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STACY: WATER-REFLECTED 10%-ENRICHED URANYL NITRATE SOLUTION IN A 60-CM-DIAMETER CYLINDRICAL TANK

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IDENTIFICATION NUMBER: LEU-SOL-THERM-004 SPECTRA

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1.0 DETAILED DESCRIPTION

1.1 Overview of Experiment

Seven critical experiments included in this evaluation are part of a series of experiments with the Static Experiment Critical Facility (STACY) performed in 1995 at the Nuclear Fuel Cycle Safety Engineering Research Facility in the Tokai Research Establishment of the Japan Atomic Energy Research Institute. In the first series of experiments using the water-reflected 60-cm-diameter and 150-cm-high cylindrical tank, seven sets of critical data were obtained. The uranium concentration of the fuel solution ranged from 225 to 310 gU/liter and the uranium enrichment was 10 wt.%. On the bottom, side, and top of the core tank was a thick water reflector. The seven critical configurations are considered to be acceptable for use as critical benchmark data.

1.2 Description of Experimental Configuration

The schematic view of the core tank is shown in Figure 1. The core tank, which is made of stainless steel SUS304, has a cylindrical shape with an inner diameter of 590 mm. The height is approximately 1500 mm. The thickness of the side wall was 3 mm, and the upper and lower flat plates were 25 and 20 mm, respectively, as shown in Figure 1. The core tank is vertically penetrated by a tube (the outer diameter is 17.3 mm and its thickness is 3.2 mm) for thermocouples; this tube extends to the bottom of the tank. Four cylindrical safety rods containing B_4C pellets and a level meter are held at the upper part of the core tank. In its withdrawn position, the bottom of the safety rod is 1850 mm above the bottom of the core tank. In its fully inserted position, the bottom of the safety rod is 50 mm above the bottom of the core tank. The stainless steel cladding of the safety rod has a diameter of 61.9 mm, an inner diameter of 54.9 mm, a bottom thickness of 3.5 mm, and total length of 2277 mm. The outer diameter of the B_4C pellet is 54.6 mm. The fuel solution is fed through the fuel feed/drain line (outer diameter: 27.2 mm, thickness: 3.4 mm) from the bottom of the core tank. When the critical height is measured, the fuel solution is in this pipe.

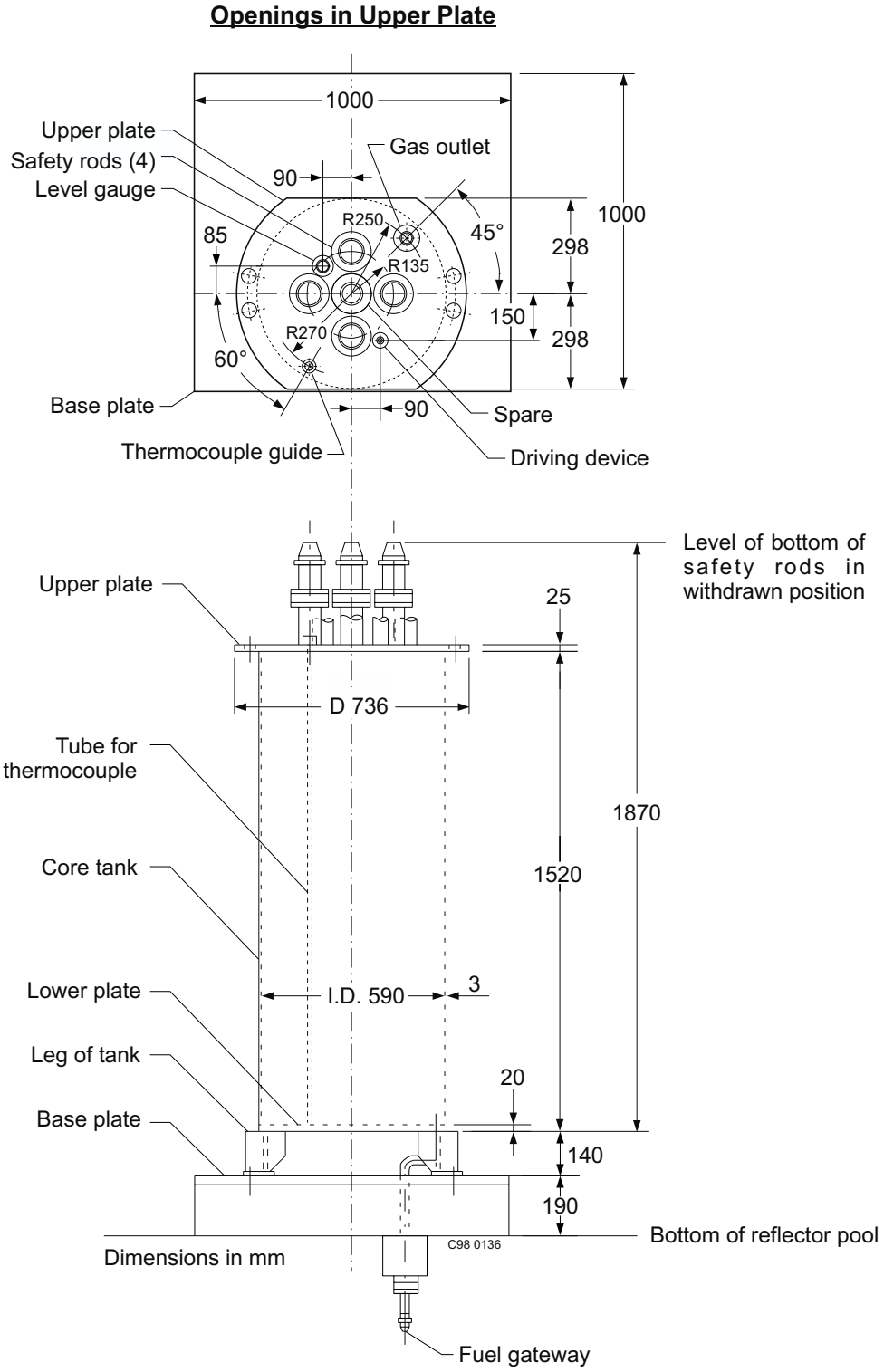

Figure 1. STACY Core Tank View

The core tank is supported by four stainless steel legs. These legs are 140 mm tall and stand on a stainless steel base plate. This plate is 1000 mm wide by 1000 mm long by 30 mm thick. The base plate is centered under the tank in one direction, and is off-center in the other direction, as shown in Figure 1. The base plate is supported by 160-mm-high stainless steel beams located on the bottom of the water-reflector pool. A guide tube (the outer diameter is 89.1 mm and the thickness is 5.5 mm) for inserting an Am-Be neutron source lies horizontally between the bottom plate of the core tank and the base plate. The center line of this tube is 100 mm below the bottom of the solution in the core tank.

The water-reflector pool is 2020 mm wide by 4020 mm long by 2400 mm high. The center of the core tank is at least 1000 mm from the pool wall. The core tank is completely flooded by light-water reflector. The height of the water reflector is 20 cm above the top of the core tank. The pool is surrounded by a metal hood which is 9 m wide by 10 m long by 9.8 m high. This hood is installed in a reactor room which is 12.6 m wide by 13.1 m long by 12.1 m high. All walls of the reactor room are made of concrete. The thickness of the concrete walls is more than 1 m.

The STACY facility consists of a core tank containing fuel solution, a solution transfer system, a fuel treatment system, and a fuel storage system. Reactivity is controlled by adjusting the fuel solution height in the core tank. Initially, a fast-feed pump is used to feed the fuel solution to just below half of the predicted critical height. After that, a slow-feed pump is used to feed the fuel solution to the near-critical state. The maximum excess reactivity and maximum reactivity addition rate are adjusted by limiting the position of the contact-type height gauge and the feed speed of the slow-feed pump. The height gauge consists of a needle to detect the surface of solution, an electric motor for changing the vertical position of the needle, and an encoder indicating the vertical position. The critical solution height was determined by observing the steady-state neutron-flux level.

Two ^{10}B counters and four gamma-ray compensation ionization chambers are positioned around the core tank to measure the neutron flux level for the start-up power range and operation power range, respectively. Maximum power is limited to 200 W. Four additional experimental neutron monitors composed of three ^{3}He proportional counters and one ^{10}B counter are also positioned around the core tank. The positions of the counters are variable depending on experimental requirements.

The seven critical conditions are summarized in Table 1.

Table 1. Critical Conditions of the STACY Experiments.

Run Number	Uranium Concentration[(a)] (g/liter)	Acidity[(a)] (mol/liter)	Core Temperature (°C)	Critical Height (mm)	Density[(a)] (g/cm^3)	Date
1	310.1±0.5	2.17±0.02	23.1	415.3±0.2	1.4827±0.0005	2/23/1995
29	290.4±0.5	2.23±0.02	24.8	467.0±0.2	1.4572±0.0005	5/30/1995
33	270.0±0.5	2.20±0.02	24.7	529.3±0.2	1.4348±0.0005	6/9/1995
34	253.6±0.5	2.24±0.02	24.8	648.5±0.2	1.4090±0.0005	6/14/1995
46	241.9±0.5	2.27±0.02	24.6	785.6±0.2	1.3936±0.0005	7/7/1995
51	233.2±0.5	2.28±0.02	22.4	955.0±0.2	1.3848±0.0005	9/20/1995
54	225.3±0.5	2.28±0.02	23.3	1303.3±0.2	1.3722±0.0005	9/26/1995

(a) These values are measured at 25°C

Table 2. Isotopic Composition of Uranium.

Isotope	Wt. %
^{234}U	0.08
^{235}U	9.97 ± 0.013
^{236}U	0.01
^{238}U	89.94

1.3 Description of Material Data

The uranium concentration, acidity, temperature, and density of the fuel solutions are listed in Table 1. The isotopic composition is listed in Table 2. The enrichment of the uranium was 9.97 ± 0.013 wt.%. Chemical analyses of the uranium concentration, acid molarity, and density of the fuel solution were made before and after each operation.

A sample of uranyl nitrate solution was taken from the dump tank, which is located in the basement of the reactor room, before and after each reactor operation. The chemical conditions in Table 1 are the latest ones before the experiments. The uranium concentrations were measured with the Davies and Gray method. The uncertainty of uranium concentrations was determined to be 0.5 g/liter. The measurement of acidity is as follows. Uranium was precipitated by adding $(NH_4)_2SO_4$ and H_2O_2 to a sample solution. Then, the total acidity was determined by titration with sodium hydroxide. The uncertainty of the acidity was determined to be 0.02 mol/liter. The density of the solution sample was measured with a digital density meter. The accuracy of this meter is 0.0001 g/cm^3. The uncertainty of density was estimated to be 0.0005g/cm^3.

The temperature of the fuel solution was measured during an operation by the thermocouples inserted in the guide tube within the core tank.

