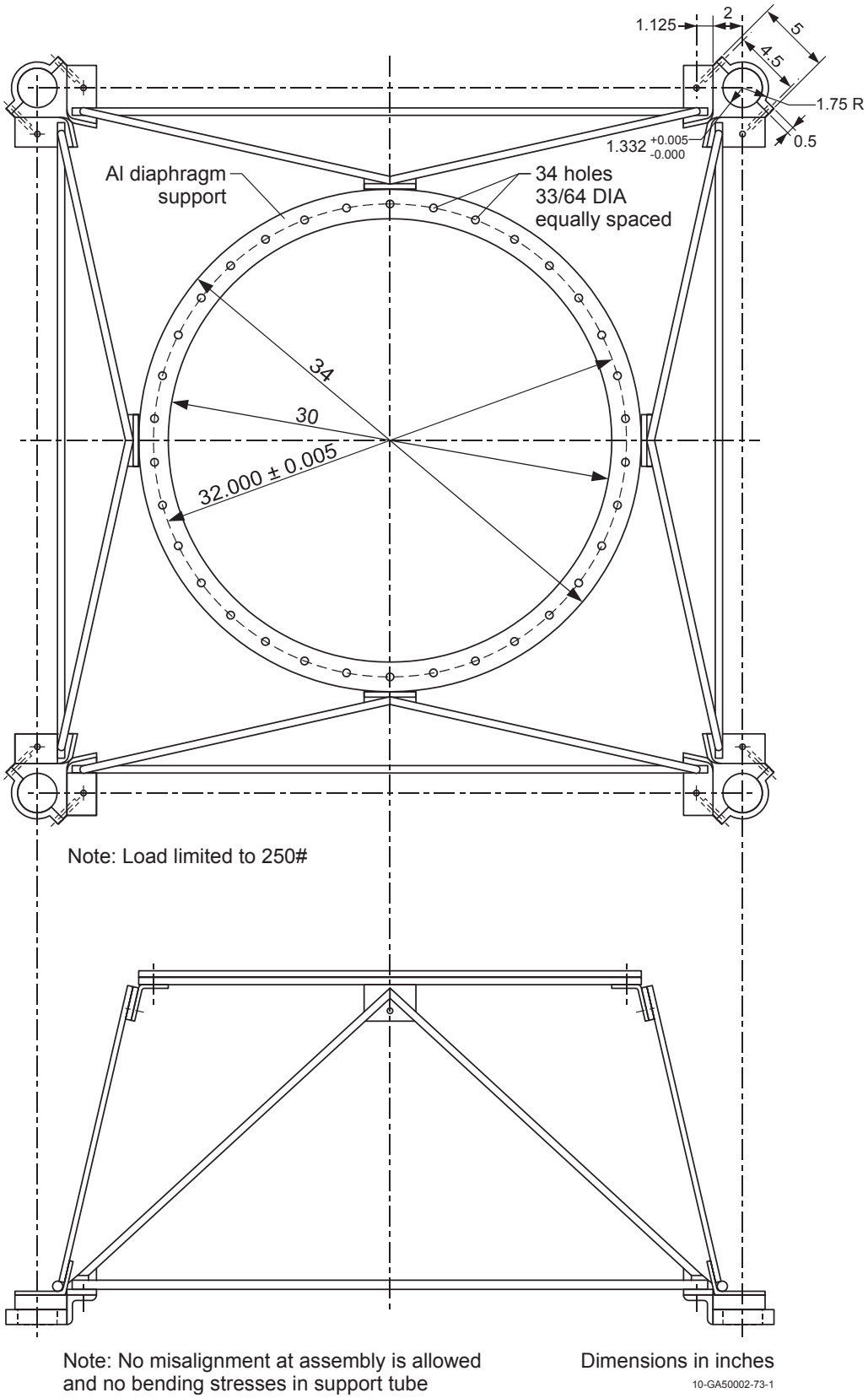


Figure B.1 Diaphragm Support Structure.

