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FAST REACTOR DESIGN ANALYSIS CODES

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FAST REACTOR DESIGN ANALYSIS CODES

Abstract

A consistent method of nuclear reactor design analysis useful for survey or specific program requirements is presented. The method exemplified treats the advanced, fast spectrum, uranium mononitride systems associated with the Lawrence Radiation Laboratory Space Power Program.

In addition to detailing the specific techniques used to couple the mechanical-thermal/neutronic analysis, a complete code listing for both convectively cooled and heatpipe reactors is given. A 16-group interim cross section library, weighted for various fast spectrum reactors, as well as a generalized thermal spectrum system, is included. The specific neutronic analysis used is a stripped version of the DTF-II transport code to which additional S_n quadrature set user information has been added.

Introduction

A portion of the engineering effort in the Lawrence Radiation Laboratory Advanced Reactor Technology Program was devoted to examining the steps required to accomplish a consistent and complete reactor design and recording this logic in digital computer codes. The procedures used by the engineering and physics groups during a series of design "exercises" were examined to establish a logical design sequence amenable to computerized formulation of "real" designs.

This approach was carried to the point where a reactor of programmatic interest could be designed and much of its performance could be analyzed in a few minutes on a modern computer. Portions of these codes have also been used to rough out as many as a thousand designs per minute for parametric surveys.

Although the work reported herein has been specifically directed toward the development of low power, advanced, fast reactor heat sources much of the coding (particularly WDTF) and all of the system philosophy is directly applicable to any other reactor analysis work.

This report contains a description of the design approach and computational sequence used, as well as a brief treatment of those subjects required for a logical continuation of this work.

Several appendices are attached to make this report more complete. Appendix A consists of two complete design codes, one for liquid metal convectively cooled reactors, and one for heatpipe cooled reactors.

There are a group of properties and neutronics subroutines common to both packages, and an interim library of 16 group cross sections prepared for this purpose.

Appendix B is a user's manual for the original DTF-II code and is presented here to make available the information required to

- a) understand the evolution of WDTF from DTF-II
- b) make possible future code revisions.

Appendix C contains details on the development of several S_n quadrature sets and their application.

Appendix D contains details regarding the compilation of the multigroup cross section libraries listed in Appendix A including the energy spectrums used.

Appendix E lists an interim set of one-group cross sections, based on a fast reactor neutron energy spectrum, for a variety of materials.

Termination of this LRL program dictates that these codes should be published for use elsewhere in space power cycle studies until such time as funds are available to reinstate a future viable reactor program. In order to permit use of the codes, the limited time and effort available have been spent making the package presented here as complete as possible rather than in editing, refining, and optimizing selected portions of the codes. These codes are consequently in a somewhat unpolished state, but are operable and have been often run in the form in which they are presented. They do contain a few minor errors, and inconsistencies as well as guides are pointed out in the comment cards interspersed throughout the codes. These errors are in areas that stand alone, however, and do not affect the remainder of the computation. The inconsistencies are generally anachronisms held over from an early stage of design which were not subsequently updated. The authors hope to provide a starting point and apologize to the reader if the necessary brevity of treatment leads to more frustration than satisfaction.

Additional information is available in the LRL literature and from the authors. In particular, machine-generated flow charts and a cross index (KWICLIST) for the codes listed here are available as supplements A and B (convective and heatpipe reactors respectively). These are quite extensive and are an invaluable tool for anyone desiring to put these into operation.

Design Approach

The traditional methods of producing an engineering design for analysis and modification by a reactor physics group followed by design changes and approximations ad infinitum almost invariably leads to a design that compromises the original constraints and is satisfactory to neither group.

In the space power field, where the constraints are so severe that the reactor should be designed for the specific mission, this procedure is intolerable. On the

assumption that a machine can be instructed to perform with greater speed and consistency any analysis a man can perform, it was decided to incorporate as many of the design and analysis steps as possible into a single pass computer program. In this manner, a consistent design could be produced with the necessary modifications being made in a logical, efficient manner. Thus the deck of computer cards has replaced the drawing cabinet as the repository of the reactor families studied by LRL.

The design and analysis given here is definitely slanted toward reactors for space use but could be easily modified for other types. Here minimization of mass and dimensions is of the utmost importance. The concern for safety on water immersion because of an aborted launch or reentry is obvious. Temperature effects are of great concern due to the nature of the heatsink. The concern for control redundancy stems from the necessity for remote operation as well as from the difficulty of repair.

The concern for power flattening is less obvious. In heatpipe reactors, radial power flattening usually leads to performance increases since each heatpipe operates as an isolated unit. Axial power shaping in these reactors does not show the same effect since the heatpipes integrate the axial profiles. Power flattening in the very smallest conventionally cooled cores is probably undesirable. Here, where criticality limits are important, fissile material depletion in regions of maximum importance to achieve a specified profile is unwarranted since mixing of the coolant will average out the power distribution outside of the core. However, as conventionally cooled cores increase in size to where peak burnup is a design criterion, power flattening again becomes a desirable constraint.

One design feature proposed, but never implemented in the design codes, would be to accomplish power flattening by porosity variations in the core. This could be easily accomplished in the design code. This could also be coupled to the water safety consideration by filling some of the more porous regions with additional layers of spectral poison.

Design and Analysis

The procedure for design and analysis consists of the coupling of a reactor thermo-mechanical design subroutine to a neutronic analysis subroutine through a simple numerical analysis interface contained in the main code. A typical design and analysis sequence for a heatpipe reactor is outlined in Figs. 1 and 2.

Design constraints such as power, operating temperature, lifetime, fuel element type, maximum average fuel burnup, etc., are specified. The reactor design subroutine is called to present a trial design for neutronic analysis. The reactor dimensions and material distributions are translated into the dimension and atom density arrays required by the neutronic subroutine. An iterative sequence consisting of a mechanical design followed by suitable neutronic analysis continues until the reactor meets the imposed criteria. This design is then analyzed in further detail.

There are two classes of reactors to be considered: large reactors that can be called burnup limited, and small reactivity limited reactors where the critical mass for a given arrangement is the dominating consideration. In the first case, the design subroutine would be called outside of the iteration loop, and design changes within the

Fig. 1. Calculation schematic.

loop would consist only of modification of those elements of the atom density array indicating changes in the enrichment of fissile materials. For the criticality limited

Fig. 2. Reactor design subroutine.

cases, the size of the reactor is an independent variable necessitating a complete re-design for each trial. In this case the design subroutine call is contained within the

iteration loop. In each case, modifications of the design to achieve the desired radial power profile and water safety criteria are included within the loop so that the reactor is designed to meet these constraints from its inception.

Use of the Codes

These codes provide in as short a time as possible a reasonably complete and consistent reactor design for further study. While the brief running times of the codes are perhaps their most dramatic feature, the completeness and self consistency of the designs produced are the most important features.

Each design can be accomplished by a single computer pass in less than 10 minutes. In the codes listed in Appendix A, this pass consists of

- a) coupled neutronic-mechanical analysis with dynamic power flattening and water safety analysis to design a hot start-of-life (SOL) reactor heat source.
- b) effect of isothermal temperature changes, from hot SOL to 300°K in uniform steps.
- c) effect of fluid control at 0% and 100% control fluid (SOL used 50% control fluid).
- d) effect on the k_{eff} eigenvalue of various reflector thicknesses from 0 cm to some chosen upper limit—usually four separate cases with the upper thickness surpassing end of life requirements.
- e) analysis for +100°K temperature perturbation effects at start, mid, and end of life including the separate cases of fuel, cladding, and coolant (internal and inlet) and accounting for fissile nuclide burnup and production at each life step.

The investigation of the various performance characteristics consists of a complete neutronic analysis of a reactor in its perturbed state. This is accomplished by describing the thermo-mechanical effect of the perturbation on the reactor and feeding the new array of dimensions and densities into the neutronic code. The standard procedure of breaking these effects down into elementary effects and using a Taylor series approach has frequently led to oversights.

Effects studied are changes in the dual control system states, the shutdown of an isothermal reactor to room temperature, water immersion and water entry into the core, burnup of fissile species and the production of fissile daughters, fuel swelling, and temperature changes in isolated components to obtain reactivity coefficients for control analyses.

The neutronic code discussed in this report is a modified version of DTF-2, a one dimensional transport code. This was selected as a happy medium between the faster diffusion codes and the slower two dimensional transport codes, but either of the latter two types could be adapted to this purpose. Monte Carlo codes could not have been used since their statistical nature does not allow convergence to the same numerical criteria with sufficient consistency for this type of analysis. The Monte Carlo codes presumably have a greater absolute accuracy but for this purpose their lower degree of relative accuracy precludes their use.

The one dimensional treatment is not the limitation it would appear for this type of reactor. End effects turn out to be surprisingly small. The ends of these cores represent typically one-third to one-quarter of the core surface areas. The cores are essentially unreflected on the ends so the flux is quite low, which contributes to small variations in leakage. This is particularly true in the heatpipe reactors where the end volumes have a large fraction of void and heatpipe material. The latter can exhibit large thermal resonances; consequently, even water entry into the end regions produces an insignificant end reflection effect. For the reactors described by these codes, the coolant channels are quite small so that significant axial streaming is confined to small angles. Monte Carlo (O5R) calculations have shown the Δk effect to be small because of streaming through the coolant channels and central cavity streaming is similarly small in the small criticality limited systems of the 2 MW_{th} range due to offset by end reflection effects.

The numerical analysis scheme coupling the design and neutronic subroutines consists of a group of one dimensional Newton-Raphson iterations. Steepest descent or Lagrangian multiplier schemes could improve this section. The iteration schemes operate in parallel rather than in series, a mathematically untenable sequence but one which is usually practical here since the fluctuations in the different independent variables are usually very small as convergence nears.

Using only the criticality option, convergence generally occurs in four to five passes. The addition of the power flattening option adds one to three passes. The inclusion of the water safety option may increase this total to a dozen or more passes. It is recommended that the water safety mechanism be defined for the reactor range in question, converted into a simple equation, and the iteration on this variable be dropped subsequently. Once an acceptable design has been achieved, it is a simple matter to vary the dimensional and atom density arrays prior to successive calls of the neutronic routine to reflect changes in dimensions and densities accompanying perturbations from design point operating conditions. The change in the neutron multiplication factor produced by each perturbation serves as a measure of the effect on the system.

There are recommendations in the code for designing a few representative systems and using curve fitting techniques to replace all the neutronic calculations for large surveys. In the latter case, only the design subroutine would be run to generate the survey curves.

Reactor Design

MATERIALS AND GEOMETRY

The reactors studied in this program have been composed of what are believed to be chemically compatible materials. Usually these have been uranium mononitride (UN) fuel, tungsten structure, and alkali metal coolant. Silver, barium, and a few other

metals have also been considered as coolants. For chemical compatibility, pressure vessels have been tungsten alloy or tantalum alloys clad with tungsten.

The reactors have all been cylindrical bundles of fuel elements arranged in hexagonal arrays in dodecagonal patterns as the nearest practical approximation of a circular cylindrical geometry. Most of these cores have been annular cylinders containing a central fluid return duct surrounded by an annulus containing a number of fluid control circuits.

Figure 3 shows a cutaway of a conventionally cooled reactor. Figure 4 shows a double ended heatpipe reactor-integral boiler combination. The heatpipes extend from

Fig. 3. Convectively cooled reactor—flight configuration.

the reactor on either end to form a double boiler. Vapor from the aft boiler returns through a single central duct. A similar duct is also seen in Fig. 3 returning the primary coolant to the reactor inlet face.

Where a coolant return is required, a single circular return minimizes the pressure drop. Furthermore, placing this return in the core center tends to depress the flux in the central regions and increase the importance of the regions affected by the side reflector. This effect can be enhanced by the use of negative reactivity control materials in the central control annulus and greatly aids in radial power profile shaping. For small central cavities, the resulting increases in core radius to achieve criticality are often smaller than the decreases in the side reflector because of its enhanced importance so that a smaller overall radius and shadow shield frequently result from this arrangement.

Fig. 4. Double ended heatpipe reactor—boiler.

CONTROLS

The reflectors translate axially. In the codes, the reflector action is described in terms of an equivalent thickness. The exact relationship between the axial position of the fixed thickness of reflector and its equivalent thickness remains to be determined. Axial translation is used to minimize shadow shield angle. Note also that this reflector could be broken into two thicknesses; the inner, thicker reflector would bring the reactor near critical at once, and an outer low inertia vernier would control criticality. Further details of these reactors are in the LRL literature. Figure 5 shows a flight configuration of a 2 MW_{th} heatpipe reactor.

Fig. 5. Double ended heatpipe reactor—flight configuration.

The internal control elements have always been liquid elements due to our belief that only fluids should be permitted to enter an all welded pressure vessel. Neutronic studies have shown that the effects of the central control elements and the side reflectors are almost completely decoupled.

The liquid controls can operate in a variety of ways. To counteract slow life-time effects, a one time irreversible mixing of isotopes could be used. With a sufficient reservoir, a few reversals might be possible. The voiding of isolated circuits by helium is another possibility. Control by void-liquid interchange in a gravity environment is obvious. In a gravity-free environment, liquid vapor separation can be achieved by radial density variations in a circumferential capillary in the control tubes with a few transverse mesh droplet collectors. V grooves would be the simplest example. An intriguing possibility involves control of the rate of vaporization by controlling the pressure and therefore the temperature and rate of heat influx by means of fluidic pressure control circuitry. This would offer a degree of self control if a predominantly positive fluid such as beryllium fluoride were used. Because of the location and the concern for the power profile, most of the control agents considered have been negative, but the self control aspects of a positive control fluid may outweigh this consideration.

The analysis of the internal control annulus is in a rudimentary state. The tube walls and the dividers separating this region from that on either side were assumed to be 40% by volume. This volume was assumed to be 9.3% interstitial fluid and the remainder was assumed to be available for the control fluid. This interstitial fluid fraction is too low, being based on an infinite array of closely packed rods. A study of the generalized packing schemes possible in this region was begun but never carried to the point where it could be incorporated into the code. It should be realized that only certain arrangements are feasible and that there is a limit to the annulus radius ratios analogous to those described for the active core in subroutine ELMTS.

Studies of control mechanisms and associated circuitry were halted because of earlier fund cutbacks. However, a mechanical reflector drive mechanism appeared feasible and satisfactory from a control requirement's standpoint. Fluidic sensing elements and control circuitry also appeared feasible, and a few elementary circuits were worked out.¹ Reactor control mechanisms and the three region, lumped-core model we believe necessary for the analysis of these reactors has been extensively treated in UCRL-70523.¹ Our codes are set up to analyze the effects postulated there and to determine the reactivity coefficients required for that control analysis. One particular self control mechanism should be pointed out, since it is not treated there. It appears that for the heatpipe reactors, fluctuations in the quantity of liquid in the boiler and in the heatpipe may be sufficient to provide a self control mechanism. It should also be pointed out that depending on the reactor design, a ratio of $^6\text{Li}/^7\text{Li}$ greater than 3% to 7% will lead to instability, and that both fluid density and volume fractions must be considered together in assessing reactivity coefficients. Frequently, one effect will dominate the other, and each may differ in sign.

FUEL ELEMENTS

Four fuel element types proposed for the hexagonal array are shown in Fig. 6. These are incorporated in the conventionally cooled reactor design code in that order. Type 4 elements are used exclusively for the heatpipe reactor design.

Other element types could easily be added. The type 1 element generally proved less attractive than the others. The type 3 element has a narrow range of fuel volume fractions but has proved quite attractive for conventionally cooled cores above 15 to 20 MW_{th}. Types 2 and 4 are generally preferable for small systems. Type 4 has the greatest range of fuel volume fractions but its bundling characteristics are inferior to those of type 2, particularly in the limiting case of no spacers.

The reactor cores are assumed to be pin-splined to the pressure vessel on one end and maintained in position by radial-axial splines within the vessel. At space reactor temperatures, useful springs do not exist. They can exist until space startup, however, supporting the core through launch. Solid alkali metal foams could also serve this function until startup. A convenient support mechanism for the slight g-loads imposed by space maneuver can be accomplished by using a radially inward hydraulic pressure difference across a membrane surrounding a closely packed core. In a conventionally cooled reactor this support is accomplished by opening the outer annulus to the core inlet pressure and coupling the interstitial core fluid to the core exit pressure. The pressure required to maintain bundle stability in a close packed array is

$$P = n \rho R$$

where n is the number of g's side acceleration, ρ is the average core density and R is the core radius. The tube loadings for the various configurations can easily be worked out by a combination of the six and three point loading schemes as shown in Figs. 7 and 8 respectively.

The maximum stress due to these loadings can be shown to be

$$0.62 \leq \frac{\sigma}{\Delta P} \left(\frac{t}{r} \right)^2 \leq 0.63$$

where ΔP is the pressure drop. For most practical cases the reactor bundle is quite stiff. It can be shown that

$$\frac{\delta R}{R} \approx 60 \frac{\Delta P}{E}.$$

A rough creep buckling analysis from some rather crude tungsten data near the half-melting point shows that at a thickness to radius ratio of 0.1, the critical radially inward pressure on the tubes for 20,000 hr is about 400 psi. This is of interest in the heat pipes where the heatpipe fluid pressure may be less than that of the boiler fluid.

A = Cell area, F_F = fuel volume fraction, F_{CL} = clad volume fraction F_S = swelling allowance fraction, F_{SC} = stagnant coolant fraction, F_C = primary coolant fraction, D_H = hydraulic diameter, α = linear swelling allowance.

Pin-type 1	Pin-type 2	Hybrid-type 3	Tube-type 4
$\Gamma = t/r_1$	$\Gamma = t/r_1$	$\beta = t_1/r_1$	$\beta = r_0/r_1$
$\beta = r_2/r_1$	$\beta = r_2/r_1$	$\Gamma = t_2/r_1$	$\Gamma = t/r_0$
$A = \frac{\sqrt{3}}{8} r_1^2 (1 + \beta)^2$	$A = \frac{r_1^2 (1 + \beta)^2}{2\sqrt{3}}$	$A = \frac{\sqrt{3}}{2} r_1^2$	$A = \frac{r_1^2}{2\sqrt{3}}$
$F_F = \frac{2\pi}{3\sqrt{3}} \left(\frac{1 - \Gamma}{1 + \beta} \right)^2 / (1 + \alpha)^3$	$F_F = \frac{\pi\sqrt{3}}{6} \left(\frac{1 - \Gamma}{1 + \beta} \right)^2 / (1 + \alpha)^3$	$F_F = \frac{\pi}{3\sqrt{3}} (1 - \beta)^2 / (1 + \alpha)^3$	$F_F = \left(1 - \frac{\pi\sqrt{3}}{6} \beta^2 \right) / (1 + \alpha)^3$
$F_{CL} = \frac{4\pi}{3\sqrt{3}} \left(\frac{\Gamma + 2\beta\Gamma - 3\Gamma^2/2}{(1 + \beta)^2} \right)$	$F_{CL} = \frac{\pi\sqrt{3}}{2} \left[\frac{2\Gamma/3 - \Gamma^2 + \beta^2}{(1 + \beta)^2} \right]$	$F_{CL} = \frac{\pi}{3\sqrt{3}} \left(\Gamma - \frac{\Gamma^2}{2} + 2\beta - \beta^2 \right)$	$F_{CL} = \frac{\pi}{2\sqrt{3}} \beta^2 (2\Gamma - \Gamma^2)$
$F_S = [(1 + \alpha)^3 - 1] F_F$	$F_S = [(1 + \alpha)^3 - 1] F_F$	$F_S = [(1 + \alpha)^3 - 1] F_F$	$F_S = [(1 + \alpha)^3 - 1] F_F$
$F_C = 1 - F_F - F_{CL} - F_S$	$F_C = 1 - F_F - F_{CL} - F_S$	$F_{SC} = 1 - \frac{\pi}{2\sqrt{3}}$	$F_C = 1 - F_F - F_{CL}$
$D_H = \frac{12F_C A}{\pi r_1} / \left(\frac{1}{2} + 2\beta - \Gamma \right)$	$D_H = \frac{8F_C A}{\pi r_1} / \left(\frac{1}{3} + \beta \right)$	$F_C = 1 - F_F - F_{CL} - F_S - F_{SC}$	$D_H = 2r_0 (1 - \Gamma)$
		$D_H = 2r_1 (1 - \Gamma)$	

Fig. 6. Fuel element geometries.

$$P = F \frac{\sqrt{3}}{2}$$

$$M = \frac{3}{\pi} \left[1 - \frac{\pi}{2\sqrt{3}} \right] Fr$$

$$\delta_2 = \frac{r^2}{EI} \left\{ M \left(\frac{\pi}{3} - \frac{\sqrt{3}}{2} \right) + Fr \left[\frac{\sqrt{3}}{2} \left(\frac{\pi}{2} - \frac{7\sqrt{3}}{8} \right) - \frac{1}{16} \right] \right\}$$

$$\delta_1 = \delta_2 / \sqrt{3} ; \delta_r = 2\delta_2 / \sqrt{3}$$

Fig. 7. Six point loading geometry.

$$P_1 = 2P_2 = F / \sqrt{3}$$

$$M_2 = -M_1 + \frac{P \cdot r}{2} = Fr \left(\frac{9\sqrt{3} - 4\pi}{8\pi\sqrt{3}} \right)$$

$$\delta_2 = \frac{r^3}{EI} F \left(\frac{4\pi^2 - 27}{48\pi} \right)$$

$$\delta_3 = \frac{Fr^3}{EI} \left(\frac{6\pi\sqrt{3} + 4\pi^2 - 81}{48\pi\sqrt{3}} \right)$$

Fig. 8. Three point loading geometry.

The region allowed for fuel swelling is assumed to be filled with semistagnant bonding fluid. The temperature drop across this fluid is only 2% to 3% of what it would be with helium and roughly 1% of what it would be with liquid metal vapor. The helium drop of 200 to 300°K seems to be intolerable from a cyclic thermal stress standpoint in the clad. This would arise as the fuel would writhe and shift. We do not believe the clad should be placed in contact with the fuel since it is doubtful that it has sufficient strength to impede fuel swelling at temperatures of interest. Thus fuel growth would result in undefinable core expansions in a closely packed core, a probably intolerable situation.

The bonding fluid can probably be used as a vehicle to provide free nitrogen required for UN chemical stability. However, fission gases will collect in the bonding fluid and must be removed by chemical separation. This will require bonding fluid circulation, the rate being determined by the requirements for bubble removal. Some preliminary work has been done in this area, but its feasibility remains to be proved.

In the design of fuel elements for a cylindrical geometry, it can be seen from Fig. 6 that the volume fractions are primarily fixed by two parameters since this reduces to a two dimensional problem. Swelling and differential thermal expansion allowances can be made, and these corrections must extend into the third dimension.

We have generally assumed that swelling is a linear function of burnup and therefore of life. There is evidence that this is not the case, and it is certainly a function of temperature. This effect is certainly not negligible, and corrections should be made as more accurate fuel swelling data becomes available.

The fuel elements have generally been designed on a thermal stress or temperature difference criterion for the fuel. For heatpipe reactors, radial heatflux into the heatpipe leading to blowoff has also been a criterion. For this we have used the data summarized by Caswell and Balzhiser² for pool boiling in alkali metals.

The thermal stress criterion is rather nebulous but convenient. Short time bending fracture tests on UN at temperature by Carborundum Co. show

Table I. Short time fracture strength.^a

T (°C)	σ (psi)
25	10,500
800	11,200
1,200	19,300
1,400	13,700
1,600	Deforms

^aUN at 81% of theoretical density.

What this situation would be in a thermally induced creep situation or with creep induced stress reversals on a fast shutdown is unknown. How severe a problem thermal cracking would be is also unknown. Chipping, wedging, ratcheting, and the increase of

surface area exposed to bonding fluid chemical transport mechanisms are all possible hazards. In any event, the thermal stress criterion is convenient since the stress varies as the square of the radius and certainly distinguishes the ballpark from the parking lot.

In computing thermal stress for odd solid prismatic shapes it should be noted that the radial and tangential components are independent of surface temperature for plane strain since for steady state

$$\nabla^2 T = q/K.$$

Thus a solution for any surface temperature profile is a solution for all, and the axial stress can be determined by a simple two dimensional integration. For hollow hex tubes it has been found that a good approximation is to compute stresses for a hollow circular tube having the same cross sectional area and the same internal diameter.

HEAT TRANSFER

For practical cases a slug flow heat transfer model usually gives the reactor designer sufficient information for preliminary design. The ratio of thermal to eddy diffusivity is so high that the coolant channel can be treated as a case of a uniformly distributed heat sink assuming a constant flow velocity. For example, this assumption yields a constant Nusselt number of 8 for a circular channel and 6 for flow between plates, excellent approximations for Peclet numbers on the order of 1000, the normal range for these reactors which incorporate close packed tubes. Consequently, the temperature distributions for odd geometries can be approximated by solving a two dimensional source-sink problem.

WATER SAFETY

Four cases for water immersion safety were analyzed by the code for each reactor type and the most reactive condition selected for dynamic design use. The four cases were

- a) All molybdenum reflectors removed and replaced by radial infinite water reflector.
- b) Same as a) plus-for heatpipe, K working fluid replaced by water.
-for convective, Li primary fluid replaced by water.
- c) Same as b) plus interstitial fluid and control fluid replaced by water in both reactor types—and in heatpipe, heatpipe volumes replaced by water.
- d) Same as c) except water reflector removed (as in raising the flooded reactor from the sea).

In all of the design analyses proper and detailed account was made of the mechanical-thermal state of the reactor as well as the neutronic so that, e. g., the material densities and dimensions of the reactor corresponded to 300°K for the water immersion analysis and were changed back to the hot condition for subsequent power operation analysis.

An obvious method for achieving water safety in the design is a blowoff side reflector which is not positioned until startup after launch and which is jettisoned by burnable straps on reentry. Other methods that have been examined are the placement of layers of rare earth spectral shift poisons in the core. These thermal poisons have a negligible effect on the fast spectrum at operating conditions and a pronounced effect on the thermalized flux occurring after water immersion. By using these as a part of the structural cladding, the cladding thickness becomes a variable that can be manipulated to provide a spectral poison. If the clad temperature remains below the transition for sigma phase a plating on the clad could be practicable.

PRESSURE VESSEL

The pressure vessel thickness is of primary interest in the design, since an overly thick pressure vessel will decouple the side reflector. There is coolant available from the working fluid radiator to cool the pressure vessel if a slight thickness of insulator is provided. This insulator thickness tends to decouple the reflector also, but there is a tradeoff in that this insulator can be partially composed of a spectral poison, such as hafnium, for water safety. A thorough study on the optimization of this region should be made and possibly be incorporated into the code.

HEATPIPE PERFORMANCE

The final topic to be treated under reactor design is heatpipe performance. The principal loss mechanism in the heatpipe is the pressure drop occurring in the vapor. This must be balanced by the capillary head available. Just enough porosity must be provided to permit heat removal. If a greater porosity is provided, the core is too porous and is consequently larger than necessary. Removal of the heat from both ends of the core can greatly improve performance. For a given porosity, this procedure doubles the flow area and decreases the head loss by a factor of four since this is a velocity-squared effect. It also decreases the length to be traveled by a factor of two for a total head savings factor of eight. This saving can be translated into a porosity change to yield a significant reduction in reactor dimensions and shadow shield mass.

The heatpipe fluid we have selected for our example is sodium. Lithium has a greater heat of vaporization but its vapor pressure is so low that a greater volumetric flow rate is required and greater pressure losses are encountered. Potassium has a greater vapor pressure and vapor density, but this is outweighed by its lower heat of vaporization with the same effect.

There is an additional complication with lithium because of the production of helium by n-alpha reactions. At the low lithium vapor pressures, this forms an appreciable volume, and while the vapor flow will collect this helium into a segregated region at the end of the condenser, the volume will grow until it can choke off the condenser if sufficient space is not provided.

The basic heatpipe equation as developed by Cotter³ is

$$\Delta P_c \cong \Delta P_v + \Delta P_g + \Delta P_\ell + \Delta P_e$$

where

ΔP_c = the pressure rise across the meniscus because of capillary forces.

ΔP_v = pressure drop in the vapor.

ΔP_g = pressure drop in the liquid because of gravity.

ΔP_ℓ = pressure drop in the liquid because of viscosity.

ΔP_e = pressure drop at the liquid-vapor interface because of evaporation-condensation.

For liquid metals in a zero g environment, the gravity and interface terms can be neglected. The formulations in Cotter's paper are for a grooved heatpipe in which the groove half width serves as the capillary radius. This, however, restricts the liquid flow to narrow channels where high liquid viscosity losses occur. A better arrangement appears to be a mesh supported by the groove lands. Thus the capillary pumping can be decoupled from the groove half width. Koopman⁴ has shown that the groove width effect can be neglected if it is greater than the thickness of the annulus between the mesh and the wall. For this case the optimum annulus thickness is no longer a constant fraction of the radius as in the grooved case. For the cases of interest the optimum ratio of vapor radius to wall radius is near 0.75, but this is a function of temperature dependent fluid properties as well as geometry, so caution should be exercised here.

Using the geometry of Fig. 9, Cotter's equations as modified by Koopman are:

Fig. 9. Heatpipe nomenclature.

$$\Delta P_c = \gamma \left(\frac{1}{r_1} + \frac{1}{r_2} \right) = \frac{2\gamma}{r_m}$$

Where γ is the surface tension and r_m is the radius of the meniscus.

$$\Delta P_\ell = \frac{4\mu_\ell Qz}{\rho_\ell \pi L (r_w^2 - r_v^2) \left(r_w^2 + r_v^2 - \frac{r_w^2 - r_v^2}{\ln r_w/r_v} \right)}.$$

For $R_z < 2000$ (laminar flow),

$$\begin{aligned} (\Delta P_v) &= \begin{cases} \frac{(1 - 4/\pi^2)Q^2}{8\rho_v r_v^4 L^2} & R_r \gg 1 \\ \frac{4\mu_v zQ}{\pi\rho_v r_v^4 L} & R_r \ll 1 \end{cases} \end{aligned}$$

for $R_z > 2000$ (turbulent flow),

$$(\Delta P_v) = \frac{0.0655 \mu_v^2 z}{\rho_v r_v^3} R_z^{7/4}$$

Now we can put all of these expressions together to obtain a governing equation.

The result is

for $R_z < 2000$,

$$\begin{aligned} \frac{2\gamma}{r_m} - \Delta P_\ell &\geq \frac{(1 - 4/\pi^2)Q^2}{8\rho_v r_v^4 L^2} & R_r \gg 1 \\ &\geq \frac{4\mu_v zQ}{\pi\rho_v r_v^4 L} & R_r \ll 1 \end{aligned}$$

for $R_z > 2000$,

$$\frac{2\gamma}{r_m} - \Delta P_\ell \geq \frac{0.0655 \mu_v^{1/4} z}{\rho_v r_v^{19/4}} \left(\frac{Q}{\pi L} \right)^{7/4}$$

If it is assumed that $R_r \gg 1$ and that $R_z < 2000$, this can be reduced to the form

$$\frac{B}{r_m} = \frac{CQ^2}{r_v^4} + \frac{ADQ}{b^4}$$

where A, B, C, and D are constants.

In the above equations Q is the power carried by the pipe, L is the total pipe length, γ is the surface tension, μ the viscosity, ρ the density and R_r and R_z are the radial and axial Reynolds numbers respectively.

Neutronics

SUBROUTINE WDTF

It was desirable to incorporate a reasonably accurate but short running neutronic subroutine (WDTF) into the reactor design analysis program. For this purpose the one dimensional cylindrical transport code DTF-II* was modified to retain only the reactivity (k_{eff}) option of the six normally available. The initial revision, called MDTF, handled five spatial zones, held the two innermost and two outermost zones to five intervals and placed one fuel region in zone three with 10 intervals. There were 16 energy groups used with 11 nuclides, S_4 approximation; and only isotropic scattering was allowed. Over a period of time it became clear that a re-evaluation of the modified code (MDTF) was advisable to allow more flexibility in choice of

- a) number of spatial zones
- b) number of nuclides
- c) scattering option (iso or anisotropic)

as well as to add an option for computation of regional power density for use in power flattening. This neutronic subroutine is called WDTF.

In the course of this re-evaluation the question of interplay between spatial interval and S_n order, the origin of S_n sets, and energy group structure were considered. These studies have been separately documented but will be liberally abstracted here to increase their usefulness. Regarding the energy grouping, it has been determined that the 16 group structure,⁵ which ranges from 10^{-6} eV to 10 MeV, incorporates at least eight groups (10^{-6} eV to 0.55 keV) which are superfluous to these fast reactor calculations (whose mean energy is in excess of 100 keV). On the other hand neutronic computational time is not seriously extended (~20% effect) by retention of the lower eight groups which are necessary to carry out the water immersion calculations. However, an additional verification of the need to allow for perhaps unexpected spectrum effects as available from the full 16 groups arose during the course of the LRL design program.⁶ It was required to place an insulator between the reactor core and the pressure vessel. At that time suitable cross sections for the insulator had not been prepared. In order to proceed with the study gold was substituted because of its similar resonance integral. Shortly thereafter the desired data became available, and the calculation was redone. Unexpected spectrum effects, important for both the fast and thermal spectrums and non linear in response were observed, which were due solely to the slight change in cross sections. These comparative results, all at start of life, are given in Table II.

*See Appendix B.

Table II. Comparison of the effect of gold-insulator interchange on the eigenvalue (k_{eff}).

Case	AuO ₂	Insulator	$\delta k, \%^a$
Bare ^b	0.97007	0.97199	+0.193
Reflected ^b	1.00061	1.00354	+0.293
E, MeV (reflector) ^b	0.393	0.391	—
Water ^c	1.01008	1.00732	-0.276
Water ^d	0.95955	0.95844	-0.111
Water ^e	1.01914	1.01828	-0.086
Water ^f	0.99094	0.99202	+0.108

^a $\delta k = k_{Hf} - k_{Au}$

^bHot start-of-life

^c300°K, ∞ water reflector

^dlike c plus all primary coolant replaced by water

^elike d plus all interstitial and control fluids replaced by water

^flike e except ∞ water reflector removed

As a gross result the above differences are small enough to be ignored in finalization of a reference design. However, they do give clear indication of spectrum induced changes which could not be ignored in reactor control analysis (which was not included in the study). For these reasons the 16 group structure was retained in the routine.

The origin of at least some of the possible S_n sets of direction cosines and calculational weights have been documented.* A short study was carried out to determine the relation between the fineness of spatial detail and the S_n order and set chosen as reflected by the resulting eigenvalue. Three groups of mesh spacings and two different S_n sets were investigated. In all cases five spatial zones were used with the mesh taken alternately as one interval per zone, five intervals per zone, or 10 intervals in the fuel zones with five intervals in the remaining zones. The S_n sets investigated were alternately Set I and Set II of Appendix C where Set I, S_4 was the original WTDF choice. The results of this study are shown in Table III and are consistent with those from a detailed study by Carlson and Bell.⁷ Increasing N or I while holding, respectively, I or N fixed obtains a convergence or "asymptotic" limit but that limit is not "exact." Rather, the "exact" value is obtainable only through proportionate increase of both N and I.

With reference to the data of Table III it may be noted that for a given S_n set there is insignificant advantage in using the mesh scheme of 10 intervals in the fuel zones over the simpler and uniform five intervals per zone. Also it is apparent the rather gross mesh density of one interval per zone produces, at least for these reactor calculations

*See Appendix C.

Table III. Effects of the interplay between spatial and angular mesh.

		Intervals per zone, I					
		1, 1, 1, 1, 1		5, 5, 5, 5, 5		10, 10, 5, 5, 5	
N	Set	k_{eff}	ϵ^a	k_{eff}	ϵ^a	k_{eff}	ϵ^a
4	I	0.9976	-0.17	1.0006	+0.13	1.0007	+0.14
4	II	0.9959	-0.34	0.9998	+0.05	0.9999	± 0.06
8	II	0.9960	-0.34	0.9992	-0.01	0.9993	—

^a ϵ = percent difference from S_0 , Set II, fine mesh case.

where the core dimensions are measured by a small number of mean free paths, quite good estimates of the "asymptotic" eigenvalue. Such conclusions are unfortunately not to be generalized but require confirmation as major system changes occur.

The results of this study indicate that a uniform spacing of five intervals per spatial zone and S_4 approximation (Set II) are quite adequate to retain "asymptotic" accuracy and minimal running time for the reactor systems studied.

An additional question arises regarding the suitability of the energy flux used to weight the evaluated cross section data to produce the structured cross sections used in the calculations. The energy flux* originally used was based on that of the LRL-F reference design. The effect of using the Godiva spectrum, which corresponds closely with that of the 2 MW_{th} systems, was -0.789% Δk whereas using a flat spectrum caused a change of +6.35% Δk . The former result in context with the expected overall accuracy of the calculations (~2%) was taken to justify the continued use of the original weighting function. An additional benefit was realized in that verification of the comparability of the 2 MW_{th} system spectrum to that of Godiva allowed the calculation of $\nu(E)$ from the LASL cross sections⁵ for use in power density analysis. It is to be noted the cross sections as used in our library list ($\nu\Sigma_{fg}$) not ν_g or Σ_{fg} .

SUBROUTINE POWDEW

To incorporate a capability for dynamic power flattening into the overall design analysis package, a new subroutine was designed and inserted into the modified DTF neutronic code. This has been named POWDEW (see Figs. 10.1-10.3) and, through the normalized power density (POW), may be called by the main sequence as POWW(POW). Through use of the contained comment cards, POWDEW is reasonably self-explanatory. One note of caution however, concerns the physical position of the fissile nuclide cross section data decks and their relation to POWDEW. As this routine is presently cast ²³³U, ²³⁵U, ²³⁸U and ²³⁹Pu must occupy deck positions 10, 11, 13, and 14 respectively. If the user chooses to alter this sequence he must change the "11" in the four (JN = stuff) cards between statements 1 and 45 and statements 30 and 15 to the new ²³⁵U position number as well as changing the coefficient n in the four (LL = IHG*n) cards to make

*See Appendix D.

$n =$ (the corresponding physical deck position -1). This assumes that the above four fissile nuclides would remain serially grouped as j , $j + 1$, $j + 3$, and $j + 4$; we have been using ^{236}U in the No. 12 or $j + 2$ slot (see Fig. 10).

WDTF COMPOSITION AND OPTIONS

To make available the versatility of the stripped 1-D transport code WDTF, its composition and options will now be discussed. In general the internal calculational procedure is unchanged from DTF-2. Input-output has, however, been completely changed in that most variables are preset (but changeable by the user) and output options either preset or available through option calls in the main sequence. Reproduced here from the complete program listing given in Appendix A are fold-out sheets listing CLICHE (a dummy subroutine providing common storage) and WDTF (Figs. 11,12). Comments have been added to these lists to improve their usefulness. Basic to the use of this neutronic subroutine is the requirement that any change in the variable values set by CLICHE requires complete recompilation of the neutronic package whereas all of the other neutronics subroutines may be changed singly. Those variables so constrained in CHICHE are

1. Maximum number of energy groups, NGM.
2. Maximum number of spatial zones, NZM.
3. Maximum total number of intervals within all zones, NIM.
4. S_n order, NSN.
5. Maximum number of nuclides, NCR.

POWDEW - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

*   FORTRAN          POWDEW          LRLTRAN VERSION 4/16/68
SUBROUTINE POWW(PWM)
USE COM
COMMON/GNATZ/KA(NZM),MISTI

DIMENSION GNU3(NGM),GNU5(NGM),GNU8(NGM),GNU9(NGM),POWF(NIM),POW(NI
IM)

C   THE VALIDITY OF THESE CALCULATIONS
C   IS BASED ON MATERIAL 10 = U233
C           MATERIAL 11 = U235
C           MATERIAL 13 = U238
C           MATERIAL 14 = PU239
C
C   THIS SUBROUTINE SEARCHES FOR THOSE ZONES WHICH CONTAIN
C   U233, U235, OR PU239 AND IGNORES ALL OTHERS
C
C   MISTI = 0 IMPLIES ISOTROPIC SCATTERING
C   MISTI = 1 IMPLIES ANISOTROPIC SCATTERING
C
C   THE COMPUTED POWER DENSITIES (POW) ARE NORMALIZED TO THE DENSITY
C   IN THE FIRST INTERVAL OF THE FIRST FUEL ZONE. XPOW IS THIS DENSITY
C   AND IS EDITED AS POWN.
C
C   SINCE THE CROSS SECTION LIBRARY LISTS NU SIGMAF RATHER THAN THE
C   NU, VALUES BASED ON TABLE 7-2, ANL5800 ARE GIVEN AS DATA AND USED
C   TO OBTAIN SIGMAF.
C
DATA (GNU3=3.02,2.70,2.61,2.57,2.53,11(2.51))
DATA (GNU5=2.94,2.62,2.53,2.49,2.46,11(2.45))
DATA (GNU8=2.80,2.50,2.45,13(0.))
DATA (GNU9=3.48,3.09,2.99,2.93,2.88,11(2.86))

C   SELECT FUELLED ZONES

IN=0
NC=0
1  DO 5 N=1,IZM
    IN=IN+KA(N)
    IF (MISTI) , .40
    JN=N*(MCR+1)+11-MCR
    GO TO 45
40  JN=N*(MCR+1)+11-MCR+2*(N-1)
45  IF (XMD(JN)-1.E-20) , .60

```

Fig. 10.1. POWDEW subroutine.

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POWDEW - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

      IF(XMD(JN-1)-1.E-20) . .60
      IF(XMD(JN+3)-1.E-20)5.5.

C     COMPUTE SIGF

60  L=IN-KA(N)+1
    DO 10 I=L,IN
      POWF(I)=0.

C     SIGF FOR U235, J=11
    DO 15 JGN=1,1GM
      NAG=(JGN-1)*IN+1
      M=2+1HM*(JGN-1)
      IF(XMD(JN)-1.E-20)50.50.
      LL=1HG+10
      CI=C(LL*M)
      SIGF5=XMD(JN)*CI/GNU5(JGN)
50  SIGF3=0.
      SIGF8=0.
      SIGF9=0.

C     SIGF FOR U233, J=10
      JN=JN-1
      IF(XMD(JN)-1.E-20)20.20.
      LL=1HG+9
      CI=C(LL*M)
      SIGF3=XMD(JN)*CI/GNU3(JGN)

C     SIGF FOR U238, J=13
20  JN=JN+3
      IF(XMD(JN)-1.E-20)25.25.
      LL=1HG+12
      CI=C(LL*M)
      IF(JGN-4) .25.25
      SIGF8=XMD(JN)*CI/GNU8(JGN)

C     SIGF FOR PU239, J=14
25  JN=JN+1
      IF(XMD(JN)-1.E-20)30.30.
      LL=1HG+13
      CI=C(LL*M)
      SIGF9=XMD(JN)*CI/GNU9(JGN)
30  POWF(I)=POWF(I)+XN(NAG)*(SIGF3+SIGF5+SIGF8+SIGF9)
      IF(MIST) . .55
      JN = N+(MCR+1)+1-MCR

```

Fig. 10.2. POWDEW subroutine.

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POWDEW - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

      GO TO 15
55  JN=N*(MCR+1)+1-MCR+2*(N-1)
      15 CONTINUE
      IF(NC-1) .35.35
      XPON=POWF(L)
      NC=NC+1
      WRITE OUTPUT TAPE 3,100,XPON
35  POW(I)=POWF(I)/XPON
      WRITE OUTPUT TAPE 3,101,I,POW(I)
      10 CONTINUE
      5 CONTINUE
100  FORMAT (1H1,5X,16H1  NORM. POWER,3X,6HPONN =,E12.5//)
101  FORMAT (5X,12.5X,F8.5/)
      RETURN
      END

```

Fig. 10.3. POWDEW subroutine.

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CLICHE - A SUBROUTINE FOR DYNAMIC DIMENSIONING OF DTF-2.

Any changes in the noted variables of CLICHE
require complete recompilation of the neutronic
code including CLICHE and WDTF.

- (a) Number of groups
- (b) Number of spatial intervals
- (c) Order of S_n quadrature
- (d) Number of nuclides
- (e) Number of spatial zones

Fig. 11. CLICHE subroutine.

```

*   FORTRAN          CLICHE          LRLTRAN VERSION 3/13/68
SUBROUTINE          CLICH
C   DUMMY SUBROUTINE FOR COMMON CLICHE
C   MAXIMUM OF 40 INTERVALS IN THIS VERSION
CLICHE COM

      (a)  (b)  (c)  (d)  (e)
PARAMETER (NGM=16,NIM=40,NSN=4,NCR=10,NZM=8,NGP=NGM+1,NIP=NIM+1,
1  NMT=NCR+2=NZM,NMM=(NSN*(NSN+1)/4+1,NMS=NZM*(NCR+3)+1)
COMMON/TAPES/ NIC,NJT(5)
COMMON/DTFKON/ ALA,ASR,AVE,AVR,BF,CEV,CNT,CYT,DFM,DFM1,DFM2,
1  DY,DZ,EPG,EPN,EPS,EOL,EOP,EQ,E,E1,E2,E3,E4,E5,E6,E7,E8,
2  E9,E10,E11,E12,E13,E14,E15,E16,E17,E18,E19,E20,ESC,ESH,
3  EYM,EYN,EYP,EY,FTP,FXM,IOL,IOR,ICM,IC,ICYT,IDFM,IO,IEYT,
4  IFN,IGE,IGH,IGP,IG,IGS,IGV,IMG,IMM,IMS,IMT,IIC,IIM,IM,
5  IPN,IPP,IP,IPV,IPVT,IOM,ISCT,ISN,ITW,IT,IDI,ID2,ID3,ID4,
6  IZM,IZP,JT,KGSFC,KS042,KS053,KS051,KS052,LC,M,MCR,HG,
7  MI,ML,MM,MS,HTP,MT,MFM,PV,PVT,RXF,RVF,XITA,XITR,XLAW,
8  XLAL,XLAP,XLAR,XLA,XNBT,XNC,XNF,XNIO,XNPM,ZZ1,ZZ2,ZZ3,
9  IPH,ITA,EAM,ZI,IDN,IIG,RLB,XNLB,IM,IDOLL,IDT
COMMON/DTFARR/ AA(NIP),AF(3),AG(NGP),B(NMM=NGP),CE(NIP),CB(2)
1  CF(NIP),CH(9),CL(NIP),C(9=NGP=NMT),CS(NIP),CT(NIP),
2  DA(NIP=NMM),DB(NIP=NMM),DC(NIP=NMM),DF(NIP),D(NMM),
3  DS(NIP=NMM),FG(NGP),FNG(NGP),F(NIP),IOX(NGP),ICX(NGP),
4  IDX(NMM),IGT(NGP),IZI(NIP),HA(NIP),HB(NMS),HC(NMS),
5  HR(NMM),MTT(NMM+2),MZ(NMS),NX(NGP),PA(NGP),PG(NGP),
6  PR(NMM),P(NMM),QG(NGP),Q(NIP=NGP),RA(NIP),RAY(NIP),
7  RLG(NGP),RM(NIP),R(NIP),SA(NIP),SAT(NIP),SB(NIP),SCG(NGP),
8  SDG(NGP),SG(NGP),SNG(NGP),ST(NIP),TAB(NGP),VE(NGP),VF(3),
9  Y(NIP),XD(NMM),X(NMM),XJ(NIP=NGP),XKE(NGP),XKI(NGP)
COMMON/DTFARR/ XMD(NMS),XNA(NIP),XNB(NGP),XNDG(NGP),XNE(NIP),
1  XND(NIP=NMM),XNG(NGP),XNI(NMM),XNLG(NGP),XNN(NIP),
2  XNR(NMM),XNR(NIP),XN(NIP=NGP),XNO(NMM),SR(NIP),CA(NIP),
3  PB(NGP),ICXX(NMT)
END CLICHE
USE COM
RETURN
END

```

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By inclusion of many comment cards WDTF is effectively self-explanatory. To obtain WDTF from a main sequence it is necessary only to call WDTF as

```
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
```

where

EFFK = output value of k_{eff}

XLEN = axial core length, cm

RADII = row vector of IZM radial zone boundaries (outer radii, cm). Note that RADII has a dimension of NZM not IZM which thus allows use of any number of spatial zones $\leq$ NZM.

ADEN = two dimensional array of atom densities (units of 10^{-24} atoms/cc).

= ADEN(I, J) and I applies to the material number and J to the spatial zone number. Note here that ADEN is dimensioned ADEN(NCR, NZM) so any number of nuclides $\leq$ MCR and zones $\leq$ NZM can be used. For example, the entry ADEN(12, 4) = 0.0931 means that material (nuclide) 12 in zone 4 has an atom density of 9.31×10^{22} atoms/cc. Materials (nuclides) not present in a particular zone must have an atom density entry of zero.

MCR = number of separate nuclides used in calculation ($\leq$ NCR).

= number of cross section decks used as data

IZM = number of spatial zones used ($\leq$ NZM).

MIST = trigger for choice of scattering treatment.

= 0 for isotropic.

= 1 for anisotropic.

Note that only one cross section deck is required for isotropic treatment of a material whereas two other cross section decks (for the same nuclide) must be used for MIST = 1. Also for MIST = 1 the two scatterer decks must be physically placed at the end of the cross section data decks, e. g., if hydrogen is used and MCR = 15, H-1 is nuclide 14 and H-2 is nuclide 15. If these are included in a MIST = 0 calculation the atom density of H-1 must be set = 0 in the main sequence (the atom density of H-Z will be separately set equal to H-1 in WDTF) since the H-1 may not be used for isotropic scattering. Thus a calculation in which one wishes to compare the results of an isotropic scattering treatment to anisotropic scattering for hydrogen would require three hydrogen cross section decks with the isotropic hydrogen deck located at any nuclide position from 1 through (MCR-2), H-1 at (MCR-1), and H-2 at MCR (see Fig. 12).

The current form of WDTF uses S_4 quadrature. Also listed in the form of comment cards, however, are corresponding sets of "DATA" for S_6 and S_8 approximation. To avoid possible difficulties, the user is urged to read carefully the adjacent comment cards for application instructions.

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WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

*   FORTRAN      WDTF 6600      LRLTRAN VERSION 4/16/68
    SUBROUTINE WDTF(EFFK,XLEN,RADII,ADEN,MCRI,IZMI,MIST)
C
C
C   DESIGNED FOR 5 INTERVALS PER ZONE, 8 CORE ZONES MAX, 18 MATERIALS
C   MAX, AND 16 ENERGY GROUPS.
C
C   THE ATOM DENSITIES (XMD),XSECTIONS (CI), AND SCALAR FLUXES (XM),
C   ARE COMMON FROM DTF.
C
C   WDTF ACTS AS THE MAIN ROUTINE FOR THE DTF-2(S4),1D(RADIAL) TRANS-
C   PORT CODE. THE S4 COSINES AND WEIGHTS WERE SELECTED TO OBTAIN
C   MAXIMUM ACCURACY OF KEFF IN CONTEXT WITH THE SPATIAL MESH AND
C   DESIRED SHORT RUNNING TIME.
C
C   IN ORDER TO PROVIDE EXPLICIT DATA FOR CORRESPONDING HIGHER SN ORDER
C   THE WEIGHTS (W), AND DIRECTION COSINES (D) FOR N=6 AND 8 ARE LIST-
C   ED BELOW. THE READER IS CAUTIONED THAT EITHER OF THESE SETS MAY
C   ONLY BE USED TO REPLACE THE S4 SET IF NSN OF CLICHE IS CHANGED
C   TO THE NEW VALUE OF N AND THE WHOLE CODE FOLLOWING CLICHE IS RE-
C   COMPILED.
C
C   DATA FOR S6
C
C   DATA(W=0. .16666667,.08333333,2(.05555556),.08333333,.16666667,
C   10. .08333333,2(.05555556),.08333333,0.,2(.05555556))
C   DATA(D=-.99346060,-.80847425,-.57735027,-.11417547,.11417547,
C   1.57735027,.80847425,-.81649658,-.57735027,-.11417547,.11417547,
C   2.57735027,-.58853155,-.11417547,.11417547)
C
C
C   DATA FOR S8
C
C   DATA(W=0. .11434821,.04600346,.04653606,2(.03850917),.04653606,
C   1.04600346,.11434821,0. .04600346,.04653606,2(.03850917),.04653606,
C   2.04600346,0. .04653606,2(.03850917),.04653606,0.,2(.03850917))
C   DATA(D=-.99381544,-.85708017,-.70273364,-.50307327,-.11104445,
C   1.11104445,.50307327,.70273364,.85708017,-.86424376,-.70273364,
C   2-.50307327,-.11104445,.11104445,.50307327,.70273364,-.71145304,
C   3-.50307327,-.11104445,.11104445,.50307327,-.51518306,-.11104445,
C   4.11104445)
C
C   CAUTION. USE THESE DATA ONLY AS DESCRIBED ABOVE.
C
C

```

Fig. 12.1. WDTF subroutine.

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WDTF - A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

C THE ACTUAL NUMBER OF ZONES (NZM) AND MATERIAL (MCR) ARE SET IN THE
 C MAIN DECK. THE NUMBER OF ENERGY GROUPS IS SET IN CLICHE (NGM) AS
 C ARE THE MAXIMUM NUMBER OF ZONES (NZM) AND THE MAXIMUM NUMBER OF
 C MATERIALS (NCR), AND SN ORDER (NSN).

C
 C ANY CHANGES IN CLICHE NECESSITATE A RECOMPILATION OF WDTF AND ALL
 C TRANSPORT CODE SUBROUTINES INCLUDING POWDEM. INDIVIDUAL SUBROUTINE
 C CHANGES HOWEVER ARE INDEPENDENT.

C
 C PROVISION FOR BOTH ISOTROPIC AND ANISOTROPIC SCATTERING ARE INCLUD-
 C ED IN WDTF. THE SCATTERING TYPE IS SELECTED BY SETTING MIST IN THE
 C MAIN PROGRAM.

C NOTE THAT FOR MIST = 1, THE SECOND ANISOTROPIC MATERIAL ATOM DENSITY
 C (FOR H-2 IF HYDROGEN) IS SET IN WDTF AS EQUAL TO THE FIRST (E.G.
 C H-1) ANISOTROPIC MATERIAL ATOM DENSITY FROM THE MAIN DECK. TO
 C FUNCTION CORRECTLY H-1 MUST BE MATERIAL NUMBER MCR-1 AND H-2 MUST
 C BE MATERIAL NUMBER MCR. IF INCLUDED IN A MIST = 0 CALCULATION THE
 C ATOM DENSITY OF H-1 SHOULD BE SET TO ZERO IN THE MAIN DECK OR THE
 C H-1 XSECTION DECK REPLACED BY THE ISOTROPIC HYDROGEN VERSION.

C
 C MIST = 0 IMPLIES ISOTROPIC SCATTERING
 C MIST = 1 IMPLIES ANISOTROPIC SCATTERING

C
 C
 C USE COM
 C COMMON/GNATZ/KA(NZM),MIST
 C DIMENSION RADII(NZM),ADEN(NCR,NZM),PNG(NIM),PNG(NIM),
 C 1 ENEV(NIM),EINT(NZM)

C
 C
 C DEFINE UNCONDITIONAL PARAMETERS

C
 C DATA(ID=0),(ITH=0),(ISH=NSN),(IGE=2),(IBL=1),(IBR=0),
 C 1 (IFN=0),(IEVT=1),(EV=0),(EVM=0),(EPS=1.E-4),(IGH=NGM),
 C 2 (IHT=3),(IHS=4),(IHM=9),(BF=1.8137994),(DZ=0),(IDFM=0),
 C 3 (DFM1=0),(DFM2=0),(XNF=1),(IPVT=0),(PY=0),(IQM=0),(IPM=0),
 C 4 (IPP=0),(FXM=0),(IIM=20),(IGS=0),(RYF=.5),(XLAL=.1),(XLAM=.5),
 C 5 (EQL=.005),(XNPM=1),(ID1=0),(ID2=0),(ID3=0),(ID4=0),(ICM=100),
 C 6 (IDT=0),(MTP=0),(NJT=5(0)),(NIC=2),(IJOB=0),
 C 7 (F=NIM(1)),(KA=5.5,5.5,5.5,5.5,5.5,5.5)
 C 24 DATA(W=0,.33333333,2(.08333333),.33333333,0,.2(.08333333))
 C DATA(D=-.99578192,-.70412415,-.09175171,.09175171,
 C 1.70412415,-.71007688,-.09175171,.09175171)
 C DATA(XK1=.204,.344,.168,.18,.09,.014,10(0.))
 C DATA(YE=34.2,19.9,14.7,11.6,7.2,7.1,14.48,.206,.101,.0566,
 C 1 .0319,.0179,.0109,.00606,.00218)

Fig. 12.2. WDTF subroutine.

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WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

Fig. 12.3. WDTF subroutine.

```

MIST1 = MIST
MCR=MCR1
IZM=IZM1
IM=5*IZM
ID = IJOB = IJOB+1 $ DY = XLEN $ IK = IJJ = 0

C SELECT SCATTERING OPTION
IF(MIST) , .30

C
C ISOTROPIC SCATTERING OPTION
C
ISCT = 1
MT = MCR+IZM $ MS = IZM*(MCR+1)
DO 40 N = 1, IZM
DO 35 I = 1, KA(N)
IK = IK+1
35 MA(IK) = N
MZ(N) = MCR+N $ IJJ = IJJ+1
MC(IJJ) = 0 $ XMD(IJJ) = 0. $ MB(IJJ) = MCR+N
DO 40 J = 1, MCR
IJJ = IJJ+1 $ MC(IJJ) = J $ MB(IJJ) = MCR+N
XMD(IJJ) = MAXIF(1.E-30, ADEN(J, N))
40 CONTINUE
GO TO 45

C
C ANISOTROPIC SCATTERING OPTION.
C
50 MT=MCR + 2*IZM $ MS=IZM*(MCR+3)
ISCT = -1
NIT=0
DO 150 N=1, IZM
DO 138 I=1, KA(N)
IK = IK+1
138 MA(IK) = N
MZ(N)=-MCR-N-NIT $ IJJ=IJJ+1
MC(IJJ)=0 $ XMD(IJJ)=0. $ MB(IJJ)=MCR+N+NIT
DO 140 J=1, MCR
IJJ=IJJ+1 $ MC(IJJ)=J $ MB(IJJ)=MCR+N+NIT
XMD(IJJ) = MAXIF(1.E-30, ADEN(J, N))
140 CONTINUE
IJJ=IJJ+1 $ XMD(IJJ)=0. $ MB(IJJ)=MCR+N+NIT+1
MC(IJJ)=0
J=MCR
IJJ=IJJ+1 $ MC(IJJ)=J $ MB(IJJ)=MCR+N+NIT+1

```

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WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

      NIT=NIT+1
      XMD(1:J1)=MAX1F(ADEN(1:J-1),N),1.E-30)
150  CONTINUE
45   IF (NJT(1)) 200, ,
      WRITE OUTPUT TAPE 3,19,XLEN,(RAD1(K),K=1,12M)
      CALL CLOCK(TM1,TM2)
      WRITE OUTPUT TAPE 3,1111,TM1,TM2
      WRITE OUTPUT TAPE 3,18,((ADEN(1,J),J=1,12M),J=1,MCR)
200  L = 1 $ R(1) = 0.
      DO 220 I=1,12M
      JIN = L+KA(1)
      DINC = (RAD1(1)-R(L))/KA(1)
      DO 210 J=L+1,JIN
210  R(J) = R(J-1)+DINC
      L = JIN $ R(L) = RAD1(1)
220  CONTINUE
      IC = LC = IIC = 0
      CALL S800
      CALL RECS(1J00)
      CALL S804
      CALL S815
      CALL DTF2
      IFN = 1
      EFFK = EV
      IF (NJT(1)) 300, ,
      AYNE = 5.251E-3 * (XNG(1GP)/XNDG(1GP))**2
      WRITE OUTPUT TAPE 3,909, 1J00,EY,AYNE
      DO 260 I=1,1M
      PNG(1) = PNDG(1) = 0.
      DO 250 J=1,1GM
      K = (J-1)*1M+1
      AT = Y(1)*XN(K)
      PNG(1) = PNG(1)+AT
250  PNDG(1) = PNDG(1)+AT/YE(J)
      AA = 0.
      IF (PNDG(1)) ,260,
      AA = PNG(1)/PNDG(1)
260  EMEY(1) = 5.251E-3*AA*AA
      K = KK = 0
      DO 280 I=1,12M
      K = KK+1 $ A1 = A2 = 0.
      KK = K-1+KA(1)
      DO 270 J=K,KK
      A1 = A1+PNG(J)
270  A2 = A2+PNDG(J)

```

Fig. 12.4. WDTF subroutine.

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WDTF - A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

      AA = 0.
      IF (A2) .280,
      AA = A1/A2
280  EINT(1) = 5.251E-3*AA*AA
      WRITE OUTPUT TAPE 3,20, (EINT(L),L=1,12M)
      IF (NJT(5)) 290,290,
      WRITE OUTPUT TAPE 59,909,1JOB,EY,AYNE
      WRITE OUTPUT TAPE 59,20,(EINT(L),L=1,12M)
      GO TO 295
290  PRINT 909,1JOB,EY,AYNE
295  IF (NJT(1)-1) 300, ,
      WRITE OUTPUT TAPE 3,22,(EMEY(L),L=1,1M)
300  RETURN
909  FORMAT(//10H ***** JOB,14,6X,8H KEFF = F12.8, 6X, 15HAYG NEUT MEY
1 = F9.6 //)
1111 FORMAT(//10X, 6HTIME . 2A0)
18  FORMAT(// 15H DENSITY ARRAY / (8E15.5))
19  FORMAT(1H1, 9H XLEN = F10.2, 2X, 8HRAII = 8F10.2 //)
20  FORMAT(//26H AVERAGE NEUT MEY PER ZONE / (8E14.6))
22  FORMAT(// 53H SPECTRUM  AVERAGE NEUTRON ENERGY (MEV) PER INTERVAL
1 / (8E15.6))
      END

```

Fig. 12.5. WDTF subroutine.

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Regarding edit options there are two paths:

a) NJT(1) which may be set (in WDTF) to any of the following values. (This is as provided originally by MDTF.)

- 1 In this case no off-line listings at all are provided—this option will allow calculations to be done most rapidly.
- 0 This is the standard output option. The on-line printer will list the job number, k_{eff} , the average neutron energy (in MeV) in the core, and the average neutron energy in each of the five zones. The same information will be listed off-line plus the input core length, radii and atom density array.
- +1 All the information obtained from option 0 will appear as well as the usual DTF final print which lists the flux by energy groups and spatial interval. The average neutron energy in each spatial interval is also listed.
- +2 This option will add to the above a listing of the input cross sections, computed macroscopic cross sections and the DTF neutron economy listing.

The present WDTF version has NJT(1) = 0 and it is suggested this be retained: sub-routine RECS (see Appendix A), which reads in the microscopic nuclide cross sections, has been modified to also write them out automatically. If it is desired to have only the nuclide identification cards printed (rather than I. D. + all input cross sections) RECS may be modified by removal of the two cards:

```
WRITE OUTPUT TAPE 3, 304, (C(I), I=L, LF)
```

```
304 FORMAT (1X, 6E14. 6).
```

The remainder of the +2 option can be obtained at will from the main sequence by the following subroutine calls (all of which are listed in Appendix A).

b) CALL FINPR. This routine gives a heading of "FINAL PRINT" followed by a row array of convergence parameter states (with headings) followed by a matrix of final radii, average radii, fissions and cumulative volume for each spatial interval (row index). Below this, separate arrays are printed for each energy group (starting with $I = 1$, the highest energy) of the scalar flux XN for each spatial interval in row vectors. Thus the flux in the 1st interval is the 1st entry, 2nd entry is the flux in 2nd interval, etc. There are six columns so that, e.g., the last entry of the 4th row is the scalar flux of interval 24.

CALL PCI. This routine gives volume and area as a function of boundary radius—listing of the S_n parameters—fission fractions—mixture information (materials formed in each zone)—separate arrays of macroscopic cross sections for each nuclide and each material mixture. These latter arrays start with nuclide 1 and ending with the mixture in zone IZM for a total length of MCR + IZM.

CALL S847. This routine lists an extensive summary of neutron economy information.

CALL BALAN. This routine lists an extensive summary of neutron balance information.

Note that a more complete explanation of these edits is contained in Appendix B.

Regarding the included list (see Appendix A) of subroutines for use with CLICHE/WDTF—besides the routine DTF2 there are listed 34 subroutines. In the glossary which follows these, the listed routines BALAN, FINPR, and PCI are not described since they are edit routines. However the routines S805, S806, S814, S815 are described but not listed earlier. This latter situation has arisen because of deletion of the adjoint calculations option (S805 and S806) and distributed source option (S814 and S815).

SELECTION OF FUEL ELEMENT ROWS

To preserve design consistency, the reactor analysis is based on fuel elements which will generate the required heat, allow the necessary heat transport, and which are located in a properly positioned and realistic manner. In this way the exact number of elements are known and all radial zone boundaries occur at real element boundaries rather than at some arbitrary fraction of the core radius.

Figure 10 shows the dodecagon row pattern for a 60° sector as used in our work. It is equally applicable to the type 2 (pin) or type 4 (hexagonal) element. Along the abscissa the rows (N) are indicated by the numbers within the 60° segment. Below these are indicated the number of elements in each of the rows. The numerology for determination of the number of elements is quite simple and, as shown in Table IV is entirely regular beyond the 6th row.

Table IV. Relation between row and number of elements.

N	$n \times 6$	Σn	$N - (n + 1)$	N	n	Σn	$N - (n + 1)$
1	1	1	—	11	7×6	295	3
2	1×6	7	0	12	11×6	361	0
3	2×6	19	0	13	12×6	433	0
4	3×6	37	0	14	13×6	511	0
5	3×6	55	1	15	10×6	571	4
6	5×6	85	0	16	15×6	661	0
7	4×6	109	2	17	16×6	757	0
8	7×6	151	0	18	17×6	859	0
9	8×6	199	0	19	13×6	937	5
10	9×6	253	0	20	19×6	1051	0

Although a table of element numbers per row was used in the coding, the following FORTRAN statements can be incorporated to perform a similar function. Given a row value of N, the total number of elements up to and including that row is given by SUM(N).

```

      IF(N-4),,100
      SUM(N) = 3*N*(N-1)+1
      GO TO 69
100   IF(N-6),,105
      SUM(N) = 3*N*(N-1)-5
      GO TO 69
C     I = 10 WILL COMPUTE N=42(MAX)
105   DO 690 I=2,10
      NN=I*(I-1)/2
      IF((4*(I-1)+7).LE.N) GO TO 690
      SUM(N) = 3*N*(N-1)+1-6*NN
      GO TO 69
690   CONTINUE
69    GO TO ____

```

The equivalent circular outside radius of the Nth row dodecagon, required by WDTF, is given by

$$r_N = 1.102 \omega \sqrt{\text{SUM}(N)}$$

where ω = half the distance across the hexagonal flats (type 4 elements)
 = outside radius of the fuel cladding (type 2 elements).

The current treatment of the polygonal boundary in the neutronic subroutine has been to use radii which yield areas equal to the corresponding polygons. To improve the accuracy of this calculation, a scheme will be discussed which, although unimplemented because of lack of time, offers a useful future approach. Brown and Kolar⁸ have investigated the reactivity effects of approximating polygonal with circular boundaries using a one-speed neutronic model. Their results show that for large (10 MW_e) reactors the error $-\frac{dk}{k}$ is $\sim 7.5 \times 10^{-4}$ while for the intermediate systems (300 kW_e) the error $-\frac{dk}{k}$ is $\sim 1.3 \times 10^{-3}$ using dodecagon boundaries.