Three elements, Fe, Cr, and Ni, were considered and measured as the main impurities contained in the fuel solutions. The concentrations of these elements were found to be independent of the uranium concentration and acid molarity. The concentrations of Fe, Ni, and Cr were less than 28 mg/liter, 11 mg/liter, and 10 mg/liter, respectively.

The core tank is made of stainless steel SUS304. Other structural materials (legs, tube for thermometer, safety-rod guide tube, base plate, water-reflector pool, fuel feed/drain pipe, and sheath of B_4C pellets) are also made of stainless steel SUS304. The measured chemical composition of the core tank is given in Table 3. The density of the stainless steel SUS304 is not known. Its is assumed that the density of the stainless steel is 7.93 g/cm^3. This value is taken from the Japanese Industrial Standard.

Table 3. Composition of Stainless Steel for Core Tank.

Element	(wt.%)
C	0.011
Si	0.625
Mn	1.33
P	0.028
S	0.002
Ni	10.25
Cr	18.265
Fe	69.489

1.4 Supplemental Experimental Measurements

From the reactor period measured at a slightly super-critical height with two compensated ionization chambers, reactivity was obtained using an inhour equation. The differential reactivity with respect to solution height was measured.

The neutron flux distribution along the vertical direction was measured using the radioactivity distribution of irradiated gold wire. The gold wire was positioned on the outer surface of the core tank and was removed after the high-power operation. An extrapolation length along the vertical direction was measured by fitting the flux distribution to the cosine function.

To measure power of the critical core, an Am-Be neutron source was inserted into the critical core. The subsequent power increased linearly with time. The ratio of the initial neutron count rate to its increasing rate was used for estimating the power of the critical state.

Subcritical experiments such as pulsed-neutron method and frequency noise analysis were also carried out and kinetic parameters were measured.

The results of these measurements are written in the logbook or other classified internal reports.

2.0 EVALUATION OF EXPERIMENTAL DATA

2.1 General Notes

The results of seven critical experiments are collected from Reference 1 and many other laboratory reports. The effects on k_{eff} of uncertainties in measured data were calculated and are described in this section. Sensitivity studies were performed with the two-dimensional neutron-transport code TWOTRAN and a 16-group cross section set collapsed from the 107-group SRAC public library based on JENDL-3.2 (with a convergence criteria of 1×10^{-5}).

2.2 Fuel Solutions

As shown in Section 1, the uncertainty of uranium concentration, enrichment, acid molarity, and solution density were determined to be 0.5 gU/liter, 0.013 wt.%, 0.02 mol/liter, and 0.0005g/cm^3, respectively. The effect of these uncertainties on calculated k_{eff} are shown in Table 4.

Table 4. Effects of Uncertainties of Fuel on k_{eff} (%).

Parameter	Uncertainty	Run No.						
		1	29	33	34	46	51	54
Enrichment	±0.013wt.%	±0.046	±0.048	±0.050	±0.051	±0.053	±0.053	±0.055
Concentration	±0.5gU/l	±0.029	±0.038	±0.048	±0.058	±0.067	±0.073	±0.079
Acid molarity	±0.02mol/l	-+0.040	-+0.038	-+0.034	-+0.031	-+0.029	-+0.027	-+0.025
Density	±0.0005g/cm^3	±0.009	±0.007	±0.004	±0.002	<0.001	-+0.002	-+0.003
Impurity (Fe)	28mg/l	-0.0009	-0.0009	-0.0010	-0.0010	-0.0011	-0.0013	-0.0007
Impurity (Cr)	10mg/l	-0.0004	-0.0004	-0.0005	-0.0005	-0.0005	-0.0005	-0.0003
Impurity (Ni)	11mg/l	-0.0006	-0.0006	-0.0007	-0.0007	-0.0007	-0.0007	-0.0005

2.3 Critical Dimensions

The core tank used for the experiments has tolerances in the diameter, side-wall thickness, and bottom-plate thickness. These tolerances are estimated to be 1.0 mm, 0.2 mm, and 0.4 mm, respectively. The accuracy of the contact-type solution-height gauge is 0.2 mm. These values were adopted as the uncertainties. The effects of these uncertainties were evaluated and are listed in Table 5.

Table 5. Effects on k_{eff} of Tolerances in Critical Dimensions.

Parameter	Uncertainty	Δk_{eff}, %						
		1	29	33	34	46	51	54
Diameter	±1.0 mm	±0.037	±0.037	±0.037	±0.038	±0.038	±0.038	±0.038
Side-Wall Thickness	±0.2 mm	±0.026	±0.026	±0.025	±0.026	±0.026	±0.026	±0.027
Bottom-Plate Thickness	±0.4 mm	±0.005	±0.004	±0.003	±0.002	±0.001	±0.001	<0.001
Critical Height	±0.2 mm	±0.009	±0.007	±0.005	±0.003	±0.002	±0.001	<0.001

2.4 Temperature

The temperature change during the operations is estimated to be within 0.3°C. The effect on k_{eff} of this temperature change is calculated and listed in Table 6. To calculate the temperature effects, a density formula[a] for uranyl nitrate solution developed at JAERI was used. This formula gives the density of uranyl nitrate solution as a function of uranium concentration, acid molarity, and temperature. The details of this formula are shown in Appendix B.

Table 6. Effects on k_{eff} of Temperature Uncertainty.

Temperature Change	Δk_{eff}, %						
	1	29	33	34	46	51	54
±0.3°C	±0.010	±0.009	±0.009	±0.008	±0.008	±0.008	±0.008

2.5 Core Tank

The density of the stainless steel SUS304 for the core tank is not known. The value from the Japanese Industrial Standard, 7.93 g/cm^3 was assumed. The sensitivity of k_{eff} to the density was investigated for Run No. 54. The calculated sensitivity is -0.043 % Δk_{eff} / $\Delta\rho$. The uncertainty of the density is assumed to be the least significant digit, 0.01g/cm^3. Therefore, the effect of the uncertainty on k_{eff} is estimated to be ±0.004 % Δk_{eff}.

Because sufficient data is known and uncertainties have been sufficiently quantified, the seven configurations are acceptable benchmark experiments.

[a] S. Sakurai et al., JAERI-M 88-127 (1988).

3.0 BENCHMARK SPECIFICATION

3.1 Description of Model

The benchmark model is shown in Figure 2. The model is very simple and it consists of the fuel solution, core tank, and light-water reflector.

In the benchmark model, the side and lower reflectors have a thickness of 30 cm. These are thinner than the actual water reflector. The thickness of 30 cm, however, is considered to be sufficiently large. The following structures and devices are not included in the benchmark model for simplification of the benchmark model:

(1) Tube for thermocouples within the core tank.
(2) Contact-type level gauge. This is hung above the surface of the fuel solutions.
(3) Four legs supporting the core tank.
(4) Fuel feed/drain pipe containing fuel solution. The outer diameter of this pipe is 27.2 mm and the thickness of the pipe wall is 3.4 mm.
(5) Guide tube for neutron source. This tube lies horizontally below the core tank. Since this tube is filled with air, it replaces water reflector.
(6) Base plate. This plate is supporting the four legs. The upper surface of this plate is 14 cm below the bottom of the core tank.
(7) Beams below the base plate. These beams are supporting the base plate and lie on the bottom of the water-reflector pool. This thickness of these beams is 16 cm.
(8) Neutron counters. The closest counter is 6 cm away from the side wall of the core tank.
(9) Upper structure of the core tank. The guide tubes of the safety rods, level measurement devices, and safety rods are located above the upper plate of the core tank.
(10) Water-reflector pool wall. The bottom of the pool is 33 cm below the core tank. The side wall of the pool is 70 cm away from the side wall of the core tank.
(11) Hood and concrete wall of the reactor room.

Among these, the water-reflector pool wall, hood, and concrete wall obviously have negligible reactivity effect, because these are separated from the core by the thick water reflector. Others may affect the criticality. Therefore, a detailed model that includes those structures was constructed. MCNP calculations using both the standard benchmark model shown in Figure 2 and the detailed model were carried out for Run No. 1. This run has the largest geometrical buckling because the fuel solution is the lowest. Therefore, the effect of detailed structures on k_{eff} may be the largest. In addition, k_{eff} is calculated for Run No. 51. The calculated k_{eff}'s are shown in Table 7.

Table 7. Comparison Between Two Models.

Run. No.	Benchmark Model	Detailed Model
1	1.00748±0.00024	1.00752±0.00025
51	1.00663±0.00019	1.00625±0.00020

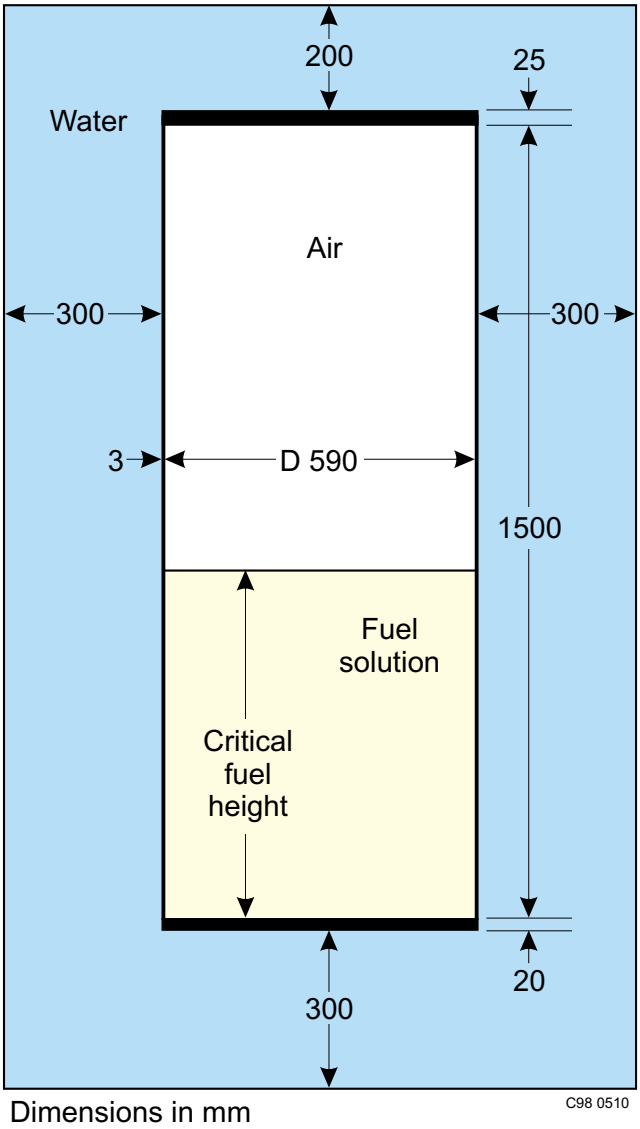

Figure 2. Benchmark Model of the STACY Experiments.

The differences of k_{eff}'s between the benchmark model and detailed model are negligibly small. Thus, the bias in calculated k_{eff} of the benchmark model is estimated to be none.