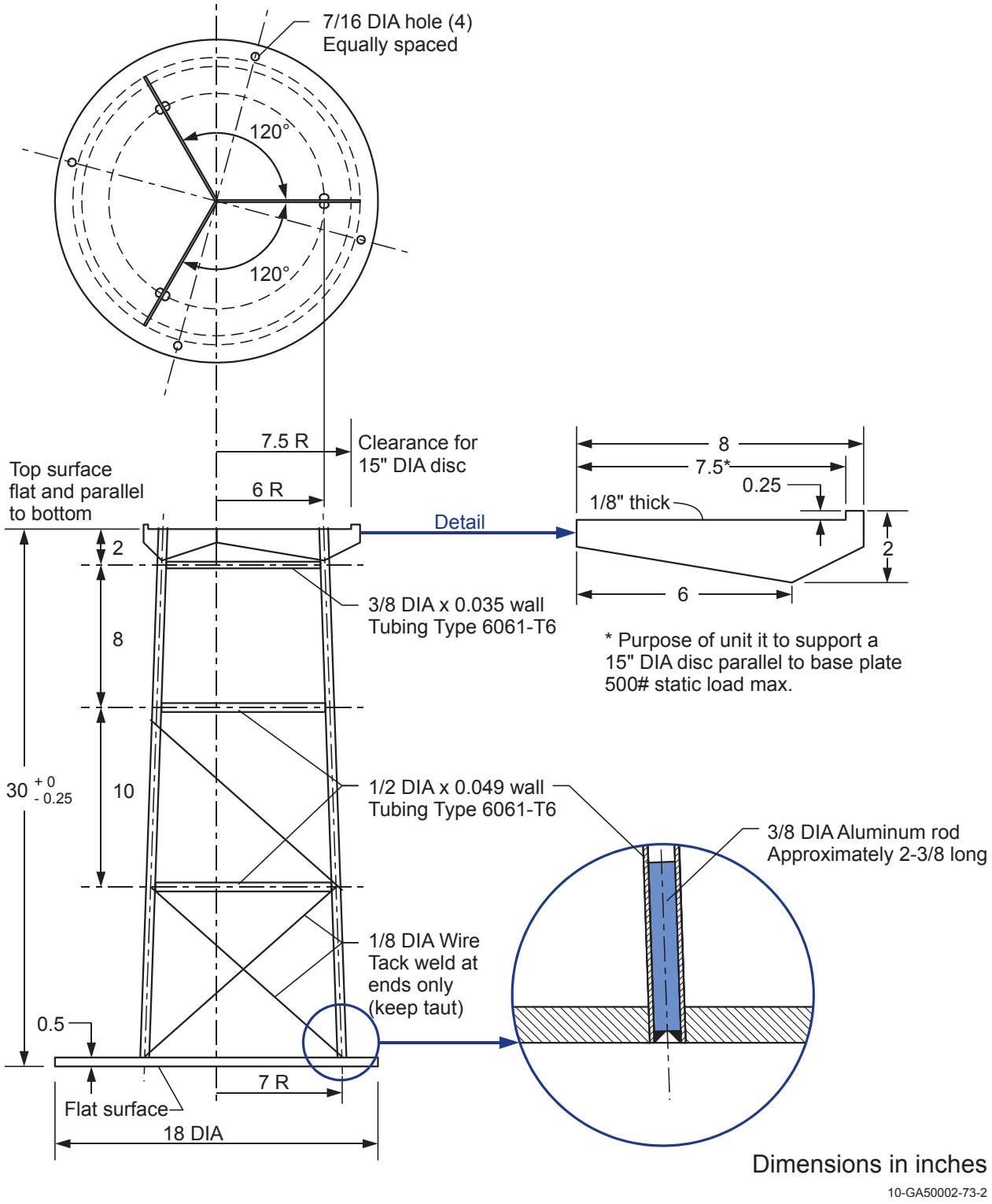


Figure B.2. Low-Mass Support Structure.