While these errors are small for the dodecagonal boundary they increase by nearly an order of magnitude upon a change to hexagonal boundaries which occurs below row 9 of Fig. 13. Since the intermediate systems often have half of their fuel rows in this range, a modified treatment of the equivalent radii is of importance. Brown and Kolar concluded that the ratio of the buckling for a polygon of side n could be related to that of a circular shape of equal area through the relation

$$\frac{B_n'^2}{B_c'^2} - 1 = f\left(\frac{1}{n^3}\right)$$

where $f\left(\frac{1}{n^3}\right)$ = 0.0865 for a square
 = 0.0252 for a hexagon
 = 0.0103 for an octagon
 = 0.0027 for a dodecagon

Fig. 13. Fuel element row pattern.

To provide at least a first order rationale to improvement of the analysis we will now consider the j th row of elements and define the "radius" to the flat as r_j , the polygonal area as A_j , and the equivalent circular radius as

$$j r_c = \left(\frac{A_j}{\pi} \right)^{1/2}$$

so that
$$j B_n^2 = \left(\frac{\nu_0}{j r_c} \right)^{1/2} f \left(\frac{1}{n^3} \right).$$

To minimize the computational error then requires that $B_n^2 \equiv B_c^2$, which implies that the computational circular radius should be taken as

$$\begin{aligned} j_{r_{c,n}} &= \frac{\nu_0}{j_{B_n}} \\ &= j_{r_c} f^{-1}\left(\frac{1}{n^3}\right) \\ &= 1.0243 r_j \quad \text{for a hexagon} \\ &= 1.0089 r_j \quad \text{for a dodecagon.} \end{aligned}$$

The reduction in computational radii caused by this scheme is thus seen to be 7.6% and 1.4% for the hexagon and dodecagon respectively since

$$\begin{aligned} j_{r_c} &= 1.1027 r_j \quad \text{for a hexagon} \\ &= 1.0233 r_j \quad \text{for a dodecagon.} \end{aligned}$$

Inclusion of this corrective scheme would require relatively little code revision. It should be noted, however, that r_j , the equivalent circular radius, should continue to be edited for layout purposes, e. g., not $j_{r_{c,n}}$.

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Appendix A

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INTRODUCTION

THESE CODE PACKAGES WERE DEVELOPED AT THE LAWRENCE RADIATION LABORATORY FOR THE ADVANCED REACTOR TECHNOLOGY PROGRAM. THEIR PURPOSE IS TO GIVE A FIRST ENGINEERING APPROXIMATION TO A REACTOR DESIGN WHERE WARRANTED. THIS DESIGN WOULD THEN BE STUDIED IN MORE DETAIL BY PHYSICS GROUPS USING MORE SOPHISTICATED TWO DIMENSIONAL AND MONTE CARLO TECHNIQUES TO REFINES THE DESIGN AND TO PERFORM THAT ANALYSIS THAT IS BEYOND THE REACH OF A ONE DIMENSIONAL TRANSPORT CODE. THE APPROACH USED HERE IS TO COUPLE A THERMO MECHANICAL DESIGN AND ANALYSIS CODE TO A STRIPPED DOWN NEUTRONIC ANALYSIS CODE THROUGH SIMPLE NUMERICAL ANALYSES. THESE CODES ARE IN AN OPERABLE THOUGH UNREFINED STATE AS THEY WERE LAST USED PRIOR TO TERMINATION OF THE PROGRAM. THERE ARE MINOR ERRORS, PRINCIPALLY IN THE FINAL PORTIONS OF THE DESIGN SUBROUTINES. THESE GENERALLY INVOLVE WEIGHTS ETC WHICH ARE NOT USED IN THE MAIN ANALYTICAL SEQUENCE AND WHICH WOULD HAVE TO BE REVISED IN ANY EVENT FOR ANY OTHER FAMILY OF REACTORS. THE REACTOR DESIGNS ARE QUITE DETAILED COVERING FEATURES SUCH AS SWELLING ALLOWANCES, INTEGRAL NUMBERS OF FUEL ELEMENTS, TEMPERATURE DEPENDENT PROPERTIES, DESIGN LIMITS ETC. NOT NORMALLY FOUND IN SURVEY TYPE CODES. THESE FACTORS DO HOWEVER HAVE A SIGNIFICANT EFFECT ON DESIGN AND PERFORMANCE. WHILE THE CODES ARE QUITE LONG, THEIR RUNNING TIME IS QUITE MODEST, AND THE NON NEUTRONIC PORTIONS CAN BE FURTHER BROKEN UP TO YIELD EVEN SHORTER RUNNING TIMES. THE NEUTRONIC CODE USED IS A MODIFIED VERSION OF THE ONE DIMENSIONAL TRANSPORT CODE DTF 2, STRIPPED FOR THE ANALYSIS OF CYLINDRICAL REACTORS. OTHER NEUTRONIC PACKAGES COULD BE SIMILARLY STRIPPED. IN THIS PROCESS, IT SHOULD BE NOTED THAT ALL SUCH A PACKAGE REQUIRES IS A FEW OPTIONS. SIGNALS AND A DIMENSIONAL AND ATOM DENSITY ARRAY. THERE ARE TWO DESIGN PACKAGES HERE. EACH IS COMPOSED OF A MAIN CALLING SEQUENCE AND A DESIGN SUBROUTINE. HRCTR AND HREAC ARE FOR HEAT PIPE COOLED REACTORS. RCTR AND REACT ARE FOR CONVENTIONALLY COOLED REACTORS. THE REMAINDER OF THE PACKAGE IS COMMON TO BOTH SETS. THIS IS BROKEN DOWN INTO THE FOLLOWING SUBROUTINES. NEWRAP IS A SIMPLE NEWTON RAPHSOIN ITERATION SUBROUTINE. PYMAT IS A BRIEF PRESSURE VESSEL MATERIAL STRENGTH SUBROUTINE. ELMTS IS A SUBROUTINE TO DETERMINE THE NUMBER OF ELEMENTS IN A HEXAGONAL ARRAY THAT WILL FIT A DODECAGONAL PATTERN THAT MAY BE SOLID OR HOLLOW. SPILL IS A BRIEF DECIMAL DUMP ROUTINE THAT HAS BEEN FOUND USEFUL FOR DEBUG PURPOSES. TRANP IS A LIQUID METAL TRANSPORT SUBROUTINE AND EYAP IS A SIMILAR ROUTINE FOR LIQUID METAL THERMODYNAMIC PROPERTIES. THE LATTER IS NOT USED IN THE REACTOR DESIGN BUT IS INCLUDED SINCE IT MAY BE USEFUL FOR CYCLE STUDIES INVOLVING THE REACTOR. CLICHE IS A DYNAMIC DIMENSIONING ROUTINE FOR THE NEUTRONIC SUBROUTINES THAT FOLLOW. PONDEN IS A SUBROUTINE FOR CALCULATING RADIAL POWER PROFILES. WDTF IS A ONE DIMENSIONAL TRANSPORT CODE (DTF 2) STRIPPED FOR USE IN THIS PACKAGE. IT INCLUDES BOTH ISOTROPIC AND ANISOTROPIC SCATTERING OPTIONS. THE CROSS

INTRODUCTION

SECTIONS TABULATED HERE ARE AN INTERIM LIST OF SPECTRUM WEIGHTED CROSS SECTIONS COMPILED BY R. DOYAS AND Y. HANSEN FROM THE HORTON EVALUATED LIBRARY. THEY ARE LISTED HERE FOR THOSE WHO MAY NOT HAVE SUCH A LIST WITH THE CAUTION THAT THESE WERE INTENDED AS AN INTERIM LIST FOR SMALL APPROXIMATE FAST REACTORS PENDING A MORE THOROUGH AND RIGOROUS GROUPING AND WEIGHTING. THEY SHOULD BE USED WITH CAUTION AND FOR SURVEY PURPOSES ONLY. TRANP, PDMAT, SPILL, AND THE ORIGINAL MODIFICATION OF DTF 2 TO SUBROUTINE FORM ARE THE WORK OF T. YARLJEN. THIS MODIFICATION WAS CONTINUED BY E. M. MCCAULEY WHO WROTE THE ISOTROPIC/ANISOTROPIC OPTIONS FOR WDTF AS WELL AS PONDEN. IN ADDITION HE CLARIFIED AND ORGANIZED THE SN QUADRATURE SETS. EYAP WAS WRITTEN BY G. PATRAW AND N. BROWN. NEWRAP, ELMTS, AND THE DESIGN AND ANALYSIS PACKAGES WERE WRITTEN BY N. BROWN. COLLABORATION BETWEEN THE ABOVE WAS EXTENSIVE. IN ADDITION, SIGNIFICANT ASSISTANCE WAS RENDERED BY M. JESTER, R. KOOPMAN, AND J. WADE.

HRCTR A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

* FORTRAN      HRCTR
  MULTIPLE ARGS TRANP,VISL,TCNL,CSPL,RHOL,RESL,TENS,PRANL,VISG,TCNG,
  'CSPG,RHOG,PRANG,SONY,PSAT,MYAP
  COMMON /HRAC/ TEMRIS,CCF,CCF2,REFCTR,RHOR,TSTRES,DR,HRLIF,TSUP,
  ITSMELL,MODE,PI,FUELDN,TBAR,ABUN,AUN,RHOUN,CONDUN,CPUN,EUN,GNUUN,
  ZPSY,AW,ABW,RHOW,CPW,CONDW,AL,RHAL,CONDL,VISCL,CPL,PSOT,STNL,RHAG,
  SYISCG,MPSTRS,ELPDHX,ELPD,ELPDOR,CORL,ELOPT,GCI,GCZ,B,G,FF,FC,FCL,
  AFS,FSC,QMTH,BU,PHIAT,PHIST,PHIA,PHIS,OPY,RN,RV,RC,RCDPT,RSCOR,HPC,
  SROCOR,RICOR,RZCOR,R3COR,THICKS,ANLHTS,A1,B1,C1,QWP,NTCOR,MYOP,SAF,
  GMDL,NCAL,DTOT,BUMX,SN,RHESH,DELA,HP2,SANY,NRS,NRA
  DIMENSION ADEN(10,0),RADII(0),ENRICH(3),ADN(10,0)
  DIMENSION POW(40),P(0,5),R(0,5),RA(0),RB(0),PBAR(0),BA(0),ER(0),
  I      DRA(0),PDA(0,5)

```

THIS CODE IS THE MAIN CALLING ROUTINE THAT COUPLES A NEUTRONIC CODE, DTF, TO A DESIGN CODE FOR HEAT PIPE COOLED REACTORS. THERE IS A SECOND VERSION FOR CONVENTIONALLY COOLED REACTORS. THE NEUTRONIC CODE HAS TWO MAIN OPTIONS FOR THIS SEQUENCE. ONE IS ISOTROPIC. AN OPTION THAT IS INDICATED BY SETTING MIST=0. THE SECOND WHICH USES AN ANISOTROPIC SCATTERING CALCULATION NECESSARY FOR WATER SAFETY ANALYSES IS CALLED BY SETTING MIST=1. THIS SEQUENCE IS SET UP TO COMPUTE A REACTOR HAVING 8 RADIAL ZONES EACH WITH FIVE SUB-INTERVALS. A SMALLER NUMBER OF ZONES MAY BE INDICATED BY SETTING IZM TO A SMALLER NUMBER. A LARGER NUMBER OF ZONES WOULD REQUIRE MAKING A FEW CHANGES IN THE DTF ROUTINE AS SET JP. MCR IS THE NUMBER OF CORE MATERIALS. A LARGER NUMBER OF MATERIALS COULD BE USED ONLY WITH A FEW CHANGES IN THE DTF ROUTINE. IN THE PRESENT SET UP, ZONE 1 IS A RETURN FROM THE AFT END BOILER, ZONE 2 IS A LIQUID CONTROL ANNULUS, ZONES 3,4,5 ARE ACTIVE CORE ZONES, ZONE 6 IS AN ANNULUS BETWEEN THE CORE AND PRESSURE VESSEL CONTAINING A MEMBRANE AND AN INSULATOR, ZONE 7 IS THE PRESSURE VESSEL, AND ZONE 8 IS THE REFLECTOR. THE MATERIAL SEQUENCE FOR THIS PARTICULAR PROBLEM IS L1,0,NA,K,N,MO,TA,W,U235,U238,U236,U239,U234,MF, AND TWO H CROSS SECTIONS NECESSARY FOR THE ANISOTROPIC COMPUTATION. THESE MATERIALS MAY BE CHANGED BY CHANGING THE APPROPRIATE EQUATION IN ADEN CALCULATION AND SETTING THE APPROPRIATE CROSS SECTION DATA. IN THAT NUMERICAL SEQUENCE. CAUTION. PONDEN, THE SUBROUTINE THAT COMPUTES THE POWER PROFILE MAKES A SEARCH FOR THE FISSILE SPECIES BASED ON THE ABOVE NUMBER SEQUENCE OF FISSILE SPECIES AND THIS WOULD REQUIRE A CHANGE IF THESE ARE PUT IN ANY OTHER LOCATION. THE USE OF MIST=1 (ANISOTROPIC OPTION) REQUIRES H 1 BE PLACED NEXT TO LAST IN THE MATERIAL LIST AND THE LAST MATERIAL TO BE H 2. WDTF MUST BE CHANGED TO PERMIT OTHER LOCATIONS. NO SUCH LIMITATION EXISTS FOR MIST=0. EITHER OPTION MAY BE USED FOR ISOTROPIC COMPUTATION IF THE ATOM DENSITY OF H 1 IS 0. IN ANY EVENT THE ATOM

HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

C DENSITY FOR M-2 IS BASED ON THAT SET FOR M-1 AND IS THUS INTERNAL-
C LY CONTROLLED. THE ANISOTROPIC OPTION IS CONSIDERABLY SLOWER.
C BEGIN THE PROGRAM BY INITIALIZING THE PROBLEM. IF MANY
C SIMILAR PROBLEMS ARE TO BE RUN IT WOULD PAY TO REPLACE THE FIRST
C SECTION OF THIS CODE WITH A DATA READ IN TO AVOID RECOMPILATION
C EACH TIME.
C
700 FORMAT (15M LENGTH,RADII 9F11.6)
701 FORMAT (1X,6E14.6)
702 FORMAT (1X,2E16.8)
779 FORMAT (1X,E16.8)
723 FORMAT (12M XLEN,RADII, 6E16.8)
724 FORMAT (1X,12F9.6)
C
C MCR IS THE NUMBER OF MATERIALS
C IZM IS THE NUMBER OF ZONES.
C JMP AND JP ARE THE FLUID SELECTIONS FOR TRMP
C BURNX IS THE MAXIMUM AVERAGE BURNUP PERMITTED
C DTOT IS THE MAXIMUM FUEL TEMPERATURE RISE ABOVE THE HEATPIPE PER-
C MISSIBLE. THIS IS SET OVERLY HIGH HERE TO ELIMINATE THIS AS A
C DESIGN CONSTRAINT FOR THIS PARTICULAR PROBLEM.
C SN IS A SWELLING ALLOWANCE PARAMETER USED IN HREAC.
C HRLIF IS THE DESIRED LIFETIME IN HOURS.
C TSTRES IS THE THERMAL STRESS LIMIT IS PSI.
C TSUP IS THE AVERAGE CORE TEMPERATURE.
C TSHELL IS THE DESIRED SHELL TEMPERATURE. INSULATION THICKNESSES
C AND COOLANT FLOWRATES TO ACHIEVE THIS MUST BE CALCULATED ELSEWHERE
C G IS THE THICKNESS TO OUTER RADIUS RATIO OF THE HEATPIPES.
C FUELON IS THE FRACTION OF THEORETICAL DENSITY IN THE FUEL.
C DELA IS A HEATPIPE GROOVE SPACING PARAMETER.
C
KZAP=3
MCR=18
IZM=8
DO 100 I=1,18
DO 100 J=1,8
100 ADEN(I,J)=0.
JMP=JP=2
BURNX=.02
DTOT=500.
SN=3.
TEMRIS=0.
RFLCTR=.001
RHOR=.002
DR=.01

```

HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

HRLIF=20000.
TSTRES=10000.
TSUP=
TSHELL=1350.
G=.1
PI=3.1415927
FUELON=.97
TBAR=TSUP-TEMRIS/2.
DELA=.25
JP=2
C
C THESE ARE TEMPERATURE DEPENDENT PROPERTIES.
C ABUN IS THE AVERAGE VALUE OF THE COEFFICIENT OF THERMAL EXPANSION
C FOR UN FROM ROOM TEMPERATURE.
C AUN IS THE INSTANTANEOUS VALUE OF THE COEFFICIENT OF EXPANSION.
C RHOON IS THE DENSITY OF UN.
C CONDON IS THE THERMAL CONDUCTIVITY OF UN.
C CPUN IS THE SPECIFIC HEAT OF UN.
C EUN IS YOUNGS MODULUS.
C GUNUN IS POISSONS RATIO.
C PSY IS A THERMAL STRESS PARAMETER.
C ABW IS THE AVERAGE COEFFICIENT OF EXPANSION FOR TUNGSTEN.
C
ABUN=(6.2477+.5.991E-5*TSUP-7.049E-7*TSUP**2)*1.E-6
AUN=(6.2477+.6.702E-5*TSUP-23.929E-7*TSUP**2)*1.E-6
RHOON=14.32*FUELON/(1.+ABUN*(TSUP-293.))**3
CONDON=-20.525/TSUP+.23423+2.2196E-5*TSUP
CPUN=(55.73+4.979E-5*TSUP-8.706E-9*TSUP**2)/290.6
EUN=31.E6
GUNUN=.1
PSY=AUN/EUN/(8.+CONDON*(1.-GUNUN))
AW=(4.406+.5437E-5*TBAR)*1.E-6
ABW=(4.406+.2718E-5*TSUP)*1.E-6
ABOT=ABIT=6.7E-6
ABOM=ABIM=5.E-6
RHOT=16.6/(1.+(ABOT*(TSHELL-293.))**3)
RHOM=10.2/(1.+(ABOM*(TSHELL-293.))**3)
RHON=19.3/(1.+(4.246+2.718E-4*TBAR)*(TBAR-293.)*1.E-6)**3
CPW=.134
CONDN=1.76*EXP(-.519E-3*TBAR)
ALI=3.928E-5
C
C MOST OF THESE ARE TRAMP CALLS FOR DATA.
C
CALL RHOL(JMP,TSUP,RHAL)

```

HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

CALL RHOG(JMP,TSUP,RHAG)
CALL HYAP(JMP,TSUP,MYOP)
MYOP=MYOP+1.E7
CALL YISL(JMP,TSUP,YISCL)
CALL TCNL(JMP,TSUP,CONDL)
CALL CSPL(JMP,TSUP,CPL)
CALL TENS(JMP,TSUP,STNL)
TDUCT=1450.
CALL PSAT(3,TDUCT,PSOT)
PSOT=PSOT+14.5+1.2
CALL RHOL(1,TSUP,RML16)
CALL RHOG(3,TDUCT,RHOG1)
CALL SONY(JP,TBAR,SANY1)
CALL YISG(JP,TBAR,YISG1)
CALL RHOL(1,TSUP,RML16)
CALL RHOG(3,TSHELL,RHOK1)
CALL RHOL(3,TSHELL,RHOKL)
CALL PSAT(2,TSUP,PNA)
PNA=14.5+PNA
CALL PSAT(3,TDUCT,PK)
PK=PK+14.5
TDOCT=TDUCT+100.
CALL PSAT(3,TDOCT,PKT)
PKT=PKT+14.5
WRITE OUTPUT TAPE 3,360,PNA,PK,PKT
360 FORMAT (5H PNA= E16.8,4H PK= E16.8,5H PKT= E16.8)
C
C THIS SEQUENCE IS FOR SILVER PROPERTIES WHICH ARE NOT INCLUDED IN
C THE TRANP CODE. THIS IS OF INTEREST FOR VERY HIGH TEMPERATURE HEAT
C PIPE OPERATION (ABOVE 1600 K).
C
C
C PSATAG=-2.0260765154-7.4304530382E-03=TSUP+1.5252012651E-05=TSUP**
C 12-0.7510151046E-09=TSUP**3+1.6222011742E-12=TSUP**4
C RHOGAG=7.7980228139E-02-1.5514224745E-04=TSUP+1.1595841244E-07=TSU
C IP=2-3.8662902761E-11=TSUP**3+4.8632809878E-15=TSUP**4
C RHOLAG=1.0400669828E01-9.0706699130E-04=TSUP
C HYAPAG=2.5840476190E10-9.2857142859E+05=TSUP
C STNLAG=1.0850000000E03-1.4000000000E-01=TSUP
C YISLAG=1.0554969126E-01-8.8925895332E-05=TSUP+3.0011395458E-08=TSU
C IP=2-3.5709976649E-12=TSUP**3
C YISGAG=7.7089285712E-04+3.6607142858E-07=TSUP
HPSTRS=EXP(2.50259*(5.89-.057+1.8E-3*TSUP+16.63+.4343*L0GF(HRL1F

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HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

11111
C
C
C HPC IS THE RATIO OF THE HEATPIPE LENGTH TO THE EVAPORATOR LENGTH.
C USING THIS AND THE FLUX LIMIT INTO THE HEATPIPE, PHIS1, ONE CAN
C CONTROL THE AVERAGE HEAT TRANSFER COEFFICIENT IN THE BOILER.
C HP2 DETERMINES WHETHER ONE OR TWO HEATPIPES ARE USED PER ELEMENT.
C A VALUE OF ONE WILL GIVE A SINGLE ENDED REACTOR-BOILER AND A VALUE
C OF 2 WILL GIVE A DOUBLE ENDED SYSTEM.
C RAT IS THE FRACTION OF THE CONTROL TUBES FILLED WITH LI6. WE HAVE
C GENERALLY DESIGNED THE REACTOR WITH THESE HALF FILLED.
C ENRICH IS THE RATIO OF U235/U238 IN THE THREE ACTIVE CORE ZONES.
C U235 IS ADDED TO THESE FOR RADIAL POWER SHAPING.
C SAF IS THE RATIO OF DESIGN POWER LOAD IN THE HEATPIPES TO THAT
C PREDICTED BY CORE AVERAGE POWER. OUR BEST GUESS IS THAT ABOUT 1.7
C IS A GOOD BUGGER FACTOR FOR MINIMUM DESIGN MARGINE.
C THIS ASSUMES A FACTOR OF 1.1 FOR POWER SURGES, 1.1 FOR RADIAL
C PEAK TO AVERAGE POWER, 1.17 FOR LOAD TO BE ASSUMED BY ADJACENT
C UNITS ON FAILURE OF A SINGLE ADJACENT HEATPIPE, AND 1.2 FOR TRANS-
C PORT PROPERTY DATA SCATTER AND HEATPIPE PERFORMANCE.
C GCI IS THE RATIO OF VAPOR TO WETTED RADIUS IN THE HEATPIPE. 0.75
C IS CLOSE TO THE OPTIMUM FOR THE GROOVE-MESH HEATPIPES.
C ELPDMX IS THE LENGTH TO DIAMETER RATIO OF THE CORE.
C PHIS1 IS THE LIMITING SURFACE HEAT FLUX INTO THE HEATPIPES IN THE
C CORE. THIS IS A LIMIT TO PREVENT FILM BOILING AND BURNOUT.
C RMESH IS THE HEATPIPE MESH SPACING FOR THE DESIGN. WE THINK THIS
C CAN DROP TO 0.02 BUT WE HAVE BEEN USING A LARGER VALUE TO CONTROL
C HEATPIPE SIZE AND CONSIDERING THE DIFFERENCE BETWEEN THIS AND .02
C AS A SAFETY MARGINE FOR PERFORMANCE.
C XKEFFD IS THE DESIRED VALUE OF THE NEUTRON MULTIPLICATION FACTOR.
C IN GENERAL THIS WILL NOT BE UNITY SINCE END EFFECTS MUST BE CON-
C SIDERED. THESE ARE GENERALLY ON THE ORDER OF A PERCENT OR SO FOR
C THIS TYPE OF REACTOR.
C BU IS THE AVERAGE CORE BURNUP.
C B IS A POROSITY PARAMETER USED IN THE DESIGN SUBROUTINE.
C
C PHIS1=.000075
C SAF=2.
C QMTH=.6
C
C TO CALCULATE A SOLID CORE SET CCF=1.E-6. TO REMOVE THE INTERNAL
C CONTROL ZONE 2 SET CCF2=1.E-6. A MORE EFFICIENT PROCEDURE WOULD
C BE TO REMOVE THESE ZONES FROM THE DESCRIPTION FOR THIS CASE. LET-
C TING THE ACTIVE CORE START AT ZONE 1.
C

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HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

CCF=.04
CCF2=CCF+.1
HP2=.2.
HPC=.3.
MODL=1
RAT=.5
ENRICH(1)=ENRICH(2)=ENRICH(3)=ENRCH=.935
SAF=1.7
GC1=.75
ELPMX=1.4
TSTRES=20000.
PHIS1=.00015
RMESH=.06
XKEFFD=1.005
CCFO=CCF2
NCAL=2
RFLCTR=2.5
BU=.01
B=.4
MIST=0
C
C THIS SECTION DOWN TO STATEMENT 1 INITIALIZES THE PROBLEM FOR THE
C NEWTON RAPHSON ITERATION SCHEME. THE LOOP FOR THIS EXTENDS DOWN
C TO JUST BELOW STATEMENT 220. IF THE CORE IS BURNUP LIMITED (I.E.
C A LARGE CORE) THE REACTOR CODE SHOULD BE CALLED OUTSIDE OF THIS
C LOOP WHICH WOULD ITERATE ON ENRICHMENT ONLY. THUS ONLY THE FUEL
C ATOM DENSITIES WOULD NEED TO BE CALCULATED INSIDE THE LOOP. IF THE
C CORE WILL BE CRITICALITY LIMITED, AN ITERATION ON BURNUP, BU, IS
C USUALLY THE MOST CONVENIENT. WE HAVE HOWEVER USED MANY OTHER VAR-
C IABLES SUCH AS RADIUS, LENGTH, PRESSURE DROP (I.E. POROSITY)
C AS INDEPENDENT VARIABLES. EACH OF THESE REQUIRES A FEW OBVIOUS
C CHANGES IN THE DESIGN SUBROUTINE.
C
11 KIT=0
KIT1=0
KIT2=0
KIT3=0
KMAX=25
KMAX1=25
KMAX2=25
KMAX3=25
FD=0.
FD1=1.
FD2=1.
FD3=1.005

```

HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

CRIT=1.E-6
CRIT1=1.E-7
CRIT2=1.E-7
CRIT3=1.E-3
VL1=1.E-6
VL11=1.E-6
VL12=1.E-6
VL13=1.E-6
VL2=.5
VL21=VL22=.9999
VL23=.05
DYNAM=.025
DYNAM1=.15
DYNAM2=.3
DYNAM3=.15=BU
V=G
V1=.4
V2=.65
V3=BU
DV1=V=.1
DV11=.01=V1
DV12=.01=V2
DV13=.01=V3
1 CONTINUE
CCF2=CCFO
C
C THIS STATEMENT CALLS THE REACTOR DESIGN SUBROUTINE.
C
CALL WREAC
C
C SET ALL THE REACTOR DIMENSIONS TO THOSE VALUES INDICATED BY THE
C DESIGN SUBROUTINE EXCEPT FOR THE INTERNAL ACTIVE CORE RADIUS WHICH
C FOR THIS CASE WILL BE DETERMINED BY LOADING REQUIREMENTS FOR
C POWER FLATTENING.
C RADIUS IS THE ARRAY OF REACTOR RADII.
C
RFLCTR=2.5
RADII(1)=ROCOR
RADII(2)=RICOR
RADII(5)=R2COR
RADII(6)=R3COR
RADII(7)=RADII(6)+THICKS
RADII(8)=RADII(7)+RFLCTR+.1
XLEN=CORL
C

```

HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

C NOTE THAT THE HEATPIPE REACTOR DESIGN ROUTINE WAS NOT SET UP TO
 C INCLUDE THE 5 MM THICK X- TRANSVERSE SPACERS IN THE CORE
 C SO THE CLAD FRACTIONS MUST BE CHANGED TO INCLUDE THESE.
 C THE HEIGHT CALCULATIONS FROM THE DESIGN CALCULATION ARE NOT REALLY
 C GOOD. THEY DO NOT INCLUDE THE THERMAL INSULATOR EITHER.

XLEN=XLEN+1.
 FFO=FF
 FSO=FS
 FF=FF+(XLEN-1.)/XLEN
 FS=FS+(XLEN-1.)/XLEN

FCM=.9068997*.19**2

FCRE=(FCL-FCM)/(XLEN-1.)/XLEN

C THIS GROUP OF EQUATIONS WAS AN ATTEMPT TO USE A SPECTRUM DEPENDENT
 C POISON, AS A FILM ON THE HEATPIPES AS A CONTROL AGENT FOR
 C SAFETY. THE FRACTION CALCULATED IN ADEN(0.5) ETC. USES THIS.

FCL=FCL+FSO+FFO-FF-FS

C IF THIS IS THE FIRST CALCULATION ASSUME A PARABOLIC FLUX
 C PROFILE AND PROCEED TO DETERMINE APPROXIMATE LOADING ZONES FOR
 C OPTIMUM RADIAL POWER FLATTENING. THERE IS LITTLE VALUE TO AXIAL
 C POWER FLATTENING FOR HEAT PIPE REACTORS.

IF (KIT1).200
 CO=.4
 C1=(1.-CO)/(RAD1(5)-RAD1(2))**2
 CA1=1.-C1*RAD1(2)**2
 CA2=2.*C1*RAD1(2)
 CA3=-C1
 GO TO 205

C IF THIS IS NOT THE FIRST FIT A SECOND ORDER POLYNOMIAL THROUGH
 C A FICTITIOUS FLUX PROFILE OBTAINED FROM THE PREVIOUS CALCULATION.
 C THIS FICTITIOUS FLUX IS REALLY ONLY THE POWER PROFILE FROM THE
 C LAST CALCULATION MATHEMATICALLY MANIPULATED TO GIVE AN INDICATION
 C OF THE DEGREE OF ENRICHMENT REQUIRED FOR THE VARIOUS ZONES. THIS
 C FICTION IS REQUIRED SINCE THE CHANGES MADE IN THE REACTOR FOR THIS
 C TRIAL MAY HAVE RESULTED IN A DIFFERENT NUMBER OF FUEL ELEMENT
 C ROWS.

200 SR=SR2+SR3+SR4+SP+SPR+SPR2+0.
 P31=P(3,5)-.5*(P(3,4)+P(3,5))

HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

P32=P(4,1)-.5*(P(4,1)+P(4,2))

DO 236 J=1,5

236 P(4,J)=P(4,J)+P31/P32

P41=P(4,5)-.5*(P(4,4)+P(4,5))

P42=P(5,1)-.5*(P(5,1)+P(5,2))

DO 237 J=1,5

237 P(5,J)=P(5,J)+P41/P42

DO 238 I=3,5

DO 238 J=1,5

238 R(1,J)=RAD1(2)+(R(1,J)-RAD2)*(RAD1(5)-RAD1(2))/(RAD5-RAD2)

DO 300 I=3,5

DO 300 J=1,5

SR=SR+R(1,J)

SR2=SR2+R(1,J)**2

SR3=SR3+R(1,J)**3

SR4=SR4+R(1,J)**4

SP=SP+P(1,J)

SPR=SPR+P(1,J)*R(1,J)

300 SPR2=SPR2+P(1,J)*R(1,J)**2

WRITE OUTPUT TAPE 3,330,((R(1,J),P(1,J),J=1,5),I=3,5)

330 FORMAT (9H R(1,J)-P(1,J) 10E11,4)

A0=.15.*(SR2+SR4-SR3**2)-SR*(SR+SR4-SR2+SR3)+SR2*(SR+SR3-SR2**2)

A1=SP*(SR2+SR4-SR3**2)-SR*(SPR+SR4-SPR2+SR3)+SR2*(SPR+SR3-SPR2+SR2

1)

A2=.15.*(SPR+SR4-SR3+SPR2)-SP*(SR+SR4-SR2+SR3)+SR2*(SR+SPR2-SPR+SR2

1)

A3=.15.*(SR2+SPR2-SR3+SPR1)-SR*(SR+SPR2-SPR+SR2)+SP*(SR+SR3-SR2**2)

CA1=A1/A0

CA2=A2/A0

CA3=A3/A0

DO 313 I=3,5

DO 313 J=1,5

313 P(1,J)=CA1+CA2*R(1,J)+CA3*R(1,J)**2

WRITE OUTPUT TAPE 3,330,((R(1,J),P(1,J),J=1,5),I=3,5)

C THIS SECTION THROUGH STATEMENT 312 WILL DETERMINE THE OPTIMUM
 C LOADING PATTERN FOR A 5 ZONE ACTIVE CORE. IT CAN EASILY BE EXTEND-
 C ED TO MORE ZONES BUT THERE DOES NOT SEEM TO BE MUCH ADVANTAGE TO
 C THIS FOR SMALL CORES WHICH HAVE A LIMITED NUMBER OF FUEL ELEMENT
 C ROWS.

205 KC=1

RA(5)=RAD1(2)

RB(5)=RAD1(5)

RC=(RAD1(5)-RAD1(2))/(FLOATF(NRS)-FLOATF(NRA))

HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

RA(5)=RB(4)+RB(5)-RC
RA(4)=RB(3)+RA(5)-RC
302 ERT=0.
DO 301 I=3,5
  PBAR(I)=(CA1*(RB(I)-2*RA(I)-2)/2.+CA2*(RB(I)-3*RA(I)-5)/3.+
  (CA3*(RB(I)-4*RA(I)-4)/4.)/(RB(I)-2*RA(I)-2)/2.)
  BA(I)=PBAR(3)/PBAR(I)
  BB=BA(I)**2
  BC=-2.*BA(I)*PBAR(I)
  ERT=ERT+(BB*CA1**2+BC*CA1+PBAR(I)-2)*(RB(I)-2*RA(I)-2)/2.+12.*
  (BB*CA1+CA2*BC+CA2)*(RB(I)-3*RA(I)-5)/3.+12.*BB*CA1+CA3*BB+CA2**2
  *(BC+CA3)*(RB(I)-4*RA(I)-4)/4.+2.*BB*CA2+CA3*(RB(I)-5*RA(I)-5)/
  35.+BB*CA3**2*(RB(I)-6*RA(I)-6)/6.)
301 CONTINUE
DO 311 I=3,5
DO 311 J=1,5
  R(I,J)=RA(I)+(FLOATF(J)-.5)*2*(RB(I)-RA(I))
  P(I,J)=CA1+CA2*R(I,J)+CA3*R(I,J)**2
311 PBA(I,J)=P(I,J)*BA(I)
WRITE OUTPUT TAPE 3,330,(R(I,J),PBA(I,J),J=1,5),I=3,5)
GO TO (303,304,306,307)KC
303 RADII(3)=RB(3)
RADII(4)=RB(4)
KC=2
RB(3)=RB(3)-RC
RA(4)=RB(3)
ERTA=ERT
BA4=BA(4)
BA5=BA(5)
GO TO 302
304 IF (ERT-ERTA),305,305
ERTA=ERT
RADII(3)=RB(3)
RB(3)=RA(4)+RB(3)-RC
BA4=BA(4)
BA5=BA(5)
GO TO 302
305 RA(5)=RA(5)-RC
RB(4)=RA(5)
RA(4)=RB(3)+RA(5)-RC
KC=3
GO TO 302
306 ERTB=ERT
RD3=RB(3)
RD4=RB(4)

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HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

BB4=BA(4)
BB5=BA(5)
RB(3)=RA(4)+RB(3)-RC
KC=4
GO TO 302
307 IF (ERT-ERTB),308,308
ERTB=ERT
RD3=RB(3)
RD4=RB(4)
BB4=BA(4)
BB5=BA(5)
RB(3)=RA(4)+RB(3)-RC
GO TO 302
308 IF (ERTB-ERTA),309,305
RADII(3)=RD3
RADII(4)=RD4
BD4=BB4
BD5=BB5
GO TO 310
309 BD4=BA4
BD5=BA5
310 DO 312 I=3,5
  DRA(I)=(RADII(I)-RADII(I-1))/5.
  DO 312 J=1,5
    R(I,J)=RADII(I-1)+(FLOATF(J)-.5)*2*(RADII(I)-RADII(I-1))
312 CONTINUE
C
C ONCE THE ZONE SPACINGS ARE KNOWN, TRANSLATE THE VOLUME FRACTIONS
C AND MATERIAL DENSITIES INTO THE ATOM DENSITY ARRAY ADEN.
C
C THWK IS THE THICKNESS IN CM OF A THERMAL INSULATOR SPACED 0.2 CM
C INSIDE THE PRESSURE VESSEL.
C THWK IS THE THICKNESS OF THE CORE CONTAINMENT MEMBRANE AND THE
C INSULATOR CLADDING COMBINED. IT IS TREATED AS A SINGLE LAYER SUR-
C ROUNDING THE CORE.
C ADEN IS THE ATOM DENSITY ARRAY. THE FIRST SUBSCRIPT DENOTES THE
C MATERIAL AND THE SECOND THE ZONE. THESE ARE IN 10**24 ATOM/CC UNITS.
C EFFK IS THE NEUTRON MULTIPLICATION FACTOR CALCULATED BY NDTP.
C
THWK=.4
THWK=.5
FR6=RADII(6)**2-RADII(5)**2
FRA=((RADII(5)+THWK)**2-RADII(5)**2)/FR6
FRB=((RADII(6)-.2)**2-(RADII(6)-THWK-.2)**2)/FR6

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NRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

FRC=1.-FRA-FRB
ADEN(4,1)=.015407*RHOKG
ADEN(1,2)=.086801*.5069*RHKL6=.5
ADEN(3,2)=.026202*.0931*RHAL
ADEN(9,2)=.0032764*.9*RHOM
ADEN(8,2)=ADEN(9,2)/3.
ADEN(3,3)=ADEN(3,4)=ADEN(3,5)=.026202*RHAL*(FS+11./36.*FC)
ADEN(8,3)=ADEN(8,4)=ADEN(8,5)=.0032764*RHOM*(1.25*(FCL-FCRE)+FCRE)
ADEN(9,3)=ADEN(9,4)=ADEN(9,5)=.0032764*RHOM*.75*(FCL-FCRE)
ADEN(5,3)=ADEN(5,4)=ADEN(5,5)=.0029897*RHOUN=FF
ADEN(4,6)=.015407*RHOKL=FRC
ADEN(9,6)=.0032764*RHOM=.75*FRA
ADEN(8,6)=ADEN(9,6)/3.
ADEN(16,6)=.0028613*9.68*FRB
ADEN(2,6)=ADEN(16,6)*2.
ADEN(7,7)=.0033291*RHOT
ADEN(6,8)=.0062783*RHOM
ADEN(10,3)=ADEN(9,3)+Y1
ADEN(11,3)=ADEN(5,3)+ENRICH(1)=(1.-Y1)
ADEN(15,3)=ADEN(5,3)+(1.-Y1)*(1.-ENRICH(1))
ADEN(10,4)=ADEN(9,4)+Y2
ADEN(11,4)=ADEN(5,4)+ENRICH(2)=(1.-Y2)
ADEN(15,4)=ADEN(5,4)+(1.-ENRICH(2))*(1.-Y2)
ADEN(10,5)=ADEN(9,5)+.995
ADEN(11,5)=ADEN(9,5)+.005*ENRICH(3)
ADEN(15,5)=ADEN(9,5)+.005*(1.-ENRICH(3))
C
C CALL THE NEUTRONIC SUBROUTINE.
C
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(1),1=1,8)
WRITE OUTPUT TAPE 3,701,(ADEN(KJ,JK),JK=1,8),KJ=1,18)
CALL MDTF(EFFK,XLEN,RADII,ADEN,MCR,12N,MIST)
EFFKA=EFFK
WRITE OUTPUT TAPE 3,779,EFFK
C
C CALCULATE THE POWER PROFILE. CALCULATE AVERAGE ZONE POWERS.
C
CALL POWM(POW)
DO 325 I=3,5
PO=0.
DO 324 J=1,5
P(I,J)=POW(5*(I-1)+J)
324 PO=P(I,J)+.2*P(I,J)+PRA(I)+PO
325 PBAR(I)=PO/(RADII(1)+.2*RADII(1-1)+.2)
WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)

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NRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

WRITE OUTPUT TAPE 3,366,(PBAR(1),1=3,5)
366 FORMAT (1X,E16.8)
Y3=BU
FN3=EFFK
YL1=1.001*YL1
YL11=YL11+1.001
YL12=YL12+1.001
YL13=YL13+1.001
YL2=1.001*YL2
YL21=YL22+YL21=.999999
YL23=YL23+1.001
CALL NEWRAP(KIT3,KMAX3,FN3,FD3,CRIT3,Y3,YL13,YL23,DY13,DYMAX3,YA3,
1DLTA3)
BU=Y3
FN1=PBAR(3)/PBAR(5)
FN2=PBAR(4)/PBAR(5)
C
C CALL NEWRAP TO PREDICT THE NEXT TRIAL ENRICHMENTS TO OBTAIN A
C BETTER POWER PROFILE.
C
C
C THIS PROBLEM IS SET UP TO USE ALL U235 IN THE OUTER ZONE AND AS
C MUCH U235 AND ORALLOY AS IS REQUIRED IN THE INNER ZONES TO YIELD
C A POWER FLATTENED CORE. Y1 AND Y2 COULD BE USED WITH ZONES 4 AND 5
C FOR A CORE THAT IS TO HAVE A FIXED ENRICHMENT OF SAY ORALLOY IN
C THE ZONE 3 AND AS MUCH U235 IN THE OUTER ZONES AS REQUIRED TO
C YIELD POWER FLATTENING. THE DEPENDENT VARIABLES FN1 AND FN2 CORRE-
C SPONDING TO THESE COULD BE THE RATIO OF PEAK POWERS IN EACH ZONE
C INSTEAD OF AVERAGE POWER ETC.
C
CALL NEWRAP(KIT1,KMAX1,FN1,FD1,CRIT1,Y1,YL11,YL21,DY11,DYMAX1,YA1,
1DLTA1)
CALL NEWRAP(KIT2,KMAX2,FN2,FD2,CRIT2,Y2,YL12,YL22,DY12,DYMAX2,YA2,
1DLTA2)
KTN1=5
KTN2=3
KTN3=3
RFLCTO=RFLCTR
C
C IF WATER SAFETY IS DESIRED GO DOWN TO THE WORST CASE OF WATER
C IMMERSION AFTER SHUTTING THE REACTOR DOWN TO ROOM TEMPERATURE.
C HERE THE WORST CASE IS KNOWN FROM PRIOR ANALYSES BUT COULD HAVE
C BEEN FOUND DYNAMICALLY BY A SEARCH FOR THE MAXIMUM EFFK. SEE THE
C SEQUENCE BETWEEN STATEMENTS 144 AND 145.
C

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HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

GO TO 227
220 CALL NEWRAP(KIT,KMAX,FN,FD,CRIT,Y,V,VL1,VL2,DY1,DYMAX,YA,DLTA)
G=Y
C
C Y IS USED AS THE INDEPENDENT VARIABLE TO PROVIDE THE SPECIFIED
C MARGINE OF WATER SAFETY. THIS MAY BE THE THICKNESS OF A BLOWOFF
C REFLECTOR, THE THICKNESS OF A FILTER MATERIAL, THE THICKNESS OF A
C NEUTRON POISON FILM ON THE CLAD AS IN THIS CASE OR SOME FRACTION
C OF SOME SPECTRUM DEPENDENT POISON. EACH SUCH OPTION WILL REQUIRE
C SOME SLIGHT MODIFICATION OF THE CODE.
C
C B=B/1.1
C
C IF THE CORE IS NOT PROPERLY CRITICAL GO BACK FOR ANOTHER DESIGN
C
220 IF (KIT9-KMAX9)1.,.
C
C AT THIS POINT THE BASE CASE REACTOR (HOT-START-OF-LIFE) HAS BEEN
C DESIGNED. THIS SEQUENCE WILL CALL ADDITIONAL INFORMATION FROM THE
C NEUTRONIC SUBROUTINES.
C
CALL FINPR
CALL PCI
CALL SB47
IF (KZAP-2)227,227.
KTN1=1
KTN2=1
KTN3=4
RFLCTR=2.5
RFLCTO=RFLCTR
C
C TAKE THE REFLECTOR OFF AND ADD IT IN INCREMENTS.
C
DO 160 JLO=1,4
RFLCTR=FLOATF(JLO-1)*1.5
RADII(8)=RADII(7)+RFLCTR*.1
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(1),1=1.0)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,KJ),JK=1,0),KJ=1,10)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZN,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
CALL POWN(POW)
DO 345 I=3,5
DO 345 J=1,5

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HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

345 P(I,J)=POW(5+((I-1)*J)
WRITE OUTPUT TAPE 3,950,((R(I,J),P(I,J),J=1,5),I=3,5)
CALL FINPR
CALL PCI
CALL SB47
160 CONTINUE
RFLCTR=RFLCTO
RADII(8)=RADII(7)+RFLCTR*.1
C
C DETERMINE THE EFFECT OF EMPTY AND FULL INTERNAL CONTROL CIRCUITS.
C HERE THE BASE CASE HAS USED HALF FILLED CIRCUITS.
C
DO 170 KR=1,2
RAT=FLOATF(KR-1)
ADEN(1,2)=.086787*RHL16*.5069 *RAT
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(1),1=1.0)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,KJ),JK=1,0),KJ=1,10)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZN,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
CALL POWN(POW)
DO 350 I=3,5
DO 350 J=1,5
350 P(I,J)=POW(5+((I-1)*J)
WRITE OUTPUT TAPE 3,950,((R(I,J),P(I,J),J=1,5),I=3,5)
CALL FINPR
CALL PCI
CALL SB47
170 CONTINUE
RAT=.5
ADEN(1,2)=.086787*RHL16*.5069 *RAT
C
C RECORD THE BASE CASE ATOM DENSITIES AND DIMENSIONS (I.E. HOT-START
C OF LIFE CONDITIONS).
C
227 FFO=FF
FSO=FS
FSCO=FSC
FCO=FC
FCLO=FCL
RAD1=RADII(1)
RAD2=RADII(2)
RAD3=RADII(3)
RAD4=RADII(4)

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HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

RAD5=RAD1(5)
RAD6=RAD1(6)
RAD7=RAD1(7)
RAD8=RAD1(8)
XLEN=XLEN
R0C0R=R0C0R
R1C0R=R1C0R
R2C0R=R2C0R
R3C0R=R3C0R
THICK=THICKS
RH0W=RH0W
RH0TQ=RH0T
RH0M=RH0M
RHL16=RHL16
RH0KL=RH0KL
RH0KG=RH0KG
RHAL=RHAL
RH0UN=RH0UN
FF1=.99
FF2=FF1**2
DO 120 I=1,10
DO 120 J=1,8
120 ADN(I,J)=ADN(I,J)
PI=.3.1415926
TBAR=TSUP
IF (KZAP-2)220,220.
C
C SHUT THE REACTOR DOWN TO ROOM TEMPERATURE IN INCREMENTS. THIS IS A
C ZERO POWER ISOTHERMAL CALCULATION, AND IT SHOULD BE NOTED THAT
C THIS IS FAR FROM THE FULL STORY ON TEMPERATURE COEFFICIENTS.
C
DO 144 KT=KTN1
T1=TSUP-900.=FLDATT(KT-1)
CALL RH0L(JMP,T1,RHAL)
CALL RH0L(1,T1,RHL16)
CALL RH0L(5,T1,RH0KL)
AB0N=(4.406+.2718E-3*TBAR)*1.E-6
AB1N=(4.406+.2718E-3*T1)*1.E-6
C
C AB0N IS THE AVERAGE EXPANSION COEFFICIENT FOR UN FROM ROOM TEMP-
C ERATURE TO TSUP.
C AB1U IS THE AVERAGE EXPANSION COEFFICIENT FROM ROOM TEMPERATURE TO
C T1 ETC.
C
AB0U=(6.2477*3.391E-3*TSUP-7.843E-7*TSUP**2)*1.E-6

```

HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

AB1U=(6.2477*3.391E-3*T1-7.843E-7*T1**2)*1.E-6
RAD1(1)=RAD1(1)+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
RAD1(2)=RAD2(1)+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
RAD1(3)=RAD3(1)+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
RAD1(4)=RAD4(1)+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
RAD1(5)=RAD5(1)+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
RAD1(6)=RAD6(1)+AB1T*(T1-295.)/((1.+AB0T*(TSHELL-295.))
RAD1(7)=RAD7(1)+AB1T*(T1-295.)/((1.+AB0T*(TSHELL-295.))
RAD1(8)=RAD8(1)+AB1N*(T1-295.)/((1.+AB0N*(TSHELL-295.))
XLEN=XLEN+((1.+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
R2C0R=R2C0R+((1.+AB1N*(T1-295.)/((1.+AB0N*(TBAR-295.))
R3C0R=R3C0R+((1.+AB1T*(T1-295.))
1/(1.+AB0
1T*(TSHELL-295.))
FF=FF0+((1.+AB1U*(T1-295.)/((1.+AB0U*(TSUP-295.))+(1.+AB0N*(TSUP-2
195.)/((1.+AB1N*(T1-295.)))**3
FS=FF0+FS0-FF
RH0N=RH0N+((1.+AB0N*(TBAR-295.)/((1.+AB1N*(T1-295.)))**3
RH0UN=RH0UN+((1.+AB0U*(TSHELL-295.)/((1.+AB1U*(T1-295.)))**3
RH0M=RH0M+((1.+AB0N*(TSHELL-295.)/((1.+AB1N*(T1-295.)))**3
RH0T=RH0T+((1.+AB0T*(TSHELL-295.)/((1.+AB1T*(T1-295.)))**3
FR6=RAD1(6)**2-RAD1(5)**2
THUK=THUK+RAD1(5)/RAD5
TH0K=TH0K+RAD1(5)/RAD5
FRA=((RAD1(5)+TH0K)**2-RAD1(5)**2)/FR6
FRB=((RAD1(6)**2-RAD1(5)**2)-THUK-.21)**2/FR6
FRC=1.-FRA-FRB
ADN(4,6)=.015407*RH0KL*FRC
ADN(9,6)=.0032764*RH0N*.75=FRA
ADN(8,6)=ADN(9,6)/3.
ADN(16,6)=ADN(16,6)+RH0N/RH0N
ADN(2,6)=ADN(16,6)*2.
ADN(4,1)=.015407*RH0KG
ADN(1,2)=.006801+.5069*RHL16*.5
ADN(3,2)=.026202+.0931*RHAL
ADN(9,2)=.0032764*.3=RH0N
ADN(8,2)=ADN(9,2)/3.
ADN(3,3)=ADN(3,4)+ADN(3,5)=.026202*RHAL*(FS+11./36.*FC)
ADN(9,3)=ADN(9,4)+ADN(9,5)=.0032764*RH0N*.75*(FCL-FCRE)
ADN(8,3)=ADN(8,4)+ADN(8,5)=.0032764*RH0N*.25*(FCL-FCRE)+FCRE)
ADN(5,3)=ADN(5,4)+ADN(5,5)=.0023897*RH0UN*FF
DO 130 I=3,5
ADN(10,1)+ADN(10,1)+RH0UN*FF/(RH0UN*FF0)
ADN(11,1)+ADN(11,1)+RH0UN*FF/(RH0UN*FF0)
130 ADN(13,1)+ADN(13,1)+RH0UN*FF/(RH0UN*FF0)
ADN(7,7)=.003291*RH0T

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WRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

ADEN(6,8)=.0062785*RHOM
IF (KTN1-4) . . 144
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(1),1,1,0)
WRITE OUTPUT TAPE 3,701,((ADEN(K,J),JK=1,8),KJ=1,18)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
144 CONTINUE
RFLCTR=15.
C
C EXAMINE THE WATER IMMERSION POSSIBILITIES. THESE ARE A SIMPLE
C DUNKING WHERE THE REFLECTOR IS REMOVED AND REPLACED WITH A SEMI
C INFINITE WATER REFLECTOR. TWO CASES OF WATER ENTRY INTO THE CORE,
C AND REMOVAL OF A WATER FILLED CORE FROM THE WATER. USUALLY
C THE CASE OF A SUBMERGED WATER FILLED CORE IS THE MOST HAZARDOUS
C CONDITION.
C
MIST=1
RADII(8)=RADII(7)+RFLCTR+.1
DO 145 KM=KTN2,KTN3
GO TO (440,430,420,410)KM
410 RFLCTR=0.
RADII(8)=RADII(7)+RFLCTR+.1
420 ADEN(2,2)=.6+.0333
ADEN(1,2)=0.
ADEN(17,2)=ADEN(2,2)*2.
ADEN(3,2)=ADEN(3,3)+ADEN(3,4)+ADEN(3,5)=0.
ADEN(2,3)=ADEN(2,4)+ADEN(2,5)+(FS+FC)=.0333
ADEN(17,3)=ADEN(17,4)+ADEN(17,5)+
ADEN(2,3)*2.
430 ADEN(4,6)=ADEN(4,1)=0.
ADEN(2,1)=.0333
ADEN(17,1)=ADEN(2,1)*2.
ADEN(2,6)=FRC=.0333
ADEN(17,6)=ADEN(2,6)*2.
440 ADEN(6,8)=0.
ADEN(2,8)=.0333
ADEN(17,8)=ADEN(2,8)*2.
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(1),1,1,0)
WRITE OUTPUT TAPE 3,701,((ADEN(K,J),JK=1,8),KJ=1,18)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK

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WRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

CALL POWN(POW)
IF (KTN1-4) . . 145
CALL FINPR
CALL PCI
CALL SB47
145 CONTINUE
FN=EFFKB-EFFKA+.04
C
C REINITIALIZE THE PROBLEM.
C
MIST=0
RADII(1)=RAD1
RADII(2)=RAD2
RADII(3)=RAD3
RADII(4)=RAD4
RADII(5)=RAD5
RADII(6)=RAD6
RADII(7)=RAD7
RADII(8)=RAD8
XLEN=XLENO
R2COR=R2CORO
R3COR=R3CORO
RFLCTR=RFLCTO
RHOUN=RHOUNO
RHOM=RHOMO
RHOT=RHOTO
RHOM=RHOMO
RHL16=RHL16O
RHOKL=RHOKLO
RHOKG=RHOKGO
RHAL=RHALO
FF=FFO
FS=FSO
FSC=FSCO
FC=FCO
FCL=FCLO
DO 225 I=1,18
DO 225 J=1,8
225 ADEN(I,J)=ADN(I,J)
IF (KTN1-4) . . 220
C
C BEGIN LIFETIME DEPENDENT CALCULATIONS. THE BURNUP AND PRODUCTION
C OF FISSILE SPECIES WILL BE APPROXIMATED BY A SIMPLE MOTHER-DAUGHTER
C CALCULATION USING APPROXIMATE ONE GROUP CROSS SECTIONS.
C HERE START, MID, AND END OF LIFE STATES ARE EXAMINED FOR THE EF-

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HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

C EFFECTS OF FUEL SWELLING, HEATPIPE BURNOUT, AND A FUEL ELEMENT PER-
C TURBATION OF 100 K. NOTE THAT THE PRODUCTION OF NEW FISSILE SPECIES
C IS NOT THE FULL STORY ON LIFETIME EFFECTS SINCE THE EFFECT OF
C FUEL SWELLING DOMINATES IN A LIQUID METAL BONDED ELEMENT.
C
228 DO 150 KLIF=1.5,2
DO 127 JJ=1,18
DO 127 JJ=1,8
127 ADEN(I,J)=ADN(I,J)
AKLIF=FLD*ATF(KLIF)
TAU=HRLIF*AKLIF/4.
IF (TAU)25,25,
DO 125 I=3,5
O +5.1E16*QHTW/(P1+RSCOR**2*CORL)
PHI=O/(ADN(10,I)+2.194*ADN(11,I)+1.421*ADN(13,I)+.1316)
B5=PHI*.1751E-24
G5=PHI*.2.367E-24
G4=PHI*.9692E-24
G5=PHI*.1.6908E-24+3.15E-17
G6=PHI*.4247E-24+9.52E-16
B5=PHI*.2778E-24
G4=PHI*.2952E-24+6.94E-18
G8=PHI*.2881E-24+4.92E-4
GC=3.41E-6
GD=PHI*.2.0595E-24+9.15E-13
B4=PHI*.1616E-24
B8=4.92E-4
B4=3.41E-6
ADEN(10,I)=ADN(10,I)+(1.-.25*BU*AKLIF*2.367*ADN(10,I))/(ADN(10,I)+
12.194*ADN(11,I)+1.421*ADN(13,I)+.1316)
ADEN(11,I)=ADN(11,I)+(1.-.25*BU*AKLIF*1.421*ADN(11,I))/(ADN(10,I)+
12.194*ADN(11,I)+1.421*ADN(13,I)+.1316)
ADEN(13,I)=ADN(13,I)+(1.-.25*BU*AKLIF*.1316*ADN(13,I))/(ADN(10,I)+
12.194*ADN(11,I)+1.421*ADN(13,I)+.1316)
ADENS=ADN(10,I)
ADEN(15,I)=ADENS*(B5/(G4-G5))=(EXP(-G5*TAU)-EXP(-G4*TAU))
ADENS=ADN(11,I)
ADEN(12,I)=ADENS*(B5/(G6-G5))=(EXP(-G5*TAU)-EXP(-G6*TAU))
ADENS=ADN(13,I)
125 ADEN(14,I)=ADENS*(B4+BB*BC/((GB-GA)*(GC-GA)*(GC-GB)*(GD-GA)*(GB-GC)
))=((GC-GB)*((GD-GC)*(EXP(-GA*TAU)-EXP(-GD*TAU))-(GD-GA)*(EXP(-
2GC*TAU)-EXP(-GD*TAU)))+(GC-GA)*((GD-GC)*(EXP(-GB*TAU)-EXP(-GD
3TAU))-(GD-GB)*(EXP(-GC*TAU)-EXP(-GD*TAU))))
GO TO 26
25 DO 126 I=3,5

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HRCTR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

ADEN(12,I)=O.
126 ADEN(14,I)=O.
C
C ACCOUNT FOR FUEL SWELLING BY DECREASING THE SWELLING VOLUME OF THE
C BONDING FLUID.
C
26 FS=FSO*(4.-AKLIF)/4.
FF=FFO+FSO-FS
ADEN(3,3)=ADEN(3,4)+ADEN(3,5)+.026202*RHAL*(FS+11./36.*FC)
WRITE OUTPUT TAPE 3,700,XLEN,(RAD1(I),I=1,8)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,KJ),KJ=1,8),KJ=1,18)
CALL MDTF(EFFK,XLEN,RAD1,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
CALL POWN(PON)
DO 335 I=3,5
DO 335 J=1,5
335 P(I,J)=PON(I+1,J)
WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)
CALL FINPR
CALL PCI
CALL S847
C
C EXAMINE THE EFFECT OF A BURNOUT INVOLVING VAPORIZATION OF ALL THE
C HEAT PIPE FLUID FROM THE WALLS OF THE HEAT PIPE
C
ADEN(3,3)=ADEN(3,4)+ADEN(3,5)+.026202*RHAL*(FS
WRITE OUTPUT TAPE 3,700,XLEN,(RAD1(I),I=1,8)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,KJ),KJ=1,8),KJ=1,18)
CALL MDTF(EFFK,XLEN,RAD1,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
C
C EXAMINE THE EFFECT OF A POWER FLUCTUATION SEEN AS A TEMPERATURE
C RISE IN THE FUEL WITH A CONSEQUENT DECREASE IN THE BONDING FLUID
C FRACTION.
C
DTR=100.
FF1=FF*(1.+AUN*DTR)**3
FS=FF+FS-FF1
ADEN(3,3)=ADEN(3,4)+ADEN(3,5)+.026202*RHAL*(FS+11./36.*FC)
WRITE OUTPUT TAPE 3,700,XLEN,(RAD1(I),I=1,8)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,KJ),KJ=1,8),KJ=1,18)

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HRCR - A DESIGN AND ANALYSIS SEQUENCE FOR HEATPIPE COOLED REACTORS

```

      CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
      EFFK=EFFK
      DEFFK=EFFK-EFFKA
      WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
      ADEN(3,3)=ADEN(3,4)+ADEN(3,5)+ADN(3,5)
C
C   IF THIS IS NOT THE END OF LIFE RETURN FOR ANOTHER LIFETIME DEPEND-
C   ENT CALCULATION.
C
150 CONTINUE
      CALL EXIT
      END

```

HREAC - A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

*   FORTRAN      HREAC
      SUBROUTINE HREAC
      COMMON /HRCR/ TEMRIS,CCF,CCF2,RFLCTR,RHOR,TSTRES,DR,HRLIF,TSUP,
      1TSHELL,MODE,PI,FUELDN,TBAR,ABUN,AUN,RHOUN,CONDUN,CPUN,EUN,GNUUN,
      2PSY,AN,ABN,RHON,CPN,CONDN,AL,RHOL,CONDL,VISCL,CPL,PSAT,STNL,RHOG,
      3YISCG,MPSTRS,ELPDHX,ELPD,ELPDGR,CORL,ELOPT,GCI,GC2,B,G,FF,FC,FCL,
      4FS,FSO,OMTH,BU,PHIAT,PHISI,PHIA,PHIS,OPY,RH,RV,RC,RCOPT,RSCOR,MPC,
      5RSCOR,RICOR,RZCOR,RSCOR,THICKS,AHLNLS,A1,B1,C1,OMP,NTCOR,MYAP,SAF,
      6MODL,NCAL,DTOT,BUNX,SN,RHESH,DELA,MP2,SANY,NRSA,NIA
C
C   THIS SUBROUTINE HREAC PROVIDES AN ENGINEERING DESIGN OF A HEATPIPE
C   REACTOR. IT MAY BE RUN WITH OR WITHOUT THE NEUTRONIC OPTION.
C   THIS CODE REQUIRES THE FOLLOWING LIMIT SPECIFICATIONS. MAXIMUM
C   BURNUP,BUNX,MAXIMUM FUEL THERMAL STRESS,TSTRES, MAXIMUM SURFACE
C   HEAT FLUX,PHISI, MAXIMUM FUEL TEMPERATURE DIFFERENCE,DTOT, AND
C   A MAXIMUM CORE L/D,ELPDHX. THESE MAY BE CIRCUMVENTED BY SETTING
C   THE LIMITS OVERLY HIGH. IT ALSO REQUIRES SPECIFICATION OF THE
C   LINEAR SHELING ALLOWANCE IN TERMS OF BURNUP AND WILL DESIGN ONLY
C   SYMMETRIC DODECAGONAL ARRAYS .
C
      CCF0=CCF2
      K9=1
      KIT1=0
      KIT2=0
      PSYM=5.E7*AN*(1.+G/5.1)/(2.*(1.-.3))
      CA=4.60460551
      CB=4.75875938
      EA=1.675309
      EB=1.66794
      ELPD1=ELPDHX
      GO TO (15,16) MODL
C
C   FOR MODL=1,THIS CODE WILL COMPUTE THAT CORE WHICH HAS THE MINIMUM
C   RADIUS (IE AT L/D MAX) USING THE POROSITY PARAMETER B AS AN INDEPT
C   VARIABLE. FOR MODL=2, IT WILL FIX B AND ALLOW THE CORE TO PANCAKE
C   BELOW THE MAXIMUM L/D PERMITTED
C   NOTE THAT IF THE POROSITY PARAMETER B INCREASES TO ABOVE .9 FOR
C   MODL = 1, IT WILL BE SET TO .9 AND THE DESIGN WILL PROCEED UNDER
C   MODL = 2 SEQUENCE.
C
C   INITIALIZE PROBLEM FOR MODE 1
C
15 KMAX2=25
      FDI=0.
      CRIT2=.005

```

HREAC - A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

      VL12=.01
      VL22=.99
      DY12=.1=0
      Y2=0
      DVMAX2=.1
      GO TO 11
C
C   INITIALIZE PROBLEM FOR MODE 2
C
16 KMAX1=25
      FDI=0.
      CRIT1=.005
      VL11=.09
      VL21=ELPDHX+.05
      VI=ELPD1
      DY11=-.05=VI
      DVMAX1=.4=VI
11 CONTINUE
C
C   FOR NCAL =1,THIS CODE WILL SET BURNUP AT APPROXIMATELY THE CRITICA
C   LITY LIMIT FOR A 90 PERCENT 235 ENRICHMENT OR AT THE MAXIMUM ALLOWA
C   BLE BURNUP LIMIT (BUNX),WHICH EVER IS LOWER. IT WILL SET NCAL=2 AT
C   THE END TO PERMIT USE WITH NEUTRONICS CODES SO NCAL MUST BE RESET
C   AT 1 BEFORECALLING EACH TIME IF A NEUTRONICS SUBROUTINE ISNT USED.
C
9 GO TO (7,8) NCAL
7 BU=OMTH*HRLIF*(1.76E-6*(1.-EXP(-CA*ELPD1**EA))-1.76E-6*(1.-EXP(-
1-CB*ELPD1**EB)))=0)
C
C   THIS EQUATION WILL YIELD A MULTIPLICATION FACTOR NEAR UNITY FOR A
C   NON HOLLOW , UN-M-LI CORE WITHOUT REFLECTOR, UNIFORMLY LOADED WITH
C   UN ENRICHED TO 90 PERCENT IN U235 WITH AN L/D IN THE RANGE FROM .2
C   TO 1.2. ANOTHER RELATION FOR THE SAME CASE GOOD FROM L/D OF .2 TO
C   3.5 IS
C
      B5=EXP(4.90580623E-2*ELPD1**2-5.7170005E-1*ELPD1+1.47042613
1-4.83219222E-1/ELPD1+1.74734232E-2/ELPD1**2)
      B9=EXP(6.86977473E-2*ELPD1**2-7.3183373E-1*ELPD1+2.92689559
1-6.28617508E-1/ELPD1+2.84246339E-2/ELPD1**2)
      BU=2.E-7*OMTH*HRLIF*(2.25*B5-1.25*B9-2.5*(B5-B9)=0)
C   A THIRD SET OF EQATIONS GOOD FOR THE CONDITIONS OF THE FIRST CASE
C   WITH THE ADDITIONAL CONDITION THAT THE FUEL IS ENRICHED WITH A
C   90 PERCENT MIXTURE OF U235 ANDU235 IS
C
      CA=4.60460551
      CB=4.75875938
      DA=1.0184175