In this benchmark model, the existence of the impurities (Fe, Cr, Ni) is neglected. The reactivity effects of these impurities were obtained in Section 2. Because the impurity concentrations are maximum values and because the calculated effects were small, they are not included in the bias in the benchmark-model k_{eff}, but their effects are included in the benchmark-model k_{eff} uncertainty.

3.2 Dimensions

The dimensions of the benchmark model are given in Figure 2. The critical heights of the benchmark model are shown in Table 8. The side and lower reflector have a thickness of 30 cm. The thickness of the top reflector is 20 cm.

Table 8. Critical Sizes of the Benchmark Model.

Run No.	Uranium concentration (gU/liter)	Solution Height (cm)
1	310.1	41.53
29	290.4	46.70
33	270.0	52.93
34	253.6	64.85
46	241.9	78.56
51	233.2	95.50
54	225.3	130.33

3.3 Material Data

Because the uranium concentration, density of the solution, and acid molarity for 25°C are known, the atom densities of the fuel solution can be obtained. The atom densities of the fuel solutions for 25°C are shown in Table 9. The derivations of these atom densities are given in Appendix C.

Table 9. Atom Densities of Fuel Solution.

Run No.	^{234}U	^{235}U	^{236}U	^{238}U	H	N	O
1	6.3833×10^{-7}	7.9213×10^{-5}	7.9114×10^{-8}	7.0556×10^{-4}	5.6956×10^{-2}	2.8778×10^{-3}	3.8029×10^{-2}
29	5.9778×10^{-7}	7.4181×10^{-5}	7.4088×10^{-8}	6.6074×10^{-4}	5.7216×10^{-2}	2.8141×10^{-3}	3.7850×10^{-2}
33	5.5579×10^{-7}	6.8970×10^{-5}	6.8884×10^{-8}	6.1432×10^{-4}	5.8085×10^{-2}	2.6927×10^{-3}	3.7826×10^{-2}
34	5.2203×10^{-7}	6.4780×10^{-5}	6.4700×10^{-8}	5.7701×10^{-4}	5.8032×10^{-2}	2.6337×10^{-3}	3.7527×10^{-2}
46	4.9795×10^{-7}	6.1792×10^{-5}	6.1715×10^{-8}	5.5039×10^{-4}	5.8189×10^{-2}	2.5925×10^{-3}	3.7414×10^{-2}
51	4.8004×10^{-7}	5.9569×10^{-5}	5.9495×10^{-8}	5.3059×10^{-4}	5.8528×10^{-2}	2.5544×10^{-3}	3.7422×10^{-2}
54	4.6378×10^{-7}	5.7551×10^{-5}	5.7480×10^{-8}	5.1262×10^{-4}	5.8561×10^{-2}	2.5144×10^{-3}	3.7278×10^{-2}

The temperature of water of the benchmark model is 25◦C. The density of water at 25◦C is 0.99704[a]. The atom densities (atoms/barn-cm) of the water reflector derived from this density are as follows:

H: 6.6658×10^{-2},
O: 3.3329×10^{-2}.

The density of the stainless steel is 7.93 g/cm^3. The atom densities of the stainless steel used for the core tank are shown in Table 10.

Table 10. Atom Densities of Stainless Steel (atoms/barn-cm).

C	Si	Mn	P
4.3736×10^{-5}	1.0627×10^{-3}	1.1561×10^{-3}	4.3170×10^{-5}
S	Ni	Cr	Fe
2.9782×10^{-6}	8.3403×10^{-3}	1.6775×10^{-2}	5.9421×10^{-2}

[a] National Astronomical Observatory (ed.), Rika Nenpyo (Chronological Scientific Tables), Maruzen Co., Ltd. (1997)[in Japanese].

It is assumed that the void region above the surface of the solution is occupied by air of the density of 0.001184 g/cm^3. The air is composed of 76.64 wt.% nitrogen and 23.36 wt.% oxygen[b] . The atom densities (atoms/barn-cm) of the air are:

N: 3.9016×10^{-5},
O: 1.0409×10^{-5}.

3.4 Tempurature Data

The temperature at which the critical solution heights were measured ranged from 22.4°C to 24.8°C. A temperature of 25°C was used in the benchmark-model calculations, because the chemical analysis results were obtained for 25°C.

3.5 Experimental and Benchmark-Model k_{eff}

Experimental value of k_{eff} is 1.

The sources of the bias in the benchmark model are:

(1) excluding impurities (Fe, Cr, Ni) from the fuel solution,
(2) simplification of the geometry of the benchmark model,
(3) temperature difference between experimental temperature and 25°C.

The effect of impurities and the geometry simplification can be neglected as explained previously. The effect of the temperature difference can be obtained by TWOTRAN (convergence criterion of 1×10^{-5}). The k_{eff}'s for experimental temperature and 25°C were calculated. The density formula (Appendix B) was used for obtaining atom densities at different temperatures. The effect of the temperature difference can be regarded as the bias in the benchmark model k_{eff}. The uncertainty of k_{eff}'s included in the benchmark models are obtained by the square root of sum of squares of individual uncertainties. Consequently, the benchmark-model k_{eff}'s are:

Run 1: 0.9994 ± 0.0008,
Run 29: 0.9999 ± 0.0009,
Run 33: 0.9999 ± 0.0009,
Run 34: 0.9999 ± 0.0010,
Run 46: 0.9999 ± 0.0010,
Run 51: 0.9994 ± 0.0011,
Run 54: 0.9996 ± 0.0011.

[b] B. TAMAMUSHI et al., Rikagaku Jiten (Science Encyclopedia), Iwanami Shoten (1975) (in Japanese). Other elements were neglected. The weight percent of nitrogen and oxygen were adjusted such that the ratio of these elements was conserved.

4.0 RESULTS OF SAMPLE CALCULATIONS

Sample calculation results using MCNP and MULTI-KENO with the JENDL-3.2 library are shown in Table 11.a. In addition, APOLLO 1-MORET III with the 99-group CEA93 library and APOLLO 2-MORET IV with the 172-group CEA93 library were used for sample calculations. These libraries are based on JEF2 data. The results are shown in Table 11.b. MONK8A results are shown in Table 11.c.

Table 11.a. Sample Calculation Results (Japan).

Code (Cross Section Set)→ Run No.↓	MCNP (Continuous-Energy JENDL-3.2)	MULTI-KENO (137-Group MGCL based on JENDL-3.2)
1	1.0072 ± 0.0006	0.9959 ± 0.0007
29	1.0075 ± 0.0006	0.9976 ± 0.0007
33	1.0053 ± 0.0006	0.9949 ± 0.0006
34	1.0073 ± 0.0006	0.9963 ± 0.0006
46	1.0096 ± 0.0006	0.9970 ± 0.0006
51	1.0074 ± 0.0005	0.9986 ± 0.0006
54	1.0067 ± 0.0006	0.9980 ± 0.0005

Table 11.b. Sample Calculation Results (France).

Code (Cross Section Set)→ Run No.↓	APOLLO 1-MORET III (CEA93 Library 99-Group)	APOLLO 2-MORET IV (CEA93 Library 172-Group)
1	1.0004 ± 0.0003	1.0003 ± 0.0010
29	1.0012 ± 0.0010	1.0055 ± 0.0010
33	0.9983 ± 0.0010	0.9992 ± 0.0010
34	1.0003 ± 0.0010	1.0001 ± 0.0010
46	1.0019 ± 0.0010	1.0029 ± 0.0010
51	0.9989 ± 0.0010	1.0004 ± 0.0010
54	1.0003 ± 0.0010	1.0001 ± 0.0010

Table 11.c. Sample Calculation Results (United Kingdom). [(a)]

Code (Cross Section Set)→ Run No.↓	MONK8A (Continuous Energy JEF2.2)
1	1.0003 ± 0.0010
2	1.0012 ± 0.0010
3	0.9958 ± 0.0010
4	1.0022 ± 0.0010
5	0.9996 ± 0.0010
6	1.0008 ± 0.0010
7	0.9991 ± 0.0010

(a) Results provided by D. Hanlon.

5.0 REFERENCES

1. Yoshinori Miyoshi, Takuya Umano, Kotaro Tonoike, Naoki Izawa, Susumu Sugikawa, Shuji Okazaki, “Critical Experiments on 10 % Enriched Uranyl Nitrate Solution Using a 60-cm-Diameter Cylindrical Core,“ *Nucl. Technol.* **118**, 69 (1997).

APPENDIX A: TYPICAL INPUT LISTINGS

A.1 MCNP Input Listings

The MCNP 4A calculations were performed using 200 active generations of 5000 neutrons each, after skipping 50 generations.

MCNP Input Listing for Run No. 1, Table 11.a

```
Run No. 1
file name=run001 ; STACY
c   R001(water)   ;U=310.1(g/lit) A=2.17(mol/lit) D=1.4827(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  41.53(cm)
c
c   cellcard
c
1   1  9.86477977E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     41.53
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R001(water)   ;U=310.1(g/lit) A=2.17(mol/lit) D=1.4827(g/cc)
c   atomic density =  9.86437864E-02
m1    1001.37c     5.6956E-02
      7014.37c     2.8778E-03
      8016.37c     3.8029E-02
     92235.37c     7.9213E-05
     92238.37c     7.0556E-04
     92234.37c     6.3833E-07
     92236.37c     7.9114E-08
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
c
```

MCNP Input Listing for Run No. 1, Table 11.a (cont'd)

```
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   41.53
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print –175
```

MCNP Input Listing for Run No. 29, Table 11.a

```
Run No. 29
file name=run029 ; STACY
c   R033(water)   ;U=290.4(g/lit) A=2.23(mol/lit) D=1.4572(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  46.70(cm)
c
c   cellcard
c
1   1  9.86151498E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     46.70
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R029(water)   ;U=290.4(g/lit) A=2.23(mol/lit) D=1.4572(g/cc)
c   atomic density =  9.86151498E-02
m1    1001.37c     5.7216E-02
      7014.37c     2.8141E-03
      8016.37c     3.7850E-02
     92235.37c     7.4181E-05
     92238.37c     6.6074E-04
     92234.37c     5.9778E-07
     92236.37c     7.4088E-08
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 29, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   46.70
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print –175
```

MCNP Input Listing for Run No. 33, Table 11.a

```
Run No. 33
file name=run033 ; STACY
c   R033(water)   ;U=270.0(g/lit) A=2.20(mol/lit) D=1.4348(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  52.93(cm)
c
c   cellcard
c
1   1  9.92878695E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     52.93
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R033(water)   ;U=270.0(g/lit) A=2.20(mol/lit) D=1.4348(g/cc)
c   atomic density =  9.92878695E-02
m1    1001.37c     5.8085E-02
      7014.37c     2.6927E-03
      8016.37c     3.7826E-02
     92235.37c     6.8970E-05
     92238.37c     6.1432E-04
     92234.37c     5.5579E-07
     92236.37c     6.8884E-08
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 33, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   52.93
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print -175
```

MCNP Input Listing for Run No. 34, Table 11.a

```
Run No. 34
file name=run034 ;
c   R034(water)   ;U=253.6(g/lit) A=2.24(mol/lit) D=1.4090(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  64.85(cm)
c
c   cellcard
c
1   1  9.88351495E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                      -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                      -6   7 -30       imp:n=1     fill=2
7   0                   #6                 imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     64.85
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                  $ transport neutrons only
c
c   material cards
c
c   R034(water)   ;U=253.6(g/lit) A=2.24(mol/lit) D=1.4090(g/cc)
c   atomic density =  9.883514953E-02
m1    1001.37c     5.8032E-02
      7014.37c     2.6337E-03
      8016.37c     3.7527E-02
     92234.37c     5.2203E-07
     92235.37c     6.4780E-05
     92236.37c     6.4700E-08
     92238.37c     5.7701E-04
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 34, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   64.85
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print –175
```

MCNP Input Listing for Run No. 46, Table 11.a

```
Run No. 46
file name=run046 ; STACY
c   R046(water)   ;U=241.9(g/lit) A=2.27(mol/lit) D=1.3936(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  78.56(cm)
c
c   cellcard
c
1   1  9.88087938E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     78.56
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R046(water)   ;U=241.9(g/lit) A=2.27(mol/lit) D=1.3936(g/cc)
c   atomic density =  9.88087938E-02
m1    1001.37c     5.8189E-02
      7014.37c     2.5925E-03
      8016.37c     3.7414E-02
     92234.37c     4.9795E-07
     92235.37c     6.1792E-05
     92236.37c     6.1715E-08
     92238.37c     5.5039E-04
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 46, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   78.56
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print -175
```

MCNP Input Listing for Run No. 51, Table 11.a

```
Run No. 51
file name=run051 ; STACY
c   R051(water)   ;U=233.2(g/lit) A=2.28(mol/lit) D=1.3848(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level  95.50(cm)
c
c   cellcard
c
1   1  9.90957913E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz     95.50
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R051(water)   ;U=233.2(g/lit) A=2.28(mol/lit) D=1.3848(g/cc)
c   atomic density =  9.90957913E-02
m1    1001.37c     5.8528E-02
      7014.37c     2.5544E-03
      8016.37c     3.7422E-02
     92234.37c     4.8004E-07
     92235.37c     5.9569E-05
     92236.37c     5.9495E-08
     92238.37c     5.3059E-04
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 51, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0   95.50
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print -175
```

MCNP Input Listing for Run No. 54, Table 11.a

```
Run No. 54
file name=run054 ; STACY
c   R054(water)   ;U=225.3(g/lit) A=2.28(mol/lit) D=1.3722(g/cc)
c   Water Reflector Thickness 30.0(cm)
c   Critical level 130.33(cm)
c
c   cellcard
c
1   1  9.89242104E-02         1  -2 -10       imp:n=1 u=1
2   4  4.94250000E-05         2  -3 -10       imp:n=1 u=1
3   2  8.68449842E-02   #1 #2                 imp:n=1 u=1
4   0                       -4   5 -20       imp:n=1 u=2 fill=1
5   3  9.99870000E-02   #4                    imp:n=1 u=2
6   0                       -6   7 -30       imp:n=1     fill=2
7   0                    #6                  imp:n=0

c
c   surface cards (origin x=0.0 y=0.0 z=0.0)
c   cylinder
 1   pz      0.0
 2   pz    130.33
 3   pz    150.0
 4   pz    152.5
 5   pz     -2.0
 6   pz    172.5
 7   pz    -32.0
10   cz     29.5
20   cz     29.8
30   cz     59.8

c
c   data cards
c
mode  n                   $ transport neutrons only
c
c   material cards
c
c   R054(water)   ;U=225.3(g/lit) A=2.28(mol/lit) D=1.3722(g/cc)
c   atomic density =  9.89242104E-02
m1    1001.37c     5.8561E-02
      7014.37c     2.5144E-03
      8016.37c     3.7278E-02
     92234.37c     4.6378E-07
     92235.37c     5.7551E-05
     92236.37c     5.7480E-08
     92238.37c     5.1262E-04
mt1   lwtr.01t    $  300K
c
c   sus304 7.93g/cm3 ; atomic density  8.68449842E-02
m2    6012.37c 4.3736e-5   $ C
     14000.37c 1.0627e-3   $ Si
     25055.37c 1.1561e-3   $ Mn
     15031.37c 4.3170e-5   $ P
     16000.37c 2.9782e-6   $ S
     28000.37c 8.3403e-3   $ Ni
     24000.37c 1.6775e-2   $ Cr
     26000.37c 5.9421e-2   $ Fe
c
c    Water (STACY) 25C
c    atomic density  9.9987E-02
m3    1001.37c 6.6658E-02
      8016.37c 3.3329E-02
mt3   lwtr.01t    $  300k
```

MCNP Input Listing for Run No. 54, Table 11.a (cont'd)

```
c
c     Air (0.001184 g/cm3)
c     atomic density  4.9425E-05
m4    7014.37c 3.9016e-5
      8016.37c 1.0409e-5
c
c    criticality cards
c
kcode  5000 1.0 50 250
sdef  cel=d1 pos=0 0 0 axs=0 0 1 rad=d2 ext=d3 erg=d4
c
si1  l 6:4:1
sp1        1
c
si2    h   0.0   29.50
sp2   -21  1
c
si3    h   0.0  130.33
sp3   -21  0
c
sp4    -3
c
prdmp  j -100 1 3
c
print -175
```

A.2 MULTI-KENO Input Listing

MULTI-KENO was developed from KENO-IV. The main difference from KENO-IV is that it can treat a ‘SUPER BOX’ array. KENO was run using approximately 200 active generations of 5000 neutrons each within the cpu time of 170 minutes. The MAIL 3.0 code processed the 137-group MGCL library based on JENDL-3.2, which provided the effective microscopic cross sections for MULTI-KENO.

Input listing of MAIL 3.0

```
   4 137   4   0   3   0   1   3
FUEL SOLUTION RUN NO.1
   7   0   3
  3010010  3070140  3080160  3922350  3922380  3922340
  3922360
 5.6956E-2 2.8778E-3 3.8029E-2 7.9213E-5 7.0556E-4 6.3833E-7
 7.9114E-8
STAINLESS STEEL STACY CORE TANK
   8   0   3
  3060120  3140000  3250550  3150310  3160000  3280000
  3240000  3260000
 4.3736E-5 1.0627E-3 1.1561E-3 4.3170E-5 2.9782E-6 8.3403E-3
 1.6775E-2 5.9421E-2
WATER
   2   0   3
  3010010  3080160
 6.6658E-2 3.3329E-2
AIR
   2   0   3
  3070140  3080160
 3.9016E-5 1.0409E-5
```

Multi-KENO Input Listing for Run No. 1, Table 11.a

```
STACY REFLECTED RUN NO.1
170.0 250  5000   50  137  137    4    4    4    9    1    1    1    1
   4    1    0 2000    0    1    0    0    0    0    0    0    0    0
 -0.0 -0.0 -0.0 -0.0 -0.0 -0.0
1 -1 1.0  2 2 1.0  3 3 1.0  4 4 1.0
*
SUPER BOX   1    1 1 1 1
BOX TYPE  1
CYLINDER  1  29.50                        41.530  0.0000  137R0.5
CYLINDER  4  29.50                        150.00  0.0000  137R0.5
CYLINDER  2  29.80                        152.50  -2.000  137R0.5
CYLINDER  3  59.80                        172.50 -32.000  137R0.5
CUBOID    0  59.80 -59.80    59.80 -59.80      172.50 -32.000  137R0.5
CELL BDY  0  59.80 -59.80    59.80 -59.80      172.50 -32.000  137R0.5
CUBOID    0  59.80 -59.80    59.80 -59.80      172.50 -32.000  137R0.5
*
CORE BDY  0  59.80 -59.80    59.80 -59.80      172.50 -32.000  137R0.5
CUBOID    0  59.80 -59.80    59.80 -59.80      172.50 -32.000  137R0.5
*
-1
END KENO
```

A.3 MORET – APOLLO Input Listings

The k_{eff} calculation is run in two steps using two code systems, each including two codes:

APOLLO 1 + MORET III
APOLLO 2 + MORET IV

1. APOLLO is one-dimensional multigroup cell code. It is used to determine material buckling B_m^2, $k_{infinity}$, and homogeneous macroscopic medium cross sections.

2. MORET is a three-dimensional multigroup Monte Carlo code. It uses macroscopic cross sections coming from APOLLO. Each calculation employed 500 histories per stage and was run to achieve a precision of 0.0010 (about at least 600000 neutrons). The APOLLO Library used is CEA93 (cross sections coming from JEF2, 172 groups for APOLLO 2 and 99 groups for APOLLO 1. Notice that the natural elements iron (Fe), chromium (Cr), and nickel (Ni) do not exist in this library, and they are, therefore, divided into isotopes. MORET IV uses P9 anisotropic treatment and MORET III does P1.

   A code called PREAPOL is used to generate the APOLLO input; in particular it models natural Fe, Cr, and Ni as the combination of their isotopes. The input for PREAPOL, APOLLO 2, and MORET IV are provided for Case 1 and PREAPOL and MORET IV for other cases. APOLLO 2 and MORET IV were run on RS 6000, PREAPOL on a personal computer.