```

HREAC- A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

C DB=7 62406E-2
C AN=1 675309
C BN=1 66794
C X=ELPDI
C F= RATIO OF U233/U235
C BU=QTH*HRLIF/(1 + 3*(25-(F-5)**2)*EXP((104-DB*LOGF(X-15)))*F)+
C 1( 78E-6*(1-EXP((A*X**AN))- 76E-6*B*(1-EXP((C*B*X**BN))))
C THESE EQUATIONS ARE FOR A SPECIAL FAMILY OF REACTORS AND WERE
C WRITTEN FOR A SET OF SURVEYS OF HEATPIPE REACTOR SYSTEMS WHERE
C LITERALLY THOUSANDS OF REACTORS HAD TO BE SEARCHED BY MONTE
C CARLO TECHNIQUES FOR OPTIMUM SYSTEM CONFIGURATIONS IN THEIR PRES-
C SENT FORM THEY ARE PROBABLY NOT OF MUCH USE TO ANYONE THEY ARE
C AN EXAMPLE OF HOW THESE CODES CAN BE EFFICIENTLY USED FOR SURVEY
C PURPOSES THE ACTIVE CORE WAS REDUCED TO A SINGLE ZONE AND
C ONLY THE CRITICALITY OPTION WAS USED TO GENERATE THE DATA ON LIM-
C ITING BURNUP LESS THAN AN HOURS TIME WAS USED TO GENERATE THIS
C DATA WHICH WAS THEN FITTED BY SIMPLE NUMERICAL ANALYSIS TECHNIQUES
C THESE EQUATIONS MAYE SINCE BEEN USED TO ADVANTAGE AS A STARTING
C POINT FOR THE DESIGN OF OTHER SLIGHTLY DIFFERENT FAMILIES OF
C REACTORS BY BRIEFLY DESIGNING A COUPLE OF EXAMPLES AND NOTING
C THAT THE LIMITING BURNUP FOR THESE FAMILIES USUALLY DIFFERED FROM
C THESE BY A CONSTANT FACTOR THESE EQUATIONS WOULD THEN BE FOLLOW-
C ED BY BU=BU*CONSTANT
C
C BU=MINIF(BUMX,BU)
C
C COMPUTE SWELLING ALLOWNANCE
C
C A=SW*BU
C
C COMPUTE VOLUME FRACTIONS
C
C FF=(1-10 882796*B**2/12)/(1+A)**5
C FCL= 9068997*B**2/12 *G-G**2)
C FS=((1+A)**3-1)*FF
C FSC=0
C FC=1-FF-FCL-FS
C CCF1=SQRTF(1+CCF)
C CCF2=CCF0
C CCF3=SQRTF(1+CCF2)
C ELPD2=ELPDI*CCF3
C
C COMPUTE EFFECTIVE POROSITY FOR STRESS AND TEMPERATURE DIFFERENCES
C
C H=B*PI/(2 *SQRTF(3))

```

HREAC- A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

CPR=1 0773503/0
C
C CALCULATE CORE AVG PWR DENSITY (MW/CM**3)
C OPY=20 565594*FF*RHOUN*BU/HRLIF
C
C CALCULATE FUEL AVG PWR DENSITY (W/CM**3)
C ODEN=OPY*1 E6/FF
C
C CALCULATE RADII
C RM1=PHIS1*2 *FC/OPY
C FSTRES=(1-2 *LOGF(H**2)-(1-H**2)*(3-H**2))/(H**2*(1-H**2))
C RM2= 00251*(1-G)*SQRTF(FSTRES*FF/(2 *PI)*OPY*PSY*FSTRES))
C DTN=(1+ABUN*(TSUP-293))/(1+ADM*(TSUP-293))
C ZO=(ODEN/(2 *CONDUN))=((CPR**2*LOGF(CPR)-5*(CPR**2-1)))
C Z1=QDEN*FF*SQRTF(3/(PI*B**2))
C Z2=(ZO+Z1*(LOGF(DTN)/COND1*LOGF(1/(1-G1)/COND1))
C PSYNT=Z1*LOGF(1/(1-G1))*(DTN/(1-G1))**2/COND1
C RMS=SQRTF(DTOT/Z2)/(1+G1*DTN)
C
C PICK THE MINIMUM HEAT PIPE RADIUS RM RM1 IS FLUX LIMITED,RM2 IS
C STRESS LIMITED,RM3 IS TEMPERATURE LIMITED (DTOT IS THE MAXIMUM
C ALLOWABLE PEAK FUEL-HEAT PIPE TEMPERATURE DIFFERENCE)
C
C RM=MINIF(RM1,RM2,RM3)
C
C CALCULATE CORE RADIUS AND IMPLIED NUMBER OF ELEMENTS
C CORVOL=QTH/OPY
C RSCOR=(CORVOL/(2 *PI*ELPD2))**((1/3))
C ANLMTS=FC*(RSCOR/RM)**2
C NL=XINTF(ANLMTS)
C IF (KIT1*KIT2-12)1,2,2
C
C CALL ELMTS TO PICK THAT DODECAGONAL ARRAY WHICH HAS THE CLOSEST
C NUMBER OF ELEMENTS TO THAT CALCULATED SET THE HEAT PIPE RADIUS
C THAT THIS IMPLIES AND PROCEED TO REBALANCE THE AXIAL FLUX (HEAT
C IN EQUALS HEAT OUT)
C 1 CALL ELMTS(NL,CCF2,NRSA,NIA)
C CCF3=SQRTF(1+CCF2)
C NLA=NL
C GO TO 3
C 2 NL=NLA
C 3 ANLMTS=FLOATF(NL)
C
C THESE ARE THE EQUATIONS FOR A GROOVE MESH HEATPIPE THESE ARE
C BASED ON THE ASSUMPTION THAT THE RADIAL REYNOLDS NUMBER IS MUCH

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HREAC- A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

C   LARGER THAN UNITY AND THAT THE AXIAL VAPOR FLOW IS NOT TURBULENT.
C   RV IS THE VAPOR RADIUS AND RW THE WETTED WALL RADIUS.
C
  RW=RSCOR*SQRT(FC/ANLMTS)
  RV=GC1*RW
  DELR=RW-RV
  DELR4=(RW-RV)**4
  A1=(1.-4./PI)**2/(5000.*MYAP**2*RHOG)
  B2PZ=YISCL/(RHOL*MYAP)
  A2P=.1997+.03209*(DELR/DELA1)+.04887*(DELR/DELA1)**2
  C1=.4.*STNL
  QPIPE=SAF*1.E13*QNTW/(ANLMTS*HP2)
  Z=(C1/RHESH-A1*QPIPE**2/DELR4)*DELR4/(B2PZ*A2P*QPIPE)
  EL=HP2*Z/HPC

C
  CORL=EL
  RSCOR=SQRT(CCF1)*RSCOR
  R1COR=SQRT(CCF2)*RSCOR
  R2COR=CCF3*RSCOR
  RSCOR=R2COR*(1.023323*DR)
  ELPD=.5*EL/R2COR
  ELPDCR=ELPD
  GO TO (17,18)MODL

18 IF (ELPDCR-ELPDHX)16.,
   IF (KIT1-1)16.
   ELPD=ELPDHX
   ELPDCR=ELPDHX*CCF3
   RSCOR=.1978*(QNTW*HRLIF/(BU*FF*RHOUN*ELPDCR))**(.1./3.)
   CORL=CORYOL/(PI*RSCOR**2)
   ANLMTS=FC*(RSCOR/RW)**2
   CALL ELMTS(NL,CCF2,NRSA,NIA)
   ANLMTS=FLOAT(NL)
   RW=RSCOR*SQRT(FC/ANLMTS)
   GO TO 5

6 FNI=ELPDCR-ELPD1
  IF (ABS(FNI)-CRIT1)5,5,
  CALL NEWRAP(KIT1,KMAX1,FNI,FD1,CRIT1,Y1,YL1,YL21,DY11,DYMAX1,YA1,
  IDLTA1)
  ELPD1=Y1
  IF (Y1-.1)5.,
  IF (KIT1-KMAX1)111,5,5
17 FN2=ELPDCR-ELPDHX
  IF (ABS(FN2)-CRIT2)5,5,
  CALL NEWRAP(KIT2,KMAX2,FN2,FD2,CRIT2,Y2,YL2,YL22,DY12,DYMAX2,YA2,
  IDLTA2)

```

HREAC- A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

  B=Y2
  IF (B-.9)23,22,22
22 GO TO (24,25)K9
24 K9=2
  B=.9
  GO TO 11
25 B=.9
  KIT2=0
  MODL=2
  GO TO 16
23 IF (KIT2-KMAX2)111.,
C   CALCULATE FUEL INSIDE RADIUS,RFUEL, OUTER FLAT RADIUS,R1,TEMP DIF
C   DTOTL, FUEL THERMAL STRESS,TSTR, CLAD THERMAL STRESS,SIGCL,SURFACE
C   FLUX,PHIS, AND VAPOR RADIUS,RV, FOR THE SELECTED VALUE OF RW.
5 RFUEL = RW*DTW/(1.-G)
  DTOTL=Z2*RFUEL**2
  TSTR=2.*PI*QPY*PSY*FSTRES*RW**2/(1.0025*(1.-G))**2*FF)
  R1=RFUEL/B
  PHIS=QPY*.5*RW/FC
  SIGCL=PSY*PSY*RW**2
  QMP=QNTW/ANLMTS
  QMP=QNTW/(ANLMTS*HP2)
  PHIA=QMP/(PI*RV**2)
  R1COR=SQRT(CCF1)*RSCOR
  R1COR=SQRT(CCF2)*RSCOR
  R2COR=CCF3*RSCOR
  RSCOR=R2COR*(1.023323*DR) +.6
  BET=.5*B2PZ*A2P/A1
  ALPH=.50.*C1*DELR4/A1
  QPOPE=SQRT(BET**2+ALPH)-BET
  SDF=QPOPE/QPIPE
  WRITE OUTPUT TAPE 3,180,DELR4,A1,B2PZ,A2P,C1,QPOPE,SDF,SAF
180 FORMAT(1X,BE14,7)
  RHOS=RHOW
  CALL MATER1(HRLIF,TSHELL,PSAT,RSCOR,THICKS,RHOS,EMS,CONS,SS)
  THKMIN=.3
  THICKS=MAX1(THICKS,THKMIN)

C
C   THESE WEIGHT EQUATIONS ARE NO LONGER ANY GOOD. THEY SHOULD BE
C   REMARKED TO INDICATE THE TRANSVERSE PLATES IN THE CORE, THE
C   THERMAL INSULATION THAT IS REQUIRED TO KEEP THE PRESSURE VESSEL
C   COOL ENOUGH TO KEEP ITS THICKNESS DOWN TO REASONABLE VALUES ETC.
C
  WSHL=2.*PI*THICKS*(1.5*(RSCOR+THICKS/2.)*CORL*HPC+.9.*(RSCOR+THICK
  S/2.))**2*RHOS =.02768

```

HREAC - A DESIGN SUBROUTINE FOR HEATPIPE COOLED REACTORS

```

HTCOR=6.2832*RSROR**3*ELPDCR*(.01432*FF+.0199*FCL)
HTRFLR=6.2832*CORL*(RSCOR*THICKS+RFLCTR/2.)*RFLCTR*RHOR
HTRCTR=HTCOR*HTSML+HTRFLR
MTU=2.*PI*RSROR**3*ELPDCR*FF*RHOUN=.236/250.
QPIPE1=QPIPE
XMDOT=QPIPE1/HYAP
VEL=XMDOT/(RHOG*PI*RY**2)
SONIC=VEL/SAHV
RDREYN=XMDOT/(2.*PI*EL*VISC)
AXREYN=XMDOT/(PI*RY*VISC)
WRITE OUTPUT TAPE 3,171,QMTH,HRLIF,BU,G,B,TSUP,RFLCTR,DR,ANLMTS,FF
1,FCL,FC,FS,RFUEL,RI,RV,RW,RMT,RN2,EL,PMIS1,PMIS,PHIA,OPY,CORYOL,
2RSCOR,CORL,ELPD,ELPDCR,ROCOR,RICOR,R2COR,R3COR,HTCOR,MTU,HTSML,
3RMESH,HTRCTR,HPC,CCF2
WRITE OUTPUT TAPE 3,172,RN3,TSTRES,TSTR,DTOT,DTOTL,THICKS,SIGCL
171 FORMAT (110M QMTH HRLIF BU G
1 B TSUP K RFLCTR CM DR /1X,E14.6,
27E15.7//110M NLMTS FF FCL FC
3 FS RFUEL CM RI CM RV /1X,E14.6,
47E15.7//110M RM CM RMIFLUX RMISTRESS EL CM
51 PMIS1(M/2) PMIS(M/2) PHIA OPY /1X,E14.6,
67E15.7//110M CORYOL (CC) RSCOR CM CORL CM ELPD
7 ELPDCR ROCOR RICOR R2COR /1X,E14.6,
87E15.7//109M RSCOR CM HTCOR KG MTU KG HTSML
9 RMESH HTRCTR HPC CCF2 /1X,E14.6,7E15.7)
172 FORMAT(109M RN3 TSTRES TSTR DTOT
1 DTOTC THICKS SIGCL /1X,7E15.7)
WRITE OUTPUT TAPE 3,173,CCF2,NL,NRS4,NIA
WRITE OUTPUT TAPE 3,174,SONIC,RDREYN,AXREYN
173 FORMAT(39M CCF2 NL NRS NIA /1X,E14.6,316)
174 FORMAT(43M HACHN RDREYN AXREYN /1X,3E14.6)
NCAL=2
RETURN
END

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

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FORTRAN RCTR
MULTIPLE ARGS TRAMP,VISL,TCNL,CSPL,RHOL,RESL,TENS,PRANL,VISG,TCNG,
1CSPG,RHOG,PRANG,SONY,PSAT,HYAP
COMMON / RCTR/ BU,NTYPE,G,B,FF,FS,FCL,FC,FSC,RSCOR,ON TM,HRLIF,
1 ELPDCR,RFUEL,TSTRES,PSY,RI,DH,NLM TS,FSTRES,PSIDRP,CORDEN,HTCOR,
2CORL,TEMRI5,TPR,MODE,CCF,CCF1,CCF2,CCF3,ROCOR,RICOR,R2COR,R3COR,
3RTRDRP,ELPD,DP,TSMELL,TSUP,PIN,THICKS,THCKSP,RHOS,RHOSP,EMS,EMSP,
4CONS,CONSP,DR,SSP,HTSML,MTSUP,MTL1,HTRCTR,MTU,RFLCTR,RHOR,FUELON,
5TBAR,ABUN,AUN,RHOUN,CONDUN,CPUN,EUN,GNUUN,AM,RMON,CONDN,CPH,ALI,
6RHOLI,CONDL1,VISCL1,CPL1,CAF2,XNO1,XNO2,XNO3,XNO4,XNO5,XNO6,XNO7
7,J,NRS,NRA,GAP
DIMENSION ADEN(10,0),RADII(0),ENRICH(5),ADN(10,0)
DIMENSION POW(40),P(0,5),R(0,5),RA(0),RB(0),PBAR(0),BA(0),ER(0),
1 DRA(0),PBA(0,5),ENRICH(4)
700 FORMAT (13M LENGTH,RADII 9F1.6)
701 FORMAT (1X,0E14.6)
780 FORMAT (1X,2E16.0)
779 FORMAT (1X,E16.0)
724 FORMAT (1X,12F9.6)
725 FORMAT (12M XLEN,RADII, 9E12.5)
C
C THIS CODE IS THE MAIN CALLING ROUTINE THAT COUPLES A NEUTRONIC
C CODE,DTF, TO A REACTOR DESIGN CODE FOR CONVENTIONALLY COOLED
C REACTORS. THERE IS A SECOND VERSION FOR HEAT PIPE COOLED REACTORS.
C THE NEUTRONIC CODE, A MODIFIED VERSION OF DTF-2 CALLED WDTF HAS
C TWO OPTIONS. THE FIRST CALLED BY SETTING MIST=0 IS AN ISOTROPIC
C SCATTERING OPTION. THE SECOND CALLED BY SETTING MIST=1 IS AN
C ANISOTROPIC SCATTERING CALCULATION REQUIRED IF THE WATER SAFETY
C CALCULATIONS ARE TO BE USED THIS PARTICULAR SEQUENCE IS SET
C UP TO COMPUTE A REACTOR HAVING 0 RADIAL ZONES EACH WITH FIVE SUB-
C INTERVALS. A SMALLER NUMBER OF ZONES MAY BE INDICATED BY SETTING
C 12M TO A SMALLER NUMBER. A LARGER NUMBER OF ZONES WOULD REQUIRE
C MAKING A FEW CHANGES IN THE DTF ROUTINE AS SET UP. MCR IS THE
C NUMBER OF CORE MATERIALS. A LARGER NUMBER OF MATERIALS COULD BE
C USED ONLY WITH A FEW CHANGES IN THE DTF ROUTINE. IN THE PRESENT SET
C UP ZONE 1 IS A RETURN FROM THE BOILER, ZONE 2 IS A LIQUID
C CONTROL ANNULUS, ZONES 3,4,5 ARE ACTIVE CORE ZONES, ZONE 6 IS AN
C ANNULUS BETWEEN THE CORE AND PRESSURE VESSEL CONTAINING A MEMBRANE
C AND AN INSULATOR, ZONE 7 IS THE PRESSURE VESSEL, AND ZONE 0 IS THE
C REFLECTOR. THE MATERIAL SEQUENCE FOR THIS PARTICULAR PROBLEM IS
C L16,L17,0,K,N,MO,TA,N,U233,U235,U236,U238,PU239,U234,HF, AND 2
C H CROSS SECTIONS NECESSARY FOR THE ANISOTROPIC COMPUTATION. THESE
C MATERIALS MAY BE CHANGED BY CHANGING THE APPROPRIATE EQUATION IN
C ADEN CALCULATION AND SETTING THE APPROPRIATE CROSS SECTION DATA
C IN THAT NUMERICAL SEQUENCE. CAUTION. POWDEN, THE SUBROUTINE THAT

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

C COMPUTES THE POWER PROFILE MAKES A SEARCH FOR THE FISSILE SPECIES
 C BASED ON THE ABOVE NUMBER SEQUENCE OF FISSILE SPECIES AND THIS
 C WOULD REQUIRE A CHANGE IF THESE ARE PUT IN ANY OTHER LOCATION.
 C THE USE OF MIST=1 (ANISOTROPIC OPTION) REQUIRES M-1 BE PLACED NEXT
 C TO LAST IN THE MATERIAL LIST AND THE LAST MATERIAL TO BE M-2. MDTF
 C MUST BE CHANGED TO PERMIT OTHER LOCATIONS. NO SUCH LIMITATION EX-
 C SISTS FOR MIST=0. EITHER OPTION MAY BE USED FOR ISOTROPIC COMP-
 C UTATION IF THE ATOM DENSITY OF M-1 IS 0. IN ANY EVENT THE ATOM
 C DENSITY FOR M-2 IS BASED ON THAT SET FOR M-1 AND IS THUS INTERNAL-
 C LY CONTROLLED. THE ANISOTROPIC OPTION IS CONSIDERABLY SLOWER.
 C
 C INITIALIZE THE PROBLEM. IF MANY SIMILAR PROBLEMS ARE TO BE RUN,
 C IT WOULD PAY TO REPLACE MUCH OF THIS SECTION WITH A DATA READ IN
 C TO AVOID RECOMPILE EACH TIME.
 C

C JP IS THE FLUID INDEX FOR TRAMP CALLED IN REACT.
 C RATL12 IS THE RATIO L16/L17 IN THE CONTROL TUBES.
 C RATL11 IS THE SAME RATIO FOR THE PRIMARY COOLANT. DEPENDING ON THE
 C REACTOR VALUES EXCEEDING .03 TO .08 WILL LEAD TO INSTABILITY.
 C ALP IS A PARAMETER THAT WAS USED TO PERMIT SPECIAL RATIOS OF
 C L16/L17 IN THE BONDING FLUID. SEE ADEN(1,5) ETC. THIS WAS USED FOR
 C A STABILITY STUDY.
 C TEMRIS IS THE COOLANT TEMPERATURE RISE DESIRED IN THE CORE.
 C TSMELL IS THE PRESSURE VESSEL TEMPERATURE.
 C TSUP IS THE REACTOR OUTLET TEMPERATURE.
 C FL12 IS THE FRACTION OF ZONE 2 DEVOTED TO CONTROL AND INTERSTITIAL
 C FLUID. BERYLLIUM FLUORIDE HAS SOME INTERESTING POSSIBILITIES HERE.
 C FLIC IS THE FRACTION OF CONTROL FLUID ACTUALLY IN ZONE 2.
 C TSTRES IS THE THERMAL STRESS DESIGN POINT.
 C PIN IS THE REACTOR INLET PRESSURE IN PSI. DONT GET FAKED INTO US-
 C ING THE VAPOR PRESSURE OF LI IN THE REACTOR UNTIL THE PRESSURE
 C DIFFERENCE BETWEEN THE BOILER FLUIDS HAS BEEN EXAMINED FROM A
 C RELIABILITY STANDPOINT. MUCH OF THE THICKNESS OF THE PRESSURE
 C VESSEL IS ALSO REQUIRED FOR RIGIDITY.
 C DR IS A CLEARANCE ALLOWANCE IN TERMS OF THE CORE RADIUS TO PERMIT
 C CORE EXPANSION IN A THERMALLY LAGGING PRESSURE VESSEL.
 C

12M=0
 MCR=10
 JP=1
 RATL12=1.
 RATL11=.02
 THUK = .4
 THOK = .5

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

GAP = THUK + THOK + .2
 ALP=1.2
 TEMRIS=75.
 TSMELL=
 TSUP=
 FL12=.6
 FLIC=.5*(FL12-.0031)

C CCF IS THE FRACTION OF THE COOLANT FLOW AREA THAT WILL BE ALLOWED
 C FOR A RETURN THROUGH THE CORE. CCF2 IS THE FRACTION OF THE ACTIVE
 C CORE AREA THAT WILL BE ALLOWED FOR BOTH THE CENTRAL RETURN AND
 C THE LIQUID CONTROL ANNULUS SURROUNDING THIS RETURN. IF A SOLID
 C CORE IS DESIRED, SET CCF=1.E-6 AND CCF2=1.1E-6. NOTE THAT CCF2 MUST
 C BE SUCH THAT IT INDICATES AN AREA GREATER THAN THAT DICTATED BY
 C CCF. NOTE ALSO THAT THE DESIGN CODE WILL REVISE CCF2 TO GIVE A
 C RADIUS COMPATIBLE WITH THE FUEL ELEMENT ROW BOUNDARIES.
 C

CCF=.3
 CCF2=.15
 CCF0=CCF2
 DO 100 J=1,MCR
 DO 100 J=1,12M
 100 ADEN(1,J)=0.
 KRFL=1
 RFLCTR=.001
 RHOR=.0102
 TSTRES=10000.
 DR=.01
 RMLIF=20000.
 ABT=7.2E-6
 ABOT=ABIT=6.7E-6
 ABOM=ABIM=5.E-6
 RHOT=16.6/(1.+(ABOT*(TSMELL-293.1))**.5)
 RHOM=10.2/(1.+(ABOM*(TSMELL-293.1))**.5)
 CALL RHOL(1,TSUP,RML16)
 CALL RHOL(3,TSMELL,RHOKL)
 CALL RHOG(3,TSMELL,RHOKI)
 ELPD=1.3
 QMTH=QNTM=.6
 PIN=25.=14.5
 21 MODE=1
 BU=.013
 NTYPE=2
 G=.1
 B=0.

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

ENRICH(1)=ENRICH(2)+ENRICH(3)+.995
RFLCTR=.3
MODE=1
XKEFFD=1.0
CCFO=CCF2

C
C THIS IS AN EXAMPLE OF THE USE OF THE CODE TO DESIGN TWO DIFFERENT
C REACTORS IN A SINGLE PASS. ONE SEQUENCE WILL DESIGN A POWER FLAT
C REACTOR AND THE OTHER WILL DESIGN A MINIMUM SIZE U233 REACTOR
C ONLY A SELECT PORTION OF THE DESIGN AND ANALYSIS SEQUENCE IS
C DESIRED FOR THE FIRST DESIGN
C
DO 146 KAT=1,2

C
C THIS SECTION INITIALIZES THE PROBLEM FOR A NEWTON RAPHSON ITERA-
C TION SCHEME. THE LOOP EXTENDS FROM STATEMENT 1 TO STATEMENT 22. IF
C THE REACTOR TO BE DESIGNED IS TO BE A BURNUP LIMITED CORE, (I.E.
C A LARGE REACTOR), THE REACTOR DESIGN CODE SHOULD BE CALLED OUTSIDE
C OF THIS LOOP AND THE ITERATION LOOP SHOULD BE USED ONLY TO LOOP ON
C THE ENRICHMENTS IN THE VARIOUS ZONES. IF THE REACTOR IS TO BE
C CRITICALITY LIMITED, THE CODE SHOULD LOOP ON BURNUP AS A MEASURE
C OF CORE SIZE
C
11 KIT=0
KIT1=0
KIT2=0
KIT3=0
KMAX=25
KMAX1=25
KMAX2=25
KMAX3=25
FD=0
FD1=1
FD2=1
FDS=.005
CRIT=1 E-6
CRIT1=1 E-7
CRIT2=1 E-7
CRIT3=1 E-3
YL1=1 E-6
YL11=1 E-6
YL12=1 E-6
YL13=1 E-6
YL2=10
YL21+YL22= 9999

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

YL23= .05
DYNMAX=1
DYNMAX1= 15
DYNMAX2= 3
DYNMAX3= 15+BU
Y=RFLCTR
Y1= 6
Y2= 7
IF (KAT-1)189,189,
Y1+Y2= 995
Y= 1
DYNMAX= .02
TSTRESS=7500
189 Y3=BU
DY1=Y= 1
DY11= .01+Y1
DY12= .01+Y2
DY13= .01+Y3
1 CONTINUE
CCF2=CCFO

C
C THIS STATEMENT CALLS THE REACTOR DESIGN SUBROUTINE
C
CALL REACT

C
C ASSUME THE ACTIVE CORE IS TO HAVE 3 RADIAL ZONES TO FLATTEN POWER
C SET ALL REACTOR DIMENSIONS TO THE VALUES DICTATED BY THE DESIGN
C SUBROUTINE EXCEPT FOR THE INTERNAL CORE RADII WHICH MUST BE SET
C BY AN OPTIMIZATION SEQUENCE IF THE CORE POWER IS TO BE RADially
C FLATTENED
C
XLEN=CORL
RADII(1)=R0COR
RADII(2)=R1COR
RADII(5)=R2COR
RADII(6)=R3COR
RADII(7)=RADII(6)+THICKS
RADII(8)=RADII(7)+RFLCTR+ 1

C
C IF THIS IS THE FIRST CALCULATION, ASSUME A PARABOLIC FLUX AND
C PROCEED TO DETERMINE APPROXIMATE OPTIMUM LOADING ZONES
C
IF (KIT1)1,200
CO= 4
CI=(1 -CO)/(RADII(5)-RADII(2))**2

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

CA1=1 (1=RAD1)(2)=2
CA2=2 (1=RAD1)(2)
CA3=-1
GO TO 205

C
C IF THIS IS NOT THE FIRST FIT A SECOND ORDER POLYNOMIAL THROUGH
C A FICTITIOUS FLUX PROFILE OBTAINED FROM THE PREVIOUS CALCULATION
C THIS FICTITIOUS FLUX IS REALLY ONLY THE POWER PROFILE FROM THE
C LAST CALCULATION MATHEMATICALLY MANIPULATED TO GIVE AN INDICATION
C OF THE DEGREE OF ENRICHMENT REQUIRED FOR THE VARIOUS ZONES THIS
C FICTION IS REQUIRED SINCE THE CHANGES MADE IN THE REACTOR FOR THIS
C TRIAL MAY HAVE RESULTED IN A DIFFERENT NUMBER OF FUEL ELEMENT
C ROWS
C
200 SR=SR2+SR3+SR4+SP+SPR+SPR2+0
P31=P(3,5)-5*(P(3,4)-P(3,5))
P32=P(4,1)+5*(P(4,1)-P(4,2))
DO 236 J=1,5
236 P(4,J)=P(4,J)+P31/P32
P41=P(4,5)-5*(P(4,4)-P(4,5))
P42=P(5,1)+5*(P(5,1)-P(5,2))
DO 237 J=1,5
237 P(5,J)=P(5,J)+P41/P42
DO 238 I=3,5
DO 238 J=1,5
238 R(I,J)=RAD1(2)+R(I,J) RAD2=(RAD1(5)-RAD1(2))/(RAD5-RAD2)
DO 300 I=3,5
DO 300 J=1,5
SR=SR+R(I,J)
SR2=SR2+R(I,J)**2
SR3=SR3+R(I,J)**3
SR4=SR4+R(I,J)**4
SP=SP+P(I,J)
SPR=SPR+P(I,J)*R(I,J)
300 SPR2=SPR2+P(I,J)*R(I,J)**2
WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)
330 FORMAT (9H R I J P J 10E11 4)
AO=15 (SR2=SR4-SR3**2)-SR*(SR=SR4-SR2+SR3)+SR2*(SR=SR3-SR2**2)
A1=SP*(SR2=SR4-SR3**2) SR=(SPR=SR4-SPR2+SR3)+SR2*(SPR=SR3-SPR2+SR2
1)
A2=15 (SPR=SR4-SR3+SPR2)-SP*(SR=SR4-SR2+SR3)+SR2*(SR=SPR2-SPR+SR2
1)
A3=15 (SR2=SPR2-SR3+SPR)-SR*(SR=SPR2-SPR+SR2)+SP*(SR=SR3-SR2**2)
CA1=A1/AO
CA2=A2/AO

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

CA3=AS/AO
DO 313 I=3,5
DO 313 J=1,5
313 P(I,J)=CA1+CA2*R(I,J)+CA3*R(I,J)**2
WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)

C
C THIS SECTION THROUGH STATEMENT 312 WILL DETERMINE THE OPTIMUM
C ZONE SPACING FOR A 5 ZONE ACTIVE CORE IT MAY BE EASILY EXTENDED
C TO MORE ZONES BUT FOR THE REACTORS IN THE FAMILY UNDER STUDY HERE
C INCREASING THE NUMBER OF ZONES DOES NOT SEEM TO SHOW MUCH BENEFIT
C
205 KC=1
RA(5)=RAD1(2)
RB(5)=RAD1(5)
RC=(RAD1(5)-RAD1(2))/(FLOATF(NRS)-FLOATF(NRA))
RA(5)=RB(4)+RB(5)-RC
RB(4)=RB(3)+RA(5)-RC
302 ERT=0
DO 301 I=3,5
PBAR(I)=(CA1*(RB(I)**2-RA(I)**2)/2+(CA2*(RB(I)**3-RA(I)**3)/3+
1CA3*(RB(I)**4-RA(I)**4)/4)/((RB(I)**2-RA(I)**2)/2)
BA(I)=PBAR(5)/PBAR(I)
BB=BA(I)**2
BC=-2*BA(I)*PBAR(I)
ERT=ERT+((BB*CA1**2+BC*CA1+PBAR(I)**2)*(RB(I)**2-RA(I)**2)/2+(2*
1BB*CA1+CA2+BC*CA2)*(RB(I)**3-RA(I)**3)/3+(2*BB*CA1+CA3+BB*CA2**2
1+BC*CA3)*(RB(I)**4-RA(I)**4)/4+2*BB*CA2*CA3*(RB(I)**5-RA(I)**5)/
35+BB*CA3**2*(RB(I)**6-RA(I)**6)/6)
301 CONTINUE
DO 311 I=3,5
DO 311 J=1,5
R(I,J)=RA(I)+(FLOATF(J)-5)*2*(RB(I)-RA(I))
P(I,J)=CA1+CA2*R(I,J)+CA3*R(I,J)**2
311 PBAR(I,J)=P(I,J)*BA(I)
WRITE OUTPUT TAPE 3,330,((R(I,J),PBAR(I,J),J=1,5),I=3,5)
GO TO (303,304,306,307)KC
303 RAD1(5)=RB(5)
RAD1(4)=RB(4)
KC=2
RB(5)=RB(5)-RC
RA(4)=RB(5)
ERTA=ERT
BA4=BA(4)
BA5=BA(5)
GO TO 302

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

304 IF (ERT-ERTA),305,305
  ERTA=ERT
  RAD11(3)=RB(3)
  RB(3)=RA(4)+RB(3)-RC
  BA4=BA(4)
  BA5=BA(5)
  GO TO 302
305 RA(5)=RA(5)-RC
  RB(4)=RA(5)
  RA(4)=RB(3)+RA(5)-RC
  KC=3
  GO TO 302
306 ERTB=ERT
  RD3=RB(3)
  RD4=RB(4)
  BB4=BA(4)
  BB5=BA(5)
  RB(3)=RA(4)+RB(3)-RC
  KC=4
  GO TO 302
307 IF (ERT-ERTB),308,308
  ERTB=ERT
  RD3=RB(3)
  RD4=RB(4)
  BB4=BA(4)
  BB5=BA(5)
  RB(3)=RA(4)+RB(3)-RC
  GO TO 302
308 IF (ERTB-ERTA),309,309
  RAD11(3)=RD3
  RAD11(4)=RD4
  BD4=BB4
  BD5=BB5
  GO TO 310
309 BD4=BA4
  BD5=BA5
310 DO 312 I=3,5
  DRA(I)=(RAD11(I)-RAD11(I-1))/5.
  DO 312 J=1,5
  R(I,J)=RAD11(I-1)+(FLOAT(J)-.5)*.2*(RAD11(I)-RAD11(I-1))
312 CONTINUE
C
C  ONCE THE ZONES ARE KNOWN, TRANSLATE THE VOLUME FRACTIONS AND
C  MATERIAL DENSITIES INTO ATOM DENSITIES FOR THE NEUTRONIC SUBROUTINE
C

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

THUK=.4
THOK=.3
FR6=RAD11(6)**2-RAD11(5)**2
FRA=((RAD11(5)+THOK)**2-RAD11(5)**2)/FR6
FRB=((RAD11(6)-.2)**2-(RAD11(6)-THUK-.2)**2)/FR6
FRD=(RAD11(6)**2-(RAD11(6)-.2)**2)/FR6
FRC=1.-FRA-FRB-FRD
ADEN(1,1)=.086801*RHOL1*RATL11
ADEN(2,1)=.086801*RHOL1*(1.-RATL11)
ADEN(1,2)=.086801*RHOL1*(.0931*RATL11+FL1C*RATL12)
ADEN(2,2)=.086801*RHOL1*(.0931*(1.-RATL11)+FL1C*(1.-RATL12))
ADEN(9,2)=.0024569*RHON*(1.-FL12)
ADEN(8,2)=ADEN(9,2)/5.
ADEN(1,3)=.086801*RHOL1*(RATL11*FC+(FS+FS)*.10*(ALP-1.))
ADEN(1,4)=ADEN(1,3)+ADEN(1,3)
ADEN(2,3)=.086801*RHOL1*(1.-RATL11)*FC+(FS+FS)*(1.-ALP)*.6))
ADEN(2,4)=ADEN(2,3)+ADEN(2,3)
ADEN(5,3)=.00240343*RHOUN*FF
ADEN(5,4)=ADEN(5,3)+ADEN(5,3)
ADEN(9,3)=.0024569*RHON*FCL
ADEN(9,4)=ADEN(9,3)+ADEN(9,3)
ADEN(8,3)=ADEN(8,4)+ADEN(8,3)+ADEN(9,3)/5.
ADEN(1,6)=.086801*RHOL1*FRC*(RATL11)
ADEN(2,6)=.086801*RHOL1*FRC*(1.-RATL11)
ADEN(4,6)=.015407*RHOKL*FRD
ADEN(9,6)=.0032764*RHON*.75*FRA
ADEN(8,6)=ADEN(9,6)/5.
ADEN(16,6)=.0028613*9.68*FRB
ADEN(3,6)=ADEN(16,6)*2.
ADEN(7,7)=.0033291*RHOT
ADEN(6,8)=.0062783*RHOM
ADEN(10,3)=ADEN(5,3)*Y1
ADEN(11,3)=ADEN(5,3)*ENR1(CH1)=(1.-Y1)
ADEN(13,3)=ADEN(5,3)*(1.-ENR1(CH1))=(1.-Y1)
ADEN(10,4)=ADEN(5,4)*Y2
ADEN(11,4)=ADEN(5,4)*ENR1(CH2)=(1.-Y2)
ADEN(13,4)=ADEN(5,4)*(1.-ENR1(CH2))=(1.-Y2)
ADEN(10,5)=ADEN(5,5)*.995
ADEN(11,5)=ADEN(5,5)*.005*ENR1(CH3)
ADEN(13,5)=ADEN(5,5)*.005*(1.-ENR1(CH3))
C
C  CALL THE NEUTRONIC SUBROUTINE.
C
WRITE OUTPUT TAPE 3,700,XLEN,(RAD11(IK),IK=1,IZM)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,IZM),KJ=1,MCR)

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

MIST=0
CALL WDTF(EFFK,XLEN,RAD1,ADEN,MCR,IZM,MIST)
EFFK=EFFK
WRITE OUTPUT TAPE 3,779,EFFK
CALL POWM(PBW)
DO 325 I=3,5
PB=0.
DO 324 J=1,5
P(I,J)=PB*(5-(I-1)+J)
324 PB=P(I,J)+2.*R(I,J)*DRA(I)+PB
325 PBAR(I)=PB/(RAD1(I)+2-RAD1(I)-1)+2)
WRITE OUTPUT TAPE 3,350,((R(I,J),P(I,J),J=1,5),I=3,5)
WRITE OUTPUT TAPE 3,366, (PBAR(I),I=3,5)
366 FORMAT (1X,3E16.8)
Y3=0*(RAD1(5)+2-RAD1(2)+2)/(1.67*Y1+.33)*(RAD1(3)+2-RAD1(2)
1)+2)+(1.67*Y2+.33)*(RAD1(4)+2-RAD1(3)+2)+(RAD1(5)+2-RAD1(4)
2)+2)
C
C SET THE DEPENDENT VARIABLE FOR THE BURNUP ITERATION.
C ITERATE ON THE BURNUP.
C
FN3=EFFK
YL1=1.001=YL1
YL11=YL11+1.001
YL12=YL12+1.001
YL13=YL13+1.001
YL2=1.001=YL2
YL21=YL22=YL21=.999999
YL23=YL23+1.001
C
C NEWRAP IS THE NEWTON RAPHSON ITERATION SUBROUTINE. PREDICT THE
C NEXT TRIAL BURNUP.
C
CALL NEWRAP(KIT3,KMAX3,FN3,F03,CRIT3,Y3,YL13,YL23,DY13,DYMAX3,YA3,
1DLTA3)
IF (KAT-1).,221
C
C SET THE DEPENDENT VARIABLES FOR THE NEWRAP CALCULATIONS TO
C CALCULATE NEW ENRICHMENTS FOR THE NEXT TRIAL.
C
FN1=P(3,1)/P(5,1)
FN2=P(4,1)/P(5,1)
CALL NEWRAP(KIT1,KMAX1,FN1,F01,CRIT1,Y1,YL11,YL21,DY11,DYMAX1,YA1,
1DLTA1)
CALL NEWRAP(KIT2,KMAX2,FN2,F02,CRIT2,Y2,YL12,YL22,DY12,DYMAX2,YA2,

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

1DLTA2)
221 KTN1=5
KTN2=3
KTN3=3
GO TO 227
220 CALL NEWRAP(KIT,KMAX,FN,F0,CRIT,Y,YL1,YL2,DY1,DYMAX,YA,DLTA)
Y3=YA3-(Y3-YA3)*(-1,-.8*DLTA/DLTA3)
BU=Y3*(1.67*Y1+.33)*(RAD1(3)+2-RAD1(2)+2)+(1.67*Y2+.33)*(RAD1
1(4)+2-RAD1(3)+2)+(RAD1(5)+2-RAD1(4)+2)/(RAD1(5)+2-RAD1
2(2)+2)
GO TO (185,186)KAT
185 RFLCTR=Y
GO TO 187
186 G=Y
RFLCTR=2.5
187 RAD2=RAD1(2)
RAD5=RAD1(5)
C
C IF DESIGN CRITERIA HAVE NOT BEEN MET, GO BACK FOR ANOTHER TRIAL.
C
22 IF (KIT3-KMAX3)1.,.
C
C AT THIS POINT THE BASE CASE REACTOR (NOT- START-OF-LIFE) HAS BEEN
C DESIGNED. THIS SEQUENCE WILL CALL ADDITIONAL INFORMATION FROM THE
C NEUTRONIC SUBROUTINES.
C
CALL FINPR
CALL PCI
CALL S047
KTN1=1
KTN2=1
KTN3=4
RFLCTR=RFLCTR
C
C STRIP OFF THE REFLECTOR AND ADD IT IN INCREMENTS TO DETERMINE
C ITS EFFECT ON REACTIVITY. NOTE THAT THE SO CALLED ZERO THICKNESS
C REFLECTOR CASE ACTUALLY HAS IMM THICKNESS REFLECTOR SINCE THE DTF
C ROUTINE MUST SUBDIVIDE THIS INTO SUBINTERVALS AND MAKE A FULL ZONE
C CALCULATION.
C
DO 160 JLO=1,4
RFLCTR=FLOAT(JLO-1)*2./5.
RAD1(8)=RAD1(7)+RFLCTR*.1
WRITE OUTPUT TAPE 3,700,XLEN,(RAD1(IK),IK=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(IK),JK),JK=1,12M),KJ=1,MCR)

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RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

      CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
      EFFKB=EFFK
      DEFFK=EFFKB-EFFKA
      WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
      CALL POWN(POW)
      DO 345 I=3,5
      DO 345 J=1,5
345 P(I,J)=POW(5*(I-1)+J)
      WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)
      CALL FINPR
      CALL PCI
      CALL SB47
160 CONTINUE
      RFLCTR=RFLCTO
      RADII(8)=RADII(7)+RFLCTR+.1
      FLICO=FLIC
C
C      EMPTY AND FILL THE CONTROL TUBES TO DETERMINE THEIR EFFECTS.
C
      DO 170 KR=1,2
      FLIC=FLOAT(KR-1)*2.*FLICO
      ADEN(1,2)=.086801*RHOL1*(1.0931*RATL1+FLIC*RATL2)
      ADEN(2,2)=.086801*RHOL1*(1.0931*(1.-RATL1)+FLIC*(1.-RATL2))
      WRITE OUTPUT TAPE 3,700,XLEN,(RADII(K),K=1,IZM)
      WRITE OUTPUT TAPE 3,701,((ADEN(KJ),KJ=1,IZM),KJ=1,MCR)
      CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
      EFFKB=EFFK
      DEFFK=EFFKB-EFFKA
      WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
      CALL POWN(POW)
      DO 350 I=3,5
      DO 350 J=1,5
350 P(I,J)=POW(5*(I-1)+J)
      WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)
      CALL FINPR
      CALL PCI
      CALL SB47
170 CONTINUE
      FLIC=FLICO
      ADEN(1,2)=.086801*RHOL1*(1.0931*RATL1+FLIC*RATL2)
      ADEN(2,2)=.086801*RHOL1*(1.0931*(1.-RATL1)+FLIC*(1.-RATL2))
C
C      RECORD THE BASE CASE DIMENSIONS AND ATOM DENSITIES.
C
227 FFO=FF

```

```

      FSO=FS
      FSCO=FSC
      FCO=FC
      FCL=FCL
      RAD1=RADII(1)
      RAD2=RADII(2)
      RAD3=RADII(3)
      RAD4=RADII(4)
      RAD5=RADII(5)
      RAD6=RADII(6)
      RAD7=RADII(7)
      RAD8=RADII(8)
      XLENO=XLEN
      ROCORO=ROCOR
      R1CORO=R1COR
      R2CORO=R2COR
      R3CORO=R3COR
      THICKO=THICKS
      RHONO=RHON
      RHOTO=RHOT
      RHOMO=RHOM
      RHL160=RHL16
      RHOKLO=RHOKL
      RHOKGO=RHOKG
      RHALO=RHAL
      RHOUNO=RHOUN
      FF1=.99
      FF2=FF1**2
      DO 120 I=1,18
      DO 120 J=1,8
120 ADN(I,J)=ADEN(I,J)
      PI=.3.1415926
      TBAR=TSUP
C
C      SHUT THE REACTOR DOWN TO ROOM TEMPERATURE IN INCREMENTS. THIS IS A
C      ZERO POWER ISOTHERMAL CALCULATION, AND IT SHOULD BE NOTED THAT
C      THIS IS FAR FROM THE FULL STORY ON TEMPERATURE COEFFICIENTS.
C
      DO 144 KT=KTNI
      T1=TSUP-300.*FLOAT(KT-1)
      CALL RHOL(1,T1,RHL16)
      CALL RHOL(3,T1,RHOKL)
      ABON=(4.406+.2718E-5*TBAR)*1.E-6
      AB1M=(4.406+.2718E-5*T1)*1.E-6
      AB0U=(6.2477+3.391E-5*(SUP-7.843E-7*TSUP**2))*1.E-6

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RCTR A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

AB1U=16.247+3.591E-3+T1 7.843E-7+T1 **2)E 6
RAD1(1)=RAD1+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
RAD1(2)=RAD2+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
RAD1(3)=RAD3+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
RAD1(4)=RAD4+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
RAD1(5)=RAD5+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
RAD1(6)=RAD6+((+AB1U*(T1-293)))/(+AB0U*(TSHELL-293))
RAD1(7)=RAD7+((+AB1U*(T1-293)))/(+AB0U*(TSHELL-293))
RAD1(8)=RAD8+((+AB1U*(T1-293)))/(+AB0U*(TSHELL-293))
XLEN=XLENO+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
R2COR=R2CRO+((+AB1U*(T1-293)))/(+AB0U*(TBAR-293))
R3COR=R3CRO+((+AB1U*(T1-293)))/(+AB0
IT=(TSHELL-293)
FF=FFO+((+AB1U*(T1-293)))/(+AB0U*(TSUP-293))
193) **2)E 6
FS=FFO+FSO
FF
RHOM=RHOMO+((+AB0U*(TBAR-293)))/(+AB1U*(T1-293))
RHOUN=RHOUNO+((+AB0U*(TSHELL-293)))/(+AB1U*(T1-293))
RHOM=RHOMO+((+AB0U*(TSHELL-293)))/(+AB1U*(T1-293))
RHOT=RHOTO+((+AB0U*(TSHELL-293)))/(+AB1U*(T1-293))
FR6=RAD1(6)**2-RAD1(5)**2
THUK=THUK+RAD1(5)/RAD5
THOK=THOK+RAD1(5)/RAD5
FRA=((RAD1(5)+THOK)**2-RAD1(5)**2)/FR6
FRB=((RAD1(6)-2)**2-(RAD1(6)-THUK-2)**2)/FR6
FRD=(RAD1(6)**2-(RAD1(6)-2)**2)/FR6
FRC=1-FRA-FRB-FRD
ADEN(4,6)=C15407+RHOKL+FRD
ADEN(9,6)=0032764+RHOM=75+FRA
ADEN(8,6)=ADEN(9,6)/3
ADEN(16,6)=ADN(16,6)+RHOM/RHOMO
ADEN(5,6)=ADEN(16,6)**2
141 ADEN(1,1)=080187+RHOL+RATL1
ADEN(2,1)=086801+RHOL+RATL1
ADEN(1,2)=086801+RHOL+((0931+RATL1+FL1C+RATL2)
ADEN(2,2)=086801+RHOL+((0931+RATL1+FL1C+RATL2)
ADEN(9,2)=0024569+RHOM+((FL12)
ADEN(8,2)=ADEN(9,2)/3
ADEN(1,3)=086801+RHOL+((RATL1+FC+(FS+FS)=10*(ALP+1))
ADEN(2,3)=086801+RHOL+((RATL1+FC+(FS+FS)=10*(ALP+6))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
ADEN(9,3)=ADEN(9,4)+ADEN(9,5)=0032764+RHOM=75+FCL
ADEN(8,3)=ADEN(8,4)+ADEN(8,5)+ADEN(9,3)/3
ADEN(5,3)=ADEN(5,4)+ADEN(5,5)=0023897+RHOUN+FF

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RCTR A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

ADEN(7,7)=0033291+RHOT
ADEN(6,8)=0062783+RHOM
DO 130 I=3,5
ADEN(10,1)+ADN(10,1)+RHOUN+FF/(RHOUNO+FFO)
ADEN(11,1)+ADN(11,1)+RHOUN+FF/(RHOUNO+FFO)
130 ADEN(13,1)+ADN(13,1)+RHOUN+FF/(RHOUNO+FFO)
IF (KTN1-4).144
WRITE OUTPUT TAPE 3,700,XLEN,(RAD1(1K),K=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ),JK=1,12M),KJ=1,MCR)
CALL WDTFIEFK,XLEN,RAD1,ADEN,MCR,12M,MIST)
EFFK=EFFK
DEFFK=EFFK+DEFFK
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
144 CONTINUE
C
C AT THIS POINT THE REACTOR IS AT ROOM TEMPERATURE
C SET THE REFLECTOR EFFECTIVELY TO INFINITY FOR WATER SAFETY CALC-
C ULATIONS FIRST CHECK SIMPLE WATER IMERSION OF THE REACTOR WITH
C THE REFLECTOR REMOVED (IT IS ASSUMED HERE THAT THIS IS TO BE THE
C METHOD OF ACHIEVING WATER SAFETY INTERNAL SPECTRAL SHIFT POISONS
C SUCH AS FRACTIONS COULD
C ALSO BE USED NEXT LET WATER INTO THE CORE IN SOME LOGICAL
C SEQUENCE FINALLY REMOVE THE REACTOR FROM THE WATER KEEPING IT
C FILLED WITH WATER FOR THIS PURPOSE 15 CM IS EFFECTIVELY INFINITE
C THICKNESS
C
RFLCTR=15
RAD1(8)=RAD1(7)+RFLCTR+1
DO 145 KW=KTN2,KTN3
GO TO (440,430,420,410)KW
410 RFLCTR=0
RAD1(8)=RAD1(7)+RFLCTR+1
420 ADEN(3,2)=6+0335
ADEN(1,2)+ADEN(2,2)=0
ADEN(17,2)+ADEN(9,2)=2
ADEN(1,3)+ADEN(1,4)+ADEN(1,5)=0
ADEN(2,3)+ADEN(2,4)+ADEN(2,5)=0
ADEN(3,3)+ADEN(3,4)+ADEN(3,5)+((FS+FS+FC)=0335
ADEN(17,3)+ADEN(17,4)+ADEN(17,5)+ADEN(3,3)=2
430 ADEN(1,6)+ADEN(1,1)+ADEN(2,6)+ADEN(2,1)+ADEN(4,6)=0
ADEN(3,1)=0335
ADEN(17,1)+ADEN(3,1)=2
ADEN(3,6)+((FRC+FRD)=0335
ADEN(17,6)+ADEN(3,6)=2
ADEN(3,2)=0931+0335

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

ADEN(17,2)=ADEN(3,2)*2
ADEN(3,3)=ADEN(3,4)+ADEN(3,5)+FC* 0395
ADEN(17,3)=ADEN(17,4)+ADEN(17,5)+ADEN(3,3)*2
IF (KTNS-4)440,440,
ADEN(1,2)= 086801+RHOL1=(          FLIC=RATL12)
ADEN(2,2)= 086801+RHOL1=(          FLIC=11 -RATL12))
ADEN(1,3)= 086801+RHOL1=(          (FSC+FS)= 10*(ALP-1 1))
ADEN(2,3)= 086801+RHOL1=(          (FS+FSC)=1 1*(5 -ALP)+ 61))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
440 ADEN(6,0)=0
ADEN(3,0)= 0395
ADEN(17,0)=ADEN(3,0)*2
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(K),K=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(K,J),J=1,12M),K=1,MCR)
MIST=1
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,700,EFFK,DEFFK
CALL POWN(POW)
IF (KTNI-4),,145
CALL FINPR
CALL PCI
CALL S047
145 CONTINUE
FN=EFFKB-EFFKA* 04
RADII(1)=RAD1
RADII(2)=RAD2
RADII(3)=RAD3
RADII(4)=RAD4
RADII(5)=RAD5
RADII(6)=RAD6
RADII(7)=RAD7
RADII(8)=RAD8
XLEN=XLENO
R2COR=R2CORO
R3COR=R3CORO
RHOUN=RHOUNO
RHOM=RHOMO
RHOT=RHOTO
RHOM=RHOMO
RML16=RML16O
RHOKL=RHOKLO
RHOKG=RHOKGO

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

RHAL=RHALO
FF=FFO
FS=FSO
FSC=FSCO
FC=FCO
FCL=FCLO
DO 225 I=1,MCR
DO 225 J=1,12M
225 ADEN(I,J)=ADN(I,J)
IF (KTNI-4),,220
146 CONTINUE
C
C BEGIN LIFETIME DEPENDENT CALCULATIONS THE BURNUP AND PRODUCTION
C OF FISSILE SPECIES WILL BE ESTIMATED BY SIMPLE MOTHER-DAUGHTER
C CALCULATIONS USING APPROXIMATE ONE GROUP DIFFUSION CROSS SECTIONS
C START, MID, AND END OF LIFE STATES ARE SEPARATELY ANALYZED FOR THE
C EFFECTS OF FUEL SWELLING, CORE COMPRESSION, AND VARIOUS TEMPERATURE
C INDUCED PERTURBATIONS
C
DO 150 KLIF=1,5 ,2
DO 127 II=1,10
DO 127 JJ=1,0
127 ADEN(II,JJ)=ADN(II,JJ)
AKLIF=FL0ATF(KLIF-1)
TAU=HRLIF=AKLIF/4
IF (TAU)25,25,
MIST=0
DO 125 I=3,5
O =3 1E16*QNTM/(PI=RSCOR=2=CORL)
PHI=Q/(ADN(10,1)+2 194*ADN(11,1)+1 421*ADN(13,1)+ 1316)
B5=PHI= 1731E-24
G3=PHI=2 367E-24
G4=PHI= 9692E-24
G5=PHI=1 6988E-24+3 13E-17
G6=PHI= 4247E-24+9 32E-16
B5=PHI= 2778E-24
GA=PHI= 2932E-24+4 94E-10
GB=PHI= 2881E-24+4 92E-4
GC=3 41E-6
GD=PHI=2 0595E-24+9 15E-13
BA=PHI= 1616E-24
BB=4 92E-4
BC=3 41E-6
ADEN(10,1)=ADN(10,1)+(1 - 25*BU=AKLIF=2 567*ADN(10,1)/(ADN(10,1)+
12 194*ADN(11,1)+1 421*ADN(13,1)+ 1316))

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

ADEN(1,1)=ADN(1,1)/(1-.25*BU*AKLIF=1.421*ADN(1,1)/(ADN(10,1)+
12.194*ADN(1,1)+1.421*ADN(15,1)+.1516)
ADEN(15,1)=ADN(15,1)/(1-.25*BU*AKLIF=.1516*ADN(15,1)/(ADN(10,1)+
12.194*ADN(1,1)+1.421*ADN(15,1)+.1516)
ADENS=ADN(10,1)
ADEN(15,1)=ADENS*(B5/(G4-G5))=(EXP(-G5*TAU)-EXP(-G4*TAU))
ADENS=ADN(1,1)
ADEN(12,1)=ADENS*(B5/(G6-G5))=(EXP(-G5*TAU)-EXP(-G6*TAU))
ADENS=ADN(15,1)
125 ADEN(14,1)=ADENS*B4*B5/(G8-GA)=(GC-GA)=(GC-GB)=(GD-GA)=(GD-GC)
1)=(GC-GB)=(GD-GC)=(EXP(-GA*TAU)-EXP(-GD*TAU))-(GC-GA)=(EXP(-
2GC*TAU)-EXP(-GD*TAU))-(GC-GA)=(GD-GC)=(EXP(-GB*TAU)-EXP(-GD
3TAU))-(GD-GB)=(EXP(-GC*TAU)-EXP(-GD*TAU)))
GO TO 26
25 DO 126 I=3,5
ADEN(12,I)=0.
126 ADEN(14,I)=0.
C
C ACCOUNT FOR FUEL SWELLING BY DECREASING THE BONDING FLUID FRACTION
C
26 FS=FS0*(1.-AKLIF)/4.
FF=FF0+FS0-FS
ADEN(1,5)=.086787*RHOL*(RATL[I]=FC+(FS*F5)=.10*(ALP-1,1)
ADEN(2,5)=.086787*RHOL*(1.-RATL[I]=FC+(FS*F5)=.1*(5.-ALP)+.61)
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
IF(TAU) ., .69
DO 696 IE=1,2
MIST=IE-1
69 WRITE OUTPUT TAPE 3,700,XLEN,(RADII(IK),IK=1,12M)
WRITE OUTPUT TAPE 3,697,MIST
697 FORMAT(10X,6MIST =,15/)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,12M),KJ=1,MCR)
696 CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
CALL POWH(POW)
DO 335 J=3,5
DO 335 J=1,5
335 P(I,J)=POW(5)=(-1)+J)
WRITE OUTPUT TAPE 3,330,((R(I,J),P(I,J),J=1,5),I=3,5)
CALL FINPR
CALL PCI
CALL 5847

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

8 KKZ=0
IF (KRFL),,9
C
C IF THE REFLECTOR IS TO COMPENSATE FOR THE LIFETIME EFFECTS FIND THE
C THICKNESS. IF NOT PROCEED TO STATEMENT 9.
C
KIT=0
KMAX=25
FD=XKEFFD
CRIT=.001
Y=REFLCTR
YL1=-4.
YL2=10.
DY1=1.
DY1=.5
DYMAX=2.
2 CONTINUE
RADII(8)=RADII(7)+REFLCTR+.1
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(IK),IK=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,12M),KJ=1,MCR)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
WRITE OUTPUT TAPE 3,779,EFFK
FN=EFFK
EFFKB=EFFK
CALL NEWRAP(KIT,KMAX,FN,FD,CRIT,Y,YL1,YL2,DY1,DYMAX,YA,DLTA)
IF (Y) 3,3,4
3 KKZ=KKZ+1
IF (KKZ-1)5,5,6
5 REFLCTR=.001
GO TO 2
6 XKEFFD=XKEFFD-.01
GO TO 11
4 REFLCTR=Y
IF (KIT-KMAX)2,,
C
C SQUEEZE THE CORE 1 PERCENT RADIIALLY TO FIND THE EFFECT OF FLUID
C PRESSURE FLUCTUATIONS ON REACTIVITY. THIS REPRESENTS A PRESSURE
C PULSE ORDERS OF MAGNITUDE TOO HIGH BUT IS NECESSARY TO DETERMINE
C THE EFFECT.
C
9 FP1=.99
FP2=.99**2
FP3=(1.-(FF+FCL)/FP2)/(1.-FF-FCL)
DO 431 I=3,5
RADII(I)=RADII(I)+FP1

```

RCTR A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

ADEN(1,1)=ADEN(1,1)*FP3
ADEN(2,1)=ADEN(2,1)*FP3
ADEN(5,1)=ADEN(5,1)/FP2
DO 431 J=8,15
431 ADEN(J,1)=ADEN(J,1)/FP2
ADEN(9,2)=ADEN(9,2)/FP2
ADEN(8,2)=ADEN(9,2)/3
RADII(2)=RADII(2)*FP1
THUK= 4
THOK= 3
FR6=RADII(6)**2/RADII(5)**2
FRA=((RADII(5)+THOK)**2-RADII(5)**2)/FR6
FRB=((RADII(6)-2)**2-(RADII(6)-THUK-2)**2)/FR6
FRD=(RADII(6)**2-(RADII(6)-2)**2)/FR6
FRC=1 FRA-FRB-FRD
ADEN(1,6)= 086801*RHOL1=FRC*RATL11
ADEN(2,6)= 086801*RHOL1=FRC*(1-RATL11)
ADEN(4,6)= 015407*RHOKL=FRD
ADEN(9,6)= 0032764*RHOM=75*FRA
ADEN(8,6)=ADEN(9,6)/3
ADEN(16,6)= 0028613*9 68*FRB
ADEN(5,6)=ADEN(16,6)*2
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(K),K=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,K),K=1,12M),KJ=1,MCR)
CALL NDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKB=EFFK
DEFFK=EFFKB-EFFKA
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
DO 432 I=3,5
RADII(I)=RADII(I)/FP1
ADEN(1,I)=ADEN(1,I)/FP3
ADEN(2,I)=ADEN(2,I)/FP3
ADEN(5,I)=ADEN(5,I)*FP2
DO 432 J=8,15
432 ADEN(J,I)=ADEN(J,I)*FP2
ADEN(9,2)=ADEN(9,2)*FP2
ADEN(8,2)=ADEN(9,2)/3
RADII(2)=RADII(2)/FP1
FR6=RADII(6)**2-RADII(5)**2
FRA=((RADII(5)+THOK)**2-RADII(5)**2)/FR6
FRB=((RADII(6)-2)**2-(RADII(6)-THUK-2)**2)/FR6
FRD=(RADII(6)**2-(RADII(6)-2)**2)/FR6
FRC=1 FRA-FRB-FRD
ADEN(1,6)= 086801*RHOL1=FRC*RATL11
ADEN(2,6)= 086801*RHOL1=FRC*(1-RATL11)

```

RCTR A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS

```

ADEN(4,6)= 015407*RHOKL=FRD
ADEN(9,6)= 0032764*RHOM=75*FRA
ADEN(8,6)=ADEN(9,6)/3
ADEN(16,6)= 0028613*9 68*FRB
ADEN(5,6)=ADEN(16,6)*2
C
C DETERMINE THE EFFECT OF TEMPERATURE SHIFTS IN FUEL, PRIMARY COOLANT
C IN THE COOLANT CHANNELS, CLAD AND BONDING FLUID, AND BIAS (1) E
C ON COOLANT TEMPERATURE SHIFTS BEFORE THE COOLANT ENTERS THE
C CORE THIS SEPARATION OF EFFECTS IS NECESSARY SINCE THERE WILL
C WILL BE BOTH AMPLITUDE AND PHASE SHIFTS IN A POWER INDUCED TEMPERA-
C TURE OSCILLATION AS IT PROGRESSES THROUGH THE CORE
C A TEMPERATURE RISE OF 100 K IS USED TO OBTAIN A LARGE ENOUGH
C CHANGE IN THE MULTIPLICATION FACTOR FOR ANALYSIS
C
DTPR=100
FF1=FF=1 +AUN=DTPR1**3
FS1=FS
C
C THE EFFECT OF A FUEL TEMPERATURE RISE IS FIRST SEEN AS A FUEL
C SHELING REDUCING THE BONDING FLUID FRACTION
C
FS=1 -FCL-FF1-FSC-FC
ADEN(1,3)= 086801*RHOL1=(RATL11*FC+(FSC+FS)= 10*(ALP-1))
ADEN(2,3)= 086801*RHOL1=((1-RATL11)*FC+(FS+FSC)= 1*(5-ALP)+6))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(K),K=1,12M)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,K),K=1,12M),KJ=1,MCR)
CALL NDTF(EFFK,XLEN,RADII,ADEN,MCR,12M,MIST)
EFFKC=EFFK
DEFFK=EFFKC-EFFKB
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK
FS=FS1
C
C EXAMINE THE EFFECT OF TEMPERATURE RISES ORIGINATING IN THE CORE
C ON THE COOLANT BY DECREASING THE COOLANT DENSITY THIS EFFECT IS
C DIFFERENT FROM AN INLET TEMPERATURE RISE WHICH WILL EFFECT THE EN-
C TIME CORE TEMPERATURE PROFILE
C
RHOL1=RHOL1/(1+AL1*DTPR1)**3
ADEN(1,3)= 086801*(RATL11*RHOL11*FC+RHOL1 = 10*(FSC+FS)= (ALP-1))
ADEN(2,3)= 086801*((1-RATL11)*RHOL11*FC+RHOL1 = (FS+FSC)= 1*(5-
1ALP)+6))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

ADEN(2,4)=ADEN(2,5)=ADEN(2,3)
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(IK),IK=1,IZM)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,IZM),KJ=1,MCR)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
EFFKC=EFFK
DEFFK=EFFKC-EFFKB
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK

```

C DETERMINE THE EFFECT OF A CLAD, STAGNANT COOLANT, AND BONDING FLUID
C TEMPERATURE RISE. THE BONDING FLUID WILL FOLLOW THE CLAD TEMPERA-
C TURE MORE CLOSELY THAN THAT OF THE FUEL IN A TEMPERATURE FLUCTUA-
C TION. THE COEFFICIENTS FOR THESE EFFECTS MAY AT TIMES BE POSITIVE.
C THIS DOES NOT MEAN THAT THE REACTOR IS UNSTABLE NECESSARILY. THIS
C MUST BE DETERMINED FROM A SEPARATE CONTROL STUDY WHICH IS NOT
C INCLUDED IN THIS CODE.

```

FMT=1.+AM=OTPR
XLEN=XLEN+FMT
DO 434 I=1,5
434 RADII(I)=RADII(I)+FMT
XFUEL=FF/FF1
DO 435 I=10,15
DO 435 J=3,5
435 ADEN(I,J)=ADEN(I,J)+XFUEL
FS1=FS
FF1=FF
FF=FF/FMT**3
FS=1.-FF-FCL-FSC-FC
ADEN(9,2)=.0024569*RHOM*(1.-FLI2)/FMT**3
ADEN(8,2)=ADEN(9,2)/5.
ADEN(9,3)=.0024569*RHOM*FCL/FMT**3
ADEN(9,4)=ADEN(9,3)+ADEN(9,3)
ADEN(8,3)=ADEN(8,4)+ADEN(8,5)+ADEN(9,3)/5.
ADEN(1,3)=.086801*(RATL1+RHOL1)*FC+RHOL1*(10*(FSC+FS)+(ALP-1.))
ADEN(2,3)=.086801*((1.-RATL1)*RHOL1)*FC+RHOL1*(FS+FSC)*(1+(5.-ALP)*.6))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
ADEN(5,3)=.00240343*RHOUN*FFO/FMT**3
ADEN(5,4)=ADEN(5,5)+ADEN(5,3)
ADEN(1,2)=.086801*RHOL1*(.0931*RATL1+FLIC+RATL2)/FMT**2
ADEN(2,2)=.086801*RHOL1*(.0931*(1.-RATL1)+FLIC*(1.-RATL2))/FMT**2
FR6=RADII(6)**2-RADII(5)**2
FRA=((RADII(5)+THOK)**2-RADII(5)**2)/FR6

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

FRB=((RADII(6)-.2)**2-(RADII(6)-THUK-.2)**2)/FR6
FRD=((RADII(6)**2-(RADII(6)-.2)**2)/FR6
FRC=1.-FRA-FRB-FRD
ADEN(1,6)=.086801*RHOL1*FRC=RATL1
ADEN(2,6)=.086801*RHOL1*FRC=(1.-RATL1)
ADEN(4,6)=.015407*RHOKL=FRD
ADEN(9,6)=.0032764*RHOM=.75*FRA
ADEN(8,6)=ADEN(9,6)/5.
ADEN(16,6)=.0028613*9.68*FRB
ADEN(3,6)=ADEN(16,6)*2.
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(IK),IK=1,IZM)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,IZM),KJ=1,MCR)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
EFFKC=EFFK
DEFFK=EFFKC-EFFKB
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK

```

C DETERMINE THE EFFECT OF THE BIAS TYPE OF COOLANT TEMPERATURE RISE
C DUE TO PHENOMENA OCCURRING OUTSIDE OF THE REACTOR.

```

RHOL1=RHOL1
FF=FF1+FMT**3/(1.+AUN=OTPR)**3
FS=FS1+FF1-FF
ADEN(1,1)=.086801*RHOL1=RATL1
ADEN(2,1)=.086801*RHOL1=(1.-RATL1)
ADEN(1,2)=.086801*RHOL1*(.0931*RATL1+FLIC+RATL2)
ADEN(2,2)=.086801*RHOL1*(.0931*(1.-RATL1)+FLIC*(1.-RATL2))
ADEN(1,3)=.086801*RHOL1*(RATL1+FC*(FSC+FS)*(10*(ALP-1.))
ADEN(1,4)=ADEN(1,5)+ADEN(1,3)
ADEN(2,3)=.086801*RHOL1*((1.-RATL1)*FC*(FSC+FS)*(1+(5.-ALP)*.6))
ADEN(2,4)=ADEN(2,5)+ADEN(2,3)
ADEN(1,6)=.086801*RHOL1*FRC=RATL1
ADEN(2,6)=.086801*RHOL1*FRC=(1.-RATL1)
WRITE OUTPUT TAPE 3,700,XLEN,(RADII(IK),IK=1,IZM)
WRITE OUTPUT TAPE 3,701,((ADEN(KJ,JK),JK=1,IZM),KJ=1,MCR)
CALL WDTF(EFFK,XLEN,RADII,ADEN,MCR,IZM,MIST)
EFFKC=EFFK
DEFFK=EFFKC-EFFKB
WRITE OUTPUT TAPE 3,780,EFFK,DEFFK

```

C BRING THE REACTOR BACK TO ITS BASE CONDITION PRIOR TO COMPUTING
C THE NEXT SET OF LIFETIME DEPENDENT EFFECTS.

```

RADII(1)=RAD1
RADII(2)=RAD2

```

RCTR - A DESIGN AND ANALYSIS SEQUENCE FOR CONVECTIVELY COOLED REACTORS.

```

RADII(3)=RAD3
RADII(4)=RAD4
RADII(5)=RAD5
RADII(6)=RAD6
RADII(7)=RAD7
RADII(8)=RAD8
XLEN=XLENO
R2COR=R2CRO
R3COR=R3CRO
RHOUN=RHOUNO
RHOM=RHOMO
RHOT=RHOTO
RHOM=RHOMO
RHL16=RHL16O
RHOKL=RHOKLO
RHOKG=RHOKGO
RHAL=RHALO
FF=FFO
FS=FSO
FSC=FSCO
FC=FCO
FCL=FCLO
DO 289 I=1,MCR
DO 289 J=1,IZM
289 ADEN(I,J)=ADN(I,J)
150 CONTINUE
CALL EXIT
END

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

*      FORTRAN      REACT
MULTIPLE ARGS TRAMP,VISL,TCNL,CSPL,RHOL,RESL,TENS,PRANL,VISG,TCNG,
!CSPG,RHOG,PRANG,SONV,PSAT,MAP
SUBROUTINE REACT
COMMON / RCTR/ BU,NTYPE,G,B,FF,FS,FCL,FC,FSC,RSCOR,OM,TM,HRLIF,
1 ELPCR,RFUEL,TSTRES,PSY,R1,DH,NLM,TS,FSTRES,PSIDRP,CORDEN,NTCOR,
2 CORL,TEMRI,TPR,MODE,CCF,CCF1,CCF2,CCF3,ROCOR,RICOR,RZCOR,R3COR,
3 RTNDRP,ELPD,DP,TSMELL,TSUP,PIN,THICKS,THICKSP,RHOS,RHOSP,EMS,EMSP,
4 CONS,CONSP,DR,SSP,MTSML,MTSUP,MTLI,NTRCTR,MTU,RLCTR,RHOR,FUELON,
5 TBAR,ABUN,AUN,RHOUN,CONDUN,CPUN,EUN,GUUN,AN,RHON,CONDN,CPW,ALI,
6 RHOLI,CONDLI,VISCLI,CPLI,CAF2,XNO1,XNO2,XNO3,XNO4,XNO5,XNO6,XNO7
7,JP,NRSA,NIA,GAP
C      THIS SUBROUTINE REACT PROVIDES AN ENGINEERING DESIGN FOR A CONVEC-
C      TIVELY COOLED REACTOR.
C      THIS SUBROUTINE CALCULATES APPROXIMATE DIMENSIONS AND WEIGHTS FOR
C      A LITHIUM COOLED, UN FUELED, W STRUCTURED, CENTRAL RETURN
C      REACTOR BASED ON REACTOR THERMAL POWER AND LIFE. IT IS FOR SURVEY
C      PURPOSES ONLY AND CONTAINS NO NEUTRONICS. THERE ARE SLIGHT INCONSI-
C      STENCIES IN DIMENSIONS. NTYPE=1 REFERS TO PIN TYPE A, 2 TO PIN TYPE
C      B, 3 TO HYBRID, AND 4 TO HEX TUBE ELEMENTS. IN MODE 1 A SPACING TY-
C      PE PARAMETER IS SPECIFIED (B) AND A FUEL VOLUME FRACTION IS CALCUL-
C      ATED. MATHEMATICAL LIMITS AND RECOMMENDED RANGES ARE: (APPROX)
C      NTYPE      B LIM      B REC      G LIM      G REC      FF LIM      FF REC
C      1          0.1547      .25-.5      0-1.      .1-.15      .906      .6-.4
C      2          0          0-.10      0-1.      .1-.15      .906      .7-.4
C      3          0-1.      .1-.15      0-1.      .1-.2      .605      .44-.48
C      4          G          .5-.7      0-1.      .1-.2      .3-.8
C      IN MODE 2 A FUEL VOLUME FRACTION IS SPECIFIED (AT TIME ZERO). A IS
C      A LINEAR SWELLING ALLOWANCE. OMTH IS THE THERMAL POWER (MW). HRLIF
C      IS THE LIFE IN MRS. ELPD IS THE REACTOR LENGTH TO DIAMETER. TSTRES
C      IS THE PERMISSIBLE FUEL THERMAL STRESS (PSI). TEMRI IS THE KELVIN
C      TEMPERATURE RISE OF THE COOLANT THROUGH THE CORE. TSUP IS THE MAXI-
C      MUM RANKINE TEMPERATURE OF THE SYSTEM. TSMELL IS THE RANKINE TEMP.
C      OF THE VESSEL. PIN IS THE MAXIMUM SYSTEM PRESSURE (PSI). DR IS A
C      THERMAL LAG SWELLING ALLOWANCE BETWEEN DUCT AND CORE. OTHER QUANTI-
C      TIES ARE,
C      CCF-CENTRAL COOLANT FRACTION
C      FF-FUEL VOLUME FRACTION OF ACTIVE CORE AT TIME ZERO
C      FCL-CLAD VOLUME FRACTION OF ACTIVE CORE
C      FS+ SWELLING VOLUME FRACTION OF ACTIVE CORE (LI AT TIME ZERO)
C      FC- PRIMARY COOLANT FRACTION OF ACTIVE CORE
C      RSCOR=RADIUS OF EQUIVALENT SOLID CORE (CM)
C      ROCOR=RADIUS OF CENTRAL RETURN (CM)
C      RICOR=INNER RADIUS OF ACTIVE CORE (CM)
C      R2COR=OUTER RADIUS OF ACTIVE CORE (CM)

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

C      R3COR=INNER RADIUS OF PRESSURE VESSEL (CM)
C      RFUEL=RADIUS OF FUEL MATERIAL (CM)+BORE FOR NTYPE=4
C      R1=RADIUS OF FUEL + CLAD OR OUTER RADIUS FOR NTYPE=4
C      DH=HYDRAULIC DIAMETER (CM)
C      NLMTS=NUMBER OF FUEL ELEMENTS
C      PSIDRP=CORE FRICTION LOSS PSI
C      DP=CORE PRESSURE DROP INCLUDING RETURN =1.2
C      NTCOR=CORE HEIGHT LESS LI (KG)
C      MTSML=PRESSURE VESSEL WEIGHT (KG)
C      MTLI=TOTAL LI IN PRESSURE VESSEL (KG)
C      MTSUP=SUPPORT WEIGHT (KG)
C      MTSTR=STRUCTURE WEIGHT
C      MTU=FUEL WEIGHT (KG)
C      NTRCTR= TOTAL REACTOR WEIGHT LESS REFLECTOR AND CONTROLS
C      INPUT QUANTITIES WHICH MUST BE SPECIFIED ARE
C      OMTH,HRLIF,TSUP,TSMELL,BU,PIN,ELPD,DR,CCF,CCF2,RLCTR,RHOR,
C      NTYPE,G,MODE,B OR FF (MODE=1 AND B SPECIFICATION ARE
C      TO BE PREFERRED )
C      PI=3.1415927
C      TSUR=TSUP+1.8
C      TSMR=TSMELL+1.8
C      FUELON=.97
C      TBAR=TSUP-TEMRI/5.2
C      ABUN=(6.2477+3.391E-5*TSUP-7.843E-7*TSUP**2)*1.E-6
C      AUN=(6.2477+6.702E-5*TSUP-23.529E-7*TSUP**2)*1.E-6
C      RHOUN=(4.32+FUELON/(1.+ABUN*(TSUP-293.1))**3
C      CONDUN=-28.525/TSUP+.25423+2.2196E-5*TSUP
C      CPUN=(35.73+4.979E-5*TSUP-8.786E-5*TSUP**2)/250.6
C      EUN=31.E6
C      GUUN=.1
C      PSY=AUN+EUN/(B.*CONDUN*(1.-GUUN))
C      AN=(4.326+.5437E-3*TBAR)*1.E-6
C      RHON=(9.5/(1.+14.246+2.718E-4*TBAR))*(TBAR-293.1)*1.E-6)**3
C      CPW=.134
C      ALI=3.928E-5
C      CONDN=1.76*EXP(-.519E-3*TBAR)
C      CALL RHOLI(JP,TBAR,RHOLI)
C      CALL TCNL(JP,TBAR,CONDLI)
C      CALL VISLI(JP,TBAR,VISCLI)
C      CALL CSPL(JP,TBAR,CPLI)
C      100 A=2.*BU
C      102 GO TO (1,2,3,4)NTYPE
C
C      THIS SECTION IS REPEATED FOUR TIMES. THE CALCULATIONS ARE THE SAME
C      EXCEPT FOR MINOR MODIFICATIONS FOR EACH OF THE FOUR FUEL ELEMENT

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

C TYPES.THESE SECTIONS COULD EASILY BE REPLACED BY THOSE FOR OTHER
 C TYPES.FIRST THE VOLUME FRACTIONS ARE CALCULATED. CORE DIMENSIONS
 C ARE CALCULATED FIRST FOR A SOLID CORE AND THEN MODIFIED TO ACCOUNT
 C FOR THE CENTRAL RETURN IF ANY.FUEL ELEMENT SIZE IS DETERMINED ON
 C THE BASIS OF ALLOWABLE STRESS. OTHER CRITERIA COULD BE USED AS IN
 C THE HEAT PIPE VERSION. SUBROUTINE ELMTS IS THEN CALLED TO REVISE
 C THESE FUEL ELEMENT DIMENSIONS TO CONFORM TO THE DODECAGONAL GEO-
 C METRY THAT FITS MOST EASILY INTO THE HEXAGONAL ARRAY USED FOR THESE
 C FUEL ELEMENT TYPES. THERMAL RESISTANCES ARE THEN CALCULATED
 C TOGETHER WITH THERMAL CAPACITANCES FOR TIME CONSTANT CALCULATIONS.
 C REYNOLDS NUMBER, PRESSURE DROP, WEIGHTS ETC. ARE THEN CALCULATED.
 C HBAR IS A HEAT TRANSFER COEFFICIENT CALCULATED FOR A SLUG FLOW
 C MODEL THAT HAS BEEN FOUND HELPFUL IN THIS REGIME.

```

1 GO TO (10,11)MODE
10 FF=1.2091996*((1.-G)/(1.+B))**2/(1.+A)**3
   GO TO 12
11 B=SQRTF(1.2091996/(FF*(1.+A)**3))*(1.-G)-1.
12 FCL=2.4183992*(G+2.+B-G-1.5+G**2)/(1.+B)**2
   FS=((1.+A)**3-1.)/FF
   FC=(1.-FF-FCL-FS)
   FSC=0.
   CCF1=CCF=FC
   CCF2=MAX1F(CCF2,CCF1)
   XN03=1.+CCF2
   CCF3=SQRTF(XN03)
   ELPDCR=ELPD=CCF3
   RSCOR=.1978*(QMTM*HRLIF/(BU*FF*RHOUN=ELPD(CR)))**(.1/.3.1)
   XN04=TSTRES=RSCOR**3=ELPD(CR*FF/(PSY*QMTM))
   RFUEL=.00251=SQRTF(XN04)
   NLMTS=FF*(RSCOR/RFUEL)**2*(1.+A)
   WRITE OUTPUT TAPE 3,604,TSTRES,NLMTS,CCF2
   CAF2=CCF2
   NL=NLMTS
   CALL ELMTS (NL,CAF2,NRSA,NIA)
   CCF2=CAF2
   NLMTS=NL
   ANLMTS=NLMTS
   XN03=1.+CCF2
   CCF3=SQRTF(XN03)
   ELPDCR=ELPD=CCF3
   RSCOR=.1978*(QMTM*HRLIF/(BU*FF*RHOUN=ELPD(CR)))**(.1/.3.1)
   XN05=ANLMTS/(FF*(1.+A))
   RFUEL=RSCOR/SQRTF(XN05)
   TSTRES=RFUEL**2*PSY*QMTM/(.00251)**2=RSCOR**3=ELPD(CR*FF)

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

WRITE OUTPUT TAPE 3,605,TSTRES,NLMTS,NRSA,NIA
R1=RFUEL*(1.+A)/(1.-G)
DH=R1*(1.+B)**2/(1.5+2.+B-G)=1.5*SQRTF(3.1/3.1415927*FC)
PH=6.2832*ANLMTS=R1
HBAR=B.*CONDL1/DH
CAPF=P1=RHOUN=CPUN=RFUEL**2
CAPCL=P1=(RHOUN=CPH=R1**2*(2.+G-G**2)+RHOL1=CP1=RFUEL**2*(2.+A+A**
121)
RSIST1=1./(B.*P1=CONDU1)
RSIST2=A/(2.+P1=CONDL1*(1.+5*A))
RSIST3=G/(4.+P1=CONDM*(1.-.75*G))
RSIST4=G/(4.+P1=CONDM*(1.-.25*G))
RSIST5=1./(2.+P1=R1=HBAR)
QYOL=P1=RFUEL**2
RSISTH=.25/(P1=CONDU1)
GO TO 5

```

```

C
C
2 GO TO (20,21)MODE
20 FF=.9068997*((1.-G)/(1.+B))**2/(1.+A)**3
   GO TO 22
21 B=SQRTF(.9068997/(FF*(1.+A)**3))*(1.-G)-1.
22 FCL=2.7206991*(12.+G-G**2)/3.+B**2/(1.+B)**2
   FS=((1.+A)**3-1.)/FF
   FC=(1.-FF-FCL-FS)
   FSC=0.
   CCF1=CCF=FC
   CCF2=MAX1F(CCF2,CCF1)
   XN03=1.+CCF2
   CCF3=SQRTF(XN03)
   ELPDCR=ELPD=CCF3
   RSCOR=.1978*(QMTM*HRLIF/(BU*FF*RHOUN=ELPD(CR)))**(.1/.3.1)
   XN04=TSTRES=RSCOR**3=ELPD(CR*FF/(PSY*QMTM))
   RFUEL=.00251=SQRTF(XN04)
   NLMTS=FF*(RSCOR/RFUEL)**2*(1.+A)
   WRITE OUTPUT TAPE 3,604,TSTRES,NLMTS,CCF2
   CAF2=CCF2
   NL=NLMTS
   CALL ELMTS (NL,CAF2,NRSA,NIA)
   CCF2=CAF2
   NLMTS=NL
   ANLMTS=NLMTS
   XN03=1.+CCF2
   CCF3=SQRTF(XN03)
   ELPDCR=ELPD=CCF3

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

RSCOR= 1978*(QMTN*HRLIF/(BU*FF*RHOUN*ELPD(CR)))**((1/3))
XN05=ANLMTS/(FF*(1+A1))
RFUEL=RSCOR/SQRTF(XN05)
TSTRES=RFUEL**2*PSY*QMTN/( 00251**2*RSCOR**3*ELPD(CR*FF))
WRITE OUTPUT TAPE 3,605,TSTRES,NLMTS,NRSA,NIA
RI=RFUEL*(1+A1)/(1-G)
DH=R1*4/(SQRTF(3))**3 14159271*(1+01)**2/(1/3+01)*FC
PH=6 2832*ANLMTS*R1
HBAR=8 *CONDL/DH
CAPL=P1*RHOUN*CPUN*RFUEL**2
CAPCL=P1*(RHOUN*CPUN*R1**2*(2-G-G**2)+RHOL*(CPL1*RFUEL**2*(2+A+A**2)))
RSIST1=1/(8*PI*CONDUN)
RSIST2=A/(12*PI*CONDL*(1+5*A1))
RSIST3=G/(14*PI*CONDUN*(1-75*G))
RSIST4=G/(14*PI*CONDUN*(1-25*G))
RSIST5=1/(12*PI*R1*HBAR)
QYDL=P1*RFUEL**2
RSISTH= 25/(PI*CONDUN)
GO TO 5
C
C
3 GO TO (30,31)MODE
30 FF= 60459979*(1-B1)**2/(1+A1)**3
GO TO 32
31 B=1-SQRTF((FF*(1+A1)**3)/ 60459979)
32 FCL= 60459979*(G-5*G**2+2*B-B**2)
FS=((1+A1)**3-1)*FF
FSC= 0931003
FC= 9068997-FF FCL-FS
CCF1=CCF*FC
CCF2=MAX1F(CCF2,CCF1)
XN03=1+CCF2
CCF3=SQRTF(XN03)
ELPD(CR*ELPD)=CCF3
RSCOR= 1978*(QMTN*HRLIF/(BU*FF*RHOUN*ELPD(CR)))**((1/3))
XN04=TSTRES*RSCOR**3*ELPD(CR*FF)/(PSY*QMTN)
RFUEL= 00251/SQRTF(XN04)
NLMTS=FF*(RSCOR/RFUEL)**2*(1+A1)
WRITE OUTPUT TAPE 3,604,TSTRES,NLMTS,CCF2
LLMTS=3*NLMTS/2
NL=LLMTS
CAF2=CCF2
CALL ELMTS (NL,CAF2,NRSA,NIA)
CCF2=CAF2

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

LLMTS=NL
NLMTS=2*LLMTS/3
ANLMTS=NLMTS
XN03=1+CCF2
CCF3=SQRTF(XN03)
ELPD(CR*ELPD)=CCF3
RSCOR= 1978*(QMTN*HRLIF/(BU*FF*RHOUN*ELPD(CR)))**((1/3))
XN05=ANLMTS/(FF*(1+A1))
RFUEL=RSCOR/SQRTF(XN05)
TSTRES=RFUEL**2*PSY*QMTN/( 00251**2*RSCOR**3*ELPD(CR*FF))
WRITE OUTPUT TAPE 3,605,TSTRES,NLMTS,NRSA,NIA
RI=RFUEL*(1+A1)/(1-B)
DH=2 *R1*(1-G)
PH=3 1416*ANLMTS*R1*(1-G)
HBAR=8 *CONDL/DH
CAPL= 8660255*R1**2*RHOUN*CPUN*FF
CAPCL= 8660255*R1**2*(RHOL*(CPL1*(FS+FSC)+RHOUN*CPUN*FCL))
RSIST1= 75/(PI*CONDUN)
RSIST2=3 *A/(PI*CONDL*(1+A1))
RSIST3=3 *B/(PI*CONDUN*(1-5*B))+3 152*B/(PI*CONDL*(1+5*B))
RSIST4=6 *G/(PI*CONDUN*(1-5*G))
RSIST5=6 /(PI*R1*(1-G)*HBAR)
QYDL=P1*RFUEL**2/6
RSISTH=1 5/(PI*CONDUN)
GO TO 5
C
C
4 GO TO (40,41)MODE
40 FF=(1-10 882796*B**2/12)/(1+A1)**3
GO TO 42
41 B=SQRTF((1-FF*(1+A1)**3)/12/10 882796)
42 FCL= 9068997*B**2*(2-G-G**2)
FS=((1+A1)**3-1)*FF
FSC=0
FC=1 FF-FCL FS
CCF1=CCF*FC
CCF2=MAX1F(CCF2,CCF1)
XN03=1+CCF2
CCF3=SQRTF(XN03)
ELPD(CR*ELPD)=CCF3
RSCOR= 1978*(QMTN*HRLIF/(BU*FF*RHOUN*ELPD(CR)))**((1/3))
H=0*PI/(12 *SQRTF(3))
FSTRES=(-2 *LOGF(H**2)-((1-H**2)*(3 H**2))/(H**2*(1-H**2)))
XN06=TSTRES*RSCOR**3*ELPD(CR*FF)/(PSY*QMTN*FSTRES)
RFUEL= 00251/SQRTF(XN06)

```


REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

DM=2 *RFUEL*(1 -G)
NLMTS=FC*(RSCOR/DM+2 )**2
WRITE OUTPUT TAPE 3,604,TSTRES,NLMTS,CCF2
CAF2=CCF2
NL=NLMTS
CALL ELMTS (NL,CAF2,NRSA,NIA)
CCF2=CAF2
NLMTS=NL
ANLMTS=NLMTS
XNO3=1 +CCF2
CCF3=SQRTF(XNO3)
ELPDOR=ELPD*(CF3)
RSCOR= 1978*(QMTW*HRLIF/(BU*FF*RHOUN*ELPDOR))**((1 /3 )
XNO7=FC/ANLMTS
DM=RSCOR+2 *SQRTF(XNO7)
RFUEL=DM/(2 *(1 -G))
TSTRES=RFUEL**2*PSY*QMTW*TSTRES/( 0025**2*RSCOR**3*ELPDOR*FF)
WRITE OUTPUT TAPE 3,605,TSTRES,NLMTS,NRSA,NIA
R1=RFUEL/B
PH=6 2832*ANLMTS*RFUEL*(1 -G)
HBAR=8 *CONDLI/DM
CAPF=R1**2/(3 464102*(RHOUN)*(CPUN*FF))
CAPCL=R1**2/(3 464102*(RHOL)*(CPL)*FS*RHOUN*CPH*FCL))
RSIST1=( 5*B**2- 5*(LOGF(B)+ 75)- 125*B**4)/(P)*CONDUN*(1 -B**2)
1**2/12 )
RSIST2=6 *A/(P)*(CONDLI*(1 + 5*A))
RSIST3=3 *G/(P)*(CONDUN*(1 - 25*G))
RSIST4=3 *G/(P)*(CONDUN*(1 - 75*G))
RSIST5=6 /(P)*RFUEL*(1 -G)*HBAR
QVOL=R1**2*FF/3 464102
CPR=1 077503/B
RSISTH= 5*RFUEL**2*(CPR**2*LOGF(CPR)- 5*(CPR**2-1 ))/(CONDUN*QVOL)

```

```

5 VFLUID=QMTW/(RHOL)*(CPL)*TEMRIS*P/RSCOR**2*FC)*1 E*6
CCF4=CCF2/FC
CCF=MINIF(CCF4,CCF1)
ROCOR=SQRTF(CCF1)*RSCOR
R1COR=SQRTF(CCF2)*RSCOR
R2COR=CCF3*RSCOR
NTU=6 2832*RSCOR**3*ELPDOR*FF= 236/250 *RHOUN
RSCOR=R2COR*(1 02323*DR)*GAP
CORDEN=19 3*FCL+14 32*FF+ 4*(1 -FF*FCL)
CORL=2 *RSCOR*ELPDOR
CORYOL=3 1416*RSCOR**2*CORL

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

REYN=VFLUID*DM*RHOL/YISCLI
PSIDRP=1 334E-6*RHOL*(CORL*VFLUID**2/(DM*REYN**2)
RTNDRP=PSIDRP*(DM/(2 *RSCOR))**2/FC)** 6/CCF**2 4
DRPMIN=(1 FC)**2+ 25/CCF**2)*RHOL*(VFLUID**2= 7251915E-9
DP=PSIDRP*RTNDRP*DRPMIN
CALL MATER1(HRLIF,TSMR ,PIN,RSCOR,THICKS,RHOS,EMS,CONS,SS)
CALL MATER1(HRLIF,TSUR,PSIDRP,R2COR,THICKSP,RHOSP,EMSP,CONSP,SSP)
ODEN=QMTW*1 E6/(FF*(CORYOL)
OFLUX=QMTW*1 E6/(PH*(CORL)

```

C THE WEIGHT CALCULATIONS IN THIS SECTION SHOULD BE REVISED TO TAKE
C INTO ACCOUNT THE THERMAL INSULATION LAYER ETC
C

```

NTCOR=6 2832*RSCOR**3*ELPDOR*( 01432*FF+ 0193*FCL)
NTSML=3 1416*(2 *(RSCOR*THICKS/2 00)*(CORL*RSCOR)+4 *(RSCOR*THICKS
1 /2 00)**2)*THICKS*RHOS= 02768
NTSUP=6 2832*(RSCOR*THICKSP/2 00)**2*THICKSP*RHOSP= 02768
NTLI=(6 2832*(RSCOR**3*ELPDOR*(1 FC)*FF)+CCF1+ 6*(CCF2-CCF1))
1 3 1416*(RSCOR**2 R2COR**2)*(CORL*RSCOR**3* 7 /3 ))= 0004
NTSTR=(3 1416*RFUEL*(ROCOR*R1COR*R2COR)*(CORL+ 4*3 1416*RSCOR**2=
1 CORL*(CCF2-CCF1))= 0193
NTRFLR=6 2832*(CORL*(RSCOR*THICKS*FLCTR/2 )=RFLCTR*RHOR
NTRCTR=NTCOR*NTLI*NTSUP*NTRSTR*NTSML*NTRFLR
NTU=2 *P/RSCOR**3*ELPDOR*FF*RHOUN= 236/250
DTBAR=ODEN*QVOL*(RSIST1+RSIST2+RSIST3+RSIST4+RSIST5)
DTMAX=ODEN*QVOL*(RSISTH+RSIST2+RSIST3+RSIST4+RSIST5)
DTCL=ODEN*QVOL*(RSIST4+RSIST5)
XNO1=1 /(CAPCL*(CAPF*(RSIST1+RSIST2+RSIST3)= (RSIST4+RSIST5))
OMEGR=SQRTF(XNO1)
ZETA= 5*OMEGR*(CAPF*(RSIST1+RSIST2+RSIST3)+(CAPF*CAPCL)*(RSIST4
1+RSIST5))
AN=ZETA*OMEGR
XNO2=ABS(1 -ZETA**2)
BN=OMEGR*SQRTF(XNO2)
CN=1 /CAPF
DN=(RSIST1+RSIST2+RSIST3+RSIST4+RSIST5)/(CAPF*CAPCL*(RSIST1+RSIST2
1+RSIST5))=(RSIST4+RSIST5))
WRITE OUTPUT TAPE 3,600,QMTW,HRLIF,BU,ELPD,NTYPE,MODE,G,B,TSUP,TEM
IRIS,TBAR,TSMEL,PIN,TSTRES,RFLCTR,CCF,CCF1,DR,FUELON,RHWR,NLMTS,FF
2,FCL,FC,FS,RFUEL,R1,DM,RSCOR,CORL,CORYOL,PH,ROCOR,R1COR,R2COR,RSCO
3R
WRITE OUTPUT TAPE 3,602,ODEN,OFLUX,VFLUID,REYN,HBAR,PSIDRP,RTNDRP,
1DP,NTRCTR,NTCOR,NTLI,NTU,NTSML,NTRFLR,THICKS,THICKSP,AUN,CONDUN,CPU
2N,EUN,GHOUN,RHOUN,PSY,AN,CONDN,CPH,RHOUN,ALI,CPLI,YISCLI,CONDLI,RHO
3LI

```

REACT- A DESIGN SUBROUTINE FOR CONVENTIONALLY COOLED REACTORS

```

600 FORMAT ( 7H FOR A F4 0.29M MNTH REACTOR OPERATING AT A F6 0.10M HR
1 BU OF F5 4.16M WITH AN L/D OF F4 2.10M AND TYPE 11.19M ELEMENTS
2H,UN,LI) //109H MODE G B TSUP K TEMRIS TBAR K TSMEL K PIN
3 PSI TSTRES RFLCTR CCF CCF1 DR FUELON RHWR // 12.2
4F6 3.5FB 1.FB 0.FB 2.5FB 5//111H NLMTS FF
5 FCL FC FS RFUEL CM R1 CM
6 DM CM // 113.2X,7E14 7// 112H RSCOR CM CORL CM
7 CORYOL CC PH CM ROCOR CM R1COR CM R2COR CM
8 RSCOR CM //1X,BE14 7 //)
602 FORMAT (112H ODEN W/CC OFLUX W/CM**2 VFLUID CM/SEC REYN NO
1 HBAR W/CM**2K PSIDRP PSI RTNDRP PSI DP PSI //1X,BE
214 7 //115H NTRCTR KG NTCOR KG NTLI KG NTU KG
3 NTSML KG NTRFLR KG THICKS CM THICKSP CM //1X,BE1
44 7 //100H AUN /K CONDUN W/CMK CPUN WSEC/GMK EUN PSI
5 NU UN RHOUN GM/CC PSY PSI CM/M AN/K //1X,BE14 7 //
6112H CONDUN W/CMK CPH WSEC/GMK RHOUN GM/CC ALI /K CPL
71 WSEC/GMK VISCLI POISE CONDLI W/CMK RHOLI GM/CC //1X,BE14 7//)
WRITE OUTPUT TAPE 3,603,CAPF,CAPCL,RSIST1,RSIST2,RSIST3,RSIST4,RSI
1ST5,RSISTH,DTBAR,DTMAX,DTCL,OMEGR,ZETA,AN,BN,DN
603 FORMAT (111H CAPF W SEC/K CAPCL W SEC/K RESIST1 K/W RESIST2 K/
1W RESIST3 K/W RESIST4 K/W RESIST5 K/W RESISTH K/W // 1X,
2BE14 7//100H DTBAR K DTMAX K DTCL K OMEGR 1/S
3SEC ZETA AN BN DN // 1X,BE14
47)
604 FORMAT (50H TSTRES NLMTS CCF2
1 /1X,E15 7,115,E15 7//)
605 FORMAT (50H TSTRES NLMTS CCF2
1 /1X,E15 7,115,E15 7,2115//)
RETURN
END

```

ELMTS - A SUBROUTINE TO FIT A HEXAGONAL ARRAY INTO A FINITE DODECAGON

```

*   FORTRAN      ELMTS
SUBROUTINE ELMTS(NL,CAF2,NRSA,NIA)
  DIMENSION NE(74)
  DATA (NE=1,7,19,37,55,85,109,151,199,253,295,361,433,511,571,601,7
157,859,937,1051,1171,1297,1393,1531,1675,1783,1939,2101,2221,2395,
22575,2761,2899,3097,3301,3511,3667,3889,4117,4289,4525,4771,5023,5
3209,5473,5743,6019,6223,6511,6805,7021,7327,7639,7957,8191,8521,88
457,9199,9451,9805,10165,10531,10801,11179,11563,11845,12241,12643,
513051,13351,13771,14197,14629,14947)
  NRM=74
C
C   THIS SUBROUTINE WILL DETERMINE THE NUMBER OF ELEMENTS AND THE
C   RATIO OF INNER AND OUTER RADII THAT ARE CLOSEST TO THOSE SPECIFIED
C   BY THE DESIGN SUBROUTINE FIRST APPROXIMATION. THIS IS ESPECIALLY
C   IMPORTANT IN REACTORS HAVING A SMALL NUMBER OF FUEL ELEMENT ROWS.
C   CAF2 IS THE NEW VALUE OF CAF2 THAT CONFORMS TO THE GEOMETRY
C   NRSA WILL BE THE NUMBER OF ROWS TO THE OUTER PERIPHERY OF THE CORE
C   INCLUDING THE OUTER RNM. NIA WILL BE THE NUMBER OF ROWS EXCLUDED
C   FROM THE CENTER. THESE NUMBERS ARE BASED ON THE NUMBERS OF ELE-
C   MENTS IN A HEXAGONAL ARRAY THAT WILL FIT INTO A DODECAGON. THIS
C   IS THE CLOSEST PRACTICAL APPROACH TO A CIRCULAR GEOMETRY FOR A
C   HEXAGONAL ARRAY. THE DIFFUSION EQUATION CAN BE SOLVED EXACTLY FOR
C   A REGULAR POLYGONAL BOUNDARY. SOLUTION OF THIS EQUATION FOR A DO-
C   DECAGON SHOWS THAT THE LEAKAGE INCREASES OVER THAT OF A CIRCLE OF
C   EQUAL AREA IS ALMOST EXACTLY COMPENSATED FOR BY THE INCREASE IN
C   REFLECTIVITY DUE TO THE LIQUID METAL SURROUNDING THE DODECAGON.
C
C
C   LET NR BE THE NUMBER OF ELEMENT ROWS. FIRST FIND NR FOR A SOLID
C   CORE THAT HAS THE CLOSEST NUMBER OF ELEMENTS. LET NL BE THE NUMBER
C   OF ELEMENTS CALCULATED IN REACT. LET NE(NR) BE THE NUMBER OF ELE-
C   MENTS AS A FUNCTION OF NR.
  NC=1
  DO 10 NR=1,NRM
    IF (NL-NE(NR)) 11,11,10
  10 CONTINUE
  GO TO 90
  11 IF (XABSF(NE(NR)-NL)-XABSF(NE(NR)-NL)) 12,12,13
  12 NRS=NR-1
C
C   NRS IS THE NUMBER OF ROWS IN THE SOLID CORE.
  GO TO 14
  13 NRS=NR
C
C   FOR HOLLOW CORES FIND THE CLOSEST RADIUS RATIO.

```

ELMTS - A SUBROUTINE TO FIT A HEXAGONAL ARRAY INTO A FINITE DODECAGON

```

  14 ANRS=FLOATF(NRS)
  ANI=(SORTF(CAF2)*(2.*ANRS+1.))-1./2.
  IF (ANI-1.126,26,141)
  141 NI=XINTF(ANI)
  ANI=INTF(ANI)
  IF (XABSF(ANI/ANRS-SORTF(CAF2))-XABSF((ANI+1.)/ANRS-SORTF(CAF2)))
    115,15,16
  15 NIA=NI
  GO TO 17
  16 NIA=NI+1
  17 NRSA=NRS
  GO TO (10,20)NC
  18 IF (NE(NRSA)-NE(NIA)-NL)19,25,25
  19 NID=NIA
  NRSD=NRSA
  NRS=NRSA+1
  NC=2
  GO TO 14
  20 IF (NE(NRSA)-NE(NIA)-NL) 21,22,22
  21 NID=NIA
  NRSD=NRSA
  NRS=NRSA+1
  GO TO 14
  22 IF (XABSF(NE(NRSA)-NE(NIA)-NL)-XABSF(NE(NRSD)-NE(NID)-NL))23,23,24
  23 NIA=NIA
  NRSA=NRSA
  GO TO 25
  24 NIA=NID
  NRSA=NRSD
  25 NL=NE(NRSA)-NE(NIA)
  ANL=FLOATF(NL)
  ANI=FLOATF(NIA)
  ANRS=FLOATF(NRSA)
  CAF2=((2.*ANI+1.)/(2.*ANRS+1.))**2
  GO TO 27
  26 NL=NE(NRS)
  27 RETURN
  90 WRITE OUTPUT TAPE 3,91,NL,NRM
  91 FORMAT (1X, 4H FOR 16, 36H ELEMENTS THE NUMBER OF ROWS EXCEEDS19)
  GO TO 27
  END

```

NEWRAF - A NEWTON RAPHSON ITERATION SUBROUTINE

```

*   FORTRAN      NEWRAF
SUBROUTINE NEWRAF(KIT,KMAX,FN,FD,CRIT,V,YL1,YL2,DY1,DYMAX,YA,DLTA)
C
C   NEWRAF IS A NEWTON-RAPHSON CONVERGENCE ROUTINE FOR ITERATIVE
C   SOLUTIONS. KIT IS THE NUMBER OF THE ITERATION. KMAX IS THE MAXIMUM
C   NUMBER OF ITERATIONS TO BE PERMITTED BEFORE A DUMP IS CALLED.
C   FN IS THE CURRENT VALUE OF THE FUNCTION. FD IS THE DESIRED VALUE.
C   CRIT IS THE ACCEPTABLE CONVERGENCE CRITERION (NOT NORMALIZED).
C   Y IS THE NEW VALUE OF THE INDEPENDENT VARIABLE. YL1 AND YL2 ARE
C   THE LOWER AND UPPER BOUNDS ON THE INDEPENDENT VARIABLE TO AVOID
C   EXTREME OVERSHOTS IN A POORLY DEFINED REGION. DY1 IS AN INITIAL
C   STEP FOR THE INDEPENDENT VARIABLE. DYMAX IS THE MAXIMUM STEP
C   PERMITTED. THIS VALUE IS DECREASED WITH EACH ITERATION TO AVOID
C   CERTAIN TYPES OF INSTABILITY.
C   A TYPICAL CALLING SEQUENCE IS AS FOLLOWS
C
C   COLUMN
C   ?
C   KIT=0      (INITIALIZE KIT)
C   KMAX=25    (SET MAXIMUM NUMBER OF ITERATIONS TO BE ALLOWED)
C   FD=        (SET DESIRED FUNCTION VALUE. E.G. KEFF-1)
C   CRIT=      (SET CONVERGENCE CRITERION. E.G. 1.E-4)
C   YL1=      (SET LOWER BOUND)
C   YL2=      (SET UPPER BOUND)
C   DY1=      (SET INITIAL INDEPENDENT VARIABLE STEP)
C   Y=        (SET INITIAL VALUE OF INDEP. VAR)
C   DYMAX=    (SET MAXIMUM STEP SIZE)
C
C   1 CONTINUE
C   FN=      (CALCULATE FN=FUNCTION OF Y)
C   CALL NEWRAF(KIT,KMAX,FN,FD,CRIT, Y,YL1,YL2, DY1,DYMAX,YA,DLTA)
C   IF (KIT-KMAX)/.. (WHEN THE DESIRED VALUE OF CONVERGENCE
C                     IS REACHED, KIT IS SET EQUAL TO KMAX TO
C                     INDICATE THE PROGRAM SHOULD PROCEED. IF
C                     KIT ARRIVES AT KMAX BEFORE THIS POINT
C                     NEWRAF WILL CALL EXIT )
C
C   DLT=FN-FD
C   KIT=KIT+1
C   AKIT=FLOATF (KIT)
C   AKMAX=FLOATF (KMAX)
C   DY=DYMAX/AKMAX
C   IF (KIT-KMAX) .6,6
C   IF (KIT-2) .1,1
C   YA=Y
C   DLTA=DLT
C   Y=Y+DY

```

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NEWRAF - A NEWTON RAPHSON ITERATION SUBROUTINE

```

GO TO 5
1 IF (ABS(FD)-CRIT)4,4,
YB=Y
Y=Y-.8*DLT*(YB-YA)/(DLT-DLTA)
YA=YB
DLTA=DLT
DY=Y-YB
IF (ABS(FD)-DYMAX)3,3,
Y=YB+(DYMAX-AKIT)*DYMI=DY/ABS(FD)
3 Y=MAX(Y,YL1)
Y=MIN(Y,YL2)
GO TO 5
4 Y=Y
KIT=KMAX
5 WRITE OUTPUT TAPE 3,7,KIT,FN,FD,YA,Y
7 FORMAT(25H FOR NEWRAF ITERATION NO 14, 4H,FN=E16.8,4H,FD=E16.8,
14H,YA=E16.8,7H,AND Y=E16.8)
RETURN
6 CALL EXIT
END

```

PYMAT - A BRIEF PRESSURE VESSEL MATERIALS STRENGTH SUBROUTINE

```

*   FORTRAN      PYMAT
C   THIS SUBROUTINE DETERMINES PRESSURE VESSEL THICKNESS AS A FUNCTION
C   OF PRESSURE, TEMPERATURE, AND RADIUS FOR TUNGSTEN AND T-222
SUBROUTINE PYMAT(XHOURS,TEMP,P,R,THICK,RMO,EM,CON,S)
PAR=TEMP/1000.*(15.+LOG(XHOURS)+.4343)
IF(PAR-65.31)1,1,2
2 CONTINUE
WRITE OUTPUT TAPE 3,3
3 FORMAT(55H MATERIAL CREEP LIMITS EXCEEDED
GO TO 5
1 IF(PAR-55.14,4,5
5 S=10.*(1-.0502*PAR+5.989)
RMO=.697
EM=1-7./2300.*TEMP+61.1+1.E6
CON=-18.*(TEMP-460.)/3240.+75.
WRITE OUTPUT TAPE 3 .99
99 FORMAT(19H HALF PURE TUNGSTEN 1
GO TO 10
4 IF(PAR-48.516,6,7
7 S=10.*(1-.159*PAR+11.914)
RMO=.605
CON=.31.5
EM=21.E6
WRITE OUTPUT TAPE 3 .98
98 FORMAT(55H T-222
GO TO 10
6 S=10.*(1-.0268*PAR+5.50)
RMO=.605
CON=.31.5
EM=21.E+6
WRITE OUTPUT TAPE 3 .97
97 FORMAT(6H T-222 )
10 CONTINUE
THICK=1.5*P*R/S
999 FORMAT(7E10,2)
WRITE OUTPUT TAPE 3,999,THICK
RETURN
END

```

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SPILL - A DECIMAL DUMP ROUTINE FOR DEBUG PURPOSES

```

*   FORTRAN      SPILL
SUBROUTINE SPILL(A,N)
DIMENSION A(2)
LA = .LOC.A(1)
LB = .LOC.A(N)
10 FORMAT(1H1,5X,7ML0C1 = .07,6X,7ML0C2 = 07 // )
20 FORMAT(010,10X,9E20,10)
WRITE(3,10)
XMIT LA,LB
FIN
WRITE(3,20)
DO 50 I=1,N,5
XMIT LA,A(I),A(I+1),A(I+2),A(I+3),A(I+4)
50 LA = LA+5
FIN
RETURN
END

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

*   FORTRAN      TRANP      VERSION OF 6/20/67
*   MULTIPLE ARGS TRANP,VISL,TCNL,CSPL,RHOL,RESL,TENS,PRANL,VISG,TCNG,
*   'CSPG,RHOG,PRANG,SONY,PSAT,HYAP
*   SUBROUTINE TRANP(JFLUID,TK,XX,TC,CP,LY)
C
C   JFLUID MATERIAL      JFLUID MATERIAL
C   1 LITHIUM            5 CESIUM
C   2 SODIUM             6 MERCURY
C   3 POTASSIUM          7 NAK-78
C   4 RUBIDIUM           8 STRONTIUM
C
C   FUNCTION TO CONVERT T IN K TO T IN F
C
DATA (LL = 0)
IF (IQQBARGS-6) 20, .
LL = LY
20 IF (LL) , .40
C
C           SAT LIQUID TRANSPORT PROPERTIES
C
CALL TCNL % TC = X
CALL CSPL % CP = X
CALL VISL
GO TO 80
C
C           SAT VAPOR TRANSPORT PROPERTIES
C
40 CALL TCNG % TC = X
CALL CSPG % CP = X
CALL VISG
80 RETURN TRANP
C
C           ENTRY VISL
C           SAT LIQUID VISCOSITY (G/SEC-CM)
C
T = TK % JF = JFLUID
GO TO (Y1L,Y2L,Y3L,Y4L,Y5L,Y6L,Y7L,Y8L), JF
Y1L X=2 924347E-3-2 648556/T+2 995261E3/T**2-5 302574E5/T**3
GO TO YEX
Y2L X = -1 04205E-3 +4 11188/T 1 74178E3/T**3 + 4 954036E5/T**4
GO TO YEX
Y3L X=-4 390586E-4+2 028652/T-5 4'0948E2/T**2+1 646804E5/T**3
GO TO YEX
Y4L X=1 559395E-3-1 112291/T+1 100170E3/T**2-8 367401E4/T**3
GO TO YEX

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

Y5L T=1 8*TK-459 67
X = 239 5/T - 59911*LOGF(T)+4 32449 %C CESIUM AGN
X = 1 E-3*EXP(X)
GO TO YEX
Y6L X=8 036587E-3-3 198839/T+2 791399E3/T**2-3 544087E5/T**3
GO TO YEX
Y7L X=3 187261E-4+8 019051E-1/T+2 142332E2/T**2+2 596542E4/T**3
GO TO YEX
Y8L X=2 15417E-3-5 576295/T+2 100457E4/T**2
YEX XX = X % RETURN VISL
C
C           ENTRY TCNL
C           SAT LIQUID THERMAL CONDUCTIVITY (W/CM-K)
C
T = TK % JF = JFLUID
GO TO (T1L,T2L,T3L,T4L,T5L,T6L,T7L,T8L), JF
T1L T=1 8*TK-459 67
X = 49998+2 7992E-4*T+2 2565E-8*T**2-2 4606E-11*T**4
GO TO TEX
T2L T=1 8*TK-459 67
X = 1 4298-6 1292E-4*T+1 7127E-7*T**2-3 0639E-11*T**4
GO TO TEX
T3L T=1 8*TK-459 67
X = 96689-4 7904E-4*T+1 3778E-7*T**2-2 4884E-11*T**4
GO TO TEX
T4L T=1 8*TK-459 67
X = 49609-8 5289E-5*T-2 8444E-8*T**2+3 4248E-12*T**4
GO TO TEX
T5L T=1 8*TK-459 67
X = 27351+7 3409E-5*T-7 4226E-8*T**2+7 4916E-12*T**4
GO TO TEX
T6L X = 14648003 +50 8368/T - 8 20005E4/T**2 +3 26295E7/T**3
I -4 43661E9/T**4
GO TO TCX
T7L X=1 384235E-1+2 05547E2/T-1 062331E5/T**2+1 60138E7/T**3
GO TO TCX
T8L X=3 91471E-1-1 084549E-4*T+1 58502E2/T
GO TO TCX
TEX X = X* 7087 %C CONVERT WATTS/IN-F TO WATTS/CM C
TCX XX = X % RETURN TCNL
C
C           ENTRY CSPL
C           SAT LIQUID SPECIFIC HEAT (W-SEC/G-K)
C
T = TK % JF = JFLUID

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

      GO TO (C1L,C2L,C3L,C4L,C5L,C6L,C7L,C8L), JF
C1L X=4 294012-1 210551E-4+T
      GO TO CEX
C2L X=1 63249 8 359602E-4+T+4 637195E-7+T+T
      GO TO CEX
C3L X=9 512849E-1-4 860081E-4+T+3 122763E-7+T+T
      GO TO CEX
C4L T=1 8+TK-459 67
      X = 4 187+ ( 09915-3 106E-5+T+1 299E-8+T+T)
      GO TO CEX
C5L T=1 8+TK-459 67
      X = 4 187+ ( 08543-9 605E-5+T+5 985E-8+T+T)
      GO TO CEX
C6L X=1 519435E-1-5 970309E-5+T+5 301029E-8+T+T
      GO TO CEX
C7L X=1 072183-4 990439E-4+T+3 125257E-7+T+T
      GO TO CEX
C8L X=1 296636E-1-9 276633E-9+T+6 91833E-8+T+T-2 303194E-11+T+T+3
      1+3 025286E-15+T+T+4
CEX XX = X          $ RETURN CSPL
C
      ENTRY RHOL
C          SAT LIQUID DENSITY (G/CM3)
C
      T = TK $ JF = JFLUID
      GO TO (R1L,R2L,R3L,R4L,R5L,R6L,R7L,R8L), JF
R1L X=5 46398E-1-9 381799E-5+T+9 318741E-9+T+T          $WC WEATHERFORD
      GO TO REX
R2L X=1 013638-2 350445E-4+T-9 861048E-10+T+T
      GO TO REX
R3L X=9 083578E-1 2 244534E-4+T-1 274617E-8+T+T          $WC NRL 6233
      GO TO REX
R4L X=1 575802-3 074245E-4+T+3 837297E-8+T+T          $WC WEATHERFORD
      GO TO REX
R5L X=1 985637-4 549765E-4+T-8 955005E-8+T+T          $WC NRL 6246
      GO TO REX
R6L X = 1 438176E-1-2 861766E-3+T+3 763475E-7+T+T
      GO TO REX
R7L X=9 3800519589E-1-2 3937338810E-4+T+3 5881034579E-9+T+T
      GO TO REX
R8L X=2 8259-3 899511E 4+T
REX XX = X          $ RETURN RHOL
C
      ENTRY RESL
C          SAT LIQUID ELECTRICAL RESISTIVITY (OHM-CM)

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

C
      T = TK $ JF = JFLUID
      GO TO (RS1,RS2,RS3,RS4,RS5,RS6,RS7,RS8), JF
RS1 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (10 186+2 9187E-3+T+6 8168E-7+T+T+1 1545E-10+T+T+T)
      GO TO RSX
RS2 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (2 1729+7 6248E-3+T+5 8313E-7+T+T+1 1260E-9+T+T+T)
      GO TO RSX
RS3 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (2 6978+1 4055E-2+T-2 0398E-6+T+T+3 5792E-9+T+T+T)
      GO TO RSX
RS4 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (6 3519+2 0821E-2+T+5 1071E-6+T+T+6 2079E-9+T+T+T)
      GO TO RSX
RS5 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (10 9086+3 3902E-2+T-1 6701E-5+T+T+1 0964E-8+T+T+T)
      GO TO RSX
RS6 CONTINUE
RS7 T=1 8+TK-459 67          $WC TEPPER
      X = 2 54E-6 = (12 8180+1 2679E-2+T-3 6501E-7+T+T+2 852E-9+T+T+T)
      GO TO RSX
RS8 CONTINUE
RSX XX = X          $ RETURN RESL
C
      ENTRY TENS
C          SAT LIQUID SURFACE TENSION (DYN/CM)
C
      T = TK $ JF = JFLUID
      GO TO (ST1,ST2,ST3,ST4,ST5,ST6,ST7,ST8), JF
ST1 X=4 544948E2-1 356226E-1+T+1 615487E-6+T+T
      GO TO STX
ST2 X=7 758952E2-1 356323+T+9 517612E-4+T+T-2 375630E-7+T+T+3
      GO TO STX
ST3 T=1 8+TK-459 67          $WC AFML-TR-65-99
      X = 1 459E4 = (8 4029E-3-2 8149E-6+T)
      GO TO STX
ST4 X=1 347196E2-5 606006E-2+T-1 513351E-5+T+T
      GO TO STX
ST5 T=1 8+TK-459 67
      X = 76 4- 03+T-83 1
      GO TO STX
ST6 X=4 876255E2+1 132794E-3+T-2 458797E-4+T+T
      GO TO STX
ST7 X=1 201687E2-3 890232E-2+T

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

STO CONTINUE

STX XX = X \$ RETURN TENS

C

ENTRY PRANL

C

SAT LIQUID PRANDTL NUMBER

C

CALL YISL \$ YL = X

CALL TCNL \$ TL = X

CALL CSPL \$ CL = X

X = CL=YL/TL

XX = X

\$ RETURN PRANL

C

ENTRY VISG

C

SAT VAPOR VISCOSITY (G/SEC-CM)

C

T = TK \$ JF = JFLUID

GO TO (Y1G,Y2G,Y3G,Y4G,Y5G,Y6G,Y7G,Y8G), JF

Y1G X = 5.675815E-5+1.167182E-7+T-1.135025E-11+T**2

GO TO YGX

Y2G X = 7.055714E-5+1.581986E-7+T-1.958133E-11+T**2

GO TO YGX

Y3G X = 3.870094E-5+1.982508E-7+T-4.928330E-11+T**2

GO TO YGX

Y4G X = 8.619203E-5+2.027719E-7+T-3.327784E-11+T**2

GO TO YGX

Y5G X = 9.520804E-5+2.22279E-7+T-4.270371E-11+T**2

GO TO YGX

Y6G X = 7.143205E-5+6.300290E-7+T+3.373479E-10+T**2

GO TO YGX

Y7G CONTINUE

Y8G X = 2.650777E-5+1.114197E-7+T+9.608582E-12+T**2

YGX XX = X \$ RETURN VISG

C

ENTRY TCNG

C

SAT VAPOR THERMAL CONDUCTIVITY (W/CM-K)

C

T = TK \$ JF = JFLUID

GO TO (T1G,T2G,T3G,T4G,T5G,T6G,T7G,T8G), JF

T1G X = 1.211242E-4+5.135221E-7+T-5.902087E-11+T**2

GO TO TCG

T2G X = 1.020605E-4 +1.694747E-7+T -1.464682E-11+T**2

GO TO TCG

T3G X = 3.033089E-5 +1.400357E-7+T -3.133830E-11+T**2

GO TO TCG

T4G X = 3.079684E-5 +6.325412E-8+T -9.535292E-12+T**2

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

GO TO TGX

T5G X = 2.243009E-5+4.234143E-8+T-6.469024E-12+T**2

GO TO TGX

T6G X = 2.749046E-6 +1.175486E-7+T -2.454670E-11+T**2

GO TO TGX

T7G CONTINUE

T8G X = 4.817088E-5-1.646801E-8+T+2.312879E-11+T**2

TGX XX = X \$ RETURN TCNG

C

ENTRY CSPG

C

SAT VAPOR SPECIFIC HEAT (M-SEC/G-K)

C

T = TK \$ JF = JFLUID

GO TO (C1G,C2G,C3G,C4G,C5G,C6G,C7G,C8G), JF

C1G X = 3.96472-1.321868E4/T+7.253337E7/T**2-5.82616E10/T**3

GO TO CGX

C2G X = -2.236022+9.507713E3/T-4.300431E6/T**2

GO TO CGX

C3G X = -6.011841E-1+4.044715E3/T-3.393891E6/T**2+8.493131E8/T**3

GO TO CGX

C4G X = -1.730578E-2+0.663483E2/T-4.075597E5/T**2

GO TO CGX

C5G X = -1.354929E-2+5.228561E2/T-2.32491E5/T**2

GO TO CGX

C6G X = 1.076087E-1-1.637431E-5+T+1.697121E-8+T**2

C7G CONTINUE

C8G X = 5.789686E-2-4.587036E-6+T+6.646289E-9+T**2-4.265266E-12+T**3

1+1.013906E-15+T**4

CGX XX = X \$ RETURN CSPG

C

ENTRY RHOG

C

SAT VAPOR DENSITY (G/CM3)

C

T = TK \$ JF = JFLUID

GO TO (R1G,R2G,R3G,R4G,R5G,R6G,R7G,R8G), JF

R1G X = EXPF(4.324234E-1-1.560572E4/T-1.124864E6/T**2)

GO TO RGX

R2G X = EXPF(1.000785-1.012916E4/T-5.75469E5/T**2)

99C NRL 6233

GO TO RGX

R3G X = EXPF(8.135742E-1-8.24119E3/T-4.269861E5/T**2)

99C NRL 6233

GO TO RGX

R4G X = EXPF(4.677273E-1-6.10964E3/T-9.252185E5/T**2)

GO TO RGX

R5G X = EXPF(1.757963-7.371427E3/T-1.931032E5/T**2)

99C NRL 6246

GO TO RGX

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

R6G X= EXPF(3.243496-4.55902E3/T-6.07443E5/T**2)
GO TO RGX
R7G CONTINUE
R8G X= EXPF(5.130898-1.334322E-3*T-1.746381E4/T+1.321905E-7*T**2)
RGX XX = X          $ RETURN RM0G
C
      ENTRY PRANG
C
      SAT VAPOR PRANDTL NUMBER
C
      CALL YISG $ YL = X
      CALL TCNG $ TL = X
      CALL CSPG $ CL = X
      X = CL*YL/TL
      XX = X          $ RETURN PRANG
C
      ENTRY S0NV
C
      SAT VAPOR SONIC VELOCITY (CM/SEC)
C
      T = TK $ JF = JFLUID
      GO TO (SY1,SY2,SY3,SY4,SY5,SY6,SY7,SY8) , JF
      SY1 X = 7.650211E4+35.0503*T-2.883303E-3*T**2          $RC WEATHERFORD
      GO TO SEX
      SY2 X=4.710855E4+1.3694E1*T-5.391655E6/T          $RC WEATHERFORD
      GO TO SEX
      SY3 X=2.134288E4+2.836652E1*T-5.800705E-3*T**2          $RC WEATHERFORD
      GO TO SEX
      SY4 X=1.954827E4+1.626642E1*T-2.611822E-3*T**2          $RC WEATHERFORD
      GO TO SEX
      SY5 X=1.277488E4+1.217007E1*T-1.763269E-3*T**2          $RC WEATHERFORD
      GO TO SEX
      SY6 CONTINUE
      GO TO SEX
      SY7 CONTINUE
      GO TO SEX
      SY8 CONTINUE
      SEX XX = X          $ RETURN S0NV
C
      ENTRY PSAT
C
      VAPOR PRESSURE (BARS)
C
      T = TK $ JF = JFLUID
      GO TO (YP1,YP2,YP3,YP4,YP5,YP6,YP7,YP8) , JF
      YP1 X = 1.01356*10.**((4.8831-7877.9/T)          $RC TIM 844 9/65
      GO TO YPX
      YP2 X=EXPF(9.983175-1.091806E4/T-6.862319E5/T**2)          $RC NRL 6233

```

TRANP - A LIQUID METALS TRANSPORT PROPERTY SUBROUTINE

```

GO TO YPX
YP3 X=EXPF(9.191863-9.030992E3/T-4.33038E5/T**2)          $RC NRL 6233
GO TO YPX
YP4 T = T+1.8
X = .06895*10.**((5.20071-6994.68/T)          $RC AGN 8090 1/64
GO TO YPX
YP5 X=EXPF(8.636035-7.715273E3/T-3.846408E5/T**2)          $RC NRL 6246
GO TO YPX
YP6 CONTINUE
GO TO YPX
YP7 CONTINUE
GO TO YPX
YP8 CONTINUE
YPX XX = X          $ RETURN PSAT
C
      ENTRY MYAP
C
      LATENT HEAT OF VAPORIZATION (J/GM)
C
      T = TK $ JF = JFLUID
      GO TO (LY1,LY2,LY3,LY4,LY5,LY6,LY7,LY8) , JF
      LY1 ETA=TK *EXPF(-3.25347234E4/(1.0*TK -13.75))/(1.0*TK -13.75)**2+
      11.05504E03/453.59243
      X = ETA*(5.02416477E7*EXPF(3.06065154E4/(1.0*TK -11-1.06307549E
      112+1.0*TK **5.87485193E8-(1.0*TK -1)**2+8.1467307E4)
      GO TO LEX
      LY2 X=4.178649E3+2.829841E-1*T-4.765964E-4*T**2
      GO TO LEX
      LY3 X=2.269079E3-1.318445E-1*T-2.003039E-4*T**2          $RC NRL 6233
      GO TO LEX
      LY4 CONTINUE
      GO TO LEX
      LY5 X=6.050302E2-6.543721E-2*T-5.902942E-5*T**2          $RC NRL 6246
      GO TO LEX
      LY6 CONTINUE
      GO TO LEX
      LY7 CONTINUE
      GO TO LEX
      LY8 CONTINUE
      LEX XX = X          $ RETURN MYAP
      END

```

EYAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

EYAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

*   FORTRAN          EYAP
SUBROUTINE EYAP (NZ,TZ,PZ,OZ,MZ,SZ,YZ)
DIMENSION POZ(8),COMPZ(8),CAZ(8),MOZ(8),MIZ(8),M2Z(8),SOZ(8),SIZ(
18),SZZ(8),C8Z(8),CCZ(8),CDZ(8),Y8Z(8),Y1Z(8),Y2Z(8),CYZ(8),CONYZ(8
2),M5Z(8),M4Z(8),CONIZ(8),CON2Z(8),S5Z(8),TPZ(8),CONSZ(8),AMOL(8),
SAKZ(7,8),BKZ(7,8),FKZ(7,8),GKZ(7,8),AK(7),BK(7),FK(7),GK(7)
DIMENSION WORD(3)
DATA (WORD(1),5500000000000000B,7500000000000000B)
COMMON /YAP/ML,MG,SL,SG,YL,YG,J,JFLUID
C THIS SUBROUTINE CALCULATES THE THERMODYNAMIC PROPERTIES OF JID
C METALS GIVEN CERTAIN STATE PARAMETERS THE DATA ON WHICH T...
C CALCULATIONS ARE BASED ARE NOT OF UNIFORM QUALITY AND DO NOT COVER
C IDENTICAL RANGES THE BEST DATA ARE FOR NA,K,Ce, AND FOR THESE THE
C SUPERHEAT PROPERTIES CAN BE DETERMINED IN THE VICINITY OF THE
C SATURATION LINE TO AVOID BLOWING UP, SUPERHEAT QUANTITIES ARE
C CALCULATED FOR THE OTHER MATERIALS USING NA PROPERTIES ABOVE THE
C SATURATED VAPOR LINE, A VALUE OF J=1 INDICATING THIS HAS OCCURRED
C OTHERWISE J=0 MATERIAL OPTIONS ARE AS FOLLOWS
C      JFLUID  FLUID      RELIABLE  DATA RANGE
C      1      LI        1935K - 2000K
C      2      NA        1144K - 1685K
C      3      K         1035K - 1652K
C      4      RB        722K - 1500K
C      5      CE        950K - 1560K
C      6      BLANK (FOR HG)
C      7      BLANK
C      8      SR        1045K 2500K
C CALLING OPTIONS, DEFINITIONS, AND DIMENSIONS ARE
C      NZ VARIABLES GIVEN      T-DEG R
C      1  T,O                  P-ATM
C      2  T,M                  M-0TU/LB
C      3  T,S                  S-0TU/LB R
C      4  P,O                  Y-CU FT/LB
C      5  P,M                  MZ,SZ,YZ ARE PER LB MIXTURE
C      6  P,S                  ML,MG,SL,SG,YL,YG ARE PER LB OF
C      7  M,S                  LIQUID OR GAS RESPECTIVELY
C      8  T,P (SUPERHEAT ONLY)
C      9  HL
C THE SUPER HEAT VALUES ARE GOOD ONLY IN THE VICINITY OF THE SATURA-
C TION LINE THIS IS NOT A SEVERE LIMITATION SINCE HIGH VALUES OF
C SUPERHEAT ARE NOT OF INTEREST IN SPACE REACTORS
C NZ AND ANY TWO OTHER QUANTITIES SHOULD BE SPECIFIED IN THE PARA-
C METER STATEMENT THE REMAINING QUANTITIES WILL BE RETURNED IN THE
C PARAMETER LIST AND IN COMMON /YAP/
DATA

```

```

1(POZ =8 35732263E4,2 27505643E4,9 70854144E3,5 38573268E3,5 62188
2392E3,0 0 ,0 0 ,1 6015002E4),
3,COMPZ=5 25347234E4,1 99912174E4,1 62859698E4,1 42173450E4,1 39552
4198E4,0 0 ,0 0 ,2 73775361E4),
5(TPZ =15 75,84 ,80 ,97 5,80 ,00 ,0 0,128 75),
6(CVZ =6 78035158E-5,4 3144587E-5,5 5010579E-5,4 15158744E-5,2 417
78116E 3,0 0 ,0 0 ,2 20932604E-5),
8(CONYZ=5 06065154E4,1 97907565E4,1 60385121E4,1 43442225E4,1 38544
9195E4,0 0 ,0 0 ,2 77038300E4)
DATA
1(MOZ =5 61934014E2,2 17017239E2,1 43974996E2,4 65381451E1,1 33099
2545E1,0 0 ,0 0 ,2 19182750E2),
3(MIZ =7 13848102E-1,1 0136009E-1,6 14052646E 2,4 29958432E-2,3 88
420152E-2,0 0 ,0 0 ,5 9784397E-2),
5(M2Z =4 33714836E-5,4 7487007E-5,3 0430941E-5,1 08512811E-5,5 279
62689E-6,0 0 ,0 0 ,2 39505934E-5),
7(SOZ =8 87464162E2,-2 05622511E2,-1 00563262E2,3 14291051, 4 696
88902E1,0 0 ,0 0 ,2 2068842E2)
DATA
1(SIZ =2 51902619, 905628347, 597896692, 256463102, 22624574, 0
2 ,0 ,0 ,7 2129694E-2),
3(SZ2 =2 21061236E-4,1 0273924E-4,6 7917997E-5,4 46325763E-5,1 796
43479E-5,0 0 ,0 0 ,5 55564163E-5),
5(Y8Z =2 83252684E-2,1 99226793E-2,2 13202343E-2,1 01001674E-2,1 1
61939292E-2,0 0 ,0 0 ,5 79686067E-3),
7(Y1Z =5 57444027E-6,-1 780842E-6,-1 792280E 6,1 19982829E 6,-2 63
82075E-6,0 0 ,0 0 ,3 05000642E-7)
DATA
1(Y2Z =-5 81807909E-11,1 2697488E-9,1 7888073E 9,4 2114049E 14,1 4
2227385E-9,0 0 ,0 0 ,7 2198826E-11),
3(CAZ =5 02416477E7,5 40268348E6,2 42428996E6,8 75345008E5,5 23848
4951E5,0 0 ,0 0 ,2 64692417E6),
5(C8Z =-1 06307549E12,-1 225780E10, 1 9280843E9,-1 59188681E9,-1 5
6051794E8,0 0 ,0 0 ,4 2746955E10),
7(CCZ =5 87485193E8,8 31250226E6,1 35492891E6,1 22605218E6,1 12155
8890E5,0 0 ,0 0 ,2 27495887E7)
DATA
1(CDZ =-8 14673070E4,-1 41967477E3, 2 4138971E2, 2 35773870E2,-2
21500478E1,0 0 ,0 0 ,3 00970707E3),
3(M5Z =1 25E 2,1 2528379E 2,5 235740E-2,1 25E-2,3 55870873E-2,0 0
4 ,0 ,1 25E-2),
5(M4Z =5 65E-6,5 6503015E 6,0 ,5 65E 6,1 20844719E 7,0 0,0 0,5 65E
6-6),
7(S5Z =6 22E-5,6 2183453E-5,3 18709004E-2,6 22E 3,2 15847003E-2,0
80,0 0,6 22E 3)

```


EYAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```
DATA(FKZ(1,6),0 ,0 ,0 ,0 ,0 ,0 )  
DATA(FKZ(1,7),0 ,0 ,0 ,0 ,0 ,0 )  
DATA(FKZ(1,8),-7 66095194E-2,-2 94813807,4 08628954E6,  
2 23586778E10,-1 41104209E13,9 19046794E16,-8 09847035E19)  
DATA(GKZ(1,1),-6 68449823E-2,1 16384309E3,-6 40140439E6,  
2 12155394E10,1 35191738E13,-6 63003431E16,5 88719895E19)  
DATA(GKZ(1,2),-6 68449823E-2,1 16384309E3,-6 40140439E6,  
2 12155394E10,1 35191738E13,-6 63003431E16,5 88719895E19)  
DATA(GKZ(1,3),-9 35394049E-2,8 79246352E2,-2 55026416E6,  
1-1 56029710E8,1 42420833E13,-2 58240676E16,1 45850067E19)  
DATA(GKZ(1,4),-6 68449823E-2,1 16384309E3,-6 40140439E6,  
2 12155394E10,1 35191738E13,-6 63003431E16,5 88719895E19)  
DATA(GKZ(1,5),-2 41418431E-1,2 47712524E3,-9 47730208E6,  
5 151027476E10,-3 42088188E12,-1 60815648E16,1 28453192E19)  
DATA(GKZ(1,6),0 ,0 ,0 ,0 ,0 ,0 )  
DATA(GKZ(1,7),0 ,0 ,0 ,0 ,0 ,0 )  
DATA(GKZ(1,8),-6 68449823E-2,1 16384309E3,-6 40140439E6,  
2 12155394E10,1 35191738E13,-6 63003431E16,5 88719895E19)  
K=5  
N = N2  
Q = Q2  
S = S2  
T = T2  
P = P2  
M = M2  
Y = Y2  
M=JFLUID  
PO = POZ(M)  
CONP = CONPZ(M)  
TP=TPZ(M)  
CA = CAZ(M)  
HO = HOZ(M)  
MI = MIZ(M)  
H2 = H2Z(M)  
SO = SOZ(M)  
SI = SIZ(M)  
S2 = S2Z(M)  
CB = CBZ(M)  
CC = CCZ(M)  
CD = CDZ(M)  
YO = YOZ(M)  
VI = VIZ(M)  
V2 = V2Z(M)  
CY = CYZ(M)  
CONY = CONYZ(M)
```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

H3 = H3Z(M)
H4 = H4Z(M)
CON1 = CON1Z(M)
CON2 = CON2Z(M)
S3 = S3Z(M)
CON3 = CON3Z(M)
R = -1545.32 / (AMOL(M)*778.172)
DO 430 J=1,7
  AK(J) = AKZ(J,M)
  BK(J) = BKZ(J,M)
  FK(J) = FKZ(J,M)
430 GK(J) = GKZ(J,M)
J = 0
6 GO TO (M1,M2,M3,M4,M5,M6,M7,M8,M9),N
M1 WORD(3) = 5H(T,Q)
GO TO 12
M2 WORD(3) = 5H(T,M)
GO TO 12
M3 WORD(3) = 5H(T,S)
GO TO 12
M4 WORD(3) = 5H(P,Q)
GO TO 1
M5 WORD(3) = 5H(P,M)
GO TO 1
M6 WORD(3) = 5H(P,S)
GO TO 1
M7 WORD(3) = 5H(H,S)
GO TO 8
M8 WORD(3) = 5H(T,P)
GO TO 200
M9 WORD(3) = 5H(HL)
GO TO 11
C
C      COMPUTE VAPOR DOME PROPERTIES
C
11 T=SQRT((M1/(12.*M2))**2-(M3-M1)/(12.*M2)
  Q=0.
GO TO 12
1 T= CONP/LOGF(P0/P)+TP
12 ETA= T *(E/PF(-CONP/(T -TP)))/(T -TP)**2)
EX = (CA*EXP(CONV/T) +CB+CC*T +CD*T **2)*ETA
14 GO TO (2,4,5,2,4,5,4,X,2),N
2 S = SQ/T+S1+S2=T+EX=Q/T
GO TO (3,9,X,3,100,X,X,9),N
3 H = M3+M1*T+M2*T+EX=Q

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

IF (N-3) 9,9,100
4 Q = (H-M3-M1)*T-M2*T+T)/EX
IF (Q) X2,15,15
15 IF (Q-1.0000001) 7,199,199
7 IF (N-6) 2,X,9
5 Q = (S-S3/T-S1-S2*T)/T/EX
IF (Q) X2,16,16
16 IF (Q-1.0000001) 10,199,199
10 GO TO 3
8 A = S-S1+M1
B = H-M3+S3
ROOT = A*A-4.*B*(S2-M2)
IF (ROOT)*X2,15,15
13 T = (A-SQRT(ROOT))/(12.*(S2-M2))
GO TO 12
9 P = P0/EXPF(CONP/(T-TP))
100 VL = VQ+V1*T+V2*T*T
VG = CV*EXPF(CONV/T)
Y = VL*(1.-Q)+VG*Q
SL = SQ/T +S1+S2*T
SG = EX/T+SL
HL = M3+M1*T+M2*T+T
HG = EX+HL
105 IF (Q) X2,106,106
106 IF (P-36.) 107,107,X1
107 IF (T-1800.) X3,110,110
110 TZ = T
PZ=P
QZ = Q
SZ = S
HZ = H
VZ = Y
RETURN
C
C      ERROR MESSAGES
C
X GO TO 110
C      ENTRY FOR WRITE OUT OF ARGUMENTS
C
ENTRY OUTYAP (NZ,TZ,PZ,QZ,MZ,SZ,VZ)
999 WRITE OUTPUT TAPE 3,1005,N,WORD(3),T,P,Q,H,S,Y
1005 FORMAT (3X,5HINDEX,15X,1HT,15X,1HP,15X,1HQ,15X,1HH,15X,1HS,15X,
1 1HY/1X,12,A5,5X,6E16.4)
GO TO 110
C

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

C      COMPUTE SUPERHEAT PROPERTIES
C
200 IF (T-CONP/LOGF(PO/P)*TP)*X2,199,199
199 Q = 1.
J = 1
GO TO (X,203,204,X,205,206,207,201),N
201 ETA = T * (EXP(-CONP/(T -TP)))/(T -TP)**2)
EX = ((CA*EXP(CONV/T) )*(CB*CC*T +CD*T **2)*ETA
PS = PO/EXP(CONP/(T-TP))
EX1 = AK(1) + M3*EXP(CON1/T)
DO 400 K=1,6
400 EX1 = EX1 + AK(K)*T**(-K)
EX2 = BK(1) + M4*EXP(CON2/T)
DO 401 K=1,6
401 EX2 = EX2 + BK(K)*T**(-K)
DELP = (PS-P)
H=H0+H1*T+H2*T**2+EX*EX1*DELP+EX2*DELP*DELP
GO TO (X,X,210,X,309,210,X,202),N
202 ETA = T * (EXP(-CONP/(T -TP)))/(T -TP)**2)
EX = ((CA*EXP(CONV/T) )*(CB*CC*T +CD*T **2)*ETA
PS = PO/EXP(CONP/(T-TP))
FX1 = FK(1) + S3/T*EXP(CON3/T)
DO 402 K=1,6
402 FX1 = FX1 + FK(K)*T**(-K)
FX2 = GK(1)
DO 403 K=1,6
403 FX2 = FX2 + GK(K)*T**(-K)
DELP = P9-P
S=(S0+EX1)/T+S1+S2*T + FX1*DELP + FX2*DELP*DELP + R*LOGF(P/PS)
GO TO (X,210,X,X,210,319,X,210),N
203 ETA = T * (EXP(-CONP/(T -TP)))/(T -TP)**2)
EX = ((CA*EXP(CONV/T) )*(CB*CC*T +CD*T **2)*ETA
PS = PO/EXP(CONP/(T-TP))
MS = H0+H1*T+H2*T**2+EX
EX1 = AK(1) + M3*EXP(CON1/T)
DO 404 K=1,6
404 EX1 = EX1 + AK(K)*T**(-K)
EX2 = BK(1) + M4*EXP(CON2/T)
DO 405 K=1,6
405 EX2 = EX2 + BK(K)*T**(-K)
H = EX1/EX2/2.
R00 = H*(H-MS)/EX2
IF (H1705,705,710
705 P = PS*M*SQRTF(R00)
GO TO 202

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

710 P = PS*M-SQRTF(R00)
GO TO 202
204 DEL = 10.
PS = PO/EXP(CONP/(T-TP))
P = PS
ETA = T * (EXP(-CONP/(T -TP)))/(T -TP)**2)
EX = ((CA*EXP(CONV/T) )*(CB*CC*T +CD*T **2)*ETA
SP = S-S0/T-S1-S2*T-EX/T
FX1 = FK(1) + S3/T*EXP(CON3/T)
DO 406 K=1,6
406 FX1 = FX1 + FK(K)*T**(-K)
FX2 = GK(1)
DO 407 K=1,6
407 FX2 = FX2 + GK(K)*T**(-K)
DO 305 JP = 1,5
DEL = DEL/10.
DO 300 LP=1,35
DELP = PS-P
SPP = FX1*DELP + FX2*DELP*DELP + R*LOGF(P/PS)
P = P-DELP
IF (SP-SPP)305,305,300
300 CONTINUE
305 P = P+DELP
GO TO 201
205 HX = H
DEL = 1000.
T = 1700.
DO 315 JT=1,4
DEL = DEL/10.
DO 310 LT=1,18
T = T+DEL
GO TO 201
309 IF (MX-H) 315,315,310
310 CONTINUE
315 T = T-DEL
H = HX
GO TO 202
206 SX = S
DEL = 1000.
T = 1700.
DO 325 JT = 1,4
DEL = DEL/10.
DO 320 LT=1,18
T = T+DEL
GO TO 202

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

319 IF(SX-S) 325,325,320
320 CONTINUE
325 T = T-DEL
S = SX
GO TO 201
207 T1 = (H-981.61)/B.
SS1 = .16*LOGF(T1)
DELP1 = SS1-S
TONE = 1800.
TTN0 = 2000.
ETA = TONE*(EXP(-CONP/(TONE-TP1))/(TONE-TP1)**2)
EX = (CA*EXP(CONV/TONE) + CB*(C+TONE+CD*TONE**2))/ETA
H0NE = H0+H1*TONE+H2*TONE**2+EX
215 ETA = TTN0*(EXP(-CONP/(TTN0-TP1))/(TTN0-TP1)**2)
EX = (CA*EXP(CONV/TTN0) + CB*(C+TTN0+CD*TTN0**2))/ETA
HTN0 = H0+H1*TTN0+H2*TTN0**2+EX
T2 = (TTN0*(H0NE-H1-TONE*(HTN0-H1))/(H0NE-HTN0)
IF (ABSF(HTN0-H1)-.1) 220,444,444
444 H0NE = HTN0
TONE = TTN0
TTN0 = T2
GO TO 215
220 ETA = T2 *(EXP(-CONP/(T2 -TP1))/(T2 -TP1)**2)
EX2 = (CA*EXP(CONV/T2 ) + CB*(C+T2 +CD*T2 **2))/ETA
SS2 = SO/T2+S1+S2*T2+EX2/T2
DELP2 = SS2-S
T2 = (T2+DELP1-T1+DELP2)/(DELP1-DELP2)
250 ETA = T2 *(EXP(-CONP/(T2 -TP1))/(T2 -TP1)**2)
EX2 = (CA*EXP(CONV/T2 ) + CB*(C+T2 +CD*T2 **2))/ETA
HS2 = H0+H1*(T2+H2*T2+T2 +EX2
PS2 = PO*EXP(-CONP/(T2-TP1))
EXA = AK(1) + H3*EXP(CON1/T2)
DO 408 K=1,6
408 EXA = EXA + AK(K+1)*T2**(-K)
EXB = BK(1) + H4*EXP(CON2/T2)
DO 409 K=1,6
409 EXB = EXB + BK(K+1)*T2**(-K)
H = EXA/EXB*.5
R00 = H*(H-HS2)/EXB
IF(H)805,805,810
805 HH2 = PS2+H*SORTF (R00)
GO TO 815
810 HH2 = PS2+H-SORTF (R00)
815 FX1 = FK(1) +S3/T2*EXP(CON3/T2)
DO 410 K=1,6

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

410 FX1 = FX1 + FK(K+1)*T2**(-K)
FX2 = GK(1)
DO 415 K=1,6
415 FX2 = FX2 + GK(K+1)*T2**(-K)
DELP = PS2 - HH2
SS2 = (SO+EX1)/T2+FX1+DELP+FX2+DELP+DELP + R*LOGF(HH2/PS2)
DELP2 = SS2-S
IF (ABSF(DELP2)-.000001) 209,209,555
555 T2 = (T2+DELP1-T1+DELP2)/(DELP1-DELP2)
GO TO 250
209 T = T2
P = HH2
210 PS = PO/EXP(-CONP/(T-TP1))
DELP = PS-P
EX1 = AK(1) + H3*EXP(CON1/T)
DO 411 K=1,6
411 EX1 = EX1 + AK(K+1)*T**(-K)
EX2 = BK(1) + H4*EXP(CON2/T)
DO 412 K=1,6
412 EX2 = EX2 + BK(K+1)*T**(-K)
FX1 = S3*EXP(CON3/T)
DO 413 K=1,7
413 FX1 = FX1 + FK(K+1)*T**(-K)
FX2 = G.
DO 414 K=1,7
414 FX2 = FX2 + GK(K+1)*T**(-K)
Y = (FX1-EX1+2.*DELP*(FX2-EX2)-R*T/P)*.36767
TX = CONP/LOGF(PO/P1)+TP
ETA = TX *(EXP(-CONP/(TX -TP1))/(TX -TP1)**2)
EXX = (CA*EXP(CONV/TX ) + CB*(C+TX +CD*TX **2))/ETA
YL = Y0+Y1*TX+Y2*TX*TX
YG = Y*EXP(CONV/TX)
SL = SO/TX+S1+S2*TX
SG = EXX/TX+SL
HL = H0+H1*TX+H2*TX*TX
HG = EXX+HL
GO TO 105
C
C TRANSFERS FOR DIAGNOSTICS
C
X1 K = 1
GO TO X
X2 K = 2
GO TO X
X3 K = 3

```

EVAP - A LIQUID METALS THERMODYNAMIC PROPERTIES SUBROUTINE

```

GO TO X
X4 K = 4
GO TO X
END

```

CLICHE - A SUBROUTINE FOR DYNAMIC DIMENSIONING OF DTF-2

```

*   FORTRAN      CLICHE      LRLTRAN VERSION 5/13/68
SUBROUTINE      CLICHE
C   DUMMY SUBROUTINE FOR COMMON CLICHE
C   MAXIMUM OF 40 INTERVALS IN THIS VERSION
CLICHE COM
PARAMETER (NGH=16,NIM=40,NSN=4,NCR=10,NZH=8,NGP=NGH+1,NIP=NIM+1,
1   NMT=NCR+2+NZH,NMM=(NSN*(NSN+1)/4+1),NMS=NZH*(NCR+3)+1)
COMMON/TAPES/ NIC,NJT(5)
COMMON/DTFKON/ ALA,ASR,AYE,AYR,BF,CEY,CNT,CYT,DFM,DFM1,DFM2,
1   DY,DZ,EPG,EPN,EPS,EOL,EOP,EO,E,E1,E2,E3,E4,E5,E6,E7,E8,
2   E9,E10,E11,E12,E13,E14,E15,E16,E17,E18,E19,E20,ESC,ESM,
3   EYM,EYN,EYP,EY,FTP,FXM,IBL,IBR,ICM,IC,ICYT,IDFM,IO,IEYT,
4   IPN,IGE,IGM,IGP,IG,IGS,IGV,IMG,IMM,IMS,IMT,IIC,IIM,IM,
5   IPN,IPP,IP,IPY,IPYT,IGM,ISCT,ISN,ITW,IT,IT1,IT2,IT3,IT4,
6   IZM,IZP,IT,KGSFC,K5842,K5833,K5851,K5852,LC,M,MCR,MG,
7   MI,ML,MM,MS,MTP,MT,NFN,PY,PyT,RXF,RyF,XITA,XITR,XLAW,
8   XLAL,XLAP,XLAR,XLA,XNBT,XNC,XNF,XNIO,XNPM,ZZ1,ZZ2,ZZ3,
9   IPH,ITA,EAM,ZI,IGN,IIG,RLB,XNLB,IM,IOULL,IOU
COMMON/DTFARR/ AA(NIP),AF(3),AG(NGP),B(NMM*NGP),CE(NIP),CB(2)
1   CF(NIP),CH(9),CL(NIP),C19=NGP*NMT),CS(NIP),CT(NIP),
2   DA(NIP=NMM),DB(NIP=NMM),DC(NIP=NMM),DE(NIP),D(NMM),
3   DS(NIP=NMM),FG(NGP),FNG(NGP),FINIP),IBX(NGP),ICX(NGP),
4   IDX(NMM),IGT(NGP),IZI(NIP),MA(NIP),MB(NMS),MC(NMS),
5   MR(NMM),MTT(NMM*2),MZ(NMS),NX(NGP),PA(NGP),PG(NGP),
6   PR(NMM),PINMM),QG(NGP),Q(NIP=NGP),RA(NIP),RAY(NIP),
7   RLG(NGP),RM(NIP),R(NIP),SA(NIP),SAT(NIP),SB(NIP),SCG(NGP),
8   SDG(NGP),SG(NGP),SNG(NGP),ST(NIP),TAB(NGP),YE(NGP),YF(3),
9   Y(NIP),WD(NMM),W(NMM),XJ(NIP=NGP),XKE(NGP),XKI(NGP)
COMMON DTFARR/ XMD(NMS),XNA(NIP),XNB(NGP),XNDG(NGP),XNE(NIP),
1   XND(NIP=NMM),XNG(NGP),XNI(NMM),XNLG(NGP),XNN(NIP),
2   XNR(NMM),XNR(NIP),XN(NIP=NGP),XNB(NMM),SR(NIP),CA(NIP),
3   PB(NGP),ICX(NMT)
END CLICHE
USE COM
RET,ORN
END

```

PONDEN - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

*   FORTRAN      PONDEN      LRLTRAN VERSION 4/16/68
SUBROUTINE PONDEN(PON)
USE COM
COMMON/GNATZ/KA(NZM),MIST1
DIMENSION GNUM(NGH),GNUM5(NGH),GNUB(NGH),GNUM9(NGH),PDMF(NIM),PDM(NI
1   IM)
C   THE VALIDITY OF THESE CALCULATIONS
C   IS BASED ON MATERIAL 10 = U235
C   MATERIAL 11 = U235
C   MATERIAL 13 = U238
C   MATERIAL 14 = PU239
C   THIS SUBROUTINE SEARCHES FOR THOSE ZONES WHICH CONTAIN
C   U235, U235, OR PU239 AND IGNORES ALL OTHERS
C   MIST1 = 0 IMPLIES ISOTROPIC SCATTERING
C   MIST1 = 1 IMPLIES ANISOTROPIC SCATTERING
C   THE COMPUTED POWER DENSITIES (PON) ARE NORMALIZED TO THE DENSITY
C   IN THE FIRST INTERVAL OF THE FIRST FUEL ZONE XPOW IS THIS DENSITY
C   AND IS EDITED AS POWN
C   SINCE THE CROSS SECTION LIBRARY LISTS NU SIGMAF RATHER THAN THE
C   NU, VALUES BASED ON TABLE 7-2, ANL5800 ARE GIVEN AS DATA AND USED
C   TO OBTAIN SIGMAF
DATA (GNUM5+3 02.2 70.2 61.2 57.2 53.11(2 51))
DATA (GNUM5+2 94.2 62.2 53.2 49.2 46.11(2 45))
DATA (GNUB+2 80.2 50.2 45.13(10 1))
DATA (GNUM9+3 48.3 09.2 99.2 93.2 88.11(2 86))
C   SELECT FUELLED ZONES
IN=0
NC=0
1   DO 5 N=1,IZM
IN=IN+KA(N)
IF(MIST1) ,.40
JN=N*(MCR+1)+1 MCR
GO TO 45
40   JN=N*(MCR+1)+1 MCR+2*(N-1)
45   IF (XMD(JN)-1 E-20) ,.60

```

PONDEN - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

      IF(XMD(JN-1)-1 E-20) , .60
      IF(XMD(JN+3)-1 E-20)5.5.
C     COMPUTE SIGF
60  L=IN-KA(N)+1
    DO 10 I=L,IN
      POWF(I)=0
C     SIGF FOR U235, J=11
    DO 15 JGN=1,1GM
      NAG=(JGN-1)*IM+1
      M=2+IMH*(JGN-1)
      IF(XMD(JN)-1 E-20)50.50,
      LL=IMG+10
      CI=CILL+MI
      SIGF5=XMD(JN)=CI/GNU5(JGN)
50  SIGF5=0
      SIGF8=0
      SIGF9=0
C     SIGF FOR U235, J=10
      JN=JN-1
      IF(XMD(JN)-1 E-20)20.20,
      LL=IMG+9
      CI=CILL+MI
      SIGF5=XMD(JN)=CI/GNU5(JGN)
C     SIGF FOR U238, J=13
20  JN=JN+3
      IF(XMD(JN)-1 E-20)25.25,
      LL=IMG+12
      CI=CILL+MI
      IF(JGN-4) .25.25
      SIGF8=XMD(JN)=CI/GNU8(JGN)
C     SIGF FOR PU239, J=14
25  JN=JN+1
      IF(XMD(JN)-1 E-20)30.30,
      LL=IMG+15
      CI=CILL+MI
      SIGF9=XMD(JN)=CI/GNU9(JGN)
30  POWF(I)=POWF(I)+XN(NAG)*(SIGF5+SIGF8+SIGF9)
      IF(MIST) , .55
      JN = N*(MCR+1)+1-MCR

```

PONDEN - A SUBROUTINE TO CALCULATE RADIAL POWER PROFILES

```

      GO TO 15
55  JN=N*(MCR+1)+1-MCR+2*(N-1)
15  CONTINUE
      IF(NC-1) .35.35
      XPON=POWF(L)
      NC=NC+1
      WRITE OUTPUT TAPE 3,100,XPON
35  POW(I)=POWF(I)/XPON
      WRITE OUTPUT TAPE 3,101,I,POW(I)
10  CONTINUE
5   CONTINUE
100 FORMAT (1H1,5X,16H I NORM POWER,3X,6HPONN *.E12 5//)
101 FORMAT (5X,12,5X,F8 5//)
      RETURN
      END

```

NDTF - A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

*   FORTRAN      NDTF 6600   LRLTRAN VERSION 4/16/68
SUBROUTINE NDTF(EFFK,XLEN,RADII,ADEN,MCR,I,IZM,MIST)
C
C
C   DESIGNED FOR 5 INTERVALS PER ZONE, 8 CORE ZONES MAX, 10 MATERIALS
C   MAX, AND 16 ENERGY GROUPS
C
C   THE ATOM DENSITIES (XMD), XSECTIONS (CI), AND SCALAR FLUXES (XN),
C   ARE COMMON FROM DTF
C
C   NDTF ACTS AS THE MAIN ROUTINE FOR THE DTF-2(S4),1D(RADIAL) TRANS-
C   PORT CODE. THE S4 COSINES AND WEIGHTS WERE SELECTED TO OBTAIN
C   MAXIMUM ACCURACY OF KEFF IN CONTEXT WITH THE SPATIAL MESH AND
C   DESIRED SHORT RUNNING TIME
C
C   IN ORDER TO PROVIDE EXPLICIT DATA FOR CORRESPONDING HIGHER SN ORDER
C   THE WEIGHTS (W), AND DIRECTION COSINES (D) FOR N=6 AND 8 ARE LIST-
C   ED BELOW. THE READER IS CAUTIONED THAT EITHER OF THESE SETS MAY
C   ONLY BE USED TO REPLACE THE S4 SET IF NSN OF CLICHE IS CHANGED
C   TO THE NEW VALUE OF N AND THE WHOLE CODE FOLLOWING CLICHE IS RE-
C   COMPILED
C
C   DATA FOR S6
C
C   DATA(W=0 , 16666667, 08333333,2( 05555556), 08333333, 16666667,
C   10 , 08333333,2( 05555556), 08333333,0 ,2( 05555556))
C   DATA(D=- 99346060,-8 0847425,- 57735027,- 11417547, 11417547,
C   1 57735027, 80847425,- 81649658,- 57735027,- 11417547, 11417547,
C   2 57735027,- 58853155,- 11417547, 11417547)
C
C   DATA FOR S8
C
C   DATA(W=0 , 11434821, 04600346, 04653606,2( 03850917), 04653606,
C   1 04600346, 11434821,0 , 04600346, 04653606,2( 03850917), 04653606,
C   2 04600346,0 , 04653606,2( 03850917), 04653606,0 ,2( 03850917))
C   DATA(D=- 99381544,- 85708017,- 70273364,- 50307327,- 11104445,
C   1 11104445, 50307327, 70273364, 85708017,- 86424376,- 70273364,
C   2- 50307327,- 11104445, 11104445, 50307327, 70273364,- 71143904,
C   3- 50307327,- 11104445, 11104445, 50307327,- 51518506,- 11104445,
C   4 11104445)
C
C   CAUTION USE THESE DATA ONLY AS DESCRIBED ABOVE
C
C

```

WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

C THE ACTUAL NUMBER OF ZONES (IZM) AND MATERIAL (MCR) ARE SET IN THE
C MAIN DECK THE NUMBER OF ENERGY GROUPS IS SET IN CLICHE (NGM) AS
C ARE THE MAXIMUM NUMBER OF ZONES (NZM) AND THE MAXIMUM NUMBER OF
C MATERIALS (NCR), AND SN ORDER (NSN)
C
C ANY CHANGES IN CLICHE NECESSITATE A RECOMPILATION OF WDTF AND ALL
C TRANSPORT CODE SUBROUTINES INCLUDING PONDEN INDIVIDUAL SUBROUTINE
C CHANGES HOWEVER ARE INDEPENDENT
C
C PROVISION FOR BOTH ISOTROPIC AND ANISOTROPIC SCATTERING ARE INCLUD-
C ED IN WDTF THE SCATTERING TYPE IS SELECTED BY SETTING MIST IN THE
C MAIN PROGRAM
C
C NOTE THAT FOR MIST =1, THE SECOND ANISOTROPIC MATERIAL ATOM DENSITY
C (FOR M=2 IF HYDROGEN) IS SET IN WDTF AS EQUAL TO THE FIRST (E G
C M=1) ANISOTROPIC MATERIAL ATOM DENSITY FROM THE MAIN DECK TO
C FUNCTION CORRECTLY M=1 MUST BE MATERIAL NUMBER MCR-1 AND M=2 MUST
C BE MATERIAL NUMBER MCR IF INCLUDED IN A MIST =0 CALCULATION THE
C ATOM DENSITY OF M=1 SHOULD BE SET TO ZERO IN THE MAIN DECK OR THE
C M=1 XSECTION DECK REPLACED BY THE ISOTROPIC HYDROGEN VERSION
C
C MIST = 0 IMPLIES ISOTROPIC SCATTERING
C MIST = 1 IMPLIES ANISOTROPIC SCATTERING
C
C
C USE COM
COMMON/GNATZ/KA(NZM),MIST1
DIMENSION RAD1(NZM),ADEN(NCR,NZM),PNG(NIM),PNGG(NIM),
1 EMEY(NIM),EINT(NZM)
C
C DEFINE UNCONDITIONAL PARAMETERS
C
DATA(ID=0),(ITH=0), (ISN=NSN),(IGE=2),(IBL=1),(IBR=0),
1 (IFN=0),(IEYT=1),(EY=0),(EYN=0),(EPS=1E-4),(IGM=NGM),
2 (INT=3),(IMS=4),(IMH=9),(BF=1.0157994),(DZ=0),(IDFM=0),
3 (DFM1=0),(DFM2=0),(XNF=1),(IPYT=0),(PY=0),(IQM=0),(IPM=0),
4 (IPP=0),(FXM=0),(IIN=20),(IGS=0),(RYF=5),(XLAL=1),(XLAM=5),
5 (EQL=005),(XNPM=1),(ID1=0),(ID2=0),(ID3=0),(ID4=0),(ICM=100),
6 (IDT=0),(MTP=0),(NJT=50),(NIC=2),(IJOB=0),
7 (F=NM1(1)),KA=5.5,5.5,5.5,5.5
24 DATA(N=0, 55555555.2( 08555555), 5555555.0, 2( 08555555))
DATA(D=- 99578192, - 70412415, - 09175171, 09175171,
1 70412415, 71007688, - 09175171, 09175171)
DATA(XK)= 204, 344, 168, 18, 09, 014,10(0)
DATA(YE=34 2,19 9,14 7,11 .6 7,2 7,1 14, 48, 206, 101, 0566,
1 0319, 0179, 0109, 00606, 00218)

```

WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

MIST1 = MIST
MCR=MCR1
IZM=IZM1
IM=5=IZM
ID = IJOB = IJOB+1 $ DY = XLEN $ IK = IJJ = 0
C
C SELECT SCATTERING OPTION
IF(MIST) , .30
C
C ISOTROPIC SCATTERING OPTION
C
ISCT = 1
MT = MCR+IZM $ MS = IZM+(MCR+1)
DO 40 N = 1,IZM
DO 35 I = 1,KA(N)
IK = IK+1
35 HA(IK) = N
MZ(N) = MCR+N $ IJJ = IJJ+1
MC(IJJ) = 0 $ XMD(IJJ) = 0 $ MD(IJJ) = MCR+N
DO 40 J = 1,MCR
IJJ = IJJ+1 $ MC(IJJ) = J $ MD(IJJ) = MCR+N
XMD(IJJ) = MAX1F(1E-30,ADEN(J,N))
40 CONTINUE
GO TO 45
C
C ANISOTROPIC SCATTERING OPTION
C
30 MT=MCR + 2+IZM $ MS=IZM+(MCR+3)
ISCT = -1
NIT=0
DO 150 N=1,IZM
DO 130 I=1,KA(N)
IK = IK+1
130 HA(IK) = N
MZ(N) = MCR+N-NIT $ IJJ=IJJ+1
MC(IJJ)=0 $ XMD(IJJ)=0 $ MD(IJJ)=MCR+N+NIT
DO 140 J=1,MCR
IJJ=IJJ+1 $ MC(IJJ)=J $ MD(IJJ)=MCR+N+NIT
XMD(IJJ) = MAX1F(1E-30,ADEN(J,N))
140 CONTINUE
IJJ=IJJ+1 $ XMD(IJJ)=0 $ MD(IJJ)=MCR+N+NIT+1
MC(IJJ)=0
J=MCR
IJJ=IJJ+1 $ MC(IJJ)=J $ MD(IJJ)=MCR+N+NIT+1

```

WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

      NIT=NIT+1
      XMD(11)=MAX(ADEN((J-1),N),1.E-30)
150  CONTINUE
45   IF (NJT(1)) 200,
      WRITE OUTPUT TAPE 3,19,XLEN,(RADII(K),K=1,12M)
      CALL CLOCK(TM1,TM2)
      WRITE OUTPUT TAPE 3,111,1,TM1,TM2
      WRITE OUTPUT TAPE 3,18,((ADEN(I,J),J=1,12M),I=1,MCR)
200  L = 1 * R(1) = 0.
      DO 220 I=1,12M
      JIN = L+KA(1)
      DINC = (RADII(1)-R(L))/KA(1)
      DO 210 J=L+1,JIN
210  R(J) = R(J-1)+DINC
      L = JIN * R(L) = RADII(1)
220  CONTINUE
      IC = LC + 1IC = 0
      CALL S800
      CALL RECS(1JOB)
      CALL S804
      CALL S813
      CALL DTF2
      IFN = 1
      EFFK = EY
      IF (NJT(1)) 300,
      AYNE = 5.251E-3 * (XNG(1GP)/XNDG(1GP))**2
      WRITE OUTPUT TAPE 3,909,1JOB,EY,AYNE
      DO 260 I=1,1M
      PNG(1) = PNDG(1) = 0.
      DO 250 J=1,1GM
      K = (J-1)/M+1
      AT = Y(1)*XN(K)
      PNG(1) = PNG(1)+AT
250  PNDG(1) = PNDG(1)+AT/YE(J)
      AA = 0.
      IF (PNDG(1)) ,260,
      AA = PNG(1)/PNDG(1)
260  EMEV(1) = 5.251E-3*AA*AA
      K = KK = 0
      DO 280 I=1,12M
      K = KK+1 * A1 = A2 = 0.
      KK = K-1+KA(1)
      DO 270 J=K,KK
      A1 = A1+PNG(J)
270  A2 = A2+PNDG(J)

```

WDTF- A ONE DIMENSIONAL TRANSPORT CODE STRIPPED FOR CYLINDRICAL REACTORS

```

      AA = 0.
      IF (A2) ,280,
      AA = A1/A2
280  EINT(1) = 5.251E-3*AA*AA
      WRITE OUTPUT TAPE 3,20,(EINT(L),L=1,12M)
      IF (NJT(5)) 290,290,
      WRITE OUTPUT TAPE 3,909,1JOB,EY,AYNE
      WRITE OUTPUT TAPE 3,20,(EINT(L),L=1,12M)
      GO TO 295
290  PRINT 909,1JOB,EY,AYNE
295  IF (NJT(1)-1) 300,
      WRITE OUTPUT TAPE 3,22,(EMEY(L),L=1,1M)
300  RETURN
909  FORMAT(//10H ***** JOB,14,6X,8H KEFF = F12.8, 6X, 15HAYG NEUT MEY
1= F9.6 //)
1111 FORMAT(//10X, 6HTIME , 24B)
18  FORMAT(// 15H DENSITY ARRAY / (8E15.5))
19  FORMAT(1H1, 9H XLEN = F10.2, 2X, 8HBRAD1 = 8F10.2 //)
20  FORMAT(//26H AVERAGE NEUT MEY PER ZONE / (8E14.6))
22  FORMAT(// 53H SPECTRUM AVERAGE NEUTRON ENERGY (MEV) PER INTERVAL
1 / (8E15.6))
      END

```

NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

A LARGE NUMBER OF ROUTINES ARE INCLUDED IN THIS SECTION SINCE THEY ARE PART OF THE NORMAL DTF-2 PACKAGE WHICH HAS BEEN EXTENSIVELY WRITTEN UP ELSEWHERE.

```

=   FORTRAN      DTF2
    SUBROUTINE DTF2
    USE COM
    CNIX X-SECTS      0441
    807 CALL S807      0442
    CMODIFY RADII      0444
    CALL S810          0445
    CCOMPUTE AREAS AND VOLUMES      0447
    CALL S811          0448
    CCOMPUTE GEOMETRIC FUNCTIONS      0450
    812 CALL S812      0451
    IF (NJT(1)-1) 821,821,
    CALL PC1
    CFISSION CALCULATION      0468
    821 CALL S821      0469
    822 CALL S822      0470
    823 CALL S823      0471
    830 IF (SENSE SWITCH 1) SEND,
    CALPHA OPTION COMPUTATION
    CALL ALPHOP
    ITG=1
    CCOMPUTE FIXED SOURCE
    824 CALL S824      0481
    CCOMPUTE ANISOTROPIC SOURCE
    825 CALL S825      0482
    1825 CONTINUE      0483
    CGROUP SKIPPING AND FLUX CONTROL
    CALL GSFC          0495
    1GOTO=KGSFC
    GOTO(832,841),1GOTO
    CCOMPUTE BASIC SOURCE
    832 CALL S832      0501
    CCOMPUTE ANGULAR FLUX
    DDB442J=1,MM
    M=J
    CSET ANGULAR FLUX BOUNDARY CONDITIONS
    842 CALL S842      0510
    IF (D(M))843,844,844
    CCOMPUTE OUTWARD FLOW NEUTRONS
    844 CALL S844      0511
    GOTO8442
    CCOMPUTE INWARD FLOW NEUTRONS
    845 CALL S845      0515
    0516

```


NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

8442 CONTINUE
C COMPUTE NEUTRON SUMS
845 CALL S845
CHECK FOR REFLECTIVE OR PERIODIC OUTER BOUNDARY
IF (IBR-1) 833,8341,8341
8341 IF (ABS(XNLG(IIG))-EPG) 833,833,834
C COMPUTE BOUNDARY SOURCE
834 CALL S834
C COMPUTE ANGULAR FLUX
D08443J=1,MH
M=J
CALL S842
IF (DM) 1843,1844,1844
1844 CALL S844
GOTO 8443
1843 CALL S843
8443 CONTINUE
CALL S845
C COMBINE FLUX COMPONENTS
CALL CFC
C PERFORM INNER ITERATION
833 CALL S833
IGOTO=KS833
GOTO(832,837,841),IGOTO
C COMPUTE CURRENT
837 CALL S837
GOTO 832
C GROUP CODE
841 CALL S841
C CHECK FOR ANISOTROPIC SCATTERING
IF (ISCT+1) 8372,8371,8372
C COMPUTE CURRENT
8371 CALL S837
C UPDATE GROUP COUNT
8372 IIG=IIG+1
IF (IGH-IIG) 847,824,824
C TOTAL GROUP CODE
847 CALL S847
C FISSION CALCULATION
CALL S821
CALL S822
CALL S823
C COMPUTE CONVERGENCE NUMBERS
CALL S851
IGOTO=KS851

```

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```

NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

8511 GOTO(8512,830,852),IGOTO
C FINAL PRINT
8512 IF (NJT(1)) 8000,8000,
CALL FINPR
8000 RETURN
3003 CALL AEND(3003)
C COMPUTE NEW PARAMETERS
852 CALL S852
IGOTO=KS852
GO TO (8512,830,807),IGOTO
4000 JJJ=-1
4002 CALL AEND(JJJ)
4010 JJJ=-2
GO TO 4002
4020 JJJ=-15
GO TO 4002
4030 JJJ=-24
GO TO 4002
SEND WRITE OUTPUT TAPE 3, 999
998 FORMAT(// 6H IC = 10, 7H LC = 10,15H EIGENVALUE = E20 6)
999 FORMAT(//10X,32HRUN TERMINATED BY SENSE SWITCH 1)
PRINT 999
PRINT 998, IC, LC, EY
WRITE OUTPUT TAPE 3, 998, IC, LC, EY
CALL OFFMON
GO TO 830
END
C
* FORTRAN ALPHOP
SUBROUTINE ALPHOP
USE COM
1 E1=0
2 IF (IEY-2) 4,3,4
3 E1=EY
4 IF (IPY-2) 6,5,6
5 E1=E1+PY
6 D0101IG=1,IGH
10 TAB(IIG)=E1/EY(IIG)
RETURN
END
* FORTRAN BALAN
SUBROUTINE BALAN
USE COM
DIMENSION SUMZ(NGM),T(25),SUMT(57)
EQUIVALENCE (MTT,T), (IZI(19),SUMT(1))

```

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0586
0590
0595
0596
0599
0600

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0601

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2700

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

WRITE OUTPUT TAPE 3,127,11G
DO 333 I=1,16
  IF(11G-I) 200,200,201
200 SUMT(I)=0.
201 CONTINUE
333 SUMZ(I)=0.
  5 IM=INT-2
  CALL SBI6
  DO 4 I=1,IM
  4 CF(I)=CE(I)
  5 IM=INT-1
  CALL SBI6
  6 DO 128 L=1,12M
  7 I=1,17
  7 T(I)=0.
  8 DO 9 I=1,IM
  8 IF(MA(I)-L) 9,82,9
  82 F(IOM) 83,84,85
  83 K=I+NX(11G)
  C FIXED SOURCE T(I)
  85 T(I)=T(I)+Y(I)=Q(K)
  84 IF(17M) 86,87,86
  C FISSIONS IN T(2)
  87 T(2)=T(2)+Y(I)=F(I)*XKE(11G)
  GO TO 89
  86 T(2)=T(2)+Y(I)=F(I)=CE(I)
  89 T(5)=T(5)+ST(I)
  C SELF SCATTER
  T(4)=T(4)+CS(I)*XNN(I)
  T(5)=T(5)+CT(I)*XNN(I)
  C ABS. NEUTRONS
  T(6)=T(6)+CF(I)*XNN(I)=Y(I)
  C TOTAL FLUX
  T( 9)=T( 9)+ Y(I)*XNN(I)
  T(16)=T(16)+ Y(I)*XNN(I)=CE(I)
  9 CONTINUE
  LMAX=0
  10 DO 100 I=1,IM
  10 IF(MA(I)-L) 100,101,100
  101 IF(I-LMAX)100,102,102
  102 LMAX=I
  100 CONTINUE
  DO 103 M=1,MM
  K=LMAX+1+IDX(M)
  C RIGHT FLUX

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DDL2775

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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T(12)= T(12)+ XND(K)*M(M)
IF(D(M))105,105,104
  C RIGHT FLOW
  104 T(13)= T(13)+ XND(K)*ND(M)
  C RIGHT CURRENT
  105 T(14)= T(14)+ XND(K)*ND(M)
  105 CONTINUE
  C RIGHT LEAKAGE
  T(15)= AA(LMAX+1)=T(14)
  11 LMIN=IM+2
  DO 110 I=1,IM
  IF(MA(I)-L) 110,111,110
  111 IF(LMIN-I) 110,110,112
  112 LMIN=I
  110 CONTINUE
  DO 113 M=1,MM
  K=LMIN + IDX(M)
  C NET LEAKAGE
  113 T(7)= T(7)+ XND(K)*ND(M)
  T(7)= T(5)-T(7)=AA(LM(I)
  C IN SCATTER
  12 IF(1PM) 121,122,121
  121 T(3)=T(3)-T(4)-T(2)-T(1)
  GO TO 123
  122 T(3)=T(3)-T(4)-T(2)
  C OUT SCATTER
  123 T(5)=T(5)-T(4)-T(6)
  C NEUTRON BALANCE
  T(10)= T(1)+T(2)+T(3)-T(7)-T(6)-T(5)
  C ZONE NUMBER
  T(11)= L
  C TOTAL DENSITY
  T( 8)= T( 9)/YE(11G)
  WRITE OUTPUT TAPE 3,129, ( T(I),I=1,16)
  DO 202 I=1,16
  SUMZ(I)=SUMZ(I)+T(I)
  202 SUMT(I)=SUMT(I)+T(I)
  129 FORMAT( 1M /BE15.6/BE15.6)
  127 FORMAT(18H1BALANCE FOR GROUP,14, /120M FIXED SOURCE *FISSION IN
  1=IN SCATTER *SELF SCATTER *OUT SCATTER *ABS. NEUTRONS *NET L
  2EAKAGE *TOTAL DENSITY //120M *TOT. FLUX *NEUTRON BALANCE*ZONE
  3 NO. *RIGHT FLUX *RIGHT FLOW *RIGHT CURRENT *RIGHT LEAKA
  4GE *FISSION DENSITY)
  128 CONTINUE
  WRITE OUTPUT TAPE 3,129, (SUMZ(I),I=1,16)

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DDL2864

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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      IF(IIG-IGH) 204,205,205
203 WRITE OUTPUT TAPE 3,127,1GP
      WRITE OUTPUT TAPE 3,129,(SUMT(I),I=1,16)
      WRITE OUTPUT TAPE 3,205
205 FORMAT(1H1)
204 RETURN
      END
*   FORTRAN          CFC
      USE COM
      SUBROUTINE CFC
1  E1=XNLB/XNLG(IIG)
2  XNLG(IIG)=E1*XNLG(IIG)+XNLB
3  RLG(IIG)=E1*RLG(IIG)+RLB
      DO 7 I=1,IM
7  XNN(I)=E1*XNN(I)+XNR(I)
      DO 12M=1,MM
      P(M)=PR(M)
12 XND(M)=E1*XND(M)+XNR(M)
      RETURN
      END
*   FORTRAN          DUFLU
      SUBROUTINE DUFLU
      A=A
      RETURN
      END
*   FORTRAN          GSFC
      SUBROUTINE GSFC
      USE COM
1  IIC=0
2  IF(SG(IIG))5,13,3
3  IF(IGS)17,17,4
4  IF(IZI(IIG))5,17,5
5  IF(IIG-1)17,17,6
13 E1=0.
      GOTO 15
6  IF(SG(IIG-1))7,13,7
7  E1=0.
8  DO 10 I=1,IM
10 E1=E1+XNN(I)*(CT(I)-CS(I))
14 E1=SG(IIG)/(E1+XNLG(IIG-1))
15 XNLG(IIG)=XNLG(IIG-1)*E1
16 RLG(IIG)=RLG(IIG-1)*E1
      GOTO 30
17 DO 21 J=1,IM
1  IM=J+1

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2865
DDL2866 21 XNN(I)=XN(K)
DDL2867 22 DO 28 J=1,MM
DDL2868 M=MM-J+1
2869 K=M+IBX(IIG)
2870 24 IF(IGR-1)25,26,26
2871 26 XND(M)=B(K)
      GOTO 27
25 XND(M)=0.
2872 27 CONTINUE
2904 28 CONTINUE
2905 KGSFC=1
2906 RETURN
2907 30 DO 33 I=1,MI
2908 33 XND(I)=XND(I)+E1
2909 34 DO 37 I=1,IM
2910 ST(I)=ST(I)+E1
2911 37 XNN(I)=XNN(I)+E1
2912 38 DO 42M=1,MM
2913 42 XND(M)=XND(M)+E1
      KGSFC=2
      RETURN
      END
*   FORTRAN          ERRO
      SUBROUTINE ERRO(MOL,JSUBR)
      USE COM
      COMMON /000000/ IFLAG(7)
      PRINT 1,MOL,JSUBR
      WRITE OUTPUT TAPE 3,1,MOL,JSUBR
1  FORMAT(2H =/2H =/9H ERROR IN,46,3H AT,16/2H =/2H =)
      GO TO 10
      ENTRY AEND (MOL)
10 WRITE OUTPUT TAPE 3,900,MOL,IFLAG(17)
900 FORMAT(10H EXIT JJJ,16,3H AT,016)
12 IF (UNIT,3) 12,14,14,14
14 CALL SPILL(AA,9696)
      CALL EXIT
      END
*   FORTRAN          FINPR
      SUBROUTINE FINPR
      USE COM
      WRITE OUTPUT TAPE 3,100
      WRITE OUTPUT TAPE 3, 101

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DDL314A
DDL314B

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

100 FORMAT (26H1 * * * FINAL PRINT * * * //)
101 FORMAT (95H 1D 1C 1C XNB(GP) EPS
      ' EQ EV XLA )
      WRITE OUTPUT TAPE 3,1,1D,1C,1C,XNB(GP),EPS,EQ,EV,XLA
1 FORMAT(315,5E16,6)
      WRITE OUTPUT TAPE 3,2,(MA(I),RA(I),RAY(I),F(I),Y(I),I=1,IP)
2 FORMAT(5H0ZONE,16H FINAL RADII,16H RAY,
      1 16H FISSIONS,16H VOLUME,/(15,4E16,7))
      L=1
      DO 4 I=1,1GM
      LF=L+IM-1
      WRITE OUTPUT TAPE 3,3,I
31 FORMAT (14H ENERGY GROUP ,15)
      WRITE OUTPUT TAPE 3,3,(XN(K),K=L,LF)
      L=LF+1
4 CONTINUE
3 FORMAT(6E16,8)
      RETURN
      END
*   FORTTRAN      PCI
      SUBROUTINE PCI
      USE COM
      IF(1C) 990,998,999
990 CONTINUE
      WRITE OUTPUT TAPE 3,1,(RA(I),Y(I),AA(I),I=1,IP)
1 FORMAT(10X,6HRADIUS,10X,6HVOLUME,12X,4HAREA/(5E16,7,15))
      WRITE OUTPUT TAPE 3,2,(N(I),D(I),ND(I),MR(I),I=1,MM)
2 FORMAT(15X,1HW,15X,1WD,14X,2HWD,13X,3H MR/(5E16,7,215))
      WRITE OUTPUT TAPE 3,5,(XK(I),XKE(I),I=1,1GP)
5 FORMAT(15X,3HXK1,15X,3HXKE/(2E16,7,15))
      WRITE OUTPUT TAPE 3,6,(MB(K),MC(K),XMD(K),K,K=1,MS)
6 FORMAT( 8H MIX-NO,8H MIX-COM,8H DENSITY /(210,5E16,8,18))
      L=1
      DO 31 I=1,MT
      LF=L+IMG-1
      WRITE OUTPUT TAPE 3,4,1,(C(K),K=L,LF)
4 FORMAT(11H X-SECT MT=15/19E15,5))
3 L=LF+1
999 RETURN
      END
*   FORTTRAN      RECS   REVISED MAY 1,1967
      SUBROUTINE RECS(IJOB)
      USE COM
      IF (IJOB=1) , ,310
      L = 1

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

KOPPS14C      DO 301 INT=1,MCR
KOPPS14D      READ INPUT TAPE NIC,302
KOPPS14E      WRITE OUTPUT TAPE 3,302
DDL3141      LF = L+IMG-1
3142          302 FORMAT(72H
      1
      1
      READ INPUT TAPE NIC,303, (C(I),I=L,LF)
      WRITE OUTPUT TAPE 3,304,(C(I),I=L,LF)
304 FORMAT (1X,6E14,6)
305 FORMAT(6E12,6)
301 L = LF+1
310 RETURN
      END
C
*   FORTTRAN      5800
      SUBROUTINES000
      USE COM
      AF(1)=1.0
      AF(2)=6.20318
      AF(3)=12.56636
      YF(1)=1.0
      YF(2)=.5
      YF(3)=.33333333
      IMG=1MM=1GM
4 DOGM=1,MT
6 ICX(M)=IMG=(M-1)
      GOT0(19,18,19),1GE
18 MM=(1SN=(1SN+4))/4
      GOT09
19 MM=1SN+1
9 MG=MM=1GM
10 IG=IM=1GM
11 IP=IM+1
12 D016M=1,MM
16 DX(M)=IP=(M-1)
      D0241IG=1,1GM
24 NX(1IG)=IM=11IG-1)
25 D029M=1,1GM
18X(M)=MM=(M-1)
29 ICX(M)=1MM=(M-1)
41 MI=MM=IP
43 XNLB=0.
      RLB=0.
44 ASR=0.
45 12P=12M+1

```

NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

      IGP=IGM+1
46 ML=MCR+MTP
47 IDN=ID
48 EPN=EPS
49 IF(ISC)51,51,50
51 JT=1
   GOT052
50 JT=0
52 IF(LC)53,54,53
53 RETURN
54 XLA=0
   ALA=0
   XLAP=0
55 CNT=0
   ICYT=0
   EQ=0
56 RETURN
   END
*   FORTRAN          S804
   SUBROUTINES804
   USE COM
   IF(IC)2,3,2
2 RETURN
3 EI=0
4 M=MM
5 MD(M)=D(M)+M(M)
6 EI=E1+MD(M)+M(M)
7 IF(MD(M))12,8,18
8 IF(D(M))10,9,10
9 CALL ERRO (6H S804,8)
   RETURN
10 MR(M)=MR(M+1)
18 M=M-1
   IF(M)20,20,5
20 IF(1 0E-04-ABSF(1 0-E1))22,21,21
21 RETURN
22 CALL ERRO (6H S804,20)
   RETURN
12 K=M
13 K=K+1
14 IF(K MM)15,15,23
23 CALL ERRO (6H S804,14)
   RETURN
15 IF(1 0E-04-ABSF(D(K)+D(M))13,16,16
16 MR(K)=M

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0668 MR(M)=K
0669 GOT018
0670 END
0671 *   FORTRAN          S807
0672 SUBROUTINES807
0673 USE COM
0674 1 NFN=1
0675 2 IF(MS)4,3,4
0676 3 RETURN
0677 4 IF(C)7,7,5
0678 5 IF(JEY-3)6,7,6
0679 6 RETURN
0680 7 D023M=1,MS
0681 9 IM=IMG
0682 10 I=MB(M)
0683 11 I=IMG+ICXX(I)
0684 12 K=MC(M)
0685 13 K=ICXX(K)+IMG
14 IF(MC(M))16,15,16
0691 15 C(I)=C(I)+XMD(M)
   GOT018
0727 16 IF(XMD(M))19,17,19
0728 17 C(I)=C(I)+EY
0729 18 I=I-1
0730 IM=IM-1
0731 21 IF(IM)22,22,14
0732 22 CONTINUE
0733 23 CONTINUE
0734 24 RETURN
0735 19 C(I)=C(I)+XMD(M)=C(K)
0736 K=K-1
0737 GOT018
0738 END
0739 *   FORTRAN          S810
0740 SUBROUTINES810
0741 USE COM
0742 1 IF(C)9,2,9
0743 2 D07=1,IM
0744 RA(I+1)=R(I)+1
0745 IF(RA(I+1))41,41,5
0746 41 CALL ERRO (6H S810,41)
0747 RETURN
0748 5 IF(R(I+1)-R(I))51,51,7
0749 51 CALL ERRO (6H S810,51)
0750 RETURN

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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7 CONTINUE
8 RA(1)=0.
  IEVTP=IEVT+1
9 GOTO(11,11,11,11,12,20),IEVTP
11 RETURN
12 D0101=1,1M
13 K=NA(1)
14 RA(1+1)=RA(1)+(R(1+1)-R(1))*((1,0+EY=RM(K))
15 IF(1,0+EY=RM(K))16,10,10
16 CALL ERRO (6M S010,16)
  RETURN
10 CONTINUE
19 RETURN
20 D023J=1,1P
23 RA(J)=EY=RM(J)/R(1P)
24 RETURN
END
*   FORTRAN          S011
SUBROUTINES011
USE COM
  IEVTP=IEVT+1
1 IF (IC) 2,4,2
2 GOTO(3,3,3,3,4,4),IEVTP
3 RETURN
4 M=IGE
  D013J=1,1P
8 GOTO(12,11,9),IGE
9 AA(J)=AF(M)=RA(J)**2
  GOTO13
11 AA(J)=AF(M)=RA(J)
  GOTO13
12 AA(J)=AF(M)
13 CONTINUE
15 IF(VF(M))16,16,17
16 CALL ERRO (6M S011,16)
  RETURN
17 D0211=1,1M
  RAV(1)=.5*(RA(1+1)+RA(1))
21 Y(1)=VF(M)=(AA(1+1)+RA(1+1)-AA(1)+RA(1))
  RETURN
END
*   FORTRAN          S012
SUBROUTINES012
USE COM
  IEVTP=IEVT+1

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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1012 1 IF(1C)2,4,2 1115
1013 2 GOTO(3,3,3,3,4,4),IEVTP 1116
1014 3 GO TO 999 1117
1015 4 D017M=1,MH 1118
1016 5 I=1M 1119
1017 6 IM=IDX(M)-1 1120
1018 7 K=IDX(M)+1M 1121
1019 8 DA(K)=ABSF(D(M))=(AA(1+1)+AA(1)) 1122
1020 01 IF(D(M))03,03,02 1123
1021 02 DS(K)=ABSF(D(M))=AA(1+1) 1124
1022 GOTO9 1125
1023 03 DS(K)=ABSF(D(M))=AA(1) 1126
1024 9 IF(M(M))11,10,11 1127
1025 10 DC(K)=0. 1128
1026 GOTO121 1129
1027 11 DC(K)=(AA(1)-AA(1+1))*(ND(M)+ND(M-1))+DC(M)+M(M-1) 1130
1028 DC(K)=DC(K)/M(M) 1131
12 IM=IM-1 1132
1029 121 DB(K)=DA(K)+DC(K) 1133
13 K=K-1 1134
1035 I=I-1 1135
14 IF(1)17,17,0 1136
1065 17 CONTINUE 1137
1066 999 RETURN 1138
1067 END 1139
*   FORTRAN          S013
SUBROUTINES013
USE COM
1 IF(1C)12,3,2 1172
1072 2 RETURN 1173
1073 3 IF(1DM+1PM)10,4,10 1174
1074 4 1IG=1GP 1175
1075 D0711IG=1,1IG 1176
1076 7 0G(11IG)=0. 1177
1077 8 IF(IEVT)9,9,10 1178
1078 9 CALL ERRO (6M S013,9) 1179
1079 RETURN 1180
1080 10 IF(1PYT-1)17,11,17 1181
1081 11 IF(PY)13,12,13 1182
1082 12 CALL ERRO (6M S013,12) 1183
1083 RETURN 1184
13 D0161IG=1,1GM 1185
1084 16 XK(11IG)=XK(11IG)/PY 1186
17 D0221IG=1,1GM 1187
1114 XK(11IG)=XK(11IG) 1188

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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      IF(YE(IIG))22,20,22
20 CALL ERRO (6H S019,20)
      RETURN
22 CONTINUE
23 TK1=0.
      TKE=0.
      D025IG=1.IGH
      TK1=TK1+XK1(IIG)
      TKE=TKE+XKE(IIG)
      XK1(IGP)=TK1
25 XKE(IGP)=TKE
      RETURN
      END
*   FORTRAN          S016
SUBROUTINES016
USE COM
1 D071=1.1H
2 K=MA(I)
3 K=XABSF(MZ(K))
4 K=ICXX(K)+ICX(IIG)+IH
5 CE(I)=C(K)
7 CONTINUE
8 IF(IDFM) 13,13,9
9 D0121=1.1H
12 CE(I)=CE(I)+DF(I)
13 IF(IM=IMT)14,16,14
14 IF(IM+2=IMT)15,24,15
15 RETURN
16 SR1=0.
      D0231=1.1H
17 IF(DY)21,21,18
18 DEN=ABSF(CE(I)+TAB(IIG))
      SR1=((DF/(DEN=DY+1.42089216))=2)=CE(I)
19 IF(DZ)21,21,20
20 SR1=((DF/(DEN=DZ+1.42089216))=2)=CE(I)+SR1
21 CL(I)=SR1+TAB(IIG)
23 CONTINUE
24 D0281=1.1H
28 CE(I)=CE(I)+CL(I)
      RETURN
      END
*   FORTRAN          S017
SUBROUTINES017
USE COM
1 IDH

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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1 K=MA(I)
      KLE=K
2 K=XABSF(MZ(K))
3 K=ICXX(K)+ICX(IIG)
4 IF(IDOLL)5,11,5
5 K=K+ING
6 IF(MZ(KLE) ) 11,11,7
7 D01C1H=1.1HM
10 CM(IM)=0.
      GOT020
11 D0141H=1.1HM
      KPH=K+IH
14 CM(IM)+Y(I)=C(KPH)
15 IF(IDFM) 20,20,16
16 D0191H=1.1HM
19 CM(IM)+CM(IM)=DF(I)
20 IF(IDOLL)22,23,22
22 CF(I)=CM(IMS)
24 CM(IMS)=0.
      RETURN
25 CS(I)=CM(IMS)
      CF(I)=0.
      GOT024
      END
*   FORTRAN          S021
SUBROUTINES021
USE COM
1 IM=IGP
2 FTP=FG(IM)
3 IF(IFN)4,4,10
4 D071=1.1G
7 XN(I)=0.
8 IFN=1
9 GO TO 999
10 D0131=1.1M
13 F(I)=0.
14 IF(ITW)23,23,15
15 D0211IG=1.1GH
      IIG=IGH-IIG+1
16 K=NX(IIG)
      D0181=1.1M
17 KP1=K+1
18 F(I)+F(I)+XKE(IIG)=XN(KP1)
21 CONTINUE
      GO TO 999

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

25 D03111G=1.1GM
   11G=1GM-111G+1
24 IM=INT-1
25 CALLS016
26 K=NX(11G)
   D0201=1.1M
27 KP1=K+1
28 F(1)=F(1)+XN(KP1)=CE(1)
31 CONTINUE
999 RETURN
   END
*   FORTRAN      S022
   SUBROUTINES022
   USE COM
2  IF(1TH)12,12,1
1  D01111G=1.1GM
   11G=1GM-111G+1
3  FG(11G)=0.
4  IM=INT-1
5  CALLS016
6  D091=1.1M
9  FG(11G)+FG(11G)+V(1)=F(1)=CE(1)
11 CONTINUE
   GOT020
12 E1=0.
   D0151=1.1M
15 E1=E1+V(1)=F(1)
16 D01911G=1.1GM
19 FG(11G)=E1+XKE(11G)
20 IM=1GP
21 FG(IM)=0.
22 D02411G=1.1GM
24 FG(IM)=FG(IM)+FG(11G)
25 IF(NFN-1)27,26,27
26 RETURN
27 E1=QG(IM)+FTP
28 IF(E1)29,29,30
29 CALL ERRO (6H S022,29)
   RETURN
30 XLA=(QG(IM)+FG(IM))/E1
31 IF(1EVT)33,32,33
32 RETURN
33 IF(FG(IM))34,34,35
34 CALL ERRO (6H S022,34)
   RETURN

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1512 35 IF(1EVT-1)32,37,32
1513 37 D04111G=1.1M
1514 38 FG(11G)+FG(11G)/XLA
1515 39 XKE(11G)+XKE(11G)/XLA
1516 41 CONTINUE
1517 42 IF(1TH)43,43,44
1518 43 RETURN
1519 44 D0471=1.1M
1520 47 F(1)=F(1)/XLA
1521 RETURN
1522 END
*   FORTRAN      S023
   SUBROUTINES023
   USE COM
1523 1 NFN=0
1524 3 IF(1EVT)0,4,0
1525 4 E1=EPS+4.0/FL0ATF(1GM+3)
1526 6 EPG=(QG(1GP)+FG(1GP))/E1
1527 7 RETURN
1528 8 IF(XNF)4,4,9
1529 9 E4=XNF/FG(1GP)
1530 D01211G=1.1GP
1531 12 FG(11G)=E4+FG(11G)
1532 13 D0161=1.1G
1533 16 XN(1)=XN(1)+E4
1534 17 IF(1SCT+1)22,10,22
1535 18 D0211=1.1G
1536 21 XJ(1)=XJ(1)+E4
1537 22 D0251=1.1M
1538 25 F(1)=F(1)+E4
1539 26 IF(1BR-1)4,27,4
1540 27 D030M=1.1MG
1541 30 B(M)=B(M)+E4
1542 GOT04
1543 END
*   FORTRAN      S024
   SUBROUTINES024
   USE COM
1544 1 ID0LL=0
1545 2 KK=NX(11G)
1546 3 IF(1TH)6,6,4
1547 4 IM=INT-1
1548 5 CALLS016
1549 6 D0 25 J=1,IM
   1=IM-J+1