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b

```
Run No. 1
*****************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES               *
*    APOLLO2 ( CEA93 172gr library) - MORET 4       *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004             *
*.....................................................*
*                                                   *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2            *
*         CASE N° 1    C(U)=310.1 g/l               *
*****************************************************
DEBUT_APOLLO2
*********************************************
*   CRAPO : version 1-0  du 03/11/97  *
*  Transformation preapol en APOLLO 2  *
*********************************************
CODE: APOLLO ;
*
*----------------------------------------
* lecture des procedures APROC
*----------------------------------------
REPROC = OUVRIR: 22 &VARIABLE 1024 10000 ;
CHARGE_APROC = LIRE: REPROC 'APROC' 'CHARGE_APROC' ;
FERME: REPROC ;
*=========================================================================
EXECUTER CHARGE_APROC ;
*=========================================================================
* APOLLO N0   1
*=========================================================================
*
TITRE: 'STACY :case C01 - water 25°C                          ' ;
*
*----------------------------------------
* options de calculs
*----------------------------------------
OPTION: &STAT &OUI ;
OPTION: &IMPRESSION &PAGE 60 129 1 ;
*
libfiles = TEXTE 'REPBBLIO' ;
ANISO = TEXTE '&P1' ;
*
*----------------------------------------
* Declaration biblio lecture des isotopes
*----------------------------------------
TOPT = TABLE: ;
TSTR = TABLE: ;
TOPT.'NGROUP' = 172 ;
TSTR.'TISO' TSTR.'MAIL' IDB REPBBLIO = BIBLIO_CEA93_V3 0 TOPT.'NGROUP'
 /home/octobre/APOLLO2/CEA93.G172.V3.DIRECT ;
DETRUIRE: BIBLIO_CEA93_V3 ;
*
*----------------------------------------
* Creation des milieux du CAS   1
*----------------------------------------
* water  25°C
TSTR.'TMIL' = TABLE: ;
APOLNO1  = MILIEU:
TSTR.'TISO'.'H2O     '     3.33290E-02
                &TEMP  25.0000 ;
*
*----------------------------------------
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
* Creation de la bibliotheque interne
*----------------------------------------
TSTR.'APOLIB' = BIBINT: &EDIT 1 IDB
APOLNO1  libfiles ;
FERMER:  libfiles ;
*
*-------------------------------------------------
* Creation de la Macrolib pour le milieu APOLNO1
*-------------------------------------------------
*
TSTR.'MACS' = MACROLIB: &EDIT 1 APOLNO1
          &TOTA &SELF &ABSO &ENER &FISS &ENER
          &SNNN &TRAC &P0   &DIFF ANISO &TRAN ANISO ;
*
APOTRIM: &EDIT 1 TSTR.'MACS'  ANISO &FICH 47 &NOMMIL APOLNO1
' water  25°C        ' ;
*=========================================================================
EXECUTER CHARGE_APROC ;
*=========================================================================
* APOLLO N0   2
*=========================================================================
*
TITRE: 'STACY case 01 : stainless steel SUS304                    ' ;
*
*----------------------------------------
* options de calculs
*----------------------------------------
OPTION: &STAT &OUI ;
OPTION: &IMPRESSION &PAGE 60 129 1 ;
*
libfiles = TEXTE 'REPBBLIO' ;
ANISO = TEXTE '&P1' ;
*
*----------------------------------------
* Declaration biblio lecture des isotopes
*----------------------------------------
TOPT = TABLE: ;
TSTR = TABLE: ;
TOPT.'NGROUP' = 172 ;
TSTR.'TISO' TSTR.'MAIL' IDB REPBBLIO = BIBLIO_CEA93_V3 0 TOPT.'NGROUP'
 /home/octobre/APOLLO2/CEA93.G172.V3.DIRECT ;
DETRUIRE: BIBLIO_CEA93_V3 ;
*
*----------------------------------------
* Creation des milieux du CAS   2
*----------------------------------------
* stainless steel SUS304
TSTR.'TMIL' = TABLE: ;
APOLNO2  = MILIEU:
TSTR.'TISO'.'MN55    '     1.15610E-03
TSTR.'TISO'.'SINAT   '     1.06270E-03
TSTR.'TISO'.'CNAT    '     4.37360E-05
TSTR.'TISO'.'FE54    '     3.50584E-03
TSTR.'TISO'.'FE56    '     5.45009E-02
TSTR.'TISO'.'FE57    '     1.24784E-03
TSTR.'TISO'.'FE58    '     1.66379E-04
TSTR.'TISO'.'CR50    '     7.28874E-04
TSTR.'TISO'.'CR52    '     1.40558E-02
TSTR.'TISO'.'CR53    '     1.59362E-03
TSTR.'TISO'.'CR54    '     3.96729E-04
TSTR.'TISO'.'NI58    '     5.67783E-03
TSTR.'TISO'.'NI60    '     2.18708E-03
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
TSTR.'TISO'.'NI61    '     9.50794E-05
TSTR.'TISO'.'NI62    '     3.03086E-04
TSTR.'TISO'.'NI64    '     7.72312E-05
                &TEMP  25.0000 ;
*
*----------------------------------------
* Creation de la bibliotheque interne
*----------------------------------------
TSTR.'APOLIB' = BIBINT: &EDIT 1 IDB
APOLNO2  libfiles ;
FERMER:  libfiles ;
*
*-------------------------------------------------
* Creation de la Macrolib pour le milieu APOLNO2
*-------------------------------------------------
*
TSTR.'MACS' = MACROLIB: &EDIT 1 APOLNO2
          &TOTA &SELF &ABSO &ENER &FISS &ENER
          &SNNN &TRAC &P0   &DIFF ANISO &TRAN ANISO ;
*
APOTRIM: &EDIT 1 TSTR.'MACS'  ANISO &NOMA &FICH 47 &NOMMIL APOLNO2
' stainless steel SUS' ;
*=========================================================================
EXECUTER CHARGE_APROC ;
*=========================================================================
* APOLLO N0   3
*=========================================================================
*
TITRE: 'STACY case 01 : air                                    ' ;
*
*----------------------------------------
* options de calculs
*----------------------------------------
OPTION: &STAT &OUI ;
OPTION: &IMPRESSION &PAGE 60 129 1 ;
*
libfiles = TEXTE 'REPBBLIO' ;
ANISO = TEXTE '&P1' ;
*
*----------------------------------------
* Declaration biblio lecture des isotopes
*----------------------------------------
TOPT = TABLE: ;
TSTR = TABLE: ;
TOPT.'NGROUP' = 172 ;
TSTR.'TISO' TSTR.'MAIL' IDB REPBBLIO = BIBLIO_CEA93_V3 0 TOPT.'NGROUP'
 /home/octobre/APOLLO2/CEA93.G172.V3.DIRECT ;
DETRUIRE: BIBLIO_CEA93_V3 ;
*
*----------------------------------------
* Creation des milieux du CAS   3
*----------------------------------------
* air
TSTR.'TMIL' = TABLE: ;
APOLNO3  = MILIEU:
TSTR.'TISO'.'N14     '     3.90160E-05
TSTR.'TISO'.'O16     '     1.04090E-05
                &TEMP  25.0000 ;
*
*----------------------------------------
* Creation de la bibliotheque interne
*----------------------------------------
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
TSTR.'APOLIB' = BIBINT: &EDIT 1 IDB
APOLNO3  libfiles ;
FERMER:  libfiles ;
*
*----------------------------------------------
* Creation de la Macrolib pour le milieu APOLNO3
*----------------------------------------------
*
TSTR.'MACS' = MACROLIB: &EDIT 1 APOLNO3
          &TOTA &SELF &ABSO &ENER &FISS &ENER
          &SNNN &TRAC &P0   &DIFF ANISO &TRAN ANISO ;
*
APOTRIM: &EDIT 1 TSTR.'MACS'  ANISO &NOMA &FICH 47 &NOMMIL APOLNO3
' air              ' ;
*=============================================================================
EXECUTER CHARGE_APROC ;
*=============================================================================
* APOLLO N0   4
*=============================================================================
*
TITRE: 'STACY case 01 : nitrate solution  C(U) = 310.1 g/l  H+ = 2.1' ;
*
*----------------------------------------
* options de calculs
*----------------------------------------
OPTION: &STAT &OUI ;
OPTION: &IMPRESSION &PAGE 60 129 1 ;
*
libfiles = TEXTE 'REPBBLIO' ;
ANISO = TEXTE '&P1' ;
*
*----------------------------------------
* Declaration biblio lecture des isotopes
*----------------------------------------
TOPT = TABLE: ;
TSTR = TABLE: ;
TOPT.'NGROUP' = 172 ;
TSTR.'TISO' TSTR.'MAIL' IDB REPBBLIO = BIBLIO_CEA93_V3 0 TOPT.'NGROUP'
 /home/octobre/APOLLO2/CEA93.G172.V3.DIRECT ;
DETRUIRE: BIBLIO_CEA93_V3 ;
*
*----------------------------------------
* Creation des milieux du CAS   4
*----------------------------------------
*Nitrate analyse    C(U)=310.100   C(PU)=0.000  H+=2.17    GD=0.00
TSTR.'TMIL' = TABLE: ;
TSTR.'TMIL'.'FISSIL1 ' = MILIEU:
TSTR.'TISO'.'U234    '     6.38334E-07
TSTR.'TISO'.'U235    '     7.92129E-05
TSTR.'TISO'.'U236    '     7.91141E-08
TSTR.'TISO'.'U238    '     7.05558E-04
TSTR.'TISO'.'H2O     '     2.84779E-02
TSTR.'TISO'.'O16     '     9.55090E-03
TSTR.'TISO'.'N14     '     2.86713E-03
                &TEMP  25.0000 ;
*
*----------------------------------------
* Creation de la bibliotheque interne
*----------------------------------------
TSTR.'APOLIB' = BIBINT: &EDIT 1 IDB
TSTR.'TMIL'.'FISSIL1 '  libfiles ;
FERMER:  libfiles ;
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
*
*----------------------------------------------
* Creation de la geometrie du cas  4
*----------------------------------------------
TSTR.'GEO' = GEOM: &CYLI &MAIL 1   &EQD 1. &MILI
             TSTR.'TMIL'.'FISSIL1 ' 1 ;
*
*----------------------------------------------
* Calcul d autoprotection
*----------------------------------------------
TSTR.'TAUTO' = TABLE: ;
TSTR.'TAUTO'.1 = TABLE: ;
TSTR.'TAUTO'.2 = TABLE: ;
TSTR.'TAUTO'.3 = TABLE: ;
TSTR.'TAUTO'.1.'ISO' = 'U238    ' ;
TSTR.'TAUTO'.2.'ISO' = 'U235    ' ;
TSTR.'TAUTO'.3.'ISO' = 'U236    ' ;
TSTR.'TAUTO'.1.'MILIEUX' = INITABLE: '"FISSIL1 '" ;
TSTR.'TAUTO'.2.'MILIEUX' = INITABLE: '"FISSIL1 '" ;
TSTR.'TAUTO'.3.'MILIEUX' = INITABLE: '"FISSIL1 '" ;
TSTR.'TAUTO'.1.'REGIONS' = INITABLE: 'RG1' ;
TSTR.'TAUTO'.2.'REGIONS' = INITABLE: 'RG1' ;
TSTR.'TAUTO'.3.'REGIONS' = INITABLE: 'RG1' ;
*
AUTOP1 TSTR.'APOLIB' TSTR.'TMIL' = AUTOPROTECTION 0 TSTR.'GEO'
     TSTR.'APOLIB'  3 TOPT.'NGROUP' TSTR.'TMIL' TSTR.'TAUTO' ;
*
*----------------------------------------------
* Calcul du Kinf sans fuites a B2=0
*----------------------------------------------
TOPT.'TYPE_B2' = 'NUL' ;
TRES TSTR TOPT = CALFLUX_PIJ_S 1 TSTR TOPT ;
*
*----------------------------------------------
* Calcul des Pij a laplacien critique
*----------------------------------------------
TOPT.'TYPE_B2' = 'CRITIQUE' ;
TRES TSTR TOPT = CALFLUX_PIJ_S 1 TSTR TOPT ;
*
APOLNO4  = MILIEU: &EQUI 1 ;
EQGEO = EQUIGEOM: TSTR.'GEO' &GLOB APOLNO4  ;
*
*----------------------------------------------
* Creation de la Macrolib pour le milieu FISSIL1
*----------------------------------------------
*
TSTR.'MACS' = PONDFLUX: TSTR.'FLX' TSTR.'MAC' TSTR.'MAIL' EQGEO ;
TSTR.'MACS' = MACROLIB: &EDIT 1 TSTR.'MACS'
          &MODI &TOTA &SELF &ABSO &ENER &FISS &ENER
          &SNNN &TRAC &P0   &DIFF ANISO &TRAN ANISO ;
*
APOTRIM: &EDIT 1 TSTR.'MACS'  ANISO &NOMA &FICH 47 &NOMMIL APOLNO4
'Nitrate analyse    C' ;
*
*EDITION: &TIME &TOUT ;
ARRET: ;
FIN_APOLLO2
cat <<'EOF'> melodie.pre
*-------------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 21/02/1997
*-------------------------------------------------------------------------
*-------------------------------------------------------------------------
*                RAPPEL GEOMETRIE
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 2 MATRICES 172 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY :case C01 - water 25°C                    CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION NOCOND TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 2 MATRICES 172 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY case 01 : stainless steel SUS304          CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE        CR        NI
        MN55      SI        C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION NOCOND TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 2 MATRICES 172 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY case 01 : air                             CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
        N14       O16
   CONC  3.9016E-05 1.0409E-05
FINC
SECTION NOCOND TOUT
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
FIN
*----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 2 MATRICES 172 GROUPES
*----------------------------------------------------------------------
*======================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.4827
*----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.170 N
*======================================================================
(
STACY case 01 : nitrate solution  C(U) = 310.1 g/l  H+ = 2.1 CAS N* 4
*Nitrate analyse    C(U)=310.100   C(PU)=0.000  H+=2.17    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=310.100   C(PU)=0.000  H+=2.17    GD=0.00
 MICRO 1 7
   U234       U235       U236       U238
   H2O        O16        NNAT
   VERIF 1.4827
   6.383340E-07 7.921290E-05 7.911409E-08 7.055584E-04
   2.847788E-02 9.550899E-03 2.877773E-03
FINC
CALCUL LES2 SECTION NOCOND TOUT
FIND
EOF
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 1 *
*                                      *
* U(9.97%)O2(NO3)2     C(U)=310.1 g/l  H+=2.17    *
*                                      *
*   CRITICAL HEIGHT 41.53 cm   WATER REFLECTED    *
*......................................*
*                                      *
*    benchmark Keff = 0.9994 +/- 0.0008          *
*                                      *
********************************************************
* precision
  SIGI 0.001 SIGE 0.001 MINI 100 PAS 50   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.1, Table 11.b (cont'd)