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

      IDN=1
      7 CALLS017
      8 IF(IOM)9,9,10
      9 SR(I)=0.
      10 GOT011
      11 IPK=1+KK
      12 SR(I)=Q(IPK)
      13 IF(ITW)13,13,12
      14 SR(I)=Y(I)+(CE(I)*F(I)+SR(I))
      15 GOT014
      16 SR(I)=Y(I)+(XKE(I)*F(I)+SR(I))
      17 IM=INT+1
      18 K=IG+IMS-IM
      19 K=K-1+IM
      20 K=K-1+IM
      21 IM=IM+1
      22 IF(IM-IMM)17,17,22
      23 CONTINUE
      24 S=0.
      25 DO27 I=1,IM
      26 S=S+SR(I)
      27 IF(IPM)30,30,31
      28 SG(IIG)=QG(IIG)+S
      29 SNG(IIG)=SG(IIG)-QG(IIG)-FG(IIG)
      30 GOT033
      31 SG(IIG)=S
      32 GOT032
      33 S=0.
      34 DO37 I=1,IM
      35 S=S+CS(I)
      36 XITR=S
      37 IM=INT
      38 CALLS016
      39 DO44 I=1,IM
      40 CT(I)=Y(I)+(CE(I))
      41 999 RETURN
      42 END
      43 * FORTRAN          S025
      44 SUBROUTINES025
      45 USE COM

```

NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

      1 DO5M=1,MM
      2 IF(IPM-1)4,5,3
      3 P(M)=0.
      4 GOT05
      5 P(M)=PA(IIG)/ABSF(D(M))
      6 CONTINUE
      7 IF(IPM-1) 8,12,8
      8 M=MM
      9 IF(PB(IIG))10,10,11
      10 M=M-1SN
      11 P(M)=P(M)+ABSF(PB(IIG))/ABSF(D(M))
      12 IF(ISC)14,999,999
      13 IDOLL=1
      14 DO 24 J=1,IM
      15 IDN=J+1
      16 IDN=1
      17 CALLS017
      18 SA(I)=0.
      19 IM=INT+1
      20 K=IG+IMS-IM
      21 K=K-1+IM
      22 IF(IM-IMM)19,19,23
      23 CONTINUE
      24 CONTINUE
      25 GO TO 20
      26 IF(IM-IMS)21,21,23
      27 S=0.
      28 DO32 I=1,IM
      29 S=S+CF(I)
      30 XITA=S
      31 999 RETURN
      32 END
      33 * FORTRAN          S032
      34 SUBROUTINES032
      35 USE COM
      36 DO 14 J=1,IM
      37 I=IM-J+1
      38 K=I+NX(IIG)
      39 XNA(I)=XNN(I)
      40 ST(I)=XNN(I)+CS(I)+SR(I)
      41 XNN(I)=0.

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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6 IF(IST)7,7,13
7 IF(X)TA)8,9,8
9 SAT(1)=SA(1)
  GOT010
8 SAT(1)=XJ(K)=CF(1)+SA(1)
10 CONTINUE
1 IF(ST(1))-ABSF(SAT(1))12,12,13
12 SAT(1)=SIGNF(ST(1),SAT(1))
13 K=K-1
14 CONTINUE
999 RETURN
END
*   FORTRAN      S033
  SUBROUTINE      S033
  USE COM
1 IIC=IIC+1
2 ESC=0
  ESM=0
  EAM=0
3 DO01=1,IM
  TEMP=XNN(1)-XNA(1)
5 ESC=ESC+CS(1)+TEMP
6 ESM=ABSF(TEMP)+CS(1)+ESM
7 EAM=ABSF(TEMP)+CT(1)-CS(1)+EAM
8 CONTINUE
9 E1=SG(IIG)/(SG(IIG)-ESC)
10 XNLG(IIG)+XNLG(IIG)=E1
11 RLG(IIG)+RLG(IIG)=E1
12 DO151=1,IM
15 XNN(1)+XNN(1)=E1
16 DO19M=1,MM
19 XND(M)+XND(M)=E1
20 IF(X)TA+X)TR)21,26,21
21 IF(IIC-1)MI 22,22,26
22 IF(ESM-EPG)23,23,31
23 IF(EAM-EPG)24,24,31
24 IF(10R-1)26,25,25
25 IF(ABSF(XNL0)-EPG)26,26,31
31 IF(X)TA) 32,33,32
32 KS033=2
  RETURN
33 KS033=1
  RETURN
26 DO301=1,MI
30 XND(1)+XND(1)=E1

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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KS033=3
RETURN
END
*   FORTRAN      S034
  SUBROUTINES034
  USE COM
3 DO01=1,IM
  XNR(1)+XNN(1)
  XNN(1)=0
  ST(1)=0
6 SAT(1)=0
8 DO12M=1,MM
  XND(M)+XND(M)
  PR(M)=P(M)
12 P(M)=0
14 XNL0=XNLG(IIG)
  RLB=RLG(IIG)
  RETURN
END
*   FORTRAN      S037
  SUBROUTINE S037
  USE COM
1 IF(IST)3,3,2
3 DO12M=1,MM
4 E1=1 5=XND(M)
  IM=IM+1DX(M)
  K=IM+NX(IIG)
  DO121=1,IM
8 IF(M-1)9,9,10
9 XJ(K)+E1=(XND(IM)+XND(IM+1))
  GOT011
10 XJ(K)=XJ(K)+E1+(XND(IM)+XND(IM+1))
11 K=K-1
  IM=IM-1
12 CONTINUE
2 RETURN
END
*   FORTRAN      S041
  SUBROUTINE S041
  USE COM
  IM=IM-2
  CALL S016
  SCG(IIG)=0
  AG(IIG)=0
  E1=0

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

DO21=1,IM
SCG(IIG)=SCG(IIG)+CS(I)*XNN(I)
CA(I)=Y(I)*CE(I)
AG(IIG)=AG(IIG)+CA(I)*XNN(I)
XNR(I)=CT(I)*XNN(I)
2 E1=E1+XNR(I)
3 IM=IM+1
CALL S016
FNG(IIG)=0.
XNG(IIG)=0.
DO41=1,IM
CF(I)=Y(I)*CE(I)
FNG(IIG)=FNG(IIG)+CF(I)*XNN(I)
4 XNG(IIG)=XNG(IIG)+Y(I)*XNN(I)
XNDG(IIG)=XNG(IIG)/YE(IIG)
5 SDG(IIG)=E1-SCG(IIG)-AG(IIG)
XNB(IIG)=DG(IIG)+FG(IIG)+SNG(IIG)-XNLG(IIG)
1-AG(IIG)-SDG(IIG)
6 IF(ABS(XNB(IIG))-EPG)0,0,113
113 CALL ERR016H S041,61
8 IF(IGR)9,13,9
9 K=1+IGX(IIG)
DO12H=1,MM
B(K)=XNB(M)
K=K+1
12 CONTINUE
15 K=IM+NX(IIG)
DO19J=1,IM
I=IM-J+1
14 XN(K)=XNN(I)
18 K=K-1
19 CONTINUE
IF(ICYT) 20,20,30
30 IF(IG1) 100,100,40
40 WRITE OUTPUT TAPE 3,43,IIG
DO 41 I=1,IP
LSTART=I
LSTOP=IP+(MM-1)*I
WRITE OUTPUT TAPE 3,42,(I,(XNB(K),K=LSTART,LSTOP,IP))
42 FORMAT(16,(0E12.4))
43 FORMAT(44H NEUTRON FLUX BY RADIUS AND DIRECTION,GROUP, .13)
41 CONTINUE
100 IF(IG2) 200,200,201
C BALANCE EDIT
201 CALL BALAN

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

2164 200 CONTINUE
2165 31 CONTINUE
2166 20 RETURN
2167 END
2168 = FORTRAN S042
2169 SUBROUTINES042
2170 USE COM
2171 IF(M-1)3,2,3
2172 2 LC=LC+1
2173 3 IF(D(M))4,14,14
2174 4 IF(IGR-1)5,6,5
2175 5 XN(M)=XNB(M)
2176 GOT08
2177 6 K=MR(M)
2178 7 XNB(M)=XNB(K)
2179 XN(M)=XNB(K)
2180 8 IF(M(M))9,9,13
2181 CDIRECTION WEIGHT NOT ZERO
2182 13 KS042=1
2183 RETURN
2184 9 DO12I=1,IM
2185 12 XNE(I)=0.
2186 GOT013
2187 14 IF(IGL-1)10,15,19
2188 19 IF(IGL-2)21,20,21
2189 21 IF(IGE-1)24,22,24
2190 24 CALL ERR016H S042,241
2191 22 IF(MD(M))23,23,25
2192 15 K=MR(M)
2193 16 XNB(M)=XN(K)
2194 XN(M)=XN(K)
2195 23 KS042=2
2196 RETURN
2197 18 XNB(M)=0.
2198 XN(M)=0.
2199 GOT023
2200 20 XN(M)=XNB(M)
2201 GOT023
2202 25 IF(MD(M-1))26,26,33
2203 26 K=M-1
2204 27 E1=0.
2205 E2=0.
2206 28 E1=E1+NB(K)
2207 29 E2=E2+NB(K)*XN(K)
2208 30 K=K-1
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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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      IF(K)32,32,28
32  XN10=(E2+0.5)/E1
33  K=NR(M)
34  XN0(M)=XN10*XN10-XN1(K)
      XN1(M)=XN0(M)
      RETURN
      END
*   FORTRAN          S843
      SUBROUTINE S843
      USE COM
      K=IP+1DX(M)
      D025J=1,IM
      1  I=IM-J+1
      2  K=K+1
      XND(K+1)=XN1(M)
      3  IF(P(M))4,6,4
      4  IF(I-1PP)6,5,6
      5  XN1(M)=P(M)+XN1(M)
      6  E1=DB(K)+CT(I)
      E2=XN1(M)+DA(K)+XNE(I)=DC(K)+S7(I)
      7  IF(1SCT)8,9,9
      8  E2=E2+D(M)+SAT(I)
      9  IF( CT(I) ) 10,10,10
10  CONTINUE
11  E3=E2/E1
      XNE(I)=E3+E3-XNE(I)
      XN1(M)=E3+E3-XN1(M)
12  IF(M(M))14,13,14
13  XNE(I)=E3
14  IF(XNE(I))15,17,17
15  IF(CT(I))16,17,16
16  E3+E3+(-.5+DB(K)-DS(K))*XNE(I)/CT(I)
      XNE(I)=0.
17  CONTINUE
18  IF(XN1(M))19,24,24
19  IF(CT(I))20,24,20
20  E3+E3+DS(K)*XN1(M)/CT(I)
21  XN1(M)=0.
      GOTO24
24  XNN(I)=M(M)+E3+XNN(I)
25  CONTINUE
27  XND(K)=XN1(M)
999 RETURN
      END
*   FORTRAN          S844

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2291 SUBROUTINE S844
2292 USE COM
2293 1 K=1+1DX(M)
2294 D025J=1,IM
2295 2 XND(K)=XND(M)
2296 E1=DB(K)+CT(I)
2297 E2=ST(I)+XND(M)+DA(K)+XNE(I)=DC(K)
2298
2299 3 IF(1SCT)4,5,5
2300 4 E2=D(M)+SAT(I)+E2
2301 5 IF( CT(I) ) 16,6,6
2302 6 CONTINUE
2303 7 E3=E2/E1
2304 XNE(I)=E3+E3-XNE(I)
2305 XND(M)=E3+E3-XND(M)
2306 8 IF(XNE(I))9,11,11
2307 9 IF(CT(I))10,11,10
2308 10 E3+E3+(-.5+DB(K)-DS(K))*XNE(I)/CT(I)
2309 XNE(I)=0.
2310 11 CONTINUE
2311 12 IF(XND(M))13,17,17
2312 13 IF(CT(I))14,17,14
2313 14 E3+E3+DS(K)*XND(M)/CT(I)
2314 XND(M)=0.
2315 GOTO17
2316 17 XNN(I)=XNN(I)+M(M)+E3
2317 18 IF(P(M))19,22,19
2318 19 IF(I-1PP)22,21,22
2319 21 XND(M)=P(M)+XND(M)
2320 22 K=K+1
2321 23 CONTINUE
2322 24 XND(K)=XND(M)
2323 999 RETURN
2324 END
*   FORTRAN          S845
      SUBROUTINE S845
      USE COM
      1  IF(1BR-2)7,2,7
      2  D06M=1,MM
      IF(D(M))4,4,6
      4  XND(M)=XN1(M)
      6  CONTINUE
      7  XNLG(IIG)=0.
      RLG(IIG)=0.
      D012M=1,MM
      XNLG(IIG)=XNLG(IIG)+ND(M)+XN1(M)

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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12 RLG(IIG)+RLG(IIG)+ND(M)+XND(M)
13 XNLG(IIG)+XNLG(IIG)+AA(I)
14 RLG(IIG)+RLG(IIG)+AA(IP)
15 XNLG(IIG)+RLG(IIG)+XNLG(IIG)
  RETURN
  END
*   FORTRAN      5847
  SUBROUTINE S847
  USE COM
  1 IM=IGP
  2 SNG(IM)=0.
  3 SCG(IM)=0.
  4 XNLG(IM)=0.
  5 AG(IM)=0.
  6 SDG(IM)=0.
  7 RLG(IM)=0.
  8 XNB(IM)=0.
  9 D026IG=1.IGM
  11 SNG(IM)=SNG(IIG)+SNG(IM)
  12 SCG(IM)=SCG(IIG)+SCG(IM)
  13 XNLG(IM)=XNLG(IIG)+XNLG(IM)
  14 AG(IM)=AG(IIG)+AG(IM)
  15 SDG(IM)=SDG(IIG)+SDG(IM)
  16 RLG(IM)=RLG(IIG)+RLG(IM)
  17 XNB(IM)=XNB(IIG)+XNB(IM)
  18 CONTINUE
  19 IF(ICVT)20,28,20
  20 FNG(IM)=0.
  21 XNDG(IM)=0.
  21 D026IG=1.IGM
  23 FNG(IM)=FNG(IM)+FNG(IIG)
  24 XNG(IM)=XNG(IM)+XNG(IIG)
  25 XNDG(IM)=XNDG(IM)+XNDG(IIG)
  26 CONTINUE
  IF (NJT(I)) 28,28,
  27 WRITE OUTPUT TAPE 3,271,(I,OG(I),FG(I),SNG(I),SCG(I),XNLG(I),I=1,
  1 JGP)
  WRITE OUTPUT TAPE 3,272,(I,AG(I),XNB(I),RLG(I),FNG(I),XNDG(I),
  1 XNG(I),I=1,IGP)
  271 FORMAT(9X,11HDIST SOURCE ,8X,12HFISS DENSITY ,12X,8HSCATT-IN ,
  1 10X,10HSELF-SCATT ,9X,11HNET LEAKAGE ,/,14,E16.8,4E20.0)
  272 FORMAT(13X,7HABSORBS ,11X,9HN-BALANCE ,11X,9HLEAKAGE ,4X,
  1 16HFISSION-NEUTRONS ,5X,15HNEUTRON DENSITY ,8X,12HNEUTRON-FLUX ,
  2 /,14,E16.8,5E20.0)

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

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28 IC=IC+1
29 XLAR=XLA
30 E1=SDG(IM)/(OG(IM)+FG(IM))
31 ALA=ASR/E1
32 ASR=E1
33 RETURN
  END
*   FORTRAN      5851
  SUBROUTINE S851
  USE COM
  1 E1=1.0-XLA
  2 E2=ABSF(E1)
  3 E3=RYF=ABSF(1.-ALA)
  4 E4=ABSF(XLAR-XLA)
  5 IF(IEY)6,14,6
  6 IF(IEY-1)9,7,9
  7 EY=XK1(IGP)/XKE(IGP)
  8 GOTO14
  9 IF(XLAP)10,13,10
  13 KS051=3
  10 GO TO 999
  10 EQP=EQ
  11 ED=(EYP-EY)/(XLAP-XLA)
  12 E5=ABSF(EQP/EQ-1.)
  13 GOTO13
  14 IF(IEY)15,16,15
  15 KS051=1
  16 GO TO 999
  16 IF(IE2-EPS) 17,17,18
  17 IF(IE3-EPS) 20,20,18
  18 IF(SENSE SWITCH)120,19
  19 KS051=2
  20 GO TO 999
  20 ICYT=1
  21 KS051=2
  999 RETURN
  END
*   FORTRAN      5852
  SUBROUTINE S852
  USE COM
  1 IF(XLAP)10,2,10
  10 IF(IE5-EOL)14,14,11
  11 IF(SENSE SWITCH)112,13
  12 ICYT=1
  13 KS052=2

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NEUTRONIC SUBROUTINES REQUIRED FOR THE DTF PACKAGE

```

GO TO 999
2 IF(E0122,3,22
3 IF(E3-EPS14,4,11
4 IF(E4-EPS15,5,11
5 EY=EY
6 XLAP=KLA
7 IF(E110,0,9
8 EY=EY+EYM
GO TO 19
9 EY=EY+EYM
GO TO 19
14 IF(CNT)10,15,10
15 IF(E2-XLAL)16,16,20
16 CNT=1.0
17 XLAP=0.
18 EY=EY+E1+E0+KNPM
19 IF(SENSE SWITCH)120,21
20 ICYT=1
21 KS052=3
GO TO 999
22 IF(ICYT)23,24,23
23 KS052=1
GO TO 999
24 IF(E2-EPS125,25,10
25 IF(E3-EPS126,26,10
26 ICYT=1
27 KS052=2
999 RETURN
28 IF(E2-XLAM)10,10,29
29 E1=SIGNF(XLAM,E1)
GO TO 10
END
C
* DATA

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GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

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2660 C GLOSSARY OF SUBROUTINES
2669 C
2670 C SUBROUTINE S000 COMPUTE INITIAL VALUES
2671 C THE PURPOSE OF THIS ROUTINE IS TO COMPUTE MODIFICATIONS OF
2672 C PARAMETERS AND CERTAIN INPUT VARIABLES, TO CLEAR OUT TO ZERO
2673 C CERTAIN FUNCTIONS, AND TO COMPUTE INPUT MULTIPLES. IT SHOULD
2674 C BE NOTED THAT THE INDEX MULTIPLE COMPUTATION IS DONOTED BY
2675 C AN X FOLLOWING A LETTER, FOR EXAMPLE, CX ARE MULTIPLES OF THE
2676 C ROW LENGTHS OF THE CROSS SECTIONS, WHEREAS CXX ARE MULTIPLES
2677 C OF THE MATRIX SIZE.
2678 C
2679 C SUBROUTINE S004 COMPUTE SN CONSTANTS
2680 C INPUT TO THIS ROUTINE IS DIM AND NIM, THE DIRECTION COSINES
2681 C AND THE DIRECTION WEIGHTS. MULTIPLES OF THESE ARE COMPUTED.
2682 C THE DIRECTION MATES FOR REFLECTIVE BOUNDARY CONDITIONS ARE
2683 C COMPUTED. THE DIRECTION COSINES ARE SYMMETRIC AND WHEN A
2684 C POSITIVE ONE IS FOUND EQUAL TO A NEGATIVE ONE, THE INDICES M
2685 C AND MPRIME ARE PUT IN THEIR RESPECTIVE MATED POSITIONS.
2686 C
2687 C SUBROUTINE S005 COMPUTE ADJOINT CROSS SECTIONS
2688 C IN THIS ROUTINE THE CROSS SECTIONS FOR EACH GROUP ARE
2689 C SWAPPED WITH CROSS SECTIONS FOR ANOTHER GROUP. THERE ARE
2690 C THREE DIFFERENT RULES FOR DOING SO, DEPENDING ON POSITION.
2691 C RULE 1 CONCERNS THE SWAPPING OF GROUPS UP TO THE POSITION
2692 C OF SIGMA TRANSPORT. RULE 2 IS CONCERNED WITH SWAPPING THE
2693 C CROSS SECTIONS THAT ARE UP-SCATTERING. RULE 3 IS CONCERNED
2694 C WITH SWAPPING IN GROUPS THAT ARE DOWN SCATTERING.
2695 C
2696 C SUBROUTINE S006 COMPUTE ADJOINT REVERSALS
2697 C THE PURPOSE OF THIS ROUTINE IS TO SWAP CERTAIN GROUP
2698 C DEPENDENT FUNCTIONS, THE FISSION FRACTIONS, VELOCITIES, AND
2699 C A SHELL SOURCE IF THERE IS ANY. IF THE INPUT TRIGGER, 103,
2700 C INDICATES THAT FLUXES WERE TO BE LOADED, THE FLUXES THEMSELVES
2701 C HAVE TO BE ADJOINTED. THIS IS TRUE ONLY IF YOU ARE STARTING
2702 C A PROBLEM FROM THE BEGINNING AND NOT FROM A DUMP.
2703 C
2704 C SUBROUTINE S013 COMPUTE INITIAL FUNCTIONS
2705 C THIS ROUTINE IS EXECUTED ONLY ONCE AND INCLUDES A CLASS
2706 C OF CALCULATIONS THAT NEEDS TO BE DONE BUT ONCE PER PROBLEM.
2707 C
2708 C THE PURPOSE OF THIS ROUTINE IS TO READ IN VARIOUS INPUT
2709 C PARAMETERS. THE FORMAT ACCEPTED BY THE ROUTINE IS 6(11,12,E9.)
2710 C THE PARAMETERS READ IN MAY BE REPEATED OR INTERPOLATED A
2711 C SPECIFIED NUMBER OF TIMES. IF THE WRONG NUMBER OF ITEMS ARE
2712 C READ IN, AN ERROR DIAGNOSTIC WILL BE PRINTED.

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GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C
C THE PURPOSE OF THIS ROUTINE IS TO READ IN VARIOUS INPUT
C PARAMETERS. THE FORMAT ACCEPTED BY THE ROUTINE IS 6(11,12,19)
C THE PARAMETERS READ IN MAY BE REPEATED. IF INTERPOLATION
C BETWEEN SUCCESSIVE INTEGERS OR IF THE WRONG NUMBER OF ITEMS
C IS READ IN, ERROR DIAGNOSTICS WILL BE PRINTED.
C
C RECS
C THE PURPOSE OF THIS ROUTINE IS TO READ IN THE CROSS SECTION
C DATA.
C
C THE PURPOSE OF THIS ROUTINE IS TO PRINT AN ERROR MESSAGE
C ACCORDING TO THE LOCATION AND TYPE OF ERROR. THE SUBROUTINE
C NAME AND STATEMENT NUMBER ARE REFERENCED.
C SUBROUTINE S807 MIX CROSS SECTIONS
C THE PURPOSE OF THIS ROUTINE IS TO MIX THE CROSS SECTIONS FOR
C EACH MATERIAL. INPUT TO THIS ROUTINE CAN BE PROVIDED EITHER
C BY CARDS OR FROM A NUCLIDE TAPE. FOR EACH MIXTURE SPECIFIED,
C CERTAIN COMPONENT CROSS SECTIONS ARE SPECIFIED TOGETHER WITH
C THEIR DENSITIES. AND IF BOTH THE MIX COMPONENT NUMBER AND THE
C MIX DENSITY NUMBER FOR THAT COMPONENT ARE ZERO, THE MIX CROSS
C SECTION BLOCK SPECIFIED IS CLEARED. IF THE NEXT COMPONENT
C NUMBER IS ZERO AND THE NEXT DENSITY NUMBER IS NON-ZERO, THEN
C THE MIX SPECIFIED IS MULTIPLIED BY THE DENSITY NUMBER SPECIFIED
C IN THE MD ENTRY. IF THE MIX COMPONENT NUMBER IS NON-ZERO,
C AND THE MIX DENSITY NUMBER IS NON-ZERO AS WELL, THEN THE
C MATERIAL NUMBER SPECIFIED IN THE COMPONENT IS MULTIPLIED
C BY THE DENSITY SPECIFIED, AND ADDED TO THE MIX NUMBER.
C THE FINAL CASE, IN WHICH THE MIX COMPONENT NUMBER IS NON-ZERO
C AND THE DENSITY NUMBER IS ZERO, IS CONCERNED WITH THE
C CONCENTRATION SEARCH. THE CROSS SECTIONS IN THE MIX ARE
C MULTIPLIED BY THE CONCENTRATION EIGENVALUE.
C
C SUBROUTINE S810 MODIFY RADII
C THE PURPOSE OF THIS ROUTINE IS TO MOVE THE INITIAL RADII
C INTO A WORKING BLOCK FOR ALL KINDS OF CALCULATIONS, ON
C THE FIRST ITERATION. FOR DELTA AND TYPE-A CALCULATIONS,
C CERTAIN MODIFICATIONS OF THE INPUT RADII ARE PERFORMED,
C DEPENDING ON THE DELTA OR THE TYPE-A EIGENVALUE.
C
C SUBROUTINE S811 COMPUTE AREAS AND VOLUMES
C THE PURPOSE OF THIS ROUTINE IS TO COMPUTE AREA FACTORS AND
C VOLUME FACTORS FOR ALL KINDS OF CALCULATIONS, ON FIRST
C ITERATIONS. THIS ROUTINE IS EXECUTED AT EVERY OUTER
C ITERATION FOR DELTA AND TYPE-A CALCULATIONS ONLY.

GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C
C COMPUTE GEOMETRIC FUNCTIONS-812
C
C SUBROUTINE S814 COMPUTE DISTRIBUTED SOURCE
C THE INPUT DISTRIBUTED SOURCE Q IS USED HERE AND IS VOLUME
C INTEGRATED TO OBTAIN THE SUM OVER ALL VOLUME. THIS VOLUME
C INTEGRATED TOTAL IS THEN USED TO NORMALIZE THE SOURCE.
C AN INPUT ERROR STATEMENT IS PRINTED IF THE SOURCE HAS BEEN
C OMITTED. THAT IS, IF THE TOTAL SOURCE IS ZERO FOR A Q CALCULATION.
C
C SUBROUTINE S815 COMPUTE SHELL SOURCE
C THIS ROUTINE IS SIMILAR TO S814 EXCEPT THAT THIS IS A SURFACE
C SOURCE RATHER THAN A VOLUME SOURCE. BOTH AN ISOTROPIC AND AN
C ANISOTROPIC COMPONENT OF THE SOURCE MAY BE SPECIFIED.
C THE SHELL SOURCE IS INTEGRATED OVER THE AREAS TO WHICH IT IS
C PERTINENT. IF THIS INTEGRAL IS ZERO, AN INPUT ERROR COMMENT
C IS PRINTED. THE INTEGRAL IS USED TO NORMALIZE THE SHELL SOURCE.
C
C SUBROUTINE S816(E)EFFECTIVE CROSS SECTION
C INPUT TO THIS ROUTINE MUST PROVIDE THE GROUP NUMBER AND THE
C POSITION OF THE CROSS SECTION REQUIRED. THE OUTPUT CONSISTS
C OF AN I LENGTH VECTOR IN THE CROSS SECTIONS FOR THE POSITIONS
C SPECIFIED, WHERE I IS THE NUMBER OF INTERVALS FOR THIS PROBLEM.
C IF DUCKLING MODIFICATION IS REQUESTED THE AXIAL LEAKAGE IS
C APPROXIMATED BY ADDING CERTAIN QUANTITIES TO THE TRANSPORT
C AND THE ABSORPTION CROSS SECTIONS.
C
C SUBROUTINE S817(E)SCATTERING CROSS SECTIONS
C THE INPUT FOR THIS ROUTINE, THE POSITION I, SPECIFIES A ZONE
C WHICH THEN SPECIFIES A MATERIAL. THE MATERIAL SPECIFIES A
C CROSS SECTION BLOCK. EITHER ANISOTROPIC OR ISOTROPIC
C COMPONENTS CAN BE SELECTED, DEPENDING UPON AN INPUT TRIGGER
C DENOTED IN THE FLOW DIAGRAMS BY A DOLLAR SIGN. THE OUTPUT
C OF THIS ROUTINE IS A PARTICULAR ROW OUT OF THE CROSS SECTION
C TABLES, AND EITHER THE ISOTROPIC SELF-SCATTERING CROSS SECTION
C OR THE ANISOTROPIC SELF-SCATTERING CROSS SECTION DEPENDING
C UPON THE DOLLAR TRIGGER.
C
C SUBROUTINE S821 FISSION NEUTRONS
C THIS ROUTINE COMPUTES THE FISSION NEUTRON DENSITY. DIFFERENT
C EQUATIONS ARE USED DEPENDING ON WHETHER A REGULAR OR ADJOINT
C SOLUTION IS REQUESTED.
C
C SUBROUTINE S822 COMPUTE FISSION SUMS
C THIS ROUTINE IS USED TO FIND THE VOLUME INTEGRAL OF THE FISSION

GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C NEUTRON DENSITY THE PRODUCT OF THE RELATIVE FISSION SPECTRUM
 C TIMES THIS VOLUME INTEGRAL IS PLACED INTO EACH GROUP AS THE
 C TOTAL FISSION CONTRIBUTION FOR THAT GROUP IN THIS CODE WE
 C DETECT THE ABSENCE OF BOTH DISTRIBUTED AND FISSION SOURCE IN
 C THE PROBLEM LAMBDA IS COMPUTED HERE AS THE RATIO OF THE
 C SOURCE FOR THIS ITERATION COMPARED TO THE PREVIOUS ITERATION
 C FOR REACTIVITY OPTIONS, CERTAIN QUANTITIES, THE FISSIONS AND
 C THE FISSION FRACTIONS, ARE DIVIDED BY THIS LAMBDA
 C THE CHIS, ARE DIVIDED BY THIS LAMBDA
 C
 C SUBROUTINE S041 GROUP CODE
 C USING THE PREVIOUSLY CALCULATED FLUXES, THIS ROUTINE COMPUTES
 C THE SELF-SCATTERING, THE ABSORPTION, THE COLLISIONS, THE SLOWING
 C DOWN, AND THE NEUTRON BALANCE FOR EACH GROUP WHEN THE CONVERGENCE
 C TRIGGER IS ON, THE TOTAL FISSIONS FOR THE GROUP ARE ALSO
 C CALCULATED THE CONVERGENCE TRIGGER IS ON ONLY DURING THE FINAL
 C PASS THROUGH THE CODE
 C
 C SUBROUTINE S023 NORMALIZE FISSIONS AND FLUXES
 C THE FIRST THING THAT IS DONE IS TO SET A TRIGGER CALLED
 C (NEW F NEEDED) WHICH, WHEN SET TO ZERO, WILL ALLOW THE
 C QUANTITY CALLED EPG WHICH IS APPROXIMATED BY THE TOTAL
 C SOURCE DIVIDED BY THE SQUARE ROOT OF THE NUMBER OF GROUPS
 C AND IS A MEASURE OF THE PRECISION THAT WILL BE REQUIRED FOR
 C INNER ITERATIONS THIS CODE ALSO NORMALIZES FISSIONS, FLUXES,
 C CURRENTS, IF THERE ARE ANY, FOR ANISOTROPIC SCATTERING, AND ALSO
 C THE RIGHT BOUNDARY FLUXES, IN CASE THERE IS EITHER A REFLECTIVE
 C OR A PERIODIC BOUNDARY CONDITION ON THE RIGHT
 C
 C SUBROUTINE S024 COMPUTE FIXED SOURCE
 C THIS ROUTINE COMPUTES THE FIXED CONTRIBUTION TO THE TOTAL SOURCE,
 C IMPLYING THAT THE SELF SCATTERING TO THE SOURCE IS NOT INCLUDED
 C THE DISTRIBUTED SOURCE, THE FISSION CONTRIBUTION, AND ANY DOWN
 C SCATTERING OR UP SCATTERING CONTRIBUTIONS ARE INCLUDED ALSO
 C COMPUTED ARE THE TOTAL REGULAR SOURCE AND THE OUT SCATTERING
 C THE PRODUCT OF THE TRANSPORT CROSS SECTION AND THE VOLUME ELEMENT
 C IS COMPUTED AND STORED IN A BLOCK FOR USE IN THE ANGULAR FLUX
 C CODES
 C
 C SUBROUTINE S025 COMPUTE ANISOTROPIC SOURCE
 C THIS ROUTINE COMPUTES THE FIXED SKEW SOURCE WHETHER ANISOTROPIC
 C OR ISOTROPIC IT COMPUTES THE FIXED ANISOTROPIC COMPONENT TO THE
 C ANISOTROPIC SOURCE (IMPLYING THAT IT DOES NOT INCLUDE THE
 C ANISOTROPIC SELF SCATTERING), THE TRIGGER IPM IS THE SUM OF THE
 C ANISOTROPIC SELF SCATTERING CROSS SECTIONS THIS TRIGGER IS USED

GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C TO DETERMINE WHETHER OR NOT TO COMPUTE CURRENTS IN THE INNER
 C ITERATIONS FOR A PROBLEM WHICH HAS ANISOTROPIC SCATTERING
 C
 C SUBROUTINE S032 COMPUTE BASIC SOURCE
 C IN THIS ROUTINE, THE SELF SCATTERING CONTRIBUTION FOR THE SOURCE
 C IS ADDED TO BOTH THE ISOTROPIC AND THE ANISOTROPIC CASE THIS IS
 C DONE FOR EACH INNER ITERATION THE ONLY PORTION OF THE SOURCE
 C THAT IS VARYING IS THE SELF-SCATTERING COMPONENT
 C
 C SUBROUTINE S033 PERFORM INNER ITERATION
 C USING THE ERROR IN THE SELF-SCATTERING, THIS ROUTINE DECIDES
 C WHETHER ANOTHER INNER ITERATION IS REQUIRED FOR CONVERGENCE THE
 C TOTAL FLUX FOR THIS ITERATION AND THE PREVIOUS ITERATION ARE
 C SUBTRACTED AND MULTIPLIED BY THE SELF-SCATTERING CROSS SECTION
 C IN THE VOLUME ELEMENT TO DETERMINE THE RESIDUAL SELF SCATTERING
 C ELEMENT THIS ROUTINE ALSO FINDS THE ERROR IN ABSORPTIONS WHEN
 C THESE ERRORS ARE SUFFICIENTLY SMALL, THE INNER ITERATIONS ARE
 C TERMINATED THESE QUANTITIES ARE COMPARED WITH EPG, COMPUTED IN
 C S023 (NORMALIZE FISSIONS AND FLUXES) IF MORE INNER ITERATIONS
 C ARE TO BE PERFORMED AND THERE IS ANISOTROPIC SELF SCATTERING IN
 C THE PROBLEM, THE COMPUTE CURRENT ROUTINE, S037, SHOULD BE
 C EXECUTED AND THEN A RETURN MADE TO RECOMPUTE THE BASIC SOURCE
 C
 C SUBROUTINE S034 COMPUTE BOUNDARY SOURCE
 C THIS ROUTINE SETS UP THE SOURCES FOR COMPUTING THE BOUNDARY
 C COMPONENT OF THE ANGULAR AND TOTAL FLUXES (COMPARABLE TO S032)
 C THIS ROUTINE SAVES CERTAIN QUANTITIES FROM THE BASIC PASS AND
 C THEN COMPUTES A BOUNDARY COMPONENT FOR THE FLUXES AND LATER ON
 C IN THE COMBINATION OF THE COMPONENTS, MAKES A LINEAR COMBINATION
 C OF THESE TWO COMPONENTS
 C
 C SUBROUTINE S037 COMPUTE CURRENTS
 C THIS ROUTINE USES THE ANGULAR FLUX TO COMPUTE THE CURRENT
 C CONTRIBUTION
 C
 C SUBROUTINE S042 SET ANGULAR FLUX BOUNDARY CONDITIONS
 C THIS ROUTINE SETS BOUNDARY CONDITIONS BOTH ON THE LEFT AND ON
 C THE RIGHT THERE ARE THREE POSSIBLE CASES, 0, 1, AND 2 THE
 C 0 SOURCE SETS ZEROS INTO THE OUTER MOST FLUX POSITION OF THE FLUX
 C BLOCK THE 1 REPRESENTS A REFLECTIVE BOUNDARY CONDITION, AND THE
 C DIRECTION MATES COMPUTED IN THE SN CODE ARE USED TO REFLECT
 C THE QUANTITIES AT THE BOUNDARY PERIODIC BOUNDARY CONDITIONS,
 C REPRESENTED BY 2, IMPLY THAT THE LEFT BOUNDARY FEEDS THE RIGHT
 C BOUNDARY AND THE RIGHT BOUNDARY FEEDS THE LEFT BOUNDARY FOR
 C THE FIRST ANGLE THE EXTRAPOLATED FLUX, NE, IS SET TO 0 PERIODIC

GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C CONDITIONS ARE ALLOWED ONLY ON PLANE GEOMETRY
 C
 C SUBROUTINE S043 COMPUTE INWARD FLOW NEUTRONS
 C THIS ROUTINE IS EXECUTED FOR VALUES MU, THE DIRECTION COSINES
 C WHICH ARE NEGATIVE TOGETHER WITH SUBROUTINE S044. THIS ROUTINE
 C COMPUTES THE ANGULAR AND THE TOTAL FLUX
 C
 C SUBROUTINE S044 COMPUTE OUTWARD FLOW NEUTRONS
 C THIS ROUTINE COMPUTES ANGULAR AND TOTAL FLUX FOR POSITIVE VALUES
 C OF THE DIRECTION COSINE
 C
 C SUBROUTINE S045 COMPUTE NEUTRON SUMS
 C THIS ROUTINE COMPUTES THE LEFT LEAKAGE, THE RIGHT LEAKAGE, AND,
 C BY TAKING THEIR DIFFERENCE, THE NET LEAKAGE IF THE RIGHT
 C BOUNDARY IS PERIODIC, THE INWARD FLOWING BOUNDARIES AT THE
 C CENTRAL MOST POSITION, ARE PLACED IN THE STORAGE BLOCK OF THE
 C OUTWARD MOST FLUXES
 C
 C SUBROUTINE S047 TOTAL GROUP CODE
 C THIS ROUTINE SUMS UP THE MATERIAL THAT WAS COMPUTED IN THE
 C GROUP CODE, S041 IT IS A SUM OVER ALL THE GROUPS THE TOTAL
 C IN-SCATTER, SELF-SCATTER, NET LEAKAGE, ABSORPTIONS, OUT-SCATTER,
 C RIGHT LEAKAGE, AND NEUTRON BALANCE ARE COMPUTED THE FISSION
 C NEUTRON SUM, THE SUM OF THE NEUTRON DENSITIES, AND A QUANTITY
 C WHICH HAS UNITS OF NEUTRON-CENTIMETERS-PER-SECOND (FOR FURTHER
 C HAND CALCULATIONS) ARE ALSO COMPUTED IF THIS IS THE FINAL PASS
 C THROUGH THE PROGRAM (CONVERGENCE TRIGGER = 1), THE BALANCE TABLE
 C IS ALSO PRINTED IN THIS TABLE ARE PRINTED THE DISTRIBUTED OR
 C SHELL SOURCE, THE FISSION SOURCE, THE SCATTERING INTO THE GROUP,
 C SELF-SCATTERING, THE NET LEAKAGE, THE ABSORPTION, SLOWING DOWN,
 C THE NEUTRON BALANCE, THE RIGHT LEAKAGE, FISSION NEUTRONS, THE
 C NEUTRON DENSITY, AND THE NEUTRON-CENTIMETERS-PER-SECOND THE
 C QUANTITY ALA IS A RATIO OF SOURCES WHICH WILL CONVERGE TO 1 WHEN
 C THE SCATTERING HAS CONVERGED
 C
 C SUBROUTINE S051 COMPUTE CONVERGENCE NUMBERS
 C THIS ROUTINE COMPUTES CERTAIN NUMBERS WHICH ARE USED TO DETERMINE
 C WHETHER OR NOT THE PROBLEM HAS CONVERGED, HOW CLOSE LAMBDA IS TO
 C 1, HOW CLOSE THE SCATTERING CONVERGENCE ALA IS TO 1 UNDER
 C CERTAIN CONDITIONS EQ, WHICH IS $DP/DLAMBDA$ (THE SLOPE OF THE
 C EIGENVALUE SEARCH CURVE), IS COMPUTED THE CONVERGENCE TRIGGER
 C CYT IS SET IN THIS CODE DEPENDING UPON 2 TESTS THE FIRST TESTS
 C THE MAGNITUDE OF $1-LAMBDA$, THAT IS, HOW CLOSE THE FISSION SOURCE
 C IS TO CONVERGENCE THE SECOND TESTS THE MAGNITUDE OF $1-ALA$, THE
 C SCATTERING CONVERGENCE NUMBER

GLOSSARY - A BRIEF DESCRIPTION OF THE FUNCTION OF THE NEUTRONICS SUBROUTINES

C
 C SUBROUTINE S052 COMPUTE NEW PARAMETERS
 C THIS ROUTINE IS ENTERED WHENEVER WE HAVE FLUX CONVERGENCE ON A
 C PARTICULAR EIGENVALUE A NEW VALUE OF THE EIGENVALUE IS THEN
 C COMPUTED
 C SUBROUTINE GSFC GROUP SKIPPING AND FLUX CONTROL
 C CERTAIN QUANTITIES ARE INITIALIZED HERE IN PREPARATION FOR THE
 C INNER ITERATIONS IF GROUP SKIPPING IS SPECIFIED, TESTS ARE
 C MADE, AND CERTAIN QUANTITIES FROM THE PREVIOUS GROUP ARE USED
 C TO COMPUTE QUANTITIES FOR THE PRESENT GROUP GROUP SKIPPING
 C IMPLIES A COMMON FLUX SHAPE BETWEEN TWO GROUPS THE FIRST GROUP
 C MAY NOT BE SKIPPED ANY NUMBER OF GROUPS WITH THE SAME FLUX
 C SHAPE MAY BE SKIPPED FLUXES ARE INITIALIZED BY SETTING THEM
 C EQUAL TO ZERO OR BY MOVING THE FLUXES OUT OF THE STORAGE BLOCK
 C FOR THE LAST ITERATION AS AN INITIAL GUESS FOR THIS ITERATION
 C IF THERE IS NO SOURCE IN THIS GROUP, ALL FLUXES ARE SET TO
 C ZERO AND A TRANSFER MADE DIRECTLY TO THE GROUP ROUTINE, S041,
 C BY-PASSING THE ANGULAR FLUX CALCULATION, S042, S043, AND S044
 C
 C SUBROUTINE ALPHOP ALPHA-OPTION COMPUTATION
 C THIS ROUTINE COMPUTES THE FIXED TIME ABSORPTION ALPHA OVER THE
 C VELOCITY, FOR AN ALPHA COMPUTATION
 C
 C SUBROUTINE CFC COMBINE FLUX COMPONENTS
 C THIS ROUTINE COMBINES THE BASIC COMPONENT AND THE BOUNDARY
 C COMPONENT IN SUCH A MANNER THAT LEAKAGES WILL EQUAL ZERO
 C

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C DTF PARAMETERS
C
C FORTRAN  DEFINITION
C
C BF      BUCKLING FACTOR 0 OR PI/(SQ ROOT OF 3)
C
C BY      DIMENSION IN Y FOR BUCKLING
C DZ      DIMENSION IN Z FOR BUCKLING
C
C EDL     DE/DL ACCURACY LIMIT
C EPS     EPSILON PRECISION FORCED ON LAMBDA
C EY      EIGENVALUE GUESS ZERO FOR Q AND K
C EYM     EIGENVALUE MODIFIER ZERO FOR Q AND K
C
C FXM     FIXUP MARKER
C
C IBR     BDRY ON RIGHT
C ICM     ITERATION COUNT MAXIMUM
C ID      PROBLEM ID
C ID1     0/1 1 = PRINT ANGULAR FLUX
C ID2     0/1 2P = PRINT BALANCE TABLES
C ID3     0/N N = PRINT ACTIVITIES BY ZONE(SEE JS,J4)
C ID4     0/1 1 = PRINT ACTIVITIES BY RADIUS
C IDFM    DENSITY FACTOR INDICATORS 0=1, 1=ENTER DF
C IDL     BDRY ON LEFTS 0=ZERO IN, 1=REFL, 2=PERIODIC
C IDT     DIFFUSION THEORY OPTION INDICATOR
C IEYT    EIGENVALUE TYPES 0=0, 1=K, 2=ALPHA, 3=C, 4=DELTA
C          5=A
C IFN     INPUTS 0=FISSIONS, 1=FLUX
C IGE     GEOMETRIES 1=PLANE, 2=CYL, 3=SPH
C IGM     NO OF GROUPS NO 1 IS HIGHEST ENERGY
C IGS     GROUP SKIPPING 0=NO, 1=ENTER IGT
C IMH     X SECTION TABLE LENGTH
C IMS     POSITION OF SIGMA S (SELF-SCATTER)
C IMT     POSITION OF SIGMA T (TOTAL)
C IIM     INNER ITERATION COUNT MAXIMUM
C IM      NO OF INTERVALS
C IPH     SHELL SOURCE MARKER 0=NONE, 1=YES, 2=SPECIAL
C IPP     SHELL SOURCE POSITION
C IPYT    PARAMETRIC EY 0=NONE, 1=K, 2=ALPHA
C IOM     DISTRIBUTED SOURCE MARKER 0=NONE, 1=ENTER 0
C ISCT    SCAT LAWS 1=ISO, -1=ANISO
C ISN     SN-ORDER
C ITH     THEORYS 0=REGULAR, 1=ADJOINT
C IZN     NO OF ZONES

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C DTF PARAMETERS
C
C MCR     NO OF X SEC SETS FROM CARD READER
C MS      NO OF MIX SPECS FOR X-SECS
C MT      TOTAL NO OF SETS, INCLUDING MIXES
C MTP     NO OF X-SEC SETS FROM TAPE
C
C PY      PARAMETRIC EY VALUE
C
C RXF     RELAXATION FACTOR
C
C XLAW    LAMBDA, HIGHER LIMIT
C XLAL    LAMBDA, LOWER LIMIT
C XNF     NORMALIZATION FACTOR
C XNPM    NEW PARAMETER FACTOR 75 FOR ALPHA, 1 OTHERWISE
C
C DTF TEMPORARIES
C
C ASR     SDG/(OG + FG)
C ALA     SCATTERING CONVERGENCE RATIO
C
C CEV     CONT EY MODIFIER
C CYT     CONVERGENCE TRIGGER
C
C ESC     SOURCE ERROR, SCATTERING
C ESM     SOURCE ERROR, ABSORPTIONS
C EPG     EPS FOR SOURCE ERROR IN GROUP
C EPM     EPSILON
C EQ      DE/DC
C EYN     EIGENVALUE
C EYP     EQ PREVIOUS
C
C FTP     TOTAL FISSIONS, PREVIOUS ITERATION
C
C IG      IM=IGM
C IC      OUTER ITERATION COUNT
C IDN     PROBLEM ID
C IGP     GROUP MAX + 1
C IGV     CURRENT GROUP INDEX
C IHG     IMH=IGH
C IIC     INNER ITERATION COUNT
C IP      INTERVAL MAX + 1
C IT      ITERATION TRIGGER
C IZP     ZONE MAX + 1
C
C JT      TRIGGER FOR J-BLOCK

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C DTF PARAMETERS
C
C LC      INNER LOOP COUNT
C
C NFN     NEW F NEEDED. 0=NO, 1= YES
C
C MG      MM=1GM
C MI      IP=MM
C ML      MCR + MTP
C MM      SN + 1 FOR PL, SPH. SN=(SN+4)/4 FOR CYL
C
C XITA    ANISO SCATTERING TRIGGERS 0= NO, 1= YES
C XITR    SCATTERING TRIGGERS 0= NO, 1= YES
C XLA     LAMBDA
C XLAP    LAMBDA FOR PREVIOUS EIGENVALUE
C XLAR    LAMBDA FOR PREVIOUS OUTER ITERATION
C XNOT    NEUTRON BALANCE
C
C DTF SYMBOLIC NAME DEFINITIONS
C
C
C FORTRAN.  DIMEN.  DEFINITION
C
C AA      IP      AREA ELEMENT      (CM**2)
C AF      3       1, 2=PI, 4=PI
C ALA     1       SCATTERING CONVERGENCE RATIO
C AS      GP      ABSORPTIONS, BY GROUP (NEUTRONS)
C ASR     1       SDG/(GG + FG)
C
C B       MM=GM   BOUNDARY FLUX AT RIGHT (NEUT/(CM**2-SEC))
C BF      1       BUCKLING FACTOR
C
C C       MM=GM+MT X-SECTIONS (INPUT=BARNS, MIXED= 1/CM)
C CB      MM=GM   X-SEC BUFFER FOR TAPE
C CE      IM      X-SEC, EXTRACTED
C CF      IM      X-SECS, FISSION
C CH      MM      X-SECS, EXTRACTED
C CL      IM      X-SECS, SYNTH. ABS.
C CNT     1       CONTINUOUS EY EVALUATION MARKER
C CS      IM      X-SECS, SELF-SCATT.
C CT      IM      X-SEC, TOTAL
C
C D       MM      DIRECTION COSINES
C DA      IP=MM   GEOMETRICAL ATTENUATION (CM**2)
C DB      IP=MM   DA + DC      (CM**2)
C DC      IP=MM   GEOMETRICAL CURVATURE (CM**2)

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C DTF PARAMETERS
C
C DF      IM      DENSITY FACTORS
C DY      1       DIM. IN Y, FOR BUCKLING (CM)
C DZ      1       DIM. IN Z, FOR BUCKLING (CM)
C DS      IP=MM   AA=ABSF(D)      (CM**2)
C
C E       20      TEMPORARY STORAGE
C EPG     1       EPS FOR GROUP, ABSOLUTE
C EPN     1       EPN + EPS
C EPS     1       PRECISION TO BE ACHIEVED, LA
C EQ      1       DEY/DLA
C EOL     1       EQ, LIMIT VALUE
C EQP     1       EQ, PREVIOUS ITER.
C EY      1       EIGENVALUE
C EYM     1       EY MODIFIER
C EYN     1       EY
C EYP     1       EY, PREVIOUS
C
C F       IM      FISSION NEUTRON DENSITY (FISS-NEUT/(CM**3))
C FF      IM      FIXUP FUNCTION, ONE GROUP
C FG      GP      F BY GROUP      (NEUTRONS)
C FNG     GP      FISSION NEUTRONS BY GROUP      (NEUTRONS)
C FTP     1       FISSION TOTAL, PREVIOUS
C Fxf     IM=GM   FIXUP FUNCTION, ALL GROUPS
C FxM     107     FIX-UP MARKER
C
C IOL     1       BOUNDARY ON LEFT
C IOR     1       BOUNDARY ON RIGHT
C IOX     GM      MULTIPLES OF MM
C IC      1       ITERATION COUNT (OUTER)
C ICM     1       IC MAXIMUM
C ICVT    1       CONVERGENCE TRIGGER
C ICX     GM      MULTIPLES OF MM
C ICXX    MT      MULTIPLES OF MG
C ID      1       PROB. IDENT. NUMBER
C IDFM    1       DF MARKER
C IDN     1       IDENT. NO. (-10)
C IDX     MM      MULTIPLES OF IP
C IEVT    1       EY-TYPE
C IFN     1       INPUT FUNCTION
C IG      1       IM=GM
C IGE     1       GEOMETRY INDICATOR
C IGM     1       NUMBER OF VELOCITY GROUPS
C IGP     1       IGM + 1
C IGS     1       GROUP SKIPPING MARKER
C IGT     GM      IDT TRIGGER, BY GROUP

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C DTF PARAMETERS

C IGV 1 GROUP, CURRENT VALUE
 C IMG 1 HM=GM
 C IMM 1 HIGHEST SIGMA POSITION
 C IMS 1 POSITION OF SIGMA GG
 C IMT 1 POSITION OF SIGMA T (TOTAL)
 C IIC 1 INNER ITERATION COUNT
 C IIM 1 IIC MAXIMUM
 C IM 1 NUMBER OF RADIAL INTERVALS
 C IP 1 IM + 1
 C IPM 1 SHELL SOURCE MARKER
 C IPP 1 SHELL SOURCE POSITION
 C IPV 1 PARAMETRIC EY
 C IOM 1 DIST SOURCE MARKER
 C ISCT 1 SCATTERING LAW INDICATOR
 C ISN 1 SN ORDER OF APPROX
 C ITW 1 THEORY
 C IZI 1 ICS TRIGGER, BY GROUP
 C IZM 1 NUMBER OF ZONES
 C IZP 1 ZM+1
 C
 C JS 103 MATERIAL NUMBERS FOR ACTIVITY PRINTS
 C JA 103 X SEC POSITIONS FOR ACTIVITY PRINTS
 C JT 1 CURRENT TRIGGER
 C
 C LC 1 LOOP COUNT (INNER LOOP)
 C
 C MA 1M ZONE NO. BY RADIUS
 C MB MS X SEC MIX NO
 C MC MS X SEC MIX COMPONENT NO
 C MCR 1 NBR OF X-SEC SETS FROM CARDS
 C MG 1 HM=GM
 C MI 1 IP=MM
 C ML 1 NBR OF X SEC SETS LOADED
 C MM 1 NBR OF ANGULAR DIRECTIONS
 C MR MM DIR INDICES FOR REFLECTION
 C MS 1 NBR OF MIX SPECS
 C MT 1 NBR OF X-SEC SETS, INCL MIXTURES
 C MTP 1 NBR OF X SEC SETS FROM TAPE
 C MTT MOS X SEC. FROM NUCLIDE TAPE
 C MZ ZM MATERIAL NBR. BY ZONE
 C
 C NFH 1 NEW F NEEDED
 C NX GM MULTIPLES OF IM
 C
 C P MM SHELL SOURCE (NEUT/(CM**2 SEC))

C DTF PARAMETERS

C PA GM SHELL SOURCE, ISOTROPIC PART (NEUT/(CM**2-SEC))
 C PB GM SHELL SOURCE, DIR PART (NEUT/(CM**2 SEC))
 C PR MM P, SAVED (NEUT/(CM**2 SEC))
 C PYT 1 PY TYPE, K OR ALPHA
 C
 C O IM=GM DIST SOURCE (NEUT/(CM**3))
 C OG GP DIST SOURCE, BY GROUP (NEUTRONS)
 C
 C R IP RADII, INITIAL (CM)
 C RA IP RADII, ACTUAL (CM)
 C RAY IM CENTER POINT OF RADIAL INTERVALS (CM)
 C RLG GP RIGHT (BDRY) LEAKAGE, BY GROUP (NEUTRONS)
 C RM IZM RADIAL ZONE MODIFIERS (DELTA CALC)
 C RXF 1 RELAXATION FACTOR
 C
 C SA IM SOURCE, ANISOTROPIC PART (NEUTRONS)
 C SAT IM SA, INCL SELF SCATTERING (NEUTRONS)
 C SCG GP SELF-SCATT, BY GROUP (NEUTRONS)
 C SDG GP SLOWING DOWN, BY GROUP (NEUTRONS)
 C SG GP SOURCE (SB), BY GROUP (NEUTRONS)
 C SNG GP SCATT-IN, BY GROUP (NEUTRONS)
 C SR IM SOURCE, ISOTROPIC PART (NEUTRONS)
 C ST IM SR, INCL SELF SCATT (NEUTRONS)
 C
 C TS IZP=103 ACTIVITY TABLE, BY ZONES (NEUTRONS)
 C T5 IM=103 ACTIVITY TABLE, BY SPACE PT (NEUT/(CM**3))
 C TAB GM TIME ABSORPTION, BY GROUP (1 CM)
 C
 C Y IM VOLUME ELEMENTS (CM**3)
 C YE GM NEUTRON SPEED (CM/SHAKE)
 C YF 3 VOLUME FACTORS 1, 1/2, 1/3
 C
 C W MM WEIGHTS FOR D
 C WD MM W=0
 C
 C XITA 1 ITER TRIGGER, ANISO SSC
 C XITR 1 ITER TRIGGER, ISOTP SSC
 C XJ IM=GM CURRENT (NEUT/(CM**2-SEC))
 C XKE GM FISSION SPECTRUM, EFFECTIVE
 C XKI GM FISSION SPECTRUM, INPUT
 C XLA 1 LAMBDA
 C XLAM 1 LA, HIGH BOUND
 C XLAL 1 LA, LOW BOUND
 C XLAP 1 LA, FOR PREY EY
 C XLAR 1 LA, FOR PREY OUTER ITER

DTF PARAMETERS

C	XND	MS	X-SEC MIX ATOMIC DENSITY	(ATOMS/CM**3)
C	XN	IM=GM	NEUTRON FLUX	(NEUT/(CM**2-SEC))
C	XNA	IM	NO ASSUMED FOR ST	(NEUT/(CM**2-SEC))
C	XNB	GP	NEUTRON BALANCE, BY GROUP	
C	XNBOT	I	NEUTRON BALANCE TOTAL	
C	XND	IP=MM	NEUTRON FLUX, BY DIRECTION	(NEUT/(CM**2 SEC))
C	XNDG	GP	NEUTRON DENSITY, BY GROUP	(NEUT/CM**3)
C	XNE	IM	NEUTRON FLUX, EXTRAPOLATED	(NEUT/(CM**2-SEC))
C	XNF	I	NORMALIZATION FACTOR	
C	XNG	GP	NEUTRON FLUX, BY GROUP	(NEUT/CM SEC)
C	XNI	MM	INWARD FLUX, BY DIRECTION	(NEUT/(CM**2-SEC))
C	XNIO	I	SOURCE FLUX	(NEUT/(CM**2-SEC))
C	XNLG	I	NET LEAKAGE, BY GROUP	(NEUT/TRANS)
C	XNN	IM	NEW NEUTRON FLUX	(NEUT/(CM**2-SEC))
C	XNO	MM	OUTWARD FLUX, BY DIRECTION	(NEUT/(CM**2 SEC))
C	XNOR			
C	XNPM	I	NEW PARAMETER FACTOR	
C	XNR	IM	NN SAVED FOR REFLECTIVE PASS	(NEUT/(CM**2-SEC))
C	XNR	IM	NN SAVED FOR REFLECTIVE PASS	(NEUT/(CM**2SEC))

CROSS SECTIONS A PROVISIONAL 16 GRP LID OF DTF ANISN XSECTS WTD FOR FAST RETRS

THESE CROSS SECTIONS WERE PREPARED BY R. DOYAS AND V. HANSEN FROM SEVERAL SOURCES PRINCIPALLY FROM THE LIBRARY EVALUATED BY R. HONERTON. THE LIBRARY CONFORMS TO THE ENERGY STRUCTURE USED IN THE 16-GROUP HANSEN-ROACH LIBRARY (ANL 5800 CM 7) THAT LIBRARY IS INCLUDED IN THIS LISTING AS SERIES 2900 PRIMARILY FOR THE ANISOTROPIC FORMS OF HYDROGEN AND DEUTERIUM AND FOR SEVERAL ISOTOPES WHICH ARE NOT CURRENTLY AVAILABLE IN THE HONERTON EVALUATED LIBRARY. THE SPECTRUM USED IN WEIGHTING THE 1100 SERIES CROSS SECTIONS WAS THAT OF A GODIVA REACTOR. THE 1200 SERIES CROSS SECTIONS WERE WEIGHTED WITH A SPECTRUM CHOSEN FROM AN INTERMEDIATE FUEL LED ZONE RADIUS OF AN EARLIER LRL REFERENCE DESIGN (LRL F1), AS GENERATED BY A 16-GROUP DTF CALCULATION. THIS SET WAS USED FOR THE BULK OF THE REPORTED REACTOR ANALYSIS WORK. THE 1600 SERIES CROSS SECTIONS WERE WEIGHTED WITH A MORE THERMAL SPECTRUM IN AN EFFORT TO PROVIDE A LIBRARY USEFUL IN SURVEY WORK OVER A WIDE RANGE OF MEAN NEUTRON ENERGIES. A COMPARISON OF THE APPLICATION OF THIS SERIES AND SERIES 1100, AS A FUNCTION OF GROUP STRUCTURE, TO VARIOUS BE/U SYSTEMS, IS PRESENTED IN APPENDIX D. THE ENERGY SPECTRUMS FOR ALL LIBRARY SERIES ARE ALSO CONTAINED IN THAT APPENDIX (FIG. 1D AND 2D).

NEITHER THE HANSEN-ROACH (2900 SERIES) OR HONERTON (1100 OR 1200) SERIES BASED LIBRARIES SHOULD BE USED IN SYSTEMS WHERE THE MEAN ENERGY OF NEUTRONS CAUSING FISSION IS NEAR THERMAL SINCE NEITHER SET CONTAINS UPSCATTER COEFFICIENTS. IT SHOULD BE REALIZED HOWEVER THAT EVEN WATER FLOODING OF THE SMALL TUNGSTEN BASED FAST REACTORS, DESCRIBED EARLIER IN THE BODY OF THIS REPORT, FAILS TO SIGNIFICANTLY LOWER THE FUEL ENERGY SPECTRUM TO THE THERMAL RANGE SO THAT THESE SERIES PROVIDE RATHER USEFUL ESTIMATES OF THE WATER SAFETY SITUATION. COMPARATIVE ANALYSIS OF THE SMALL FAST SPECTRUM REACTORS UNDER PROGRAM CONSIDERATION, USING THE '200 AND '600 SERIES, 16-GROUP CROSS SECTIONS, HAVE DEMONSTRATED THAT THE WATER SAFETY CALCULATION IS EQUALLY WELL ESTIMATED BY EITHER SERIES. THESE CROSS SECTIONS WERE INTENDED AS AN INTERIM LIBRARY ONLY. PENDING MORE THOROUGH AND RIGOROUS GROUPING AND WEIGHTING. THESE CROSS SECTIONS SHOULD BE USED FOR SURVEY PURPOSES ONLY WITH THE UNDERSTANDING THAT NEITHER THE AUTHORS NOR THE LABORATORY MAKES ANY CLAIM FOR THEIR VALIDITY. THEY ARE BEING PUBLISHED IN THE INTERESTS OF PROVIDING AS COMPLETE A PACKAGE AS POSSIBLE FOR SURVEY WORK THAT THIS MAY CONTINUE UNTIL FUNDS ARE AVAILABLE FOR FURTHER SPACE REACTOR RESEARCH. PLEASE DO NOT SEPARATE THESE CROSS SECTIONS FROM THIS CAUTION OR PUBLISH THEM IN ANY FORM. THESE HAVE A WAY OF CREEPING INTO THE LITERATURE WITHOUT PROPER EVALUATION AND ARE PUBLISHED HERE WITH NO SLIGHT MISGIVINGS.

TO USE THESE CROSS SECTIONS WITH THE CODE SIMPLY REMOVE THE TWO SEPARATION CARDS AND PLACE THE DECK FOR EACH MATERIAL INCLUDING THE TITLE CARD IN THE ORDER OF THE ADEN (ATOM DENSITY) SUBSCRIPTS. THESE HAVE BEEN LISTED IN

CROSS SECTIONS - A PROVISIONAL 16 GRP LIB OF DTF-ANISM XSECTS WTD FOR FAST RCTRS

THE TWO MAIN PROGRAMS (ADEN-ADEN(I,J) WHERE I=NUCLIDE NUMBER AS DEFINED BY ITS PHYSICAL POSITION IN THE XSECTION DATA DECK AND J= ZONE GEOMETRICAL NUMBER) NOTE THAT THE TWO ANISOTROPIC CROSS SECTION SETS REFERRED TO IN THE MAIN PROGRAM ARE THE ANISOTROPIC CROSS SECTIONS OF THE 2900 SERIES WHICH MUST BE DISTINGUISHED FROM THE HYDROGEN AND DEUTERIUM CROSS SECTIONS CALLED HYDROGEN 1 AND HYDROGEN 2 OCCASIONALLY WHEN WE HAVE NOT HAD CROSS SECTIONS AVAILABLE FOR A MATERIAL WE HAVE USED THE CROSS SECTIONS FOR A MATERIAL HAVING WHAT APPEARS TO BE A SIMILAR SPECTRAL DISTRIBUTION FROM STANDARD CROSS SECTION REFERENCES FOR EXAMPLE WE USED GOLD IN PLACE OF MAFNIUM FOR A TIME UNTIL WF XSECTIONS WERE AVAILABLE NATURALLY WE USED THE PROPER CONSTANTS FOR MAFNIUM IN COMPUTING THE ADEN ARRAY SO THAT WE HAD THE PROPER ATOM DENSITY THE DIFFERENCE IN THE MULTIPLICATION FACTORS COMPUTED WITH THE TWO SETS WAS NEGLECTABLE HOWEVER A COMPARISON OF THE WATER PERTURBATION EFFECTS CALCULATED WITH THE TWO SETS NOT ONLY SHOWED SLIGHT DIFFERENCES BUT DIFFERENCES IN SIGN AS WELL DEMONSTRATING SLIGHT SPECTRAL EFFECTS

C IN ORDER TO PROVIDE A MEASURE OF COMPLETENESS, THE KEY TO THE LRL CROSS
C SECTION LIBRARY 4 DIGIT NUMBERS IS GIVEN BELOW

	FIRST DIGIT	SECOND DIGIT
C	0 DUMMY MATERIAL (EMPTY SET)	0 FLAT FLUX
C	1 HOWERTON EVALUATED *SECT	1 GODIVA FLUX
C	2 HANSEN-ROACH (LANS 2941)	2 LRL-F FLUX
C		
C	3 - ORIGINATED BY R DOYAS	3 - FISSION SPECTRUM
C	4 ORIGINATED BY Y HAMPEL	4 - SUPERNOVA TYPE SPECTRA
C	5 - TRANSFER COEFFICIENTS	(UCRL-7027)
C	LIMITED TO 5 DOWNSCATTERS	5 - BE0/U235 + 247/1
C	AS IN DTG-11	(UCRL-7027)
C	6 - UNDEFINED	6 BE0/U235 + 3000/1
C	7 - UNDEFINED	7 - UNDEFINED
C	8 - UNDEFINED	8 - SPECIAL FLUX HEIGHT
C	9 - SOURCE UNKNOWN	REFER TO COMMENTS FOR PARTICULAR MATERIAL
C		9 - UNKNOWN FLUX HEIGHTING

THIRD AND FOURTH DIGITS DESIGNATE ARBITRARY SEQUENTIAL NUMBERS

C THE CROSS SECTIONS FOR EACH NUCLIDE CONSIST OF 25 CARDS. NUMBER 1 IS THE
C TITLE CARD AND NUMBERS 2 TO 25 ARE 6E12.5. THE FOLLOWING DUMMY CROSS SEC
C TION ARRAY DEMONSTRATES THE ARRANGEMENT.

CROSS SECTIONS A PROVISIONAL 16 GRP LIB OF DTF-ANISM XSECTS MTD FOR FAST RETRS

[illegible]

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

C	NUCLIDE	NUMBER	NUCLIDE	NUMBER	NUCLIDE	NUMBER
C	H-1	1101	MO	1118	H-3	1140
C	H-2	1102	EU	1119	HE-3	1141
C	LI-6	1103	GO	1120	HE-4	1142
C	LI-7	1104	TA 181	1121	B-10	1143
C	BE-9	1105	M	1122	F	1144
C	BORON	1106	AU	1123	CL	1145
C	C-12	1107	PO	1124	A	1146
C	N-14	1108	U-235	1125	CA	1148
C	O-16	1109	U-234	1126	TI	1149
C	NA-23	1110	U-235	1127	MN	1150
C	AL	1111	U-236	1128	CU	1151
C	SILICON	1112	U-238	1129	SN	1152
C	P-31	1113	PU-239	1130	U-237	1153
C	K	1114	PU-240	1131	U-239	1154
C	FE	1115	PU-241	1132	U-240	1155
C	GALLIUM	1116	MG	1133	PU-238	1156
C	NB-93	1117				

16 9 1101	HYDROGEN-1	MICRO	293K	SPN-76	HOWERTON
0 37410E-03 0	0 60103E 00-0	74887E 00 0	0	DOYAS 2	
0 0	0	44379E-03 0	0 97000E 00DOYAS 3		
-0 11563E 01 0 71974E 00 0	0	0	0	DOYAS 4	
0 46936E-03 0	0 13400E 01-0	19464E 01 0 75923E 00 0	0 22492E-00DOYAS 5		
0 0	0	0 48303E-03 0	0 18582E 01DOYAS 6		
-0 19844E 01 0 18255E 01 0	0 75923E 00 0	22492E-00 0	0	DOYAS 7	
0 49331E-03 0	0 29952E 01-0	13068E 01 0 28816E 01 0	0 10953E 01DOYAS 8		
0 45554E-00 0 13495E-00 0	0	0 49847E-03 0	0 48797E 01DOYAS 9		
0 24405E-00 0 35703E 01 0	0 79724E 00 0	30303E-00 0 12603E-00 0	0 44984E-01DOYAS 10		
0 53179E-03 0	0 63004E 01 0	11039E 01 0 38172E 01 0	0 60222E 00DOYAS 11		
0 13447E-00 0 51114E-01 0	0 25814E-01 0	12275E-02 0	0 66984E 01DOYAS 12		
0 44101E-00 0 42434E 01 0	0 66801E 00 0	10539E-00 0 23533E-01 0	0 10953E-01DOYAS 13		
0 28587E-02 0	0 67593E 01 0	51795E 00 0 51187E 01 0	0 77939E 00DOYAS 14		
0 12269E-00 0 19357E-01 0	0 52829E-02 0	64465E-02 0	0 67731E 01DOYAS 15		
-0 26026E 01 0 43669E 01 0	0 79624E 00 0	12124E-00 0 19086E-01 0	0 43016E-02DOYAS 16		
0 11651E-01 0	0 67783E 01-0	33833E 01 0 62462E 01 0	0 12477E 01DOYAS 17		
0 22750E-00 0 34640E-01 0	0 81797E-02 0	20423E-01 0	0 67871E 01DOYAS 18		
-0 26026E 01 0 71050E 01 0	0 21862E 01 0	43669E-00 0 79624E-01 0	0 17320E-01DOYAS 19		
0 36967E-01 0	0 68036E 01-0	33833E 01 0 62462E 01 0	0 20300E 01DOYAS 20		
0 62462E 00 0 12477E-00 0	0 34124E-01 0	62449E-01 0	0 68291E 01DOYAS 21		
-0 48333E 01 0 60900E 01 0	0 18738E 01 0	60900E 00 0 18738E-00 0	0 62385E-01DOYAS 22		
0 10377E-00 0	0 68704E 01-0	13533E 01 0 87000E 01 0	0 30450E 01DOYAS 23		
0 93692E 00 0 30450E-00 0	0 12492E-00 0	20742E-00 0	0 69741E 01DOYAS 24		
0 67667E 01 0 81200E 01 0	0 29000E 01 0	10150E 01 0 31231E-00 0	0 10150E-00DOYAS 25		

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

C	16 9 1102	HYDROGEN-2	MICRO	293K	SPN-76	HOWERTON
C	0 30000E-04 0	0 11539E 01 0	55220E-01 0	0	DOYAS 27	
0	0	0	0 30000E-04 0	0	20971E 01DOYAS 28	
0 31683E-00 0 57125E 00 0	0	0	0	0	DOYAS 29	
0 30000E-04 0	0 26688E 01 0	22058E-00 0 47726E-00 0	0 18503E-00DOYAS 30			
0 0	0	0 30000E-04 0	0	28401E 01DOYAS 31		
0 45758E-00 0 10213E 01 0	0 71823E 00 0	33366E-00 0	0	DOYAS 32		
0 30000E-04 0	0 25288E 01 0	10221E 01 0 19441E 01 0	0 14270E 01DOYAS 33			
0 58473E 00 0 34304E-01 0	0	0 30000E-04 0	0 22492E 01DOYAS 34			
0 15110E 01 0 14909E 01 0	0 43839E-00 0	21872E-04 0	0 13425E-03DOYAS 35			
0 30000E-04 0	0 22707E 01 0	16464E 01 0 73249E 00 0	0 15765E-01DOYAS 36			
0 0	0	0 30000E-04 0	0 22752E 01DOYAS 37			
0 15036E 01 0 62055E 00 0	0 57026E-02 0	0	0	DOYAS 38		
0 30000E-04 0	0 22752E 01 0	15157E 01 0 76530E 00 0	0 37724E-02DOYAS 39			
0 0	0	0 30000E-04 0	0 22752E 01DOYAS 40			
0 92644E 00 0 71649E 00 0	0 62540E-02 0	0	0	DOYAS 41		
0 30000E-04 0	0 22752E 01 0	77945E 00 0 11769E 01 0	0 42967E-01DOYAS 42			
0 0	0	0 35102E-04 0	0	22752E 01DOYAS 43		
0 92644E 00 0 13386E 01 0	0 17182E-00 0	0	0	DOYAS 44		
0 62744E-04 0	0 22752E 01 0	77945E 00 0 11769E 01 0	0 15710E-00DOYAS 45			
0 0	0	0 10602E-03 0	0	22752E 01DOYAS 46		
0 50669E 00 0 11498E 01 0	0 17002E-00 0	0	0	DOYAS 47		
0 17607E-03 0	0 22754E 01 0	11619E 01 0 16387E 01 0	0 34592E-00DOYAS 48			
0 17947E-02 0	0	0 35175E-03 0	0 22752E 01DOYAS 49			
0 22752E 01 0 11133E 01 0	0 12978E-00 0	0	0	DOYAS 50		

C	16 9 1103	LITHIUM-6	MICRO	293K	SPN-76	HOWERTON
C	0 10518E-00 0	0 15169E 01 0	43225E-00 0	0	DOYAS 52	
0	0	0	0 22035E-00 0	0	11479E 01DOYAS 53	
0 50691E 00 0 62105E 00 0	0	0	0	0	DOYAS 54	
0 29875E-00 0	0 10898E 01 0	22675E-00 0 35969E-00 0	0 40062E-01DOYAS 55			
0 0	0	0 47615E-00 0	0	15832E 01DOYAS 56		
0 60148E 00 0 56430E 00 0	0 32320E-01 0	17450E-00 0	0	DOYAS 57		
0 16042E 01 0	0 48997E 01 0	31488E 01 0 50554E 00 0	0	DOYAS 58		
0 28656E-01 0 14591E 00 0	0 74932E 00 0	0	0	15744E 01		
0 79017E 00 0 14667E-00 0	0	0	0	DOYAS 60		
0 14628E 01 0	0 23625E 01 0	87975E 00 0 34911E-01 0	0	DOYAS 61		
0 0	0	0 36108E 01 0	0	45035E 01		
0 85860E 00 0 19910E-01 0	0	0	0	DOYAS 63		
0 83431E 01 0	0 92325E 01 0	85622E 00 0 34060E-01 0	0	DOYAS 64		
0 0	0	0 18775E 02 0	0	19664E 02DOYAS 65		
0 79345E 00 0 33159E-01 0	0	0	0	DOYAS 66		

C SERIES 1100 CROSS SECTION LIBRARY GODIYA WEIGHTED

0 34384E 02 0	0 35273E 02 0	0 76814E 00 0	0 95924E-01 0	DOYAS 67
0 0	0	0 59960E 02 0	0 60449E 02DOYAS 68	
0 79345E 00 0	0 12124E-00 0	0 0	0 DOYAS 69	
0 10870E 03 0	0 10967E 03 0	0 76814E 00 0	0 95924E-01 0	DOYAS 70
0 0	0	0 18157E 03 0	0 18246E 03DOYAS 71	
0 70464E 00 0	0 12124E 00 0	0 0	0 DOYAS 72	
0 30563E 03 0	0 30652E 03 0	0 82472E 00 0	0 18474E-00 0	DOYAS 73
0 0	0	0 60498E 03 0	0 60587E 03DOYAS 74	
0 88938E 00 0	0 64660E-01 0	0 0	0 DOYAS 75	

C

16 9 1104 LITHIUM-7	MICRO	293K	SPN-76	HOWERTON
0 10000E-09 0	0 16901E 01 0	0 82742E 00 0	0	
0 0	0	0 10000E-09 0	0 14485E 01	
0 89955E 00 0	0 73388E 00 0	0 0	0 DOYAS 79	
0 10001E-05 0	0 13176E 01 0	0 45850E-00 0	0 52251E 00 0	25183E-01DOYAS 80
0 0	0	0 10001E-05 0	0 11562E 01DOYAS 81	
0 7354E 00 0	0 84272E 00 0	0 25934E-01 0	0 67891E-01 0	DOYAS 82
0 10001E-05 0	0 23799E 01 0	0 23039E 01 0	0 42068E 00 0	16419E-01
0 135 4E-03 0	0 29852E-01 0	0 10001E-05 0	0 89169E 00DOYAS 84	
0 86129E 00 0	0 75976E-01 0	0 0	0 33480E-03 0	66427E-02
0 10001E-05 0	0 95010E 00 0	0 93282E 00 0	0 30390E-01 0	DOYAS 86
0 0	0	0 34243E-04 0	0 99031E 00	
0 95995E 00 0	0 17278E-01 0	0 0	0 DOYAS 88	
0 12597E-02 0	0 99580E 00 0	0 96505E 00 0	0 30325E-01 0	DOYAS 89
0 0	0	0 18772E-02 0	0 99586E 00	
0 90868E 00 0	0 29492E-01 0	0 0	0 DOYAS 91	
0 19774E 02 0	0 99587E 00 0	0 88608E 00 0	0 85302E-01 0	DOYAS 92
0 0	0	0 32774E-02 0	0 99888E 00DOYAS 93	
0 90998E 00 0	0 10781E-00 0	0 0	0 DOYAS 94	
0 54825E 02 0	0 10041E 01 0	0 89021E 00 0	0 85620E 01 0	DOYAS 95
0 0	0	0 88581E-02 0	0 10082E 01DOYAS 96	
0 83412E 00 0	0 10838E 00 0	0 0	0 DOYAS 97	
0 14001E 01 0	0 10133E 01 0	0 94149E 00 0	0 16517E-00 0	DOYAS 98
0 0	0	0 21601E-01 0	0 10195E 01DOYAS 99	
0 99785E 00 0	0 57811E 01 0	0 0	0 DOYAS100	

C

16 9 1105 BERYLLIUM 9	MICRO	293K	SPN 76	HOWERTON
0 75445E 01 0	0 13561E 01 0	0 39625E 00 0	0	DOYAS102
0 0	0	0 49655E-01 0	0 16526E 01DOYAS103	
0 10894E 01 0	0 45666E-00 0	0 0	0 DOYAS104	
0 72764E 02 0	0 22795E 01 0	0 10005E 01 0	0 48987E-00 0	62406E 01DOYAS105
0 0	0	0 42723E 02 0	0 34570E 01DOYAS106	
0 26313E 01 0	0 12716E 01 0	0 11860E 03 0	0 23180E 00 0	DOYAS107

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

0 22446E 02 0	0 39984E 01 0	0 36571E 01 0	0 82145E 00 0	0 20000E-05DOYAS108
0 47272E 01 0	0 60023E 00 0	0 12262E-02 0	0 5.397E 01DOYAS109	
0 51071E 01 0	0 33901E-00 0	0 0	0 DOYAS110	
0 10010E-02 0	0 55399E 01 0	0 54696E 01 0	0 12740E-00 0	DOYAS111
0 0	0	0 10018E-02 0	0 55538E 01DOYAS112	
0 54332E 01 0	0 69252E-01 0	0 0	0 DOYAS113	
0 10020E-02 0	0 55538E 01 0	0 54364E 01 0	0 11962E-00 0	DOYAS114
0 0	0	0 10020E-02 0	0 55538E 01DOYAS115	
0 52166E 01 0	0 11645E-00 0	0 0	0 DOYAS116	
0 10020E-02 0	0 55538E 01 0	0 51271E 01 0	0 33688E-00 0	DOYAS117
0 0	0	0 10020E-02 0	0 55538E 01DOYAS118	
0 52166E 01 0	0 42578E-00 0	0 0	0 DOYAS119	
0 10272E-02 0	0 55539E 01 0	0 51271E 01 0	0 33688E-00 0	DOYAS120
0 0	0	0 20591E-02 0	0 55541E 01DOYAS121	
0 49034E 01 0	0 42578E-00 0	0 0	0 DOYAS122	
0 34580E-02 0	0 55541E 01 0	0 53237E 01 0	0 64862E 00 0	DOYAS123
0 0	0	0 56020E-02 0	0 55542E 01DOYAS124	
0 55486E 01 0	0 22697E-00 0	0 0	0 DOYAS125	

C

16 9 1106 BORON	MICRO	293K	SPN-76	HOWERTON
0 44020E-01 0	0 94146E 00 0	0 49492E-00 0	0	DOYAS127
0 0	0	0 65530E-01 0	0 17918E 01DOYAS128	
0 12348E 01 0	0 33900E-00 0	0 0	0 DOYAS129	
0 40336E-01 0	0 21060E 01 0	0 13509E 01 0	0 49342E-00 0	14942E-01DOYAS130
0 0	0	0 11877E-00 0	0 25135E 01DOYAS131	
0 16443E 01 0	0 71470E 00 0	0 16006E-01 0	0	DOYAS132
0 27725E-00 0	0 34688E 01 0	0 29866E 01 0	0 75045E 00 0	DOYAS133
0 0	0 12646E-01 0	0 76006E 00 0	0 45007E 01DOYAS134	
0 36719E 01 0	0 20495E-00 0	0 0	0 38462E-06DOYAS135	
0 14820E 01 0	0 52359E 01 0	0 37169E 01 0	0 68764E-01 0	DOYAS136
0 0	0	0 21418E 01 0	0 58957E 01DOYAS137	
0 36901E 01 0	0 36976E-01 0	0 0	0 DOYAS138	
0 36684E 01 0	0 74224E 01 0	0 36918E 01 0	0 63776E-01 0	DOYAS139
0 0	0	0 10573E 02 0	0 14327E 02DOYAS140	
0 35743E 01 0	0 62089E-01 0	0 0	0 DOYAS141	
0 22250E 02 0	0 26004E 02 0	0 35269E 01 0	0 17962E 00 0	DOYAS142
0 0	0	0 43273E 02 0	0 47027E 02DOYAS143	
0 35743E 01 0	0 22701E 00 0	0 0	0 DOYAS144	
0 83667E 02 0	0 87421E 02 0	0 35269E 01 0	0 17962E-00 0	DOYAS145
0 0	0	0 14423E 03 0	0 14799E 03DOYAS146	
0 34080E 01 0	0 22701E-00 0	0 0	0 DOYAS147	
0 23547E 03 0	0 23923E 03 0	0 36328E 01 0	0 34593E-00 0	DOYAS148
0 0	0	0 47516E 03 0	0 47891E 03DOYAS149	
0 37539E 01 0	0 12107E-00 0	0 0	0 DOYAS150	

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

C
C
16 9 1107 CARBON-12 MICRO 293K SPN-76 HOWERTON
0 19447E-01 0 0 16179E 01 0 10265E 01 0 0 DOYAS152
0 0 0 0 1 00000E-06 0 0 17600E 01 DOYAS153
0 13239E 01 0 56306E 00 0 0 0 0 DOYAS154
1 00000E-06 0 0 21753E 01 0 12796E 01 0 43627E-00 0 DOYAS155
0 0 0 0 1 00000E-06 0 0 20602E 01 DOYAS156
0 22882E 01 0 89563E 00 0 0 83370E-02 0 0 DOYAS157
1 00000E-06 0 0 37025E 01 0 34949E 01 0 57196E 00 0 DOYAS158
0 0 53582E-03 0 1 00000E-06 0 0 42851E 01 DOYAS159
0 42154E 01 0 20754E-00 0 0 0 0 60467E-06 DOYAS160
1 00000E-06 0 0 43455E 01 0 43075E 01 0 69754E-01 0 DOYAS161
0 0 0 1 00000E-06 0 0 43697E 01 DOYAS162
0 43050E 01 0 37966E-01 0 0 0 0 DOYAS163
1 00000E-06 0 0 43445E 01 0 42815E 01 0 64774E-01 0 DOYAS164
0 0 0 1 00000E-06 0 0 43445E 01 DOYAS165
0 41621E 01 0 63062E-01 0 0 0 0 DOYAS166
1 00000E 06 0 0 43445E 01 0 41140E 01 0 18243E-00 0 DOYAS167
0 0 0 1 00000E-06 0 0 0 0 DOYAS168
0 41971E 01 0 23057E-00 0 0 0 0 DOYAS169
1 00000E-06 0 0 44783E 01 0 42581E 01 0 18617E-00 0 DOYAS170
0 0 0 1 00000E-06 0 0 0 0 DOYAS171
0 41869E 01 0 24026E-00 0 0 0 0 DOYAS172
1 00000E-06 0 0 46140E 01 0 44818E 01 0 37079E-00 0 DOYAS173
0 0 0 1 00000E-06 0 0 0 0 DOYAS174
0 46940E 01 0 13218E-00 0 0 0 0 DOYAS175
C
C
16 9 1108 NITROGEN-14 MICRO 293K SPN-76 HOWERTON
0 30088E-00 0 0 13783E 01 0 73506E 00 0 0 DOYAS177
0 0 0 0 12208E-00 0 0 15912E 01 DOYAS178
0 11085E 01 0 33246E-00 0 0 0 0 DOYAS179
0 36965E-01 0 0 15928E 01 0 11142E 01 0 36062E-00 0 59209E-02 DOYAS180
0 0 0 0 40361E-01 0 0 20147E 01 DOYAS181
0 15314E 01 0 44162E-00 0 0 37026E-02 0 0 DOYAS182
0 17587E 02 0 0 30719E 01 0 29093E 01 0 44296E-00 0 DOYAS183
0 0 29643E-03 0 0 16115E-02 0 0 46189E 01 DOYAS184
0 45451E 01 0 16087E-00 0 0 0 0 13337E-04 DOYAS185
0 29111E-02 0 0 56893E 01 0 56396E 01 0 72202E-01 0 DOYAS186
0 0 0 0 74902E-02 0 0 71299E 01 DOYAS187
0 70202E 01 0 46775E-01 0 0 0 0 DOYAS188
0 17415E-01 0 0 86680E 01 0 85403E 01 0 10224E-00 0 DOYAS189
0 0 0 0 39847E-01 0 0 0 0 DOYAS190
0 89927E 01 0 11035E-00 0 0 0 0 DOYAS191

C SERIES 1100 CROSS SECTION LIBRARY GODIYA WEIGHTED

0 71076E-01 0 0 95752E 01 0 90854E 01 0 32918E-00 0 DOYAS192
0 0 0 0 12596E-00 0 0 97494E 01 DOYAS193
0 92848E 01 0 41872E-00 0 0 0 0 DOYAS194
0 22445E 00 0 0 99612E 01 0 93098E 01 0 33864E-00 0 DOYAS195
0 90522E 01 0 42689E-00 0 0 0 0 DOYAS196
0 62014E 00 0 0 10361E 02 0 95082E 01 0 64833E 00 0 DOYAS197
0 0 0 0 13060E 01 0 0 11305E 02 DOYAS199
0 99992E 01 0 23505E-00 0 0 0 0 DOYAS200
C
C
16 9 1109 OXYGEN-16 MICRO 293K SPN-76 HOWERTON
0 37756E-01 0 0 16309E 01 0 11589E 01 0 0 DOYAS202
0 0 0 0 20001E-05 0 0 14065E 01 DOYAS203
0 10746E 01 0 42061E-00 0 0 0 0 DOYAS204
0 20001E-05 0 0 38464E 01 0 25019E 01 0 33183E-00 0 37505E-02 DOYAS205
0 0 0 0 20001E-05 0 0 0 0 DOYAS206
0 27497E 01 0 13445E 01 0 0 99177E-02 0 0 DOYAS207
0 20001E-05 0 0 41281E 01 0 40103E 01 0 10756E 01 0 DOYAS208
0 0 0 0 20001E-05 0 0 0 0 DOYAS209
0 33161E 01 0 11789E-00 0 0 0 0 DOYAS210
0 20001E-05 0 0 33739E 01 0 33520E 01 0 38105E-01 0 DOYAS211
0 0 0 0 20001E-05 0 0 0 0 DOYAS212
0 35693E 01 0 21845E-01 0 0 0 0 DOYAS213
0 20001E 05 0 0 36417E 01 0 36044E 01 0 38361E-01 0 DOYAS214
0 0 0 0 20001E-05 0 0 0 0 DOYAS215
0 35337E 01 0 37346E-01 0 0 0 0 DOYAS216
0 20001E-05 0 0 36417E 01 0 35052E 01 0 10804E-00 0 DOYAS217
0 0 0 0 20001E-05 0 0 0 0 DOYAS218
0 35337E 01 0 13655E-00 0 0 0 0 DOYAS219
0 20001E-05 0 0 36417E 01 0 35052E 01 0 10804E-00 0 DOYAS220
0 0 0 0 20001E-05 0 0 0 0 DOYAS221
0 34337E 01 0 13655E-00 0 0 0 0 DOYAS222
0 20001E-05 0 0 36477E 01 0 35724E 01 0 20807E-00 0 DOYAS223
0 0 0 0 20001E-05 0 0 0 0 DOYAS224
0 38871E 01 0 75304E 01 0 0 0 DOYAS225
C
C
16 9 1110 SODIUM-23 MICRO 293K SPN-76 HOWERTON
0 30466E 02 0 0 14061E 01 0 81209E 00 0 0 DOYAS227
0 0 0 0 29267E-03 0 0 16284E 01 DOYAS228
0 12518E 01 0 43894E-00 0 0 0 0 DOYAS229
0 12447E-03 0 0 24717E 01 0 14738E 01 0 39630E-00 0 11127E 00 DOYAS230
0 0 0 0 0 21654E 03 0 0 41450E 01 DOYAS231
0 36227E 01 0 99772E 00 0 0 40654E 01 0 0 DOYAS232

C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

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0 63963E-03 0 0 36264E 01 0 55490E 01 0 50854E 00 0 D0YAS253
0 0 0 14808E 03 0 0 12138E-02 0 0 40609E 01D0YAS254
0 40282E 01 0 76711E-01 0 12588E-01 0 0 0 D0YAS255
0 18891E-02 0 0 71580E 01 0 62230E 01 0 31491E-01 0 D0YAS256
0 93390E-03 0 0 0 0 22495E-02 0 0 10055E 03D0YAS257
0 10052E 03 0 93307E 00 0 0 0 0 0 D0YAS258
0 51718E-02 0 0 0 29625E 01 0 29373E 01 0 20589E-01 0 D0YAS259
0 0 0 0 62015E-07 0 13395E-01 0 0 0 29746E 01D0YAS260
0 29031E 01 0 19959E-01 0 0 0 0 0 0 D0YAS261
0 23439E-01 0 0 0 30007E 01 0 29036E 01 0 58166E 01 0 D0YAS262
0 0 0 0 0 41404E-01 0 0 0 30256E 01D0YAS263
0 29257E 01 0 73686E-01 0 0 0 0 0 0 D0YAS264
0 68362E 01 0 0 30579E 01 0 29156E 01 0 58448E-01 0 D0YAS265
0 0 0 0 0 10016E-00 0 0 0 30838E 01D0YAS266
0 28716E 01 0 73929E-01 0 0 0 0 0 0 D0YAS267
0 15998E-00 0 0 0 31346E 01 0 29354E 01 0 11206E 00 0 D0YAS268
0 0 0 0 0 31776E-00 0 0 0 32479E 01D0YAS269
0 29501E 01 0 39182E 01 0 0 0 0 0 D0YAS250
C
C
16 9 1111 ALUMINUM-27 MICRO 293K SPN-76 HOWERTON
0 41664E-01 0 0 15284E 01 0 66846E 00 0 0 D0YAS252
0 0 0 0 0 36873E-02 0 0 0 19181E 01D0YAS253
0 14573E 01 0 45080E-00 0 0 0 0 0 D0YAS254
0 19427E 04 0 0 23790E 01 0 19732E 01 0 42897E-00 0 61126E-01D0YAS255
0 0 0 0 0 49639E-03 0 0 0 29599E 01D0YAS256
0 26742E 01 0 38613E 00 0 73474E-02 0 25111E-00 0 0 D0YAS257
0 16215E-02 0 0 0 42421E 01 0 41678E 01 0 28522E-00 0 19675E 01D0YAS258
0 40839E-01 0 55260E-01 0 0 56401E-02 0 0 0 60147E 01D0YAS259
0 60038E 01 0 72684E-01 0 0 0 0 0 0 D0YAS260
0 41969E-02 0 0 0 11294E 01 0 11204E 01 0 53211E-02 0 D0YAS261
0 0 0 0 0 50020E-02 0 0 0 14193E 01D0YAS262
0 14061E 01 0 47859E-02 0 0 0 0 0 0 12333E 06D0YAS263
0 50020E-02 0 0 0 14193E 01 0 14063E 01 0 82196E-02 0 D0YAS264
0 0 0 0 0 70761E-02 0 0 0 14214E 01D0YAS265
0 13912E 01 0 80023E-02 0 0 0 0 0 0 D0YAS266
0 10659E-01 0 0 0 14250E 01 0 13850E 01 0 23149E-01 0 D0YAS267
0 0 0 0 0 15905E-01 0 0 0 14302E 01D0YAS268
0 13912E 01 0 29258E-01 0 0 0 0 0 0 D0YAS269
0 26607E 01 0 0 14409E 01 0 13850E 01 0 23149E-01 0 D0YAS270
0 0 0 0 0 44255E-01 0 0 0 14586E 01D0YAS271
0 13697E 01 0 29258E 01 0 0 0 0 0 0 D0YAS272
0 74532E 01 0 0 14903E 01 0 14001E 01 0 44584E-01 0 D0YAS273
0 0 0 0 0 14762E-00 0 0 0 15663E 01D0YAS274
0 14186E 01 0 15708E-01 0 0 0 0 0 0 D0YAS275

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C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

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C
16 9 1112 SILICON MICRO 293K SPN-76 HOWERTON
0 51255E-01 0 0 16030E 01 0 53461E 00 0 0 D0YAS277
0 0 0 0 0 15675E-02 0 0 0 21515E 01D0YAS278
0 15703E 01 0 88131E 00 0 0 0 0 0 D0YAS279
0 21074E-02 0 0 0 21004E 01 0 16840E 01 0 34520E-00 0 12190E-00D0YAS280
0 0 0 0 0 32541E-02 0 0 0 31188E 01D0YAS281
0 28826E 01 0 41431E-00 0 15184E-00 0 13356E-01 0 0 D0YAS282
0 61231E 02 0 0 44400E 01 0 44170E 01 0 23291E-00 0 D0YAS283
0 36864E 01 0 59607E 03 0 0 14356E-01 0 0 15168E 01D0YAS284
0 14930E 01 0 16941E-01 0 0 0 0 16458E 02 0 D0YAS285
0 24501E-01 0 0 18176E 01 0 17865E 01 0 95081E-02 0 D0YAS286
0 0 0 0 74977E-02 0 24501E 01 0 0 20709E 01D0YAS287
0 20350E 01 0 66356E-02 0 0 0 0 0 D0YAS288
0 24501E-01 0 0 0 20709E 01 0 20354E 01 0 11395E 01 0 D0YAS289
0 0 0 0 0 24501E-01 0 0 0 20709E 01D0YAS290
0 20144E 01 0 11094E-01 0 0 0 0 0 D0YAS291
0 24501E-01 0 0 0 20709E 01 0 20059E 01 0 32093E 01 0 D0YAS292
0 0 0 0 0 24501E-01 0 0 0 20709E 01D0YAS293
0 20144E 01 0 40562E-01 0 0 0 0 0 D0YAS294
0 24501E 01 0 0 20709E 01 0 20059E 01 0 32093E 01 0 D0YAS295
0 0 0 0 0 60237E 01 0 0 21077E 01D0YAS296
0 19856E 01 0 40562E-01 0 0 0 0 0 D0YAS297
0 12456E-00 0 0 0 21739E 01 0 20277E 01 0 61878E-01 0 D0YAS298
0 0 0 0 0 15375E 00 0 0 22039E 01D0YAS299
0 20502E 01 0 21671E-01 0 0 0 0 0 D0YAS300
C
C
16 9 1113 PHOSPHORUS-31 MICRO 293K SPN-76 HOWERTON
0 10678E-00 0 0 19595E 01 0 61488E 00 0 0 D0YAS302
0 0 0 0 0 23405E-01 0 0 0 20782E 01D0YAS303
0 15803E 01 0 60805E 00 0 0 0 0 D0YAS304
0 10001E-01 0 0 16781E 01 0 14212E 01 0 33327E-00 0 15026E 00D0YAS305
0 0 0 0 0 10001E-01 0 0 0 21993E 01D0YAS306
0 20294E 01 0 24687E-00 0 13596E-00 0 36812E-00 0 0 D0YAS307
0 10001E-01 0 0 0 28653E 01 0 27925E 01 0 15995E 00 0 D0YAS308
0 32553E-02 0 11139E-00 0 0 10001E-01 0 0 0 37413E 01D0YAS309
0 37086E 01 0 62716E-01 0 0 0 0 0 D0YAS310
0 10001E-01 0 0 0 45988E 01 0 45780E 01 0 22701E-01 0 D0YAS311
0 0 0 0 93467E-07 0 10001E-01 0 0 0 36026E 01D0YAS312
0 35760E 01 0 10849E-01 0 0 0 0 1 00000E 06D0YAS313
0 10001E-01 0 0 0 33266E 01 0 33005E 01 0 16569E-01 0 D0YAS314
0 0 0 1 00000E 06 0 10001E 01 0 0 33266E 01D0YAS315
0 32700E 01 0 16131E-01 0 0 0 0 1 00000E 06D0YAS316

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C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

0 10120E-01 0	0 33267E 01 0	32576E 01 0	46666E-01 0	DOYAS317
0 0	1 00000E-06 0	12189E-01 0	0	0 33279E 01DOYAS318
0 32688E 01 0	58980E-01 0	0	0	1 00000E-06DOYAS319
0 23418E-01 0	0 33262E 01 0	32441E 01 0	46534E-01 0	DOYAS320
0 0	1 00000E 06 0	37724E-01 0	0	0 33368E 01DOYAS321
0 32083E 01 0	58636E-01 0	0	0	1 00000E-06DOYAS322
0 68903E-01 0	0 34706E 01 0	33682E 01 0	90790E-01 0	DOYAS323
0 0	1 00000E-06 0	12695E-00 0	0	0 37660E 01DOYAS324
0 36391E 01 0	33906E-01 1	00000E-06 1	00000E-06 1	00000E-06DOYAS325

16 9 1114 POTASSIUM	MICRO	293K	SPN-76	HONERTON
0 15953E-00 0	0 18911E 01 0	10250E 01 0	0	DOYAS327
0 0	0	69469E-01 0	0	0 20669E 01DOYAS328
0 18537E 01 0	36228E-00 0	0	0	DOYAS329
0 18434E-01 0	0 16442E 01 0	14420E 01 0	13371E-00 0	14320E-00DOYAS330
0 0	0	10002E-01 0	0	0 15543E 01DOYAS331
0 14410E 01 0	18369E-00 0	26232E-02 0	17244E-00 0	DOYAS332
0 10002E-01 0	0 22363E 01 0	22012E 01 0	10324E-00 0	DOYAS333
0 0	0 28619E-01 0	0 10002E-01 0	0	0 35889E 01DOYAS334
0 35721E 01 0	25045E-01 0	0	0 53273E-02 0	DOYAS335
0 10002E-01 0	0 25132E 01 0	24954E 01 0	68022E-02 0	DOYAS336
0 0	0 13055E-03 0	10251E-01 0	0	0 30463E 01DOYAS337
0 30285E 01 0	78772E-02 0	0	0	1 00000E-06DOYAS338
0 23733E-01 0	0 19671E 01 0	19360E 01 0	75715E-02 0	DOYAS339
0 0	1 00000E-06 0	39804E-01 0	0	0 19726E 01DOYAS340
0 19115E 01 0	73280E-02 0	0	0	1 00000E-06DOYAS341
0 83377E-01 0	0 20379E 01 0	19274E 01 0	21294E-01 0	DOYAS342
0 0	1 00000E-06 0	13487E-00 0	0	0 21170E 01DOYAS343
0 19602E 01 0	27195E-01 0	0	0	1 00000E-06DOYAS344
0 23581E-00 0	0 22412E 01 0	19776E 01 0	21944E-01 0	DOYAS345
0 0	1 00000E 06 0	35614E-00 0	0	0 23887E 01DOYAS346
0 19889E 01 0	27744E-01 0	0	0	1 00000E-06DOYAS347
0 64678E 00 0	0 27198E 01 0	20580E 01 0	43638E-01 0	DOYAS348
0 0	1 00000E-06 0	12731E 01 0	0	0 33453E 01DOYAS349
0 20722E 01 0	14963E-01 1	00000E-06 1	00000E-06 1	00000E-06DOYAS350

16 9 1115 IRON	MICRO	293K	SPN-76	HONERTON
0 59492E-02 0	0 22180E 01 0	87205E 00 0	0	DOYAS352
0 0	0	20000E-05 0	0	0 22529E 01DOYAS353
0 14731E 01 0	56088E 00 0	0	0	DOYAS354
0 20000E-05 0	0 18906E 01 0	14126E 01 0	38038E-00 0	44276E-00DOYAS355
0 0	0	98292E 03 0	0	0 25394E 01DOYAS356
0 23967E 01 0	20850E-00 0	33641E 00 0	29835E-00 0	DOYAS357

C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

0 95782E-02 0	0 35624E 01 0	35199E 01 0	14168E-00 0	26954E 00DOYAS358
0 63006E-01 0	38419E-01 0	0 18710E-01 0	0	0 69920E 01DOYAS359
0 69656E 01 0	32885E-01 0	0	0	DOYAS360
0 25007E-01 0	0 60749E 01 0	60415E 01 0	76731E-02 0	DOYAS361
0 0	0	0 29774E-01 0	0	0 56916E 01DOYAS362
0 56386E 01 0	0 83952E-02 0	0	0	DOYAS363
0 43847E-01 0	0 10039E 02 0	99678E 01 0	23221E-01 0	DOYAS364
0 0	0	99987E-04 0	81910E-01 0	0 10784E 02DOYAS365
0 10621E 02 0	27674E-01 0	0	0	DOYAS366
0 13704E-00 0	0 10893E 02 0	10654E 02 0	80628E-01 0	DOYAS367
0 0	0	0 17119E-00 0	0	0 10899E 02DOYAS368
0 10647E 02 0	10212E-00 0	0	0	DOYAS369
0 27133E-00 0	0 10942E 02 0	10569E 02 0	80057E-01 0	DOYAS370
0 0	0	0 47976E-00 0	0	0 11150E 02DOYAS371
0 10516E 02 0	10118E-00 0	0	0	DOYAS372
0 77445E 00 0	0 11445E 02 0	10616E 02 0	15418E-00 0	DOYAS373
0 0	0	0 15944E 01 0	0	0 12311E 02DOYAS374
0 10717E 02 0	53965E-01 0	0	0	DOYAS375

16 9 1116 GALLIUM	MICRO	293K	SPN-76	HONERTON
0 32920E-02 0	0 22681E 01 0	59981E 00 0	0	DOYAS377
0 0	0	0 78819E-02 0	0	0 25708E 01DOYAS378
0 10096E 01 0	42789E-00 0	0	0	DOYAS379
0 98999E-02 0	0 33789E 01 0	21572E 01 0	31720E-00 0	33867E-00DOYAS380
0 0	0	0 15560E-01 0	0	0 44633E 01DOYAS381
0 39320E 01 0	74770E 00 0	90563E 00 0	75304E 00 0	DOYAS382
0 30795E-01 0	0 58472E 01 0	57610E 01 0	47625E-00 0	45426E-00DOYAS383
0 33047E-00 0	19045E-00 0	0 69305E-01 0	0	0 68955E 01DOYAS384
0 68099E 01 0	54094E-01 0	39468E-01 0	98048E-02 0	DOYAS385
0 80455E-01 0	0 74665E 01 0	73758E 01 0	16269E-01 0	0 12351E-02DOYAS386
0 0	0	0 92398E-01 0	0	0 88884E 01DOYAS387
0 87779E 01 0	10252E-01 0	0	0	DOYAS388
0 63846E-01 0	0 20965E 02 0	20886E 02 0	18079E-01 0	DOYAS389
0 0	0	0 57443E-01 0	0	0 69297E 01DOYAS390
0 68427E 01 0	16068E-01 0	0	0	0 56582E 06DOYAS391
0 10350E-00 0	0 53947E 01 0	52451E 01 0	29603E-01 0	DOYAS392
0 0	0	0 25530E 00 0	0	0 66883E 01DOYAS393
0 63922E 01 0	46072E 01 0	0	0	DOYAS394
0 43722E 00 0	0 73726E 01 0	68824E 01 0	40741E-01 0	DOYAS395
0 0	0	0 77143E 00 0	0	0 77344E 01DOYAS396
0 68845E 01 0	53046E 01 0	0	0	DOYAS397
0 12960E 01 0	0 80959E 01 0	67729E 01 0	78465E-01 0	DOYAS398
0 0	0	0 21000E 01 0	0	0 83214E 01DOYAS399
0 62214E 01 0	27030E-01 0	0	0	DOYAS400

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

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C
C
16 9 1117 NI0BIUM-93 MICRO 293K SPN-76 HOWERTON
1 00000E-06 0 0 29020E 01 0 78497E 00 0 0 DOYAS402
0 0 0 0 16899E-03 0 0 37354E 01DOYAS403
0 16023E 01 0 96810E 00 0 0 DOYAS404
0 12412E-01 0 0 43021E 01 0 31611E 01 0 56281E-00 0 67417E 00DOYAS405
0 0 0 0 38263E-01 0 0 55793E 01DOYAS406
0 53581E 01 0 52911E 00 0 11693E 01 0 40790E-00 0 0 DOYAS407
0 74506E-01 0 0 74357E 01 0 73170E 01 0 14277E-00 0 56075E 00DOYAS408
0 59223E 00 0 71320E-01 0 0 13080E-00 0 0 79220E 01DOYAS409
0 77806E 01 0 44237E 01 0 50617E-01 0 11873E-00 0 86278E-02 0 DOYAS410
0 23164E-00 0 0 69278E 01 0 66911E 01 0 11469E-01 0 DOYAS411
0 0 0 0 85640E 00 0 0 63136E 01DOYAS412
0 54488E 01 0 50769E-02 0 0 0 DOYAS413
0 18439E 01 0 0 72043E 01 0 53522E 01 0 84161E-02 0 DOYAS414
0 0 0 0 15966E-02 0 16193E 01 0 0 69799E 01DOYAS415
0 53367E 01 0 81935E-02 0 0 0 DOYAS416
0 11000E 01 0 0 64604E 01 0 53304E 01 0 23703E-01 0 DOYAS417
0 0 0 0 11000E 01 0 0 64604E 01DOYAS418
0 53367E 01 0 29958E-01 0 0 0 DOYAS419
0 11000E 01 0 0 64604E 01 0 53304E 01 0 23703E-01 0 DOYAS420
0 0 0 0 11000E 01 0 0 64604E 01DOYAS421
0 53148E 01 0 29958E-01 0 0 0 DOYAS422
0 11000E 01 0 0 64604E 01 0 53444E 01 0 45550E-01 0 DOYAS423
0 0 0 0 11000E 01 0 0 64604E 01DOYAS424
0 53604E 01 0 15977E-01 0 0 0 DOYAS425
C
C
16 9 1118 MOLYBDENUM MICRO 293K SPN-76 HOWERTON
1 00000E-06 0 0 28308E 01 0 81774E 00 0 0 DOYAS 2
0 0 0 0 70318E-02 0 0 35348E 01DOYAS 3
0 18559E 01 0 10629E 01 0 0 DOYAS 4
0 14131E-01 0 0 46457E 01 0 32194E 01 0 78735E 00 0 37442E 00DOYAS 5
0 0 0 0 22834E-01 0 0 59815E 01DOYAS 6
0 54158E 01 0 98406E 00 0 74555E 00 0 32052E-00 0 0 DOYAS 7
0 31169E 01 0 0 76895E 01 0 76171E 01 0 54287E 00 0 42815E-00DOYAS 8
0 15895E 00 0 65781E 01 0 0 36854E 01 0 0 76835E 01DOYAS 9
0 76352E 01 0 41242E 01 0 0 0 DOYAS 10
0 39832E 01 0 0 69731E 01 0 69275E 01 0 11294E-01 0 DOYAS 11
0 0 0 0 40000E-01 0 0 65817E 01DOYAS 12
0 65293E 01 0 57883E-02 0 0 0 DOYAS 13
0 40000E-01 0 0 92687E 01 0 92203E 01 0 12440E 01 0 DOYAS 14
0 0 0 0 28042E 02 0 0 51149E 02DOYAS 15
0 23083E 02 0 85478E 02 0 0 0 56582E-06DOYAS 16

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C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

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0 11495E 00 0 0 54572E 01 0 53129E 01 0 23028E-01 0 DOYAS 17
0 0 0 0 17045E-00 0 0 57992E 01DOYAS 18
0 56035E 01 0 29378E-01 0 0 DOYAS 19
0 31220E-00 0 0 62655E 01 0 59211E 01 0 25327E-01 0 DOYAS 20
0 0 0 0 52083E 00 0 0 64808E 01DOYAS 21
0 59109E 01 0 32235E-01 0 0 DOYAS 22
0 87250E 00 0 0 68325E 01 0 59428E 01 0 49116E 01 0 DOYAS 23
0 0 0 0 17513E 01 0 0 76913E 01DOYAS 24
0 59600E 01 0 17191E-01 0 0 DOYAS 25
C
C
16 9 1119 EUROPIUM MICRO 293K SPN-76 HOWERTON
0 85591E-02 0 0 34270E 01 0 94503E 00 0 0 DOYAS 27
0 0 0 0 71448E-01 0 0 45067E 01DOYAS 28
0 23703E 01 0 12930E 01 0 0 DOYAS 29
0 13948E-00 0 0 50871E 01 0 32040E 01 0 90357E 00 0 69808E 00DOYAS 30
0 0 0 0 17592E-00 0 0 71243E 01DOYAS 31
0 61399E 01 0 12189E 01 0 97801E 00 0 40556E-00 0 DOYAS 32
0 41041E-00 0 0 94746E 01 0 89592E 01 0 80024E 00 0 52473E 00DOYAS 33
0 18335E 00 0 12525E-00 0 0 13854E 01 0 0 10869E 02DOYAS 34
0 94670E 01 0 10470E-00 0 82293E-02 0 0 DOYAS 35
0 98249E 01 0 0 18779E 02 0 89438E 01 0 15616E-01 0 37285E-03DOYAS 36
0 0 0 0 43199E 02 0 0 51680E 02DOYAS 37
0 85124E 01 0 45269E-02 0 0 DOYAS 38
0 62169E 02 0 0 71197E 02 0 90205E 01 0 85045E-02 0 DOYAS 39
0 0 0 0 13841E 03 0 0 14654E 03DOYAS 40
0 81070E 01 0 82878E-02 0 0 DOYAS 41
0 27415E 03 0 0 28211E 03 0 79358E 01 0 21291E-01 0 DOYAS 42
0 0 0 0 84919E 03 0 50422E 03 0 0 51218E 03DOYAS 43
0 79414E 01 0 26909E-01 0 0 DOYAS 44
0 63633E 03 0 0 64430E 03 0 79358E 01 0 21291E 01 0 DOYAS 45
0 0 0 0 17573E 04 0 0 17652E 04DOYAS 46
0 79217E 01 0 26909E-01 0 0 DOYAS 47
0 24153E 04 0 0 24235E 04 0 79483E 01 0 41004E-01 0 DOYAS 48
0 0 0 0 18839E 04 0 0 18918E 04DOYAS 49
0 79627E 01 0 14351E-01 0 0 DOYAS 50
C
C
16 9 1120 GADOLINIUM MICRO 293K SPN-76 HOWERTON
1 00000E-06 0 0 34621E 01 0 98884E 00 0 0 DOYAS 52
0 0 0 0 64685E-01 0 0 45068E 01DOYAS 53
0 23789E 01 0 12928E 01 0 0 DOYAS 54
0 15629E-00 0 0 50905E 01 0 32144E 01 0 90181E 00 0 69808E 00DOYAS 55
0 0 0 0 17465E 00 0 0 75361E 01DOYAS 56
0 65443E 01 0 12150E 01 0 97801E 00 0 40536E-00 0 DOYAS 57

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C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED.

0.26501E-00 0. 0.10150E 02 0.97599E 01 0.80891E 00 0.92475E 0000YAS 58
 0.18335E-00 0.12525E-00 0. 0.80889E 00 0. 0.10777E 0200YAS 59
 0.99506E 01 0.10468E-00 0.82295E-02 0. 0. 0. 00YAS 60
 0.24071E 01 0. 0.12367E 02 0.99547E 01 0.16274E-01 0.37205E-0300YAS 61
 0. 0. 0. 0.66106E 01 0. 0.16521E 0200YAS 62
 0.99008E 01 0.53282E-02 0. 0. 0. 0. 00YAS 63
 0.12397E 03 0. 0.29732E 02 0.10270E 02 0.91295E-02 0. 00YAS 64
 0. 0. 0. 0.31272E 02 0. 0.42512E 0200YAS 65
 0.11191E 02 0.11088E-01 0. 0. 0. 0. 00YAS 66
 0.12397E 03 0. 0.15694E 03 0.32936E 02 0.49492E-01 0. 00YAS 67
 0. 0. 0. 0.04919E-03 0.35824E 02 0. 0.46647E 0200YAS 68
 0.10791E 02 0.34035E-01 0. 0. 0. 0. 00YAS 69
 0.22726E 03 0. 0.24477E 03 0.17470E 02 0.32088E-01 0. 00YAS 70
 0. 0. 0. 0.11592E 03 0. 0.12868E 0300YAS 71
 0.12677E 02 0.38911E-01 0. 0. 0. 0. 00YAS 72
 0.21991E 04 0. 0.22247E 04 0.25413E 02 0.74584E-01 0. 00YAS 73
 0. 0. 0. 0.22183E 05 0. 0.22308E 0500YAS 74
 0.12510E 03 0.17331E-00 0. 0. 0. 0. 00YAS 75

C
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16 9 1121 TANTALUM-181 MICRO 293K SPN-76 HONERTON
 0.34739E-01 0. 0.37487E 01 0.11858E 01 0. 0. 00YAS 77
 0. 0. 0. 0.96954E-01 0. 0.46767E 0100YAS 78
 0.22642E 01 0.13237E 01 0. 0. 0. 0. 00YAS 79
 0.14452E-00 0. 0.50344E 01 0.26814E 01 0.10306E 01 0.72205E 0000YAS 80
 0. 0. 0. 0.20650E-00 0. 0.56560E 0100YAS 81
 0.44190E 01 0.16095E 01 0.10813E 01 0.40885E-00 0. 0. 00YAS 82
 0.37388E-00 0. 0.65894E 01 0.61188E 01 0.10305E 01 0.60302E 0000YAS 83
 0.20372E-00 0.10608E-00 0. 0.86630E 00 0. 0.87413E 0100YAS 84
 0.78673E 01 0.96783E-01 0. 0. 0. 0. 00YAS 85
 0.29882E 01 0. 0.12090E 02 0.90988E 01 0.76820E-02 0. 00YAS 86
 0. 0. 0. 0.14407E 02 0. 0.20406E 0200YAS 87
 0.59956E 01 0.30844E-02 0. 0. 0. 0. 00YAS 88
 0.24123E 02 0. 0.29201E 02 0.50736E 01 0.41420E-02 0. 00YAS 89
 0. 0. 0. 0.96099E 02 0. 0.10108E 0300YAS 90
 0.49689E 01 0.38533E-02 0. 0. 0. 0. 00YAS 91
 0.10481E 03 0. 0.11232E 03 0.72556E 01 0.11147E-01 0. 00YAS 92
 0. 0. 0. 0.36191E 03 0. 0.40617E 0300YAS 93
 0.44241E 02 0.25399E-00 0. 0. 0. 0. 00YAS 94
 0.68000E 01 0. 0.11973E 02 0.51589E 01 0.12636E-01 0. 00YAS 95
 0. 0. 0. 0.57554E 01 0. 0.10735E 0200YAS 96
 0.49585E 01 0.14089E-01 0. 0. 0. 0. 00YAS 97
 0.75250E 01 0. 0.12505E 02 0.49725E 01 0.21468E-01 0. 00YAS 98
 0. 0. 0. 0.12802E 02 0. 0.17782E 0200YAS 99
 0.49800E 01 0.75140E-02 0. 0. 0. 0. 00YAS100

C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED.

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16 9 1122 TUNGSTEN MICRO 293K SPN-76 HONERTON
 0.16498E-01 0. 0.37496E 01 0.11283E 01 0. 0. 00YAS102
 0. 0. 0. 0.39322E-01 0. 0.47444E 0100YAS103
 0.21169E 01 0.25160E-00 0. 0. 0. 0. 00YAS104
 0.49462E-01 0. 0.50558E 01 0.28574E 01 0.22761E-00 0.37299E-0000YAS105
 0. 0. 0. 0.76458E-01 0. 0.57154E 0100YAS106
 0.44494E 01 0.81983E 00 0.13724E 01 0.14837E 01 0. 0. 00YAS107
 0.11432E-00 0. 0.72529E 01 0.68764E 01 0.11332E 01 0.10728E 0100YAS108
 0.87501E 00 0.56745E 00 0. 0.21863E-00 0. 0.10500E 0200YAS109
 0.10272E 02 0.26217E-00 0.56344E-01 0.25623E-00 0.11304E-00 0. 00YAS110
 0.97343E 00 0. 0.12062E 02 0.11086E 02 0.93997E-02 0. 00YAS111
 0. 0. 0. 0.94483E 01 0. 0.15495E 0200YAS112
 0.60432E 01 0.31919E-02 0. 0. 0. 0. 00YAS113
 0.43988E 02 0. 0.48971E 02 0.49795E 01 0.38969E-02 0. 00YAS114
 0. 0. 0. 0.30901E 02 0. 0.35884E 0200YAS115
 0.49724E 01 0.37939E-02 0. 0. 0. 0. 00YAS116
 0.16567E 04 0. 0.16617E 04 0.49695E 01 0.10975E-01 0. 00YAS117
 0. 0. 0. 0.44640E 02 0. 0.49624E 0200YAS118
 0.49724E 01 0.13871E-01 0. 0. 0. 0. 00YAS119
 0.39033E 01 0. 0.88867E 01 0.49695E 01 0.10975E-01 0. 00YAS120
 0. 0. 0. 0.35605E 01 0. 0.85428E 0100YAS121
 0.49612E 01 0.13871E-01 0. 0. 0. 0. 00YAS122
 0.59967E 01 0. 0.10941E 02 0.49366E 01 0.21055E-01 0. 00YAS123
 0. 0. 0. 0.11869E 02 0. 0.16830E 0200YAS124
 0.49612E 01 0.73240E-02 0. 0. 0. 0. 00YAS125

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16 9 1123 GOLD-197 MICRO 293K SPN-76 HONERTON
 0.20846E-01 0. 0.38277E 01 0.10558E 01 0. 0. 00YAS127
 0. 0. 0. 0.97341E-01 0. 0.44287E 0100YAS128
 0.19447E 01 0.21470E-00 0. 0. 0. 0. 00YAS129
 0.14620E-00 0. 0.42013E 01 0.23355E 01 0.20820E-00 0.38324E-0000YAS130
 0. 0. 0. 0.20186E-00 0. 0.46796E 0100YAS131
 0.35444E 01 0.65564E 00 0.12747E 01 0.15749E 01 0. 0. 00YAS132
 0.36949E-00 0. 0.71113E 01 0.65041E 01 0.88930E 00 0.85711E 0000YAS133
 0.80327E 00 0.61932E 00 0. 0.58190E 00 0. 0.95440E 0100YAS134
 0.89554E 01 0.23777E-00 0.44031E-01 0.20686E-00 0.10051E-00 0. 00YAS135
 0.15632E 01 0. 0.99348E 01 0.83689E 01 0.66587E-02 0. 00YAS136
 0. 0. 0. 0.59993E 01 0. 0.11494E 02
 0.54917E 01 0.26353E-02 0. 0. 0. 0. 00YAS137
 0.17181E 02 0. 0.21190E 02 0.40065E 01 0.29073E-02 0. 00YAS138
 0. 0. 0. 0.37459E 02 0. 0.56174E 0200YAS139
 0.18700E 02 0.28304E-02 0. 0. 0. 0. 00YAS140

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED.

0.34204E 01 0.	0.12590E 02 0.91289E 01 0.14111E-01 0.	D0YAS141
0.	0.74083E-06 0.11168E 04 0.	0.12926E 04D0YAS142
0.17586E 03 0.40913E-01 0.	0.	1.00000E-06D0YAS143
0.35733E 02 0.	0.42272E 02 0.65212E 01 0.12891E-01 0.	D0YAS144
0.	1.00000E-06 0.22850E 02 0.	0.31671E 02D0YAS145
0.87812E 01 0.18627E-01 0.	0.	1.00000E-06D0YAS146
0.31371E 02 0.	0.41337E 02 0.99529E 01 0.39423E-01 0.	D0YAS147
0.	1.00000E-06 0.60319E 02 0.	0.70177E 02D0YAS148
0.98575E 01 0.13799E-01 1.00000E-06 1.00000E-06 1.00000E-06 1.00000E-06D0YAS149		

C

16 9 1124 LEAD	MICRO	293K	SPN-76	HOMERTON
1.00000E-06 0.	0.40783E 01 0.20332E 01 0.	0.	D0YAS151	
0.	1.00000E-06 0.	0.40879E 01D0YAS152		
0.30595E 01 0.73090E 00 0.	0.	0.	D0YAS153	
0.21334E-04 0.	0.45673E 01 0.41503E 01 0.25784E-00 0.72480E 00D0YAS154			
0.	0.61774E-03 0.	0.46878E 01D0YAS155		
0.45633E 01 0.25196E-00 0.57429E 00 0.50762E 00 0.	0.	D0YAS156		
1.00000E-03 0.	0.66717E 01 0.66493E 01 0.11499E-00 0.16511E-00D0YAS157			
0.19632E-00 0.12126E-00 0.	1.00000E-03 0.	0.38853E 01D0YAS158		
0.98766E 01 0.21457E-01 0.	0.	D0YAS159		
1.00000E-03 0.	0.10756E 02 0.10750E 02 0.76395E-02 0.	D0YAS160		
0.	0.10366E-02 0.	0.10964E 02D0YAS161		
0.10956E 02 0.44344E-02 0.	0.	D0YAS162		
0.23846E-02 0.	0.10966E 02 0.10956E 02 0.75970E-02 0.	D0YAS163		
0.	0.88675E-02 0.47550E-02 0.	0.10968E 02D0YAS164		
0.10942E 02 0.73961E-02 0.	0.	D0YAS165		
0.77870E-02 0.	0.10971E 02 0.10936E 02 0.21396E-01 0.	D0YAS166		
0.	0.11755E-01 0.	0.10975E 02D0YAS167		
0.10942E 02 0.27042E-01 0.	0.	D0YAS168		
0.21329E-01 0.	0.10985E 02 0.10936E 02 0.21396E-01 0.	D0YAS169		
0.	0.36002E-01 0.	0.11048E 02D0YAS170		
0.10971E 02 0.27042E-01 0.	0.	D0YAS171		
0.63850E-01 0.	0.11072E 02 0.10994E 02 0.41490E-01 0.	D0YAS172		
0.	0.11900E-00 0.	0.11082E 02D0YAS173		
0.10936E 02 0.14423E-01 0.	0.	D0YAS174		

C

16 9 1125 URANIUM-233	MICRO	293K	SPN-76	HOMERTON
0.17994E 01 0.54670E 01 0.44117E 01 0.10953E 01 0.			D0YAS176	
0.	0.20397E 01 0.53211E 01 0.	0.46952E 01D0YAS177		
0.14060E 01 0.12407E-00 0.	0.	0.	D0YAS178	
0.20568E 01 0.49988E 01 0.49845E 01 0.20089E 01 0.11209E-00 0.20894E-00D0YAS179				
0.	0.21670E 01 0.50472E 01 0.	0.58835E 01D0YAS180		
0.33212E 01 0.36287E-00 0.66615E 00 0.88301E 00 0.	0.	D0YAS181		

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED.

0.24810E 01 0.56539E 01 0.82265E 01 0.56868E 01 0.37740E-00 0.44737E-00D0YAS182	
0.41904E-00 0.34556E-00 0.	0.31491E 01 0.69269E 01 0.11380E 02D0YAS183
0.82251E 01 0.58684E-01 0.17897E-01 0.10849E-00 0.52179E-01 0.	D0YAS184
0.53765E 01 0.11866E 02 0.14632E 02 0.92523E 01 0.62031E-02 0.	D0YAS185
0.	0.95157E 01 0.21334E 02 0.21045E 02D0YAS186
0.11522E 02 0.33643E-02 0.	0.
0.18002E 02 0.41089E 02 0.30308E 02 0.12298E 02 0.76677E-02 0.	D0YAS187
0.	0.39343E 02 0.89394E 02 0.51311E 02D0YAS188
0.11947E 02 0.71664E-02 0.	0.
0.87156E 02 0.18264E 03 0.99124E 02 0.11942E 02 0.20731E-01 0.	D0YAS189
0.	0.13611E 03 0.26881E 03 0.14808E 03D0YAS190
0.11947E 02 0.26202E-01 0.	0.
0.41251E 03 0.74687E 03 0.42422E 03 0.11676E 02 0.20731E-01 0.	D0YAS191
0.	0.14425E 03 0.32452E 03 0.15622E 03D0YAS192
0.11928E 02 0.26202E-01 0.	0.
0.20308E 03 0.45062E 03 0.21563E 03 0.12542E 02 0.39927E-01 0.	D0YAS193
0.	0.37366E 03 0.85324E 03 0.58497E 03D0YAS194
0.11414E 02 0.13974E-01 0.	0.

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16 9 1126 URANIUM-234	MICRO	293K	SPN-76	HOMERTON
0.15517E 01 0.47029E 01 0.42361E 01 0.11418E 01 0.			D0YAS201	
0.	0.	0.15397E 01 0.39821E 01 0.45389E 01D0YAS202		
0.15783E 01 0.13206E-00 0.	0.	0.	D0YAS203	
0.13011E 01 0.31117E 01 0.48659E 01 0.24504E 01 0.12788E-00 0.21729E-00D0YAS204				
0.	0.	0.10032E 01 0.20990E 01 0.56081E 01D0YAS205		
0.40204E 01 0.43651E-00 0.75445E 00 0.87739E 00 0.			D0YAS206	
0.38828E-00 0.34638E-00 0.80670E 01 0.75949E 01 0.55763E 00 0.54667E 00D0YAS207				
0.47789E-00 0.34068E-00 0.	0.54705E 00 0.24580E-05 0.11161E 02D0YAS208			
0.10607E 02 0.83839E-01 0.26803E-01 0.13121E-00 0.60661E-01 0.			D0YAS209	
0.10784E 01 0.24515E-05 0.13013E 02 0.11930E 02 0.76633E-02 0.			D0YAS210	
0.	0.23678E 01 0.24502E-05 0.14336E 02D0YAS211			
0.11961E 02 0.42782E-02 0.	0.	0.	D0YAS212	
0.42308E 01 0.24500E-05 0.16199E 02 0.11961E 02 0.73291E-02 0.			D0YAS213	
0.	0.69145E 01 0.24500E-05 0.18883E 02D0YAS214			
0.11947E 02 0.71353E-02 0.	0.	0.	D0YAS215	
0.10222E 02 0.24500E-05 0.22190E 02 0.11942E 02 0.20642E-01 0.			D0YAS216	
0.	0.	0.15467E 02 0.24500E-05 0.27435E 02D0YAS217		
0.11947E 02 0.26089E-01 0.	0.	0.	D0YAS218	
0.23185E 02 0.24500E-05 0.35153E 02 0.11942E 02 0.20642E-01 0.			D0YAS219	
0.	0.	0.35000E 02 0.24500E-05 0.46968E 02D0YAS220		
0.11928E 02 0.26089E-01 0.	0.	0.	D0YAS221	
0.53000E 02 0.24500E-05 0.64968E 02 0.11954E 02 0.39754E-01 0.			D0YAS222	
0.	0.76000E 02 0.24500E-05 0.87968E 02D0YAS223			
0.11968E 02 0.13914E-01 0.	0.	0.	D0YAS224	

C SERIES 1100 CROSS SECTION LIBRARY GODIYA WEIGHTED

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C
16 9 1127 URANIUM-235 MICRO 295K SPN-76 HONERTON
0 13155E 01 0 39812E 01 0 43297E 01 0 11296E 01 0 0 DOYAS226
0 0 0 0 13342E 01 0 33479E 01 0 46127E 01 DOYAS227
0 15434E 01 0 14849E-00 0 0 0 DOYAS228
0 12810E 01 0 29761E 01 0 50224E 01 0 25918E 01 0 15830E-00 0 25861E-00 DOYAS229
0 0 0 0 13351E 01 0 28733E 01 0 56494E 01 DOYAS230
0 38642E 01 0 75765E 00 0 10900E 01 0 11097E 01 0 0 DOYAS231
0 17059E 01 0 33226E 01 0 83744E 01 0 65716E 01 0 41703E 00 0 38856E-00 DOYAS232
0 48669E 00 0 43434E-00 0 0 29505E 01 0 53263E 01 0 12406E 02 DOYAS233
0 94484E 01 0 57705E-01 0 22715E-01 0 34359E-02 0 0 DOYAS234
0 54752E 01 0 87812E 01 0 16369E 02 0 10891E 02 0 69270E-02 0 39184E 01 DOYAS235
0 10226E-01 0 0 0 97636E 01 0 15753E 02 0 20734E 02 DOYAS236
0 10964E 02 0 39048E-02 0 0 0 DOYAS237
0 25324E 02 0 40856E 02 0 56295E 02 0 10964E 02 0 66894E 02 0 0 DOYAS238
0 0 0 0 48828E 02 0 78776E 02 0 59817E 02 DOYAS239
0 10971E 02 0 65125E-02 0 0 0 DOYAS240
0 10840E 03 0 17490E 03 0 11935E 03 0 10923E 02 0 18840E-01 0 DOYAS241
0 0 0 0 11736E 03 0 17002E 03 0 12961E 03 DOYAS242
0 12224E 02 0 23811E-01 0 0 0 DOYAS243
0 30829E 02 0 51271E 02 0 44220E 02 0 13360E 02 0 22265E-01 0 DOYAS244
0 0 0 0 76698E 02 0 16041E 03 0 90661E 02 DOYAS245
0 15916E 02 0 30305E-01 0 0 0 DOYAS246
0 21422E 03 0 41570E 03 0 22818E 03 0 13947E 02 0 46180E-01 0 DOYAS247
0 0 0 0 40032E 03 0 81895E 03 0 41428E 03 DOYAS248
0 13963E 02 0 16163E-01 0 0 0 DOYAS249
C
16 9 1128 URANIUM-236 MICRO 295K SPN-76 HONERTON
0 10021E 01 0 30569E 01 0 42372E 01 0 11636E 01 0 0 DOYAS251
0 0 0 0 82947E 00 0 21282E 01 0 45287E 01 DOYAS252
0 15543E 01 0 16429E-00 0 0 0 DOYAS253
0 52885E 00 0 12230E 01 0 48891E 01 0 24588E 01 0 17605E-00 0 28711E-00 DOYAS254
0 0 0 0 14191E-00 0 12123E-00 0 55363E 01 DOYAS255
0 40804E 01 0 71172E 00 0 11370E 01 0 12094E 01 0 0 DOYAS256
0 13451E-00 0 24231E 05 0 81920E 01 0 76771E 01 0 12507E 01 0 96182E 00 DOYAS257
0 73392E 00 0 47213E-00 0 0 22395E-00 0 23987E-05 0 10834E 02 DOYAS258
0 10602E 02 0 38147E 00 0 63280E-01 0 22785E 00 0 97921E 01 0 0 DOYAS260
0 77644E 00 0 23916E-05 0 12709E 02 0 11929E 02 0 86088E-02 0 0 DOYAS261
0 0 0 0 17759E 02 0 23903E-05 0 29727E 02 DOYAS262
0 11961E 02 0 42415E-02 0 0 0 DOYAS263
0 26083E 02 0 23900E-05 0 38051E 02 0 11961E 02 0 72662E-02 0 0 DOYAS264
0 0 0 0 32241E 02 0 23900E 05 0 44209E 02 DOYAS265
0 11948E 02 0 70740E-02 0 0 0 DOYAS265

```

C SERIES 1100 CROSS SECTION LIBRARY GODIYA WEIGHTED

```

0 35594E 01 0 23900E 05 0 15527E 02 0 11942E 02 0 20464E 01 0 DOYAS266
0 0 0 0 50283E 03 0 23900E 05 0 51480E 03 0 DOYAS268
0 11948E 02 0 25864E-01 0 0 0 DOYAS269
0 50000E 00 0 23900E-05 0 12468E 02 0 11942E 02 0 20464E-01 0 DOYAS270
0 0 0 0 50000E 00 0 23900E-05 0 12468E 02 DOYAS271
0 11929E 02 0 25864E-01 0 0 0 DOYAS272
0 50000E 00 0 23900E-05 0 12468E 02 0 11954E 02 0 39413E 01 0 DOYAS273
0 0 0 0 17778E 01 0 23900E 05 0 13746E 02 DOYAS274
0 11968E 02 0 13794E-01 0 0 0 DOYAS274
C
16 9 1129 URANIUM-238 MICRO 295K SPN-76 HONERTON
0 61162E 00 0 18366E 01 0 41987E 01 0 11930E 01 0 0 DOYAS276
0 0 0 0 50463E 00 0 12100E 01 0 45983E 01 DOYAS277
0 17078E 01 0 18622E 00 0 0 0 DOYAS278
0 18263E-00 0 88076E-01 0 50001E 01 0 28157E 01 0 19746E-00 0 52932E 00 DOYAS279
0 0 0 0 16515E-00 0 24244E-05 0 56700E 01 DOYAS280
0 44937E 01 0 76305E 00 0 12652E 01 0 14193E 01 0 0 DOYAS281
0 15813E 00 0 23682E-05 0 81416E 01 0 75575E 01 0 96305E 00 0 99714E 00 DOYAS282
0 81504E 00 0 55384E 00 0 36386E-00 0 23400E 05 0 11755E 02 DOYAS283
0 11383E 02 0 42588E 00 0 48070E 01 0 24158E 00 0 10820E 00 0 DOYAS285
0 58690E 00 0 23319E 05 0 14097E 02 0 13505E 02 0 84812E-02 0 DOYAS286
0 0 0 0 15502E 01 0 23303E 05 0 15871E 02 DOYAS287
0 14312E 02 0 49057E-02 0 0 0 DOYAS288
0 67523E 01 0 23301E 05 0 23034E 02 0 16066E 02 0 93759E-02 0 DOYAS289
0 0 0 0 20264E 02 0 23300E-05 0 49777E 02 DOYAS290
0 29505E 02 0 21617E-00 0 0 0 DOYAS291
0 47741E 02 0 23300E-05 0 71376E 02 0 23618E 02 0 83096E 02 0 DOYAS292
0 0 0 0 15152E 03 0 23300E 05 0 16917E 03 0 DOYAS293
0 17635E 02 0 17069E-01 0 0 0 DOYAS294
0 36371E 00 0 23300E-05 0 93713E 01 0 89883E 01 0 15285E 01 0 DOYAS295
0 0 0 0 0 0 69857E 00 0 23300E-05 0 95378E 01 DOYAS296
0 88110E 01 0 19276E-01 0 0 0 DOYAS297
0 11748E 01 0 23300E-05 0 97319E 01 0 85475E 01 0 28183E-01 0 DOYAS298
0 0 0 0 17476E 01 0 23300E-05 0 10060E 02 DOYAS299
0 85124E 01 0 96540E 02 0 0 0 DOYAS299
C
16 9 1130 PLUTONIUM-239 MICRO 295K SPN-76 HONERTON
0 19703E 01 0 67448E 01 0 45105E 01 0 10787E 01 0 0 DOYAS301
0 0 0 0 20940E 01 0 62714E 01 0 47605E 01 DOYAS302
0 15870E 01 0 11711E 00 0 0 0 DOYAS303
0 19353E 01 0 54696E 01 0 51237E 01 0 25089E 01 0 11020E 00 0 20047E 00 DOYAS304
0 0 0 0 18700E 01 0 49662E 01 0 59848E 01 DOYAS305
0 37827E 01 0 45442E 00 0 66950E 00 0 84932E 00 0 0 DOYAS306

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C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

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0 14991E-01 0 0 34098E 01 0 33160E 01 0 62371E-01 0 D0YAS 94
0 0 0 0 14998E-01 0 0 34098E 01D0YAS 95
0 33324E 01 0 78830E-01 0 0 0 D0YAS 96
0 15000E-01 0 0 34098E 01 0 33160E 01 0 62371E-01 0 D0YAS 97
0 0 0 0 20430E-01 0 0 33819E 01D0YAS 98
0 32440E 01 0 78830E-01 0 0 0 D0YAS 99
0 30201E-01 0 0 33316E 01 0 32608E 01 0 11748E-00 0 D0YAS100
0 0 0 0 40509E-01 0 0 32510E 01D0YAS101
0 32104E 01 0 40607E-01 0 0 0 D0YAS102

```

C

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16 9 1140 HYDROGEN-3 MICRO 293K SPN-76 HOWERTON
0 0 0 16298E 01 0 41124E-00 0 0 D0YAS 52
0 0 0 0 0 0 0 21561E 01D0YAS 53
0 64709E 00 0 77172E 00 0 0 0 D0YAS 54
0 0 0 19116E 01 0 37793E 00 0 53398E 00 0 38533E-00D0YAS 55
0 0 0 0 0 0 0 16032E 01D0YAS 56
0 50621E 00 0 10053E 01 0 95234E 00 0 62463E-01 0 0 D0YAS 57
0 0 0 12087E 01 0 78805E 00 0 10970E 01 0 52838E 00D0YAS 58
0 22684E-01 0 74673E-03 0 0 0 0 10288E 01D0YAS 59
0 89385E 00 0 42064E-00 0 12683E-04 0 0 0 D0YAS 60
0 0 0 10133E 01 0 92666E 00 0 13496E-00 0 0 D0YAS 61
0 0 0 0 0 0 0 10133E 01D0YAS 62
0 87474E 00 0 86619E-01 0 0 0 0 D0YAS 63
0 0 0 10133E 01 0 87840E 00 0 13854E-00 0 0 D0YAS 64
0 0 0 0 0 0 0 10133E 01D0YAS 65
0 64335E 00 0 13429E-00 0 0 0 0 D0YAS 66
0 0 0 10133E 01 0 57662E 00 0 36497E-00 0 63017E-03D0YAS 67
0 0 0 0 0 0 0 10133E 01D0YAS 68
0 64335E 00 0 43435E-00 0 49668E-02 0 0 0 D0YAS 69
0 0 0 10133E 01 0 57662E 00 0 36497E-00 0 23041E-02D0YAS 70
0 0 0 0 0 0 0 10133E 01D0YAS 71
0 45287E 00 0 41660E-00 0 49668E-02 0 0 0 D0YAS 72
0 0 0 10133E 01 0 75028E 00 0 56041E 00 0 20061E-01D0YAS 73
0 0 0 0 0 0 0 10133E 01D0YAS 74
0 10133E 01 0 26300E-00 0 20305E-05 0 0 0 D0YAS 75

```

C

```

16 9 1141 HELIUM-3 MICRO 293K SPN-76 HOWERTON
0 46949E-00 0 0 15948E 01 0 19496E-00 0 0 D0YAS 58
0 0 0 0 0 0 0 80508E 00 0 0 26010E 01D0YAS 59
0 48293E 00 0 66649E 00 0 0 0 0 D0YAS 60
0 88175E 00 0 0 27809E 01 0 29402E-00 0 55384E 00 0 22924E-00D0YAS 61
0 0 0 0 0 0 0 92133E 00 0 0 24761E 01D0YAS 62
0 42460E-00 0 11220E 01 0 73980E 00 0 34580E-01 0 0 D0YAS 63

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C SERIES 1100 CROSS SECTION LIBRARY GODIYA WEIGHTED

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0 12917E 01 0 0 27510E 01 0 97844E 00 0 11501E 01 0 48509E-00D0YAS 64
0 19312E-01 0 0 0 33858E 01 0 0 0 44793E 01D0YAS 65
0 96923E 00 0 48085E 00 0 79633E 05 0 0 0 D0YAS 66
0 79413E 01 0 0 87543E 01 0 74638E 00 0 12426E-00 0 D0YAS 67
0 0 0 0 19212E 02 0 0 0 19992E 02D0YAS 68
0 67288E 00 0 66646E 01 0 0 0 0 D0YAS 69
0 46176E 02 0 0 46955E 02 0 67569E 00 0 10657E-00 0 D0YAS 70
0 0 0 0 10565E 03 0 0 0 10643E 03D0YAS 71
0 49488E-00 0 10327E 00 0 0 0 0 D0YAS 72
0 18925E 03 0 0 19003E 03 0 44355E 00 0 28075E-00 0 48480E 03D0YAS 73
0 0 0 0 33162E 03 0 0 0 33240E 03D0YAS 74
0 49488E 00 0 33412E-00 0 38208E 02 0 0 0 D0YAS 75
0 59915E 03 0 0 59993E 03 0 44355E 00 0 28075E 00 0 17725E 02D0YAS 76
0 0 0 0 10142E 04 0 0 0 10150E 04D0YAS 77
0 34836E-00 0 32046E 00 0 38208E-02 0 0 0 D0YAS 78
0 16856E 04 0 0 16863E 04 0 57713E 00 0 43109E 00 0 15432E-01D0YAS 79
0 0 0 0 33679E 04 0 0 0 33686E 04D0YAS 80
0 77945E 00 0 20231E 00 0 15679E 05 0 0 0 D0YAS 81