```
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE
 SEALINK 4  APO2      4    1 2 3 4
FINCHIMIE
*
GEOMETRY
*..................... water reflector tank .......................
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*.......... tank : top and bottom plates st.st. SUS 304 L ......
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.............tank : cylindrical wall  st.st. SUS 304 L ..................
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....................  air ........................................
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* ..........fissile solution Hc = 41.53 cm .......................
  TYPE 5 CYLZ 29.50 20.765
  VOLUME 5 4 5 4   0.0 0.0 52.765
*...........     sources    .....................................
  SOURCE 1 5 500 0.0 0.0 52.765
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.29, Table 11.b

```
Run No. 29
*****************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES               *
*    APOLLO2 ( CEA93 172gr library) - MORET 4       *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004             *
*                                                   *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2            *
*         CASE N° 29   C(U)=290.4 g/l               *
*****************************************************
*---------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*---------------------------------------------------------------------
*---------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*---------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*---------------------------------------------------------------------
*=====================================================================
(
STACY :case C29 - water 25°C                        CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION NOCOND TOUT
FIN
*---------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*---------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*---------------------------------------------------------------------
*=====================================================================
(
STACY case 29 : stainless steel SUS304                    CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE        CR        NI
        MN55      SI        C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION NOCOND TOUT
FIN
*---------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*---------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*---------------------------------------------------------------------
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.29, Table 11.b (cont'd)

```
*=============================================================================
(
STACY case 29 : air                              CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
   N14 O16
  CONC  3.9016E-05 1.0409E-05
FINC
SECTION NOCOND TOUT
FIN
*-----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=============================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.4572
*-----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*-----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*-----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*-----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*-----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.230 N
*=============================================================================
(
STACY case 29 : nitrate solution  C(U) = 290.4 g/l  H+ = 2.2 CAS N* 4
*Nitrate analyse    C(U)=290.400   C(PU)=0.000  H+=2.23    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=290.400   C(PU)=0.000  H+=2.23    GD=0.00
 MICRO 1 7
       U234        U235        U236        U238
       H2O         O16         NNAT
  VERIF 1.4572
       5.977819E-07 7.418067E-05 7.408813E-08 6.607358E-04
       2.860781E-02 9.242028E-03 2.814105E-03
FINC
CALCUL LES2 SECTION TOUT
FIND
EOF
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.29, Table 11.b (cont'd)

```
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 29*
*                                        *
* U(9.97%)O2(NO3)2 C(U)=290.4  H+=2.23 d=1.45717  *
*                                        *
*   CRITICAL HEIGHT 46.70 cm   WATER REFLECTED    *
*.....*
*                                        *
*    benchmark Keff = 0.9999 +/- 0.0009          *
*                                        *
**************************************************
* precision
  SIGI 0.001  SIGE 0.001  MINI 100 PAS 20   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE   SEALINK 4 APO2 4 1 2 3 4
FINCHIMIE
*
GEOMETRY
*..... water reflector tank .....
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*..... tank : top and bottom plates st.st. SUS 304 L .....
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.....tank : cylindrical wall  st.st. SUS 304 L .....
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....  air .....
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* .....fissile solution Hc = 46.7 cm .....
  TYPE 5 CYLZ 29.50 23.35
  VOLUME 5 4 5 4   0.0 0.0 55.35
*.....     sources     .....
  SOURCE 1 5 500 0.0 0.0 55.35
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.33, Table 11.b

```
Run No. 33
*******************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES             *
*    APOLLO2 ( CEA93 172gr library) - MORET 4     *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004           *
*                                                 *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2          *
*         CASE N° 33   C(U)=270.0 g/l             *
*******************************************************
cat <<'EOF'> melodie.pre
*-----------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY :case C33 - water 25°C                        CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION NOCOND TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY case 33 : stainless steel SUS304                    CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE        CR        NI
        MN55      SI        C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION NOCOND TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.33, Table 11.b (cont'd)

```
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-------------------------------------------------------------------------
*=========================================================================
(
STACY case 33 : air                              CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
    N14 O16
   CONC  3.9016E-05 1.0409E-05
FINC
SECTION NOCOND TOUT
FIN
*-------------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-------------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-------------------------------------------------------------------------
*=========================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.4348
*-------------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*-------------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*-------------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*-------------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*-------------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.200 N
*=========================================================================
(
STACY case 33 : nitrate solution  C(U) = 270.0 g/l  H+ = 2.2 CAS N* 4
*Nitrate analyse    C(U)=270.000   C(PU)=0.000  H+=2.20    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=270.000   C(PU)=0.000  H+=2.20    GD=0.00
 MICRO 1 7
        U234       U235        U236        U238
        H2O        O16         NNAT
   VERIF 1.4348
        5.55789E-07 6.896963E-05 6.888359E-08 6.143205E-04
         .0290426   8.783471E-03 2.692692E-03
FINC
CALCUL LES2 SECTION TOUT
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.33, Table 11.b (cont'd)

```
FIND
EOF
DEBUT_MORET
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 33*
*                                        *
* U(9.97%)O2(NO3)2  C(U)=270.0  H+=2.20 d=1.43479 *
*                                        *
*   CRITICAL HEIGHT 52.93 cm   WATER REFLECTED    *
*.....*
*                                        *
*    benchmark Keff = 0.9999 +/- 0.0009          *
*                                        *
**************************************************
* precision
  SIGI 0.001 SIGE 0.001 MINI 100 PAS 20   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
* 1   *-  water
* 2   *-  stainless steel ( tank  top  and  bottom )
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE SEALINK APO2    4    1 2 3 4
FINCHIMIE
*
GEOMETRY
*..... water reflector tank .....
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*..... tank : top and bottom plates st.st. SUS 304 L .....
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.....tank : cylindrical wall  st.st. SUS 304 L .....
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....  air .....
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* .....fissile solution Hc = 52.93 cm .....
  TYPE 5 PLAZ INF  84.93
  VOLUME 5 4 5 4   0.0 0.0 58.0 ETSUP 1 4
*.....     sources    .....
  SOURCE 1 5 500 0.0 0.0 58.0
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.34, Table 11.b

```
Run No. 34
*******************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES             *
*    APOLLO2 ( CEA93 172gr library) - MORET 4     *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004           *
*                                                 *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2          *
*         CASE N° 34   C(U)=253.6 g/l             *
*******************************************************
cat <<'EOF'> melodie.pre
*-----------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY :case C34 - water 25°C                        CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY case 34 : stainless steel SUS304                    CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE         CR         NI
        MN55       SI         C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.34, Table 11.b (cont'd)

```
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY case 34 : air                              CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
    N14 O16
   CONC  3.9016E-05 1.0409E-05
FINC
SECTION TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.409
*----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.240 N
*======================================================================
(
STACY case 34 : nitrate solution  C(U) = 253.6 g/l  H+ = 2.2 CAS N* 4
*Nitrate analyse    C(U)=253.600   C(PU)=0.000  H+=2.24    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=253.600   C(PU)=0.000  H+=2.24    GD=0.00
 MICRO 1 7
       U234        U235        U236        U238
       H2O         O16         NNAT
  VERIF 1.409
       5.220299E-07 6.478037E-05 6.469956E-08 5.770061E-04
       2.901591E-02 8.511364E-03 2.633697E-03
FINC
CALCUL LES2 SECTION TOUT
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.34, Table 11.b (cont'd)

```
FIND
EOF
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 34*
*                                        *
* U(9.97%)O2(NO3)2  C(U)=253.6  H+=2.24  d=1.40902*
*                                        *
*   CRITICAL HEIGHT 64.85 cm   WATER REFLECTED    *
*.....*
*                                        *
*    benchmark Keff = 0.9999 +/- 0.0010          *
*                                        *
**************************************************
* precision
  SIGI 0.001 SIGE 0.001 MINI 100 PAS 20   NOBIL ALEA 11
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE  SEALINK 4 APO2 4 1 2 3 4
FINCHIMIE
*
GEOMETRY
*..... water reflector tank .....
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*..... tank : top and bottom plates st.st. SUS 304 L .....
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.....tank : cylindrical wall  st.st. SUS 304 L .....
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....  air .....
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* .....fissile solution Hc = 64.85 cm .....
  TYPE 5 PLAZ INF 96.85
  VOLUME 5 4 5 4   0.0 0.0 65.0 ETSUP 1 4
*.....     sources    .....
  SOURCE 1 5 500 0.0 0.0 65.0
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.46, Table 11.b

```
Run No. 46
*******************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES             *
*    APOLLO1 ( CEA93 99 gr library) - MORET 3     *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004           *
*                                                 *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2          *
*         CASE N° 46   C(U)=241.9 g/l             *
*******************************************************
cat <<'EOF'> melodie.pre
*----------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*----------------------------------------------------------------------
*----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY :case C46 - water 25°C                        CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION TOUT
FIN
*----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
(
STACY case 46 : stainless steel SUS304                    CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE         CR         NI
        MN55       SI         C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION TOUT
FIN
*----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.46, Table 11.b (cont'd)

```
*----------------------------------------------------------------------
*======================================================================
(
STACY case 46 : air                              CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
    N14 O16
   CONC  3.9016E-05 1.0409E-05
FINC
SECTION TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.3936
*----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.270 N
*======================================================================
(
STACY case 46 : nitrate solution  C(U) = 241.9 g/l  H+ = 2.2 CAS N* 4
*Nitrate analyse    C(U)=241.900   C(PU)=0.000  H+=2.27    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=241.900   C(PU)=0.000  H+=2.27    GD=0.00
 MICRO 1 7
       U234        U235        U236        U238
       H2O         O16         NNAT
  VERIF 1.3936
       4.979458E-07 6.179168E-05 6.17146E-08 5.503856E-04
       2.909471E-02 8.319436E-03 2.592491E-03
FINC
CALCUL LES2 SECTION TOUT
FIND
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.46, Table 11.b (cont'd)

```
EOF
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 46*
*                                        *
* U(9.97%)O2(NO3)2 C(U)=241.9  H+=2.27  d=1.39357 *
*                                        *
*   CRITICAL HEIGHT 78.56 cm   WATER REFLECTED    *
*.....*
*                                        *
*    benchmark Keff = 0.9999 +/- 0.0010          *
*                                        *
**************************************************
* precision
  SIGI 0.001  SIGE 0.001  MINI 100 PAS 20   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE  SEALINK  4 APO2 4   1 2 3 4
FINCHIMIE
*
GEOMETRY
*..... water reflector tank .....
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*..... tank : top and bottom plates st.st. SUS 304 L .....
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.....tank : cylindrical wall  st.st. SUS 304 L .....
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....  air .....
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* .....fissile solution Hc = 78.56 cm .....
  TYPE 5 PLAZ INF 110.56
  VOLUME 5 4 5 4   0.0 0.0 65.0 ETSUP 1 4
*.....     sources    .....
  SOURCE 1 5 500 0.0 0.0 64.0
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.51, Table 11.b

```
Run No. 51
*******************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES             *
*    APOLLO2 ( CEA93 172 gr library) - MORET 4    *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004           *
*                                                   *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2          *
*         CASE N° 51   C(U)=233.2 g/l             *
*******************************************************
cat <<'EOF'> melodie.pre
*-----------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*-----------------------------------------------------------------------
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY :case C51 - water 25°C                        CAS N* 1

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* water  25°C
 MICRO 1 1
    H2O
   CONC  0.033329
FINC
SECTION TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*-----------------------------------------------------------------------
*=======================================================================
(
STACY case 51 : stainless steel SUS304                    CAS N* 2

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* stainless steel SUS304
 MICRO 1 6
        FE         CR         NI
        MN55       SI         C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION TOUT
FIN
*-----------------------------------------------------------------------
*                RAPPEL GEOMETRIE
*-----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.51, Table 11.b (cont'd)

```
*----------------------------------------------------------------------
*======================================================================
(
STACY case 51 : air                              CAS N* 3

SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
* air
 MICRO 1 2
    N14 O16
   CONC  3.9016E-05 1.0409E-05
FINC
SECTION TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA86 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.3848
*----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.280 N
*======================================================================
(
STACY case 51 : nitrate solution  C(U) = 233.2 g/l  H+ = 2.2 CAS N* 4
*Nitrate analyse    C(U)=233.200   C(PU)=0.000  H+=2.28    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P1 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=233.200   C(PU)=0.000  H+=2.28    GD=0.00
 MICRO 1 7
       U234        U235        U236        U238
       H2O         O16 NNAT
  VERIF 1.3848
       4.800370E-07 5.956933E-05 5.949502E-08 5.305908E-04
       2.926415E-02 8.158196E-03 2.554438E-03
FINC
CALCUL LES2 SECTION TOUT
FIND
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.51, Table 11.b (cont'd)

```
EOF
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 51*
*                                        *
* U(9.97%)O2(NO3)2 C(U)=233.2  H+=2.28  d=1.38480 *
*                                        *
*   CRITICAL HEIGHT 95.50 cm   WATER REFLECTED    *
*.....*
*                                        *
*    benchmark Keff = 0.9993 +/- 0.0010          *
*                                        *
**************************************************
* precision
  SIGI 0.001  SIGE 0.001  MINI 100 PAS 20   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
* medium
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE  SEALINK APO2  4    1 2 3 4
FINCHIMIE
*
GEOMETRY
*..... water reflector tank .....
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*..... tank : top and bottom plates st.st. SUS 304 L .....
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.....tank : cylindrical wall  st.st. SUS 304 L .....
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....  air .....
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* .....fissile solution Hc = 95.50 cm .....
  TYPE 5 PLAZ INF 127.5
  VOLUME 5 4 5 4   0.0 0.0 82.0 ETSUP 1 4
*.....     sources    .....
  SOURCE 3 5 300 0.0 0.0 82.0
         5 100 0.0 0.0 52.0
         5 100 0.0 0.0 102.0
FINGEOMETRY
FINDATA
FIN_MORET4
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.54, Table 11.b

```
Run No. 54
*******************************************************
*       C.E.A / I.P.S.N. SYSTEM CODES             *
*    APOLLO2 ( CEA93 172 gr library) - MORET 4    *
*.....................................................*
*       I.C.S.B.E.P : LEU-SOL-THERM-004           *
*                                                 *
*      STACY EXPERIMENT U(9.97%)O2(NO3)2          *
*         CASE N° 54   C(U)=225.3 g/l             *
*******************************************************
cat <<'EOF'> melodie.pre
*-------------------------------------------------------------------------
*     CODE MELODIE version 2.1 du 24/06/1998
*-------------------------------------------------------------------------
(
 water  25°C
*-----------------------------------------
*--- APOLLO SPECTRE: MILIEU DE STRUCTURE ---
*-----------------------------------------
)
OPTION BEUN CEA93 GROU 172 P9 TEMPER  25  FINOPTION
 GEOM HOMO
CHIMIE
*water  25°C
 MICRO 1 1
 H2O
   CONC  0.033329
FINC
SECTION TOUT
FIN
(
 stainless steel SUS304
*-----------------------------------------
*--- APOLLO SPECTRE: MILIEU DE STRUCTURE ---
*-----------------------------------------
)
OPTION BEUN CEA93 GROU 172 P9 TEMPER  25  FINOPTION
 GEOM HOMO
CHIMIE
*stainless steel SUS304
 MICRO 1 6
        FE        CR        NI
        MN55      SI        C
   CONC  5.9421E-02 1.6775E-02 8.3403E-03
        1.1561E-03 1.0627E-03 4.3736E-05
FINC
SECTION TOUT
FIN
(
 air
*-----------------------------------------
*--- APOLLO SPECTRE: MILIEU DE STRUCTURE ---
*-----------------------------------------
)
OPTION BEUN CEA93 GROU 172 P9 TEMPER  25  FINOPTION
 GEOM HOMO
CHIMIE
*air
 MICRO 1 2
        N14       O16
   CONC  3.9016E-05 1.0409E-05
FINC
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.54, Table 11.b (cont'd)

```
SECTION TOUT
FIN
*----------------------------------------------------------------------
*               RAPPEL GEOMETRIE
*----------------------------------------------------------------------
* GEOMETRIE HOMOGENE    BIBLIO CEA93 1 MATRICE  16 GROUPES
*----------------------------------------------------------------------
*======================================================================
* MILIEU FISSILE 1:
* LOI DE DILUTION : Nitrate analyse
*     Densit* :1.3722
*----------------------------------------------------------------------
*     VECTEUR ISOTOPIQUE    MASSE
*----------------------------------------------------------------------
*     Uranium:
*     U234: 0.080
*     U235: 9.970
*     U236: 0.010
*     U238: 89.940
*----------------------------------------------------------------------
*  Impuret? (g/l) :
*   Fe=0.000  Cr=0.000  Ni=0.000  Mn=0.000  Ca=0.000  Cu=0.000
*   Al=0.000  Mg=0.000  Zn=0.000  Na=0.000  Co=0.000
*----------------------------------------------------------------------
* MASSES ATOMIQUES MOYENNES
* Uranium: 237.74411 - Plutonium:  - Uranium+Plutonium:
*----------------------------------------------------------------------
*     POISON (g/l) :  Gd=.    Cd=.   Bnat=.
*     ACIDITE : 2.280 N
*======================================================================
(
STACY case 54  * U(9.97%)O2(NO3)2   C(U)=225.3  H+=2.28      CAS N* 4
*Nitrate analyse    C(U)=225.300   C(PU)=0.000  H+=2.28    GD=0.00
SORTIE SECTIONS CELLULE
)
OPTION BEUN  GROU 172 P9 TEMPER  25  FINOPTION
GEOMETRIE HOMOGENE
CHIMIE
*Nitrate analyse    C(U)=225.300   C(PU)=0.000  H+=2.28    GD=0.00
 MICRO 1 7
       U234        U235        U236        U238
       H2O         O16         NNAT
  VERIF 1.3722
       4.637751E-07 5.755133E-05 5.747953E-08 5.126163E-04
       2.928033E-02 7.998109E-03 2.514417E-03
FINC
CALCUL LES2 SECTION TOUT
FIND
EOF
DEBUT_MORET4
***  ICSBEP ******** LEU-SOL-THERM-04 **** CASE 54*
*                                        *
* U(9.97%)O2(NO3)2  C(U)=225.3  H+=2.28  d=1.3722 *
*                                        *
*   CRITICAL HEIGHT 130.33cm   WATER REFLECTED    *
*.......................................*
*                                        *
*    benchmark Keff = 0.9996 +/- 0.0011          *
*                                        *
**********************************************
* precision
  SIGI 0.001 SIGE 0.001 MINI 100 PAS 20   NOBIL
* SIGI 0.015 SIGE 0.015  MINI 10 NOBIL
```

APOLLO2 (CEA93 172gr library) - MORET 4 for Run No.54, Table 11.b (cont'd)

```
* medium
* 1   *-  water
* 2   *-  stainless steel
* 3   *-  air
* 4   *-  U(10)O2(NO3)2 solution
CHIMIE  SEALINK APO2      4  1 2 3 4
FINCHIMIE
*
GEOMETRY
*..................... water reflector tank .......................
  TYPE 1 CYLZ 59.80  102.25
  VOLUME 1 0 1 1   0.0 0.0 102.25
*.......... tank : top and bottom plates st.st. SUS 304 L ......
  TYPE 2 CYLZ 29.80  77.25
  VOLUME 2 1 2 2   0.0 0.0 107.25
*.............tank : cylindrical wall  st.st. SUS 304 L ...................
  TYPE 3 CYLZ 29.80  75.00
  VOLUME 3 2 3 2   0.0 0.0 107.0
*.....................  air ........................................
  TYPE 4 CYLZ 29.50  75.0
  VOLUME 4 3 4 3   0.0 0.0 107.0
* ..........fissile solution Hc = 130.33cm .......................
  TYPE 5 PLAZ INF 162.33
  VOLUME 5 4 5 4   0.0 0.0 100. ETSUP 1 4
*...........      sources     .....................................
  SOURCE 3 5 300 0.0 0.0 100.0
         5 100 0.0 0.0  70.0
         5 100 0.0 0.0 130.0
FINGEOMETRY
FINDATA
FIN_MORET4
```

A.4 MONK8A Input Listings

Each MONK8A calculation, using its standard JEF2.2-based cross section library, employed 1000 superhistories per stage and was run for approximately 50 stages, to achieve a precision of 0.0014. The results from two calculations using different random number seeds were averaged for each experiment to give a combined statistical precision of about 0.10% (1σ).

MONK8A Input Listings Case 1 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.01
* ------------------------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* ---------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 310.1  gU/l
* Solution Height           :  41.53 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS  MATERIAL 1 DENSITY 0.0
U234  PROP 6.3833E-07  U235  PROP 7.9213E-05
U236  PROP 7.9114E-08  U238  PROP 7.0556E-04
H1    PROP 5.6956E-02  N     PROP 2.8778E-03
O     PROP 3.8029E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS  MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS  MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 41.53      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
```

MONK8A Input Listings Case 1 of Table 11.c (cont'd).

```
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 2 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.02
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* --------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 290.4  gU/l
* Solution Height           :  46.70 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 5.9778E-07  U235  PROP 7.4181E-05
U236  PROP 7.4088E-08  U238  PROP 6.6074E-04
H1    PROP 5.7216E-02  N     PROP 2.8141E-03
O     PROP 3.7850E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 46.70      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 2 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 3 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.03
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* --------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 270.0  gU/l
* Solution Height           :  52.93 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 5.5579E-07  U235  PROP 6.8970E-05
U236  PROP 6.8884E-08  U238  PROP 6.1432E-04
H1    PROP 5.8085E-02  N     PROP 2.6927E-03
O     PROP 3.7826E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 52.93      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 3 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 4 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.04
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* ---------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 253.6  gU/l
* Solution Height           :  64.85 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 5.2203E-07  U235  PROP 6.4780E-05
U236  PROP 6.4700E-08  U238  PROP 5.7701E-04
H1    PROP 5.8032E-02  N     PROP 2.6337E-03
O     PROP 3.7527E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 64.85      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 4 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 5 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.05
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* ---------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 241.9  gU/l
* Solution Height           :  78.56 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 4.9795E-07  U235  PROP 6.1792E-05
U236  PROP 6.1715E-08  U238  PROP 5.5039E-04
H1    PROP 5.8189E-02  N     PROP 2.5925E-03
O     PROP 3.7414E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 78.56      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 5 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 6 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.06
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* ---------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 233.2  gU/l
* Solution Height           :  95.50 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 4.8004E-07  U235  PROP 5.9569E-05
U236  PROP 5.9495E-08  U238  PROP 5.3059E-04
H1    PROP 5.8528E-02  N     PROP 2.5544E-03
O     PROP 3.7422E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05  O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 95.50      ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 6 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

MONK8A Input Listings Case 7 of Table 11.c.

```
* MONK VALIDATION CALCULATION 51.07
* --------------------------------
* Calculation performed by W V Wright - January 1999

* Summary of experiment
* ---------------------
* Fissile Material:         10% enriched uranyl nitrate solution
* Geometry:                 Cylindrical
* Neutron Poison:           None
* Reflector:                Water
* Reference:                T Yamamoto, Y Miyoshi
*                           STACY: Water-Reflected 10%-Enriched Uranyl
*                           Nitrate Solution in a 60cm Diameter
*                           Cylindrical tank
*                           LEU-SOL-THERM-004 (30/09/98)
* Code Package:             MONK8A-UKNDL

* Critical Parameters Data -

* Uranium Concentration     : 225.3   gU/l
* Solution Height           :  130.33 cm

* Additional Notes -

* The experimental temperature was assumed to be 25 degrees C (298 K)
* MONK nuclear data temperature is at 20 degrees C.

* Keyword Parameters -
*
* solution height (height of solution above tank inner base)
*
BEGIN MATERIAL SPECIFICATION
NMATERIALS 4

* material 1 - uranyl nitrate solution
* material 2 - stainless steel
* material 3 - water
* material 4 - air

ATOMS MATERIAL 1 DENSITY 0.0
U234  PROP 4.6378E-07  U235  PROP 5.7551E-05
U236  PROP 5.7480E-08  U238  PROP 5.1262E-04
H1    PROP 5.8561E-02  N     PROP 2.5144E-03
O     PROP 3.7278E-02

ATOMS MATERIAL 2 DENSITY 0.0
C     PROP 4.3736E-05  SI    PROP 1.0627E-03
MN    PROP 1.1561E-03  P     PROP 4.3170E-05
S     PROP 2.9782E-06  NI    PROP 8.3403E-03
CR    PROP 1.6775E-02  FE    PROP 5.9421E-02

ATOMS MATERIAL 3 DENSITY 0.0
H1    PROP 6.6658E-02  O     PROP 3.3329E-02

ATOMS MATERIAL 4 DENSITY 0.0
N     PROP 3.9016E-05
O     PROP 1.0409E-05

USE H1INH2O FOR H1 IN ALL MATERIALS
END

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

BEGIN MATERIAL GEOMETRY
PART 1 NEST
ZROD M1  3*0.0        29.5 130.33     ! fuel solution
ZROD M4  3*0.0        29.5 150.0      ! inside tank
ZROD M2  2*0.0 -2.0   29.8 154.5      ! tank wall
ZROD M3  2*0.0 -32.0  59.8 204.5      ! water reflector
```

MONK8A Input Listings Case 7 of Table 11.c (cont'd).

```
END

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

BEGIN CONTROL DATA
STAGES -1  100  1000  STDV 0.0014
END

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

BEGIN SOURCE GEOMETRY
ZONEMAT
ZONE 1  PART 1 / MATERIAL 1
END
```

APPENDIX B: DENSITY FORMULA[a]

The density formula usable for U(VI)-nitrate aqueous solution, Pu(IV)-nitrate aqueous solution, and U(VI)-Pu(IV)-nitrate aqueous solution was used for sensitivity calculations in Section 2. The equation is as follows:

$$\begin{aligned}\rho = {} & 0.99833 + 1.6903\times10^{-3}\cdot C_{Pu25} + 1.4276\times10^{-3}\cdot C_{U25} \\ & + 3.9956\times10^{-2}\cdot C_{HN25} - 8.696\times10^{-8}\cdot\left(C_{Pu25}\right)^2 \\ & - 1.087\times10^{-7}\cdot\left(C_{U25}\right)^2 - 8.513\times10^{-4}\cdot\left(C_{HN25}\right)^2 \\ & - 5.442\times10^{-6}\cdot T^2 - 4.4889\times10^{-5}\cdot C_{Pu25}\cdot C_{HN25} \\ & - 1.310\times10^{-6}\cdot C_{Pu25}\cdot T - 1.564\times10^{-5}\cdot C_{U25}\cdot C_{HN25} \\ & - 9.487\times10^{-7}\cdot C_{U25}\cdot T - 8.684\times10^{-5}\cdot C_{HN25}\cdot T\ ,\end{aligned}$$

where

ρ = density of solution at T °C (g/cm$_3$),
C_{Pu25}: concentration of plutonium at 25°C (g/liter),
C_{U25}: concentration of uranium at 25°C (g/liter),
C_{HN25}: molarity of nitric acid at 25°C (mol),
T: Temperature (°C).

This equation is valid under the following conditions:

C_{U25} < 530 g/liter,
C_{PU25} < 480 g/liter,
$C_{Pu25}+C_{U25}$ < 350 g/liter (valid for mixed fuel solution),
C_{HN25} < 7 mol,
10°C < T < 60°C.

The accuracy of this equation is ± 0.0032 g/cm^3.

[a] S. Sakurai and S. Tachimori, "Modified density equation for aqueous solutions with plutonium (IV), uranium (VI) and nitric acid," JAERI-M88-127 (1988) (in Japanese).

APPENDIX C: DERIVATION OF ATOM DENSITIES OF FUEL SOLUTION

Atomic weight of H=	A1=	1.0079
Atomic weight of N=	A7=	14.0067
Atomic weight of O=	A8=	15.9994
Atomic weight of U234=	A24=	234.0409
Atomic weight of U235=	A25=	235.0439
Atomic weight of U236=	A26=	236.0456
Atomic weight of U238=	A28=	238.0508
Wt. % of U234=	W24=	0.08
Wt. % of U235=	W25=	9.97
Wt. % of U236=	W26=	0.01
Wt. % of U238=	W28=	89.94
Uranium density (g/l)=	UD=	310.1
Acidity (mol/l)=	AC=	2.17
Density (g/cc)=	D=	1.4827
Avogadro's number=	AV=	0.60221
Atom density of U234= N24=	UD/1000*W24/100/A24*AV=	6.3833×10^{-7}
Atom density of U235= N25=	UD/1000*W25/100/A25*AV=	7.9213×10^{-5}
Atom density of U236= N26=	UD/1000*W26/100/A26*AV=	7.9114×10^{-8}
Atom density of U238= N28=	UD/1000*W28/100/A28*AV=	7.0556×10^{-4}
Total Uranium atom density=	UN=	7.8549×10^{-4}
HNO3		
NH(HNO3)=	AC/1000*AV=	1.3068×10^{-3}
NN(HNO3)=	AC/1000*AV=	1.3068×10^{-3}
NO(HNO3)=	AC/1000*AV*3=	3.9204×10^{-3}
Density of HNO3(g/cc)= DN=	AC*(A1+A7+3*A8)/1000=	0.136737776
UO2(NO3)2		
Molecular weight of UO2(NO3)2= MWU=	(N24*A24+N25*A25+N26*A26 +N28*A28)/UN+2*A7+8*A8=	393.7527074
Density of UO2(NO3)2= DU=	MWU*UN/AV=	0.513588816
Density of H2O= DH=	D-DU-DN=	0.832373408
NH(H2O)=	DH/(2*A1+A8)*AV*2=	5.5649×10^{-2}
NO(H2O)=	DH/(2*A1+A8)*AV=	2.7824×10^{-2}
Atom density of H=	NH(HNO3)+NH(H2O)=	5.6956×10^{-2}
Atom density of O=	NO(H2O)+NO(HNO3)+8*UN=	3.8029×10^{-2}
Atom density of N=	NN(HNO3)+2*UN=	2.8778×10^{-3}