```

C

```

16 9 1142 HELIUM-4 MICRO 293K SPN-76 HOWERTON
0 0 0 12601E 01 0 25963E 00 0 0 0 D0YAS 86
0 0 0 0 0 0 0 0 25314E 01D0YAS 87
0 67373E 00 0 94169E 00 0 0 0 0 D0YAS 88
0 0 0 0 57681E 01 0 14981E 01 0 12511E 01 0 58734E-01D0YAS 89
0 0 0 0 0 0 0 0 28957E 01D0YAS 90
0 13864E 01 0 38567E 01 0 60663E 00 0 0 0 D0YAS 91
0 0 0 10197E 01 0 82505E 00 0 15093E 01 0 41334E 00D0YAS 92
0 0 0 0 0 0 0 0 70379E 00D0YAS 93
0 65372E 00 0 19462E-00 0 0 0 0 D0YAS 94
0 0 0 0 61025E 00 0 58354E 00 0 50078E-01 0 D0YAS 95
0 0 0 0 0 0 0 0 60829E 00D0YAS 96
0 56201E 00 0 26704E 01 0 0 0 0 D0YAS 97
0 0 0 0 60829E 00 0 56323E 00 0 46286E-01 0 D0YAS 98
0 0 0 0 0 0 0 0 60829E 00D0YAS 99
0 47793E 00 0 45062E-01 0 0 0 0 D0YAS100
0 0 0 0 60829E 00 0 44353E 00 0 13036E-00 0 D0YAS101
0 0 0 0 0 0 0 0 60829E 00D0YAS102
0 47793E-00 0 16476E 00 0 0 0 0 D0YAS103
0 0 0 0 60829E 00 0 44353E 00 0 13036E 00 0 D0YAS104
0 0 0 0 0 0 0 0 60829E 00D0YAS105
0 36428E 00 0 16402E-00 0 0 0 0 D0YAS106
0 0 0 0 60829E 00 0 52042E 00 0 24401E 00 0 74040E 03D0YAS107
0 0 0 0 0 0 0 0 60829E 00D0YAS108
0 60829E 00 0 87870E 01 0 0 0 0 D0YAS109

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C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

C
 16 9 1143 BORON-10 MICRO 295K SPN-76 HOWERTON
 0 15622E-00 0 0 12392E 01 0 44459E 00 0 0 DOYAS114
 0 0 0 0 0 29464E-00 0 0 19649E 01DOYAS115
 0 11005E 01 0 43711E 00 0 0 DOYAS116
 0 20617E-00 0 0 21339E 01 0 98146E 00 0 50049E 00 0 82067E-01DOYAS117
 0 0 0 0 46550E-00 0 0 31283E 01DOYAS118
 0 19981E 01 0 94608E 00 0 54558E-01 0 95358E 01 0 0 DOYAS119
 0 10901E 01 0 0 45713E 01 0 33137E 01 0 66472E 00 0 19916E 03DOYAS120
 0 14717E 01 0 23880E-01 0 0 27206E 01 0 0 48140E 01DOYAS121
 0 20593E 01 0 16753E-00 0 0 0 0 DOYAS122
 0 48484E 01 0 0 73642E 01 0 24773E 01 0 34054E-01 0 DOYAS123
 0 0 0 0 0 12099E 02 0 0 15668E 02DOYAS124
 0 35010E 01 0 38540E 01 0 0 0 0 34514E 06DOYAS125
 0 30667E 02 0 0 34389E 02 0 36537E 01 0 68685E-01 0 DOYAS126
 0 0 0 0 0 71252E 02 0 0 74986E 02DOYAS127
 0 35366E 01 0 68193E-01 0 0 0 0 DOYAS128
 0 13300E 03 0 0 13673E 03 0 34845E 01 0 19727E-00 0 DOYAS129
 0 0 0 0 0 24116E 03 0 0 24489E 03DOYAS130
 0 35366E 01 0 24933E-00 0 0 0 0 DOYAS131
 0 43767E 03 0 0 44140E 03 0 34845E 01 0 19727E-00 0 DOYAS132
 0 0 0 0 0 72468E 03 0 0 72842E 03DOYAS133
 0 33539E 01 0 24933E-00 0 0 0 0 DOYAS134
 0 12159E 04 0 0 21966E 04 0 36009E 01 0 37993E-00 0 DOYAS135
 0 0 0 0 0 24331E 04 0 0 24368E 04DOYAS136
 0 37339E 01 0 13298E-00 0 0 0 0 DOYAS137

C
 16 9 1144 FLUORINE-19 MICRO 295K SPN-76 HOWERTON
 0 95788E-01 0 0 15464E 01 0 33300E-00 0 0 DOYAS142
 0 0 0 0 0 70000E-03 0 0 24491E 01DOYAS143
 0 18140E 01 0 72881E 00 0 0 0 DOYAS144
 0 70000E 03 0 0 28995E 01 0 19362E 01 0 50610E 00 0 13022E-00DOYAS145
 0 0 0 0 0 70000E 03 0 0 37825E 01DOYAS146
 0 24369E 01 0 96258E 00 0 91688E-01 0 21523E-00 0 0 DOYAS147
 0 70000E 03 0 0 67193E 01 0 47185E 01 0 13449E 01 0 DOYAS148
 0 36539E 01 0 43460E 01 0 0 18521E-02 0 0 83451E 01DOYAS149
 0 83115E 01 0 20001E 01 0 0 0 0 0 DOYAS150
 0 35676E 02 0 0 34220E 01 0 34019E 01 0 31829E-01 0 DOYAS151
 0 0 0 0 0 40771E-02 0 0 33097E 01DOYAS152
 0 32748E 01 0 16522E-01 0 0 0 0 DOYAS153
 0 48304E-02 0 0 34882E 01 0 34554E 01 0 30839E-01 0 DOYAS154
 0 0 0 0 0 49679E-02 0 0 31384E 01DOYAS155
 0 30611E 01 0 27979E-01 0 0 0 0

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

0 49903E 02 0 0 30849E 01 0 29821E 01 0 72347E 01 0 DOYAS157
 0 0 0 0 0 49968E-02 0 0 32232E 01DOYAS158
 0 31391E 01 0 97742E 01 0 0 0 DOYAS159
 0 49990E-02 0 0 32704E 01 0 31649E 01 0 79080E-01 0 DOYAS160
 0 0 0 0 0 49997E-02 0 0 32995E 01DOYAS161
 0 31391E 01 0 10058E-00 0 0 0 0 DOYAS162
 0 49999E-02 0 0 33388E 01 0 32786E 01 0 15513E-00 0 DOYAS163
 0 0 0 0 0 50000E-02 0 0 35711E 01DOYAS164
 0 35661E 01 0 55203E-01 0 0 0 0 DOYAS165

C
 16 9 1145 CHLORINE MICRO 295K SPN-76 HOWERTON
 0 55418E-01 0 0 20572E 01 0 88124E 00 0 0 DOYAS198
 0 0 0 0 0 20000E-05 0 0 21074E 01DOYAS199
 0 16781E 01 0 53546E 00 0 0 0 DOYAS200
 0 20000E-05 0 0 19115E 01 0 16821E 01 0 25682E-00 0 44658E-00DOYAS201
 0 0 0 0 0 20000E-05 0 0 17045E 01DOYAS202
 0 15823E 01 0 22931E-00 0 13872E-00 0 11897E-00 0 DOYAS203
 0 43165E-02 0 0 18749E 01 0 18423E 01 0 12220E-00 0 DOYAS204
 0 33772E-01 0 19709E-01 0 0 23344E-01 0 0 27712E 01DOYAS205
 0 27369E 01 0 28247E-01 0 0 0 0 DOYAS206
 0 49939E-01 0 0 23470E 01 0 22937E 01 0 10520E-01 0 DOYAS207
 0 0 0 0 0 50363E-07 0 12560E-00 0 0 17137E 01DOYAS208
 0 15769E 01 0 33625E-02 0 0 0 0 DOYAS209
 0 11131E-00 0 0 42427E 01 0 39030E 01 0 11175E-01 0 DOYAS210
 0 0 0 0 0 67641E 00 0 0 91557E 01DOYAS211
 0 83393E 01 0 28385E-01 0 0 0 0 DOYAS212
 0 13407E 01 0 0 13895E 02 0 12304E 02 0 14004E-00 0 DOYAS213
 0 0 0 0 0 31810E 01 0 0 16915E 02DOYAS214
 0 13567E 02 0 21039E-00 0 0 0 0 DOYAS215
 0 58688E 01 0 0 19603E 02 0 13523E 02 0 16697E-00 0 DOYAS216
 0 0 0 0 0 85841E 01 0 0 22518E 02DOYAS217
 0 13413E 02 0 21103E-00 0 0 0 0 DOYAS218
 0 13290E 02 0 0 27024E 02 0 13622E 02 0 32157E-00 0 DOYAS219
 0 0 0 0 0 21778E 02 0 0 35512E 02DOYAS220
 0 13734E 02 0 11255E-00 0 0 0 0 DOYAS221

C
 16 9 1146 ARGON MICRO 295K SPN-76 HOWERTON
 0 68789E-02 0 0 19917E 01 0 84121E 00 0 0 DOYAS226
 0 0 0 0 0 86026E-02 0 0 23417E 01DOYAS227
 0 19884E 01 0 39962E-00 0 0 0 0 DOYAS228
 0 92351E-02 0 0 17999E 01 0 16438E 01 0 15309E-00 0 28261E-00DOYAS229
 0 0 0 0 0 95732E-02 0 0 12166E 01DOYAS230
 0 11643E 01 0 14683E-00 0 23688E-01 0 42607E-00 0 0 DOYAS231

C SERIES 1100 CROSS SECTION LIBRARY GODIVA WEIGHTED

0 98272E-02 0	0 14098E 01 0	0 13812E 01 0	0 42715E 01 0	0 D0YAS232
0 10213E 00 0	0 35848E-01 0	0 99549E-02 0	0 15507E 01	0 D0YAS233
0 15347E 01 0	0 18772E-01 0	0 0	0 65841E-01 0	0 52887E-05 D0YAS234
0 99917E-02 0	0 12294E 01 0	0 12177E 01 0	0 60821E-02 0	0 D0YAS235
0 0	0	0 99907E-02 0	0 0	0 74854E 00
0 73597E 00 0	0 17329E-02 0	0 0	0 0	0 D0YAS237
0 10159E-01 0	0 67840E 00 0	0 66583E 00 0	0 25693E-02 0	0 D0YAS238
0 0	0	0 22539E-01 0	0 0	0 66921E 00 D0YAS239
0 63982E 00 0	0 24098E-02 0	0 0	0 0	0 D0YAS240
0 30442E-01 0	0 66945E 00 0	0 63039E 00 0	0 68514E-02 0	0 0
0 0	0	0 44074E-01 0	0 0	0 67765E 00 D0YAS242
0 62685E 00 0	0 86162E-02 0	0 0	0 0	0 D0YAS243
0 75300E-01 0	0 70906E 00 0	0 62907E 00 0	0 67234E-02 0	0 D0YAS244
0 0	0	0 12386E-00 0	0 0	0 77576E 00 D0YAS245
0 63825E 00 0	0 86910E-02 0	0 0	0 0	0 D0YAS246
0 20586E-00 0	0 87139E 00 0	0 66050E 00 0	0 13649E-01 0	0 D0YAS247
0 0	0	0 41151E-00 0	0 0	0 10885E 01 D0YAS248
0 67699E 00 0	0 50260E-02 0	0 0	0 0	0 D0YAS249

C

16 9 1148	CALCIUM	MICRO	293K	SPN-76	HOWERTON
1 00000E-02 0	0 19095E 01 0	0 12158E 01 0	0 0	0 D0YAS282	
0 0	0	0 12095E-01 0	0 0	0 19214E 01 D0YAS283	
0 17796E 01 0	0 31165E-00 0	0 0	0 0	0 D0YAS284	
0 13200E-01 0	0 22418E 01 0	0 19052E 01 0	0 12969E-00 0	0 14742E-00 D0YAS285	
0 0	0	0 13200E-01 0	0 0	0 19739E 01 D0YAS286	
0 19006E 01 0	0 32340E-00 0	0 17769E-00 0	0 0	0 D0YAS287	
0 13200E 01 0	0 32185E 01 0	0 31754E 01 0	0 60119E-01 0	0 D0YAS288	
0 0	0 48866E-01 0	0 13200E-01 0	0 0	0 13335E 01 D0YAS289	
0 13150E 01 0	0 29921E-01 0	0 0	0 0	0 12637E-04 D0YAS290	
0 13200E-01 0	0 13309E 01 0	0 13148E 01 0	0 33003E-02 0	0 D0YAS291	
0 0	0	0 13200E-01 0	0 0	0 13309E 01 D0YAS292	
0 15127E 01 0	0 29064E-02 0	0 0	0 0	0 D0YAS293	
0 13200E-01 0	0 13309E 01 0	0 13128E 01 0	0 49869E-02 0	0 D0YAS294	
0 0	0	0 13200E-01 0	0 0	0 13309E 01 D0YAS295	
0 13036E 01 0	0 48550E-02 0	0 0	0 0	0 D0YAS296	
0 15996E-01 0	0 13279E 01 0	0 12942E 01 0	0 14045E-01 0	0 D0YAS297	
0 0	0	0 28183E-01 0	0 0	0 13291E 01 D0YAS298	
0 12873E 01 0	0 17619E-01 0	0 0	0 0	0 D0YAS299	
0 58850E-01 0	0 13290E 01 0	0 12532E 01 0	0 13637E-01 0	0 D0YAS300	
0 0	0	0 85264E-01 0	0 0	0 13289E 01 D0YAS301	
0 12187E 01 0	0 16961E-01 0	0 0	0 0	0 D0YAS302	
0 14275E-00 0	0 13342E 01 0	0 11821E 01 0	0 24915E-01 0	0 D0YAS303	
0 0	0	0 28047E 00 0	0 0	0 18906E 01 D0YAS304	
0 16101E 01 0	0 93466E-02 0	0 0	0 0	0 D0YAS305	

C SERIES 1100 CROSS SECTION LIBRARY GODIVA WEIGHTED

C

16 9 1149	TITANIUM	MICRO	293K	SPN-76	HOWERTON
1 00000E 06 0	0 21715E 01 0	0 89281E 00 0	0 0	0 D0YAS310	
0 0	0	0 1 00000E-06 0	0 0	0 26918E 01 D0YAS311	
0 20156E 01 0	0 57627E 00 0	0 0	0 0	0 D0YAS312	
0 49428E-03 0	0 22979E 01 0	0 19346E 01 0	0 57943E 00 0	0 13733E-00 D0YAS313	
0 0	0	0 14328E-01 0	0 0	0 22271E 01 D0YAS314	
0 20840E 01 0	0 35220E-00 0	0 96700E 01 0	0 49259E-00 0	0 D0YAS315	
0 20000E-01 0	0 28485E 01 0	0 27848E 01 0	0 12875E-00 0	0 10676E-01 D0YAS316	
0 0	0 72979E-01 0	0 20000E-01 0	0 0	0 12685E 02 D0YAS317	
0 12337E 02 0	0 43720E-01 0	0 0	0 0	0 D0YAS318	
0 20615E-01 0	0 50749E 02 0	0 50719E 02 0	0 32754E-00 0	0 D0YAS319	
0 0	0	0 28399E-01 0	0 0	0 48359E 01 D0YAS320	
0 47946E 01 0	0 90952E-02 0	0 0	0 0	0 D0YAS321	
0 54551E-01 0	0 41958E 01 0	0 41286E 01 0	0 12968E 01 0	0 D0YAS322	
0 0	0 12213E 06 0	0 11934E-00 0	0 0	0 42605E 01 D0YAS323	
0 41047E 01 0	0 12625E-01 0	0 0	0 0	0 D0YAS324	
0 23361E-00 0	0 43748E 01 0	0 40950E 01 0	0 36523E 01 0	0 D0YAS325	
0 0	0	0 38431E-00 0	0 0	0 45255E 01 D0YAS326	
0 41047E 01 0	0 46161E-01 0	0 0	0 0	0 D0YAS327	
0 66335E 00 0	0 0	0 48046E 01 0	0 40950E 01 0	0 36523E-01 0	
0 0	0	0 0	0 11197E 01 0	0 52609E 01 D0YAS329	
0 40709E 01 0	0 46161E-01 0	0 0	0 0	0 D0YAS330	
0 18589E 01 0	0 0	0 60001E 01 0	0 41166E 01 0	0 70341E-01 0	
0 0	0	0 0	0 37178E 01 0	0 78590E 01 D0YAS332	
0 41412E 01 0	0 24619E-01 0	0 0	0 0	0 D0YAS333	

C

16 9 1150	MANGANESE-55	MICRO	293K	SPN 76	HOWERTON
0 53181E-03 0	0 22576E 01 0	0 88027E 00 0	0 0	0 D0YAS338	
0 0	0	0 24210E-02 0	0 0	0 25347E 01 D0YAS339	
0 15905E 01 0	0 56696E 00 0	0 0	0 0	0 D0YAS340	
0 35153E-02 0	0 24271E 01 0	0 15239E 01 0	0 43140E-00 0	0 45668E-00 D0YAS341	
0 0	0	0 41946E-02 0	0 0	0 28848E 01 D0YAS342	
0 24714E 01 0	0 43263E-00 0	0 42658E-00 0	0 31128E-00 0	0 D0YAS343	
0 96473E-02 0	0 35007E 01 0	0 33219E 01 0	0 12265E 00 0	0 46702E-00 D0YAS344	
0 83783E-01 0	0 45790E 01 0	0 29494E 01 0	0 0	0 81171E 01 D0YAS345	
0 80808E 01 0	0 13298E 00 0	0 21631E 00 0	0 0	0 0	
0 58496E-01 0	0 0	0 17074E 02 0	0 16798E 02 0	0 68528E-02 0	
0 70190E-01 0	0 0	0 61948E-01 0	0 0	0 36060E-01 0	
0 26321E 03 0	0 21714E 00 0	0 0	0 0	0 26333E 03 0	
0 11136E 00 0	0 0	0 28750E 03 0	0 28737E 03 0	0 61494E-01 0	
0 0	0	0 25583E 00 0	0 0	0 39335E 01 0	
0 36572E 01 0	0 12156E-01 0	0 0	0 0	0 0	

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

0 52361E 00 0	0 30491E 01 0	0 25030E 01 0	0 20403E-01 0	00YAS393
0 0	0	0 84381E 00 0	0 3079'E 0100YAS394	
0 22186E 01 0	0 22436E-01 0	0	0	00YAS395
0 15247E 01 0	0 37710E 01 0	0 22243E 01 0	0 16703E-01 0	00YAS396
0 0	0	0 23820E 01 0	0 47024E 0100YAS397	
0 22807E 01 0	0 22826E-01 0	0	0	00YAS398
0 38407E 01 0	0 65681E 01 0	0 27121E 01 0	0 39749E-01 0	00YAS399
0 0	0	0 81499E 01 0	0 11137E 0200YAS360	
0 29874E 01 0	0 15307E-01 0	0	0	00YAS361

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16 9 1151	COPPER	MICRO	293K	SPN-76	MONENTON
0 22022E-01 0	0 23191E 01 0	0 81357E 00 0	0	0	00YAS366
0 0	0	0 73269E-02 0	0	0 26240E 0100YAS367	
0 15007E 01 0	0 70594E 00 0	0	0	0	00YAS368
0 92432E-02 0	0 31417E 01 0	0 25954E 01 0	0 12895E-00 0	0 45552E-0000YAS369	
0 0	0	0 12317E-01 0	0	0 39800E 0100YAS370	
0 34311E 01 0	0 37264E-00 0	0 75292E 00 0	0 27438E-00 0	0	00YAS371
0 26479E-01 0	0 45767E 01 0	0 45079E 01 0	0 15658E-00 0	0 16448E-0000YAS372	
0 23411E-00 0	0 51587E-01 0	0 53528E-01 0	0	0 63293E 0100YAS373	
0 62562E 01 0	0 42291E-01 0	0	0	0	00YAS374
0 96902E-01 0	0 96363E 01 0	0 95316E 01 0	0 19578E-01 0	0	00YAS375
0 0	0	0 10000E 00 0	0	0 15651E 0200YAS376	
0 15522E 02 0	0 77445E-02 0	0	0	0	00YAS377
0 10000E-00 0	0 65294E 01 0	0 64132E 01 0	0 28399E-01 0	0	00YAS378
0 0	0 55403E-06 0	0 10000E-00 0	0	0 73747E 0100YAS379	
0 72257E 01 0	0 16121E-01 0	0	0	0	00YAS380
0 12531E-00 0	0 76396E 01 0	0 74520E 01 0	0 49073E-01 0	0	00YAS381
0 0	0	0 23998E-00 0	0	0 77589E 0100YAS382	
0 74697E 01 0	0 62269E-01 0	0	0	0	00YAS383
0 43794E-00 0	0 79569E 01 0	0 74567E 01 0	0 49268E-01 0	0	00YAS384
0 0	0	0 73177E 00 0	0	0 82507E 0100YAS385	
0 74240E 01 0	0 62269E-01 0	0	0	0	00YAS386
0 12309E 01 0	0 87498E 01 0	0 74857E 01 0	0 94887E-01 0	0	00YAS387
0 0	0	0 24376E 01 0	0	0 99611E 0100YAS388	
0 75236E 01 0	0 33210E 01 0	0	0	0	00YAS389

C

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16 9 1152	TIN	MICRO	293K	SPN-76	MONENTON
0 16085E-01 0	0 29356E 01 0	0 10217E 01 0	0	0	00YAS394
0 0	0	0 72847E-01 0	0	0 33824E 0100YAS395	
0 24378E 01 0	0 10247E 01 0	0	0	0	00YAS396
0 10070E-00 0	0 40299E 01 0	0 35991E 01 0	0 46215E-00 0	0 53116E 0000YAS397	
0 0	0	0 11145E-00 0	0	0 46294E 0100YAS398	
0 44297E 01 0	0 27919E-00 0	0 34768E-00 0	0 29957E-00 0	0	00YAS399

C SERIES 1100 CROSS SECTION LIBRARY - GODIYA WEIGHTED

0 11200E-00 0	0 50519E 01 0	0 49157E 01 0	0 80595E-01 0	0 46354E-0100YAS400
0 61976E 01 0	0 50955E 01 0	0 11200E-00 0	0	0 60211E 0100YAS401
0 59020E 01 0	0 24270E-01 0	0	0	0
0 11200E-00 0	0 55104E 01 0	0 53948E 01 0	0 71501E-02 0	0
0 0	0	0 11200E-00 0	0	0 50757E 0100YAS404
0 49576E 01 0	0 35548E-02 0	0	0	0 45097E-0200YAS405
0 11200E-00 0	0 56116E 01 0	0 54939E 01 0	0 61058E-02 0	0
0 0	0 36557E-02 0	0 11200E-00 0	0	0 54357E 0100YAS407
0 53082E 01 0	0 56549E-02 0	0	0	0
0 11200E-00 0	0 46423E 01 0	0 45101E 01 0	0 15408E-01 0	0
0 0	0	0 11200E-00 0	0	0 47884E 0100YAS410
0 46602E 01 0	0 20199E-01 0	0	0	0
0 11200E-00 0	0 48401E 01 0	0 47075E 01 0	0 16236E-01 0	0
0 0	0	0 12070E-00 0	0	0 48526E 0100YAS413
0 47008E 01 0	0 20612E-01 0	0	0	0
0 19560E-00 0	0	0 48450E 01 0	0 46388E 01 0	0 31076E-01 0
0 0	0	0 39174E-00 0	0	0
0 43921E 01 0	0 10495E-01 0	0	0	0 47839E 0100YAS416
0	0	0	0	0 00YAS417

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16 9 1153	URANIUM-237	MICRO	293K	SPN-76	MONENTON
0 81387E 00 0	0 24823E 01 0	0 43821E 01 0	0 11477E 01 0	0	00YAS422
0 0	0	0	0 79084E 00 0	0 19276E 01 0	0 46129E 0100YAS423
0 15318E 01 0	0 16784E-00 0	0	0	0	00YAS424
0 85530E 00 0	0 19070E 01 0	0 50934E 01 0	0 23087E 01 0	0 19431E-00 0	0 32411E-0000YAS425
0 0	0	0	0 90872E 00 0	0 18707E 01 0	0 60378E 0100YAS426
0 36474E 01 0	0 12343E 01 0	0 14502E 01 0	0 14409E 01 0	0	00YAS427
0 10036E 01 0	0 17367E 01 0	0 79278E 01 0	0 63096E 01 0	0 12125E 01 0	0 68827E 0000YAS428
0 64577E 00 0	0 57497E 00 0	0	0 89534E 00 0	0 98705E 00 0	0 95118E 0100YAS429
0 86104E 01 0	0 31568E-00 0	0 15411E-00 0	0 68146E-02 0	0	00YAS430
0 12939E 01 0	0 47080E-00 0	0 10823E 02 0	0 95245E 01 0	0 59766E-02 0	0 29898E-0000YAS431
0 11506E-00 0	0	0 29735E 01 0	0 36524E-00 0	0 16150E 0200YAS432	
0 13168E 02 0	0 43068E-02 0	0	0	0	00YAS433
0 56475E 01 0	0 35401E 00 0	0 19619E 02 0	0 13964E 02 0	0 85050E-02 0	00YAS434
0 0	0	0 68650E 01 0	0 35400E-00 0	0 20828E 0200YAS435	
0 13939E 02 0	0 82177E-02 0	0	0	0	00YAS436
0 70634E 01 0	0 35400E-00 0	0 21026E 02 0	0 13935E 02 0	0 23773E-01 0	00YAS437
0 0	0	0 71216E 01 0	0 35400E-00 0	0 21084E 0200YAS438	
0 13939E 02 0	0 30046E-01 0	0	0	0	00YAS439
0 71414E 01 0	0 35400E 00 0	0 21104E 02 0	0 13935E 02 0	0 23773E-01 0	00YAS440
0 0	0	0 71471E 01 0	0 35400E-00 0	0 21110E 0200YAS441	
0 13917E 02 0	0 30046E-01 0	0	0	0	00YAS442
0 71490E 01 0	0 35400E-00 0	0 21112E 02 0	0 13947E 02 0	0 45785E-01 0	00YAS443
0 0	0	0 71498E 01 0	0 35400E-00 0	0 21112E 0200YAS444	
0 13963E 02 0	0 16025E-01 0	0	0	0	00YAS445

C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

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C
C
16 9 1154 URANIUM-239 MICRO 293K SPN-76 HOWERTON
0 31920E-00 0 97674E 00 0 43789E 01 0 11561E 01 0 0 D0YAS450
0 0 0 0 30563E-00 0 63515E 00 0 46130E 01D0YAS451
0 15334E 01 0 19569E-00 0 0 0 0 D0YAS452
0 35039E-00 0 62407E 00 0 50888E 01 0 23065E 01 0 22900E-00 0 38619E-00D0YAS453
0 0 0 0 38345E-00 0 60048E 00 0 56493E 01D0YAS454
0 33012E 01 0 15470E 01 0 17612E 01 0 17521E 01 0 0 D0YAS455
0 24362E-00 0 32715E 00 0 67840E 01 0 57003E 01 0 16992E 01 0 87610E 00D0YAS456
0 78374E 00 0 69870E 00 0 0 12185E-00 0 50480E-01 0 86593E 01D0YAS457
0 85315E 01 0 42829E-00 0 16047E-00 0 87853E-02 0 0 D0YAS458
0 12825E-00 0 65027E-01 0 98717E 01 0 97587E 01 0 98944E-02 0 41174E-00D0YAS459
0 10495E-00 0 0 0 17218E-00 0 16340E-00 0 14452E 02D0YAS460
0 14271E 02 0 47969E-02 0 0 0 0 D0YAS461
0 29269E-00 0 41932E-00 0 14562E 02 0 14261E 02 0 86703E-02 0 0 D0YAS462
0 0 0 0 59560E 00 0 85192E 00 0 14518E 02D0YAS463
0 13939E 02 0 81484E-02 0 0 0 0 D0YAS464
0 91944E 00 0 14098E 01 0 14882E 02 0 13935E 02 0 23571E-01 0 0 D0YAS465
0 0 0 0 16894E 01 0 25905E 01 0 15684E 02D0YAS466
0 13971E 02 0 29791E-01 0 0 0 0 D0YAS467
0 28719E 01 0 44036E 01 0 16921E 02 0 14019E 02 0 23702E-01 0 0 D0YAS468
0 0 0 0 43558E 01 0 66483E 01 0 18348E 02D0YAS469
0 13967E 02 0 30004E-01 0 0 0 0 D0YAS470
0 68880E 01 0 10562E 02 0 20891E 02 0 13947E 02 0 45396E-01 0 0 D0YAS471
0 0 0 0 13454E 02 0 20633E 02 0 27417E 02D0YAS472
0 13963E 02 0 15889E-01 0 0 0 0 D0YAS473

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C
C
16 9 1155 URANIUM-240 MICRO 293K SPN-76 HOWERTON
0 49144E-00 0 15025E 01 0 41979E 01 0 11893E 01 0 0 D0YAS478
0 0 0 0 37352E-00 0 89731E 00 0 46033E 01D0YAS479
0 16852E 01 0 19677E-00 0 0 0 0 D0YAS480
0 92109E-01 0 10194E-00 0 49957E 01 0 28164E 01 0 20764E-00 0 34790E-00D0YAS481
0 0 0 0 15923E-00 0 25707E-05 0 56689E 01D0YAS482
0 44893E 01 0 79294E 00 0 13496E 01 0 14895E 01 0 0 D0YAS483
0 25439E-00 0 25108E-05 0 81492E 01 0 75187E 01 0 97181E 00 0 10421E 01D0YAS484
0 87111E 00 0 57984E 00 0 0 41127E-00 0 22807E-05 0 11775E 02D0YAS485
0 11336E 02 0 37606E 00 0 48566E-01 0 25213E 00 0 11622E 00 0
0 60019E 00 0 22720E-05 0 13978E 02 0 13375E 02 0 27397E-01 0
0 0 0 0 73221E 00 0 22703E-05 0 12817E 02D0YAS488
0 12078E 02 0 42945E-02 0 0 0 0 D0YAS489
0 75000E 00 0 22701E-05 0 99562E 01 0 92015E 01 0 59611E-02 0 0 D0YAS490
0 0 0 0 75000E 00 0 22700E-05 0 87287E 01D0YAS491
0 79653E 01 0 46378E-02 0 0 0 0 D0YAS492

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C SERIES 1100 CROSS SECTION LIBRARY - GODIVA WEIGHTED

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0 75000E 00 0 22700E-05 0 87287E 01 0 79617E 01 0 13412E-01 0 0 D0YAS493
0 0 0 0 75000E 00 0 22700E-05 0 87287E 01
0 79653E 01 0 16952E-01 0 0 0 0
0 75000E 00 0 22700E-05 0 87287E 01 0 79617E 01 0 13412E 01 0 0 D0YAS496
0 0 0 0 75000E 00 0 22700E-05 0 87287E 01D0YAS497
0 79528E 01 0 16952E-01 0 0 0 0 D0YAS498
0 75000E 00 0 22700E-05 0 87287E 01 0 79696E 01 0 25831E-01 0 0 D0YAS499
0 0 0 0 10500E 01 0 22700E-05 0 90287E 01D0YAS500
0 79787E 01 0 90409E 02 0 0 0 0 D0YAS501

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C
C
16 9 1156 PLUTONIUM-238 MICRO 293K SPN-76 HOWERTON
0 21889E 01 0 75839E 01 0 43823E 01 0 11218E 01 0 0 D0YAS 2
0 0 0 0 21874E 01 0 66673E 01 0 46196E 01D0YAS 3
0 15255E 01 0 81289E-01 0 0 0 0 D0YAS 4
0 22400E 01 0 64309E 01 0 50925E 01 0 23004E 01 0 93030E-01 0 13871E-00D0YAS 5
0 0 0 0 22965E 01 0 63881E 01 0 51093E 01D0YAS 6
0 36439E 01 0 23415E-00 0 48513E-00 0 63892E 00 0 0 D0YAS 7
0 25553E 01 0 68863E 01 0 88792E 01 0 63073E 01 0 16257E-00 0 25556E-00D0YAS 8
0 29530E-00 0 25762E-00 0 0 37922E 01 0 91433E 01 0 12194E 02D0YAS 9
0 83959E 01 0 16618E-01 0 63667E-02 0 62402E 01 0 33316E-01 0 0 D0YAS 10
0 52386E 01 0 11150E 02 0 14455E 02 0 92133E 01 0 58409E-02 0 0 D0YAS 11
0 0 0 0 11213E 02 0 15232E 02 0 22373E 02D0YAS 12
0 11152E 02 0 33571E-02 0 0 0 0 D0YAS 13
0 14517E 02 0 16688E 02 0 28480E 02 0 15954E 02 0 84050E-02 0 0 D0YAS 14
0 0 0 0 15752E 02 0 17131E 02 0 29715E 02D0YAS 15
0 13939E 02 0 81828E 02 0 0 0 0 D0YAS 16
0 15953E 02 0 17203E 02 0 29916E 02 0 13933E 02 0 25672E 01 0 0 D0YAS 17
0 0 0 0 65453E 02 0 19285E 02 0 79271E 02D0YAS 18
0 13795E 02 0 29918E-01 0 0 0 0 D0YAS 19
0 15089E 03 0 22852E 02 0 16446E 03 0 15539E 02 0 25075E 01 0 0 D0YAS 20
0 0 0 0 17541E 03 0 25875E 02 0 18891E 03D0YAS 21
0 13452E 02 0 28948E 01 0 0 0 0 D0YAS 22
0 18358E 03 0 24208E 02 0 19685E 03 0 15458E 02 0 44011E 01 0 0 D0YAS 23
0 0 0 0 27189E 03 0 34119E 02 0 28555E 03D0YAS 24
0 13663E 02 0 15387E-01 0 0 0 0 D0YAS 25

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C SERIES 1200 CROSS SECTION LIBRARY - LRL F WEIGHTED

C	NUCLIDE	NUMBER	NUCLIDE	NUMBER	NUCLIDE	NUMBER
C	H-1	1201	MO	1218	M-3	1240
C	H-2	1202	EU	1219	HE-3	1241
C	LI-6	1203	GO	1220	HE-4	1242
C	LI-7	1204	TA-181	1221	B-10	1243
C	BE-9	1205	M	1222	F	1244
C	BORON	1206	AU	1223	CL	1245
C	C-12	1207	PO	1224	A	1246
C	N-14	1208	U-233	1225	CA	1248
C	C-16	1209	U-234	1226	TI	1249
C	NA-23	1210	U-235	1227	HM	1250
C	AL	1211	U-236	1228	CU	1251
C	SI	1212	U-238	1229	SN	1252
C	P-31	1213	PU-239	1230	U-237	1253
C	K	1214	PU-240	1231	J-239	1254
C	FE	1215	PU-241	1232	U-240	1255
C	GA	1216	MG	1233	PU-238	1256
C	NO-93	1217	RE	3268	AG	3271
C			I/Y	3270	HF	3272

16 9 1201	HYDROGEN-1	MICRO	293K	SPN 76	HOMERTON
0 37154E-03 0	0 59294E 00 0	71218E 00 0	0	DOYAS 2	
0 0	0 0	0 44486E-03 0	0	0 98052E 00DOYAS 3	
0 12076E 01 0	0 69586E 00 0	0 0	0	0 DOYAS 4	
0 46927E-03 0	0 13379E 01-0	0 19390E 01 0	0 78131E 00 0	0 21746E-00DOYAS 5	
0 0	0 0	0 48332E-03 0	0	0 18752E 01DOYAS 6	
0 20706E 01 0	0 18180E 01 0	0 78131E 00 0	0 21746E-00 0	0 DOYAS 7	
0 49380E 03 0	0 31148E 01 0	0 17989E 01 0	0 29590E 01 0	0 10908E 01DOYAS 8	
0 46879E 00 0	0 13047E 00 0	0 49870E-03 0	0	0 50674E 01DOYAS 9	
0 74808E 00 0	0 40780E 01 0	0 81866E 00 0	0 30179E-00 0	0 12970E-00 0 45491E-01DOYAS 10	
0 57322E 03 0	0 0	0 63706E 01 0	0 26593E-00 0	0 47888E 01 0 68789E 00DOYAS 11	
0 13809E 00 0	0 50905E 01 0	0 26565E-01 0	0 12646E-02 0	0 67010E 01DOYAS 12	
0 26984E 02 0	0 54190E 01 0	0 83805E 00 0	0 12037E-00 0	0 24165E-01 0 10908E 01DOYAS 13	
0 28663E 02 0	0 0	0 67594E 01 0	0 48741E-00 0	0 54794E 01 0 99533E 00DOYAS 14	
0 15394E-00 0	0 22109E-01 0	0 54249E-02 0	0 64464E 02 0	0 67731E 01DOYAS 15	
0 26022E 01 0	0 43884E 01 0	0 85235E 00 0	0 15483E 00 0	0 23944E-01 0 49152E-02DOYAS 16	
0 11650E 01 0	0 0	0 67783E 01 0	0 55823E 01 0	0 62459E 01 0 12538E 01DOYAS 17	
0 24353E-00 0	0 44237E-01 0	0 10262E-01 0	0 20420E-01 0	0 67871E 01DOYAS 18	
0 25992E 01 0	0 71043E 01 0	0 21861E 01 0	0 43884E-00 0	0 85235E-01 0 22118E-01DOYAS 19	
0 36950E-01 0	0 0	0 68036E 01 0	0 33732E 01 0	0 62439E 01 0 20298E 01DOYAS 20	
0 62459E 00 0	0 12538E 00 0	0 36529E-01 0	0 62387E-01 0	0 68291E 01DOYAS 21	
0 48098E 01 0	0 60839E 01 0	0 18732E 01 0	0 60894E 00 0	0 18738E-00 0 62691E-01DOYAS 22	
0 10313E 00 0	0 0	0 68698E 01-0	0 12437E 01 0	0 86823E 01 0 30420E 01DOYAS 23	
0 93658E 00 0	0 30447E 00 0	0 12492E-00 0	0 20047E-00 0	0 69671E 01DOYAS 24	

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED

0 67667E 01 0 80104E 01 0	0 28941E 01 0	0 10140E 01 0	0 31219E-00 0	0 10149E 00DOYAS 25	
C					
C					
16 9 1202	HYDROGEN-2	MICRO	293K	SPN-76	HOMERTON
0 30000E-04 0	0	0 11324E 01 0	0 87502E-01 0	0	DOYAS 27
0 0 0	0	0	0 30000E 04 0	0	0 21233E 01DOYAS 28
0 29510E-00 0 53863E 00 0	0	0	0	0	DOYAS 29
0 30000E-04 0	0	0 26669E 01 0	0 22477E-00 0	0 49038E-00 0	0 18233E-00DOYAS 30
0 0 0	0	0	0 30000E-04 0	0	0 28405E 01DOYAS 31
0 42946E-00 0 10197E 01 0	0 72823E 00 0	0 32002E-00 0	0	0	DOYAS 32
0 30000E-04 0	0 25003E 01 0	0 86148E 00 0	0 19532E 01 0	0 14224E 01DOYAS 33	
0 60961E 00 0 30729E-01 0	0	0 30000E-04 0	0	0 22458E 01DOYAS 34	
0 12787E 01 0 16139E 01 0	0 45784E-00 0	0 22537E-04 0	0	0 17416E-03DOYAS 35	
0 30000E-04 0	0 22723E 01 0	0 13763E 01 0	0 95445E 00 0	0 24882E-01DOYAS 36	
0 0 0	0 0 0	0 30000E-04 0	0	0 22752E 01DOYAS 37	
0 14206E 01 0 88444E 00 0	0 12630E-01 0	0	0	0	DOYAS 38
0 30000E-04 0	0 22752E 01 0	0 15099E 01 0	0 84519E 00 0	0 11443E-01DOYAS 39	
0 0 0	0 0 0	0 30000E-04 0	0	0 22752E 01DOYAS 40	
0 92651E 00 0 72207E 00 0	0 93814E-02 0	0	0	0	DOYAS 41
0 30000E-04 0	0 22752E 01 0	0 77964E 00 0	0 11769E 01 0	0 43180E-01DOYAS 42	
0 0 0	0 0 0	0 35097E-04 0	0	0 22752E 01DOYAS 43	
0 92708E 00 0 13385E 01 0	0 17180E-00 0	0	0	0	DOYAS 44
0 62715E-04 0	0 22753E 01 0	0 78135E 00 0	0 11765E 01 0	0 15704E-00DOYAS 45	
0 0 0	0 0 0	0 10591E-03 0	0	0 22753E 01DOYAS 46	
0 51111E 00 0 11487E 01 0	0 16982E-00 0	0	0	0	DOYAS 47
0 17498E-03 0	0 22754E 01 0	0 11825E 01 0	0 16354E 01 0	0 34515E-00DOYAS 48	
0 17890E-02 0	0	0 35990E-03 0	0	0 22755E 01DOYAS 49	
0 22752E 01 0 10927E 01 0	0 12870E-00 0	0	0	0	DOYAS 50

16 9 1203	LITHIUM-6	MICRO	293K	SPN-76	HOMERTON
0 10268E-00 0	0 15146E 01 0	0 46433E-00 0	0	0	DOYAS 52
0 0 0	0 0 0	0 22245E-00 0	0	0	11375E 01DOYAS 53
0 47112E-00 0 57868E 00 0	0 0 0	0 0 0	0	0	DOYAS 54
0 29821E-00 0	0 10893E 01 0	0 23162E-00 0	0 38129E-00 0	0 42980E-01DOYAS 55	
0 0 0	0 0 0	0 48908E-00 0	0	0	16149E 01DOYAS 56
0 57880E 00 0 55949E 00 0	0 36787E 01 0	0 21060E-00 0	0	0	DOYAS 57
0 15348E 01 0	0 46315E 01 0	0 28936E 01 0	0 54699E 00 0	0	DOYAS 58
0 25903E-01 0 11779E 00 0	0 0 0	0 78302E 00 0	0	0	16048E 01
0 74869E 00 0 20311E-00 0	0 0 0	0 0 0	0	0	DOYAS 60
0 16146E 01 0	0 25170E 01 0	0 84414E 00 0	0 73125E-01 0	0	DOYAS 61
0 0 0	0 0 0	0 37158E 01 0	0	0	46083E 01
0 84218E 00 0 58287E-01 0	0 0 0	0 0 0	0	0	DOYAS 63
0 83670E 01 0	0 0 0	0 92564E 01 0	0 85654E 00 0	0 50278E-01 0	DOYAS 64
0 0 0	0 0 0	0 18775E 02 0	0	0	19664E 02DOYAS 65

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.79348E 00 0.32038E-01 0.	0.	0.	0.	DOYAS 66
0.34382E 02 0.	0.35272E 02 0.76821E 00 0.95904E-01 0.	DOYAS 67		
0.	0.	0.59590E 02 0.	0.60439E 02 DOYAS 68	
0.79366E 00 0.12117E-00 0.	0.	0.	DOYAS 69	
0.10873E 03 0.	0.10961E 03 0.76882E 00 0.95721E-01 0.	DOYAS 70		
0.	0.	0.18139E 03 0.	0.18228E 03 DOYAS 71	
0.70660E 00 0.12056E-00 0.	0.	0.	DOYAS 72	
0.30366E 03 0.	0.30459E 03 0.80003E 00 0.18278E-00 0.	DOYAS 73		
0.	0.	0.58465E 03 0.	0.58554E 03 DOYAS 74	
0.88938E 00 0.59333E-01 0.	0.	0.	DOYAS 75	

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16 9 1204 LITHIUM-7	MICRO	293K	SPN-76	HOMERTON
0.10000E-09 0.	0.16964E 01 0.88227E 00 0.	0.		
0.	0.	0.10000E-09 0.	0.14411E 01	
0.83694E 00 0.68671E 00 0.	0.	0.	DOYAS 79	
0.10001E-05 0.	0.13188E 01 0.47347E-00 0.57381E 00 0.28100E-01 DOYAS 80			
0.	0.	0.10001E-05 0.	0.11584E 01 DOYAS 81	
0.71161E 00 0.82889E 00 0.29971E-01 0.68224E-01 0.	0.	0.	DOYAS 82	
0.10001E-05 0.	0.22032E 01 0.20870E 01 0.44684E 00 0.16394E-01	0.89980E 00 DOYAS 84		
0.12065E-03 0.28364E-01 0.	0.10001E-05 0.	0.25265E-03 0.36263E-02		
0.83441E 00 0.11624E 00 0.	0.	0.65391E-01 0.	DOYAS 86	
0.10001E-05 0.	0.95539E 00 0.90370E 00 0.65391E-01 0.	0.99065E 00	DOYAS 88	
0.	0.	0.50211E-04 0.	DOYAS 89	
0.94543E 00 0.51650E-01 0.	0.	0.	DOYAS 91	
0.12639E-02 0.	0.99580E 00 0.96590E 00 0.45167E-01 0.	0.99586E 00	DOYAS 92	
0.	0.	0.18772E-02 0.	DOYAS 93	
0.90870E 00 0.29037E-01 0.	0.	0.	DOYAS 94	
0.19774E-02 0.	0.99587E 00 0.88619E 00 0.85282E-01 0.	0.99888E 00 DOYAS 95		
0.	0.	0.32765E-02 0.	DOYAS 96	
0.91018E 00 0.10774E-00 0.	0.	0.	DOYAS 97	
0.54817E-02 0.	0.10041E 01 0.89089E 00 0.85421E-01 0.	0.10081E 01 DOYAS 98		
0.	0.	0.88441E-02 0.	DOYAS 99	
0.83614E 00 0.10770E-00 0.	0.	0.	DOYAS 100	
0.15972E-01 0.	0.10133E 01 0.94663E 00 0.16316E-00 0.	0.10190E 01 DOYAS 101		
0.	0.	0.20942E-01 0.		
0.99802E 00 0.52671E-01 0.	0.	0.		

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16 9 1205 BERYLLIUM-9	MICRO	293K	SPN-76	HOMERTON
0.73896E-01 0.	0.13390E 01 0.43042E-00 0.	0.	DOYAS 102	
0.	0.	0.47437E-01 0.	0.16407E 01 DOYAS 103	
0.10345E 01 0.40831E-00 0.	0.	0.	DOYAS 104	
0.73070E-02 0.	0.22729E 01 0.10115E 01 0.93890E 00 0.67225E-01 DOYAS 105			
0.	0.	0.42169E-02 0.	0.34513E 01 DOYAS 106	

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.25450E 01 0.12540E 01 0.13896E-03 0.24438E-00 0.	0.	DOYAS 107	
0.21462E-02 0.	0.40976E 01 0.35610E 01 0.90208E 00 0.20000E-09 DOYAS 108		
0.39392E-01 0.58986E 00 0.	0.11815E-02 0.	0.52904E 01 DOYAS 109	
0.50057E 01 0.53443E 00 0.	0.	DOYAS 110	
0.10012E-02 0.	0.55446E 01 0.53312E 01 0.28351E-00 0.	DOYAS 111	
0.	0.	0.10018E-02 0.	0.55538E 01 DOYAS 112
0.53727E 01 0.21243E-00 0.	0.	DOYAS 113	
0.10020E-02 0.	0.55538E 01 0.54391E 01 0.18016E-00 0.	DOYAS 114	
0.	0.	0.10020E-02 0.	0.55538E 01 DOYAS 115
0.52161E 01 0.11375E-00 0.	0.	DOYAS 116	
0.10020E-02 0.	0.55538E 01 0.51274E 01 0.33679E-00 0.	DOYAS 117	
0.	0.	0.10020E-02 0.	0.55538E 01 DOYAS 118
0.52168E 01 0.42548E-00 0.	0.	DOYAS 119	
0.10270E-02 0.	0.55538E 01 0.51301E 01 0.33600E-00 0.	DOYAS 120	
0.	0.	0.20553E-02 0.	0.55541E 01 DOYAS 121
0.49128E 01 0.42276E-00 0.	0.	DOYAS 122	
0.34501E-02 0.	0.55541E 01 0.53459E 01 0.63928E 00 0.	DOYAS 123	
0.	0.	0.54138E-02 0.	0.55542E 01 DOYAS 124
0.55488E 01 0.20471E-00 0.	0.	DOYAS 125	

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16 9 1206 BORON	MICRO	293K	SPN-76	HOMERTON
0.44082E-01 0.	0.92938E 00 0.52535E 00 0.	0.	DOYAS 127	
0.	0.	0.63729E-01 0.	0.18055E 01 DOYAS 128	
0.11966E 01 0.31566E-00 0.	0.	0.	DOYAS 129	
0.40550E-01 0.	0.21244E 01 0.13780E 01 0.54520E 00 0.17799E-01 DOYAS 130			
0.	0.	0.12180E-00 0.	0.25820E 01 DOYAS 131	
0.16186E 01 0.70598E 00 0.	0.16272E-01 0.	0.	DOYAS 132	
0.29234E-00 0.	0.35420E 01 0.29192E 01 0.84159E 00 0.	DOYAS 133		
0.	0.10838E-01 0.	0.85272E 00 0.	0.45966E 01 DOYAS 134	
0.35877E 01 0.33050E-00 0.	0.	0.	0.22610E-06 DOYAS 135	
0.15352E 01 0.	0.52891E 01 0.36388E 01 0.15624E-00 0.	DOYAS 136		
0.	0.	0.21660E 01 0.	0.59199E 01 DOYAS 137	
0.36573E 01 0.11512E-00 0.	0.	0.	DOYAS 138	
0.36788E 01 0.	0.74328E 01 0.36936E 01 0.96662E-01 0.	DOYAS 139		
0.	0.	0.10573E 02 0.	0.14327E 02 DOYAS 140	
0.35743E 01 0.60361E-01 0.	0.	0.	DOYAS 141	
0.22249E 02 0.	0.26003E 02 0.35271E 01 0.17957E-00 0.	DOYAS 142		
0.	0.	0.43265E 02 0.	0.47019E 02 DOYAS 143	
0.35748E 01 0.22684E-00 0.	0.	0.	DOYAS 144	
0.83620E 02 0.	0.87374E 02 0.35286E 01 0.17912E-00 0.	DOYAS 145		
0.	0.	0.14409E 03 0.	0.14784E 03 DOYAS 146	
0.34134E 01 0.22529E-00 0.	0.	0.	DOYAS 147	
0.23405E 03 0.	0.25780E 03 0.36454E 01 0.34051E-00 0.	DOYAS 148		
0.	0.	0.45931E 03 0.	0.46306E 03 DOYAS 149	

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.3759E-01	0.1085E-00	0.	0.	0.	DOYAS190
C					
16 9 1207	CARBON-12	MICRO	295K	SPN-76	HONERTON
0.2242E-01	0.	0.1610E-01	0.1079E-01	0.	DOYAS192
0.	0.	0.	1.0000E-06	0.	DOYAS193
0.1267E-01	0.5003E-00	0.	0.	0.	DOYAS194
1.0000E-06	0.	0.2172E-01	0.1291E-01	0.4861E-00	DOYAS195
0.	0.	0.	1.0000E-06	0.	DOYAS196
0.2237E-01	0.8003E-00	0.	0.8052E-02	0.	DOYAS197
1.0000E-06	0.	0.3766E-01	0.3427E-01	0.6394E-00	DOYAS198
0.	0.6249E-03	0.	1.0000E-06	0.	DOYAS199
0.4133E-01	0.3387E-00	0.	0.	0.3719E-06	DOYAS200
1.0000E-06	0.	0.4352E-01	0.4233E-01	0.1602E-00	DOYAS201
0.	0.	0.	1.0000E-06	0.	DOYAS202
0.4269E-01	0.1190E-00	0.	0.	0.	DOYAS203
1.0000E-06	0.	0.4344E-01	0.4283E-01	0.9847E-01	DOYAS204
0.	0.	0.	1.0000E-06	0.	DOYAS205
0.4162E-01	0.6116E-01	0.	0.	0.	DOYAS206
1.0000E-06	0.	0.4344E-01	0.4114E-01	0.1823E-00	DOYAS207
0.	0.	0.	1.0000E-06	0.	DOYAS208
0.4197E-01	0.2303E-00	0.	0.	0.	DOYAS209
1.0000E-06	0.	0.4478E-01	0.4239E-01	0.1856E-00	DOYAS210
0.	0.	0.	1.0000E-06	0.	DOYAS211
0.4192E-01	0.2383E-00	0.	0.	0.	DOYAS212
1.0000E-06	0.	0.4613E-01	0.4495E-01	0.3647E-00	DOYAS213
0.	0.	0.	1.0000E-06	0.	DOYAS214
0.4691E-01	0.1181E-00	0.	0.	0.	DOYAS215
C					
16 9 1208	NITROGEN-14	MICRO	295K	SPN-76	HONERTON
0.3024E-00	0.	0.1362E-01	0.7597E-00	0.	DOYAS177
0.	0.	0.	0.1195E-00	0.	DOYAS178
0.1080E-01	0.2089E-00	0.	0.	0.	DOYAS179
0.3777E-01	0.	0.1594E-01	0.1124E-01	0.4037E-00	DOYAS180
0.	0.	0.	0.3962E-01	0.	DOYAS181
0.1508E-01	0.4326E-00	0.	0.4437E-02	0.	DOYAS182
0.1705E-02	0.	0.3172E-01	0.2903E-01	0.4988E-00	DOYAS183
0.	0.3337E-03	0.	0.1652E-02	0.	DOYAS184
0.4597E-01	0.2672E-00	0.	0.	0.	DOYAS185
0.3292E-02	0.	0.5823E-01	0.5671E-01	0.1684E-00	DOYAS186
0.	0.	0.	0.7710E-02	0.	DOYAS187
0.7015E-01	0.1481E-00	0.	0.	0.	DOYAS188
0.1745E-01	0.	0.8671E-01	0.8547E-01	0.1560E-00	DOYAS189
0.	0.	0.	0.3984E-01	0.	DOYAS190

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.8992E-01	0.1067E-00	0.	0.	0.	DOYAS191
0.7107E-01	0.	0.9575E-01	0.9085E-01	0.3290E-00	DOYAS192
0.	0.	0.	0.1259E-00	0.	DOYAS193
0.9285E-01	0.4183E-00	0.	0.	0.	DOYAS194
0.2243E-00	0.	0.9961E-01	0.9313E-01	0.3376E-00	DOYAS195
0.	0.	0.	0.3875E-00	0.	DOYAS196
0.9063E-01	0.4234E-00	0.	0.	0.	DOYAS197
0.6160E-00	0.	0.1035E-02	0.9531E-01	0.6372E-00	DOYAS198
0.	0.	0.	0.1262E-01	0.	DOYAS199
0.9982E-01	0.2075E-00	0.	0.	0.	DOYAS200
C					
16 9 1209	OXYGEN-16	MICRO	295K	SPN-76	HONERTON
0.4180E-01	0.	0.1615E-01	0.1198E-01	0.	DOYAS202
0.	0.	0.	0.2000E-05	0.	DOYAS203
0.1050E-01	0.3590E-00	0.	0.	0.	DOYAS204
0.2000E-05	0.	0.3809E-01	0.2497E-01	0.3766E-00	DOYAS205
0.	0.	0.	0.2000E-05	0.	DOYAS206
0.2784E-01	0.1311E-01	0.	0.1177E-01	0.	DOYAS207
0.2000E-05	0.	0.4000E-01	0.3802E-01	0.1217E-01	DOYAS208
0.	0.	0.	0.2000E-05	0.	DOYAS209
0.3264E-01	0.1982E-00	0.	0.	0.	DOYAS210
0.2000E-05	0.	0.3399E-01	0.3330E-01	0.8995E-01	DOYAS211
0.	0.	0.	0.2000E-05	0.	DOYAS212
0.3551E-01	0.6963E-01	0.	0.	0.	DOYAS213
0.2000E-05	0.	0.3641E-01	0.3605E-01	0.5869E-01	DOYAS214
0.	0.	0.	0.2000E-05	0.	DOYAS215
0.3533E-01	0.3602E-01	0.	0.	0.	DOYAS216
0.2000E-05	0.	0.3641E-01	0.3505E-01	0.1080E-00	DOYAS217
0.	0.	0.	0.2000E-05	0.	DOYAS218
0.3534E-01	0.1364E-00	0.	0.	0.	DOYAS219
0.2000E-05	0.	0.3641E-01	0.3506E-01	0.1077E-00	DOYAS220
0.	0.	0.	0.2000E-05	0.	DOYAS221
0.3437E-01	0.1354E-00	0.	0.	0.	DOYAS222
0.2000E-05	0.	0.3647E-01	0.3580E-01	0.2043E-00	DOYAS223
0.	0.	0.	0.2000E-05	0.	DOYAS224
0.3876E-01	0.6685E-01	0.	0.	0.	DOYAS225
C					
16 9 1210	SODIUM-23	MICRO	295K	SPN-76	HONERTON
0.3379E-02	0.	0.1411E-01	0.8531E-00	0.	DOYAS227
0.	0.	0.	0.2856E-03	0.	DOYAS228
0.1197E-01	0.4052E-00	0.	0.	0.	DOYAS229
0.1250E-03	0.	0.2467E-01	0.1518E-01	0.4352E-00	DOYAS230
0.	0.	0.	0.2235E-03	0.	DOYAS231

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED

0	35370E-01	0	94944E-00	0	0	45669E-01	0	0	DOYAS252		
0	68105E-03	0	0	0	36198E-01	0	34864E-01	0	54390E-00	DOYAS253	
0	0	0	29306E-03	0	0	0	12856E-02	0	0	41635E-01	DOYAS254
0	40857E-01	0	13271E-00	0	13395E-01	0	0	0	0	DOYAS255	
0	19403E-02	0	0	0	12026E-02	0	89912E-01	0	76581E-01	DOYAS256	
0	10208E-02	0	0	0	0	0	22820E-02	0	0	95953E-02	DOYAS257
0	95919E-02	0	30332E-01	0	0	0	0	0	0	DOYAS258	
0	51898E-02	0	0	0	29625E-01	0	29581E-01	0	31667E-01	DOYAS259	
0	0	0	0	0	70911E-07	0	13394E-01	0	0	29746E-01	DOYAS260
0	29031E-01	0	19160E-01	0	0	0	0	0	0	DOYAS261	
0	23439E-01	0	0	0	30007E-01	0	29037E-01	0	58147E-01	DOYAS262	
0	0	0	0	0	0	0	41594E-01	0	0	30255E-01	DOYAS263
0	29259E-01	0	73621E-01	0	0	0	0	0	0	DOYAS264	
0	68353E-01	0	0	0	30579E-01	0	29162E-01	0	58261E-01	DOYAS265	
0	0	0	0	0	0	0	10003E-00	0	0	30837E-01	DOYAS266
0	28737E-01	0	73270E-01	0	0	0	0	0	0	DOYAS267	
0	15906E-00	0	0	0	31536E-01	0	29400E-01	0	10992E-00	DOYAS268	
0	0	0	0	0	0	0	30603E-00	0	0	32411E-01	DOYAS269
0	29351E-01	0	34569E-01	0	0	0	0	0	0	DOYAS270	

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16	9	1211	ALUMINUM-27	MICRO	293K	SPN-76	HOWERTON				
0	43409E-01	0	0	15248E-01	0	68851E-00	0	DOYAS252			
0	0	0	0	33139E-02	0	0	0	19332E-01	DOYAS253		
0	14592E-01	0	41540E-00	0	0	0	0	DOYAS254			
0	19421E-04	0	0	23774E-01	0	19733E-01	0	37459E-00	67490E-01	DOYAS255	
0	0	0	0	0	0	51005E-03	0	0	29808E-01	DOYAS256	
0	26550E-01	0	38392E-00	0	32755E-01	0	25469E-00	0	0	DOYAS257	
0	18419E-02	0	0	44775E-01	0	43477E-01	0	32530E-00	20143E-01	DOYAS258	
0	63370E-01	0	55322E-01	0	0	60858E-02	0	0	55878E-01	DOYAS259	
0	53686E-01	0	12794E-00	0	0	0	0	0	DOYAS260		
0	44701E-02	0	0	12333E-01	0	12133E-01	0	13091E-01	0	DOYAS261	
0	0	0	0	0	0	50020E-02	0	0	0	14193E-01	DOYAS262
0	14016E-01	0	15558E-01	0	0	0	0	0	0	12328E-06	DOYAS263
0	50020E-02	0	0	14193E-01	0	14066E-01	0	12660E-01	0	DOYAS264	
0	0	0	0	0	0	70759E-02	0	0	0	14214E-01	DOYAS265
0	13912E-01	0	76691E-02	0	0	0	0	0	0	DOYAS266	
0	10659E-01	0	0	14250E-01	0	13851E-01	0	23142E-01	0	DOYAS267	
0	0	0	0	0	0	15902E-01	0	0	0	14302E-01	DOYAS268
0	13912E-01	0	29232E-01	0	0	0	0	0	0	DOYAS269	
0	26594E-01	0	0	14409E-01	0	13853E-01	0	23074E-01	0	DOYAS270	
0	0	0	0	0	0	44212E-01	0	0	0	14585E-01	DOYAS271
0	13706E-01	0	28992E-01	0	0	0	0	0	0	DOYAS272	
0	74052E-01	0	0	14897E-01	0	14019E-01	0	43715E-01	0	DOYAS273	
0	0	0	0	0	0	14266E-00	0	0	0	15618E-01	DOYAS274

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED

0	14191E-01	0	13829E-01	0	0	0	0	DOYAS275
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16	9	1212	SILICON	MICRO	293K	SPN-76	HOWERTON			
0	54508E-01	0	0	15914E-01	0	53421E-00	0	DOYAS277		
0	0	0	0	0	0	15855E-02	0	21492E-01	DOYAS278	
0	15667E-01	0	0	87931E-00	0	0	0	DOYAS279		
0	21028E-02	0	0	20938E-01	0	16794E-01	0	32321E-00	10903E-00	DOYAS280
0	0	0	0	0	0	32914E-02	0	0	31326E-01	DOYAS281
0	28637E-01	0	41234E-00	0	12241E-00	0	13549E-01	0	0	DOYAS282
0	64715E-02	0	0	42321E-01	0	41999E-01	0	26565E-00	0	DOYAS283
0	36628E-01	0	82262E-03	0	0	15941E-01	0	0	15264E-01	DOYAS284
0	14870E-01	0	23739E-01	0	0	0	15988E-02	0	0	DOYAS285
0	24501E-01	0	0	18963E-01	0	18502E-01	0	23423E-01	0	DOYAS286
0	0	0	0	72838E-02	0	24501E-01	0	0	20709E-01	DOYAS287
0	20289E-01	0	21594E-01	0	0	0	0	0	0	DOYAS288
0	24501E-01	0	0	20709E-01	0	20358E-01	0	17556E-01	0	DOYAS289
0	0	0	0	0	0	24501E-01	0	0	20709E-01	DOYAS290
0	20144E-01	0	10628E-01	0	0	0	0	0	0	DOYAS291
0	24501E-01	0	0	20709E-01	0	20059E-01	0	32082E-01	0	DOYAS292
0	0	0	0	0	0	24501E-01	0	0	20709E-01	DOYAS293
0	20145E-01	0	40525E-01	0	0	0	0	0	0	DOYAS294
0	24501E-01	0	0	20709E-01	0	20063E-01	0	31987E-01	0	DOYAS295
0	0	0	0	0	0	60062E-01	0	0	21075E-01	DOYAS296
0	19868E-01	0	40191E-01	0	0	0	0	0	0	DOYAS297
0	12420E-00	0	0	21735E-01	0	20302E-01	0	60666E-01	0	DOYAS298
0	0	0	0	0	0	15326E-00	0	0	22034E-01	DOYAS299
0	20502E-01	0	19070E-01	0	0	0	0	0	0	DOYAS300

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16	9	1213	PHOSPHORUS-31	MICRO	293K	SPN-76	HOWERTON				
0	10828E-00	0	0	19486E-01	0	63369E-00	0	DOYAS302			
0	0	0	0	0	0	23660E-01	0	20647E-01	DOYAS303		
0	15563E-01	0	57268E-00	0	0	0	0	DOYAS304			
0	10001E-01	0	0	16784E-01	0	14218E-01	0	35028E-00	14837E-00	DOYAS305	
0	0	0	0	0	0	10001E-01	0	0	22323E-01	DOYAS306	
0	20400E-01	0	24658E-00	0	13119E-00	0	37793E-00	0	0	DOYAS307	
0	10001E-01	0	0	29780E-01	0	28576E-01	0	18235E-00	0	DOYAS308	
0	32556E-02	0	10764E-00	0	0	10001E-01	0	0	37569E-01	DOYAS309	
0	56707E-01	0	11034E-00	0	0	0	0	0	0	DOYAS310	
0	10001E-01	0	0	44914E-01	0	44460E-01	0	56235E-01	0	DOYAS311	
0	0	0	0	10813E-06	0	10001E-01	0	0	0	35856E-01	DOYAS312
0	35501E-01	0	35393E-01	0	0	0	0	0	0	00000E-06	DOYAS313
0	10001E-01	0	0	33266E-01	0	33012E-01	0	25544E-01	0	DOYAS314	
0	0	0	1	00000E-06	0	10001E-01	0	0	33266E-01	DOYAS315	

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED

0 32700E 01 0 15441E 01 0 0 0 1 00000E-06 D0YAS316
 0 10120E-01 0 0 33267E 01 0 32577E 01 0 46650E-01 0 D0YAS317
 0 0 0 1 00000E 06 0 12183E 01 0 0 33275E 01 D0YAS318
 0 32690E 01 0 58926E-01 0 0 0 0 1 00000E-06 D0YAS319
 0 23407E 01 0 0 33262E 01 0 32447E 01 0 46380E-01 0 D0YAS320
 0 0 0 1 00000E-06 0 37676E-01 0 0 33366E 01 D0YAS321
 0 32100E 01 0 58095E 01 0 0 0 0 1 00000E-06 D0YAS322
 0 68591E 01 0 0 34691E 01 0 33711E 01 0 88990E-01 0 D0YAS323
 0 0 0 1 00000E-06 0 12264E-00 0 0 37441E 01 D0YAS324
 0 36215E 01 0 29452E 01 1 00000E-06 1 00000E-06 1 00000E-06 1 00000E-06 D0YAS325

C

16 9 1214 POTASSIUM MICRO 293K SPN-76 HONERTON
 0 16160E 00 0 0 18775E 01 0 10330E 01 0 0 D0YAS327
 0 0 0 0 67492E-01 0 0 20569E 01 D0YAS328
 0 18274E 01 0 33601E-00 0 0 0 D0YAS329
 0 18634E-01 0 0 16463E 01 0 14437E 01 0 15519E-00 0 14579E-00 D0YAS330
 0 0 0 0 10002E-01 0 0 15658E 01 D0YAS331
 0 14375E 01 0 18396E-00 0 37005E-02 0 17183E-00 0 0 D0YAS332
 0 10002E-01 0 0 22891E 01 0 22391E 01 0 11828E-00 0 D0YAS333
 0 0 0 29198E 01 0 0 10002E-01 0 0 35115E 01 D0YAS334
 0 34845E 01 0 43974E-01 0 0 0 29611E-02 0 0 D0YAS335
 0 10002E-01 0 0 26866E 01 0 26507E 01 0 17025E-01 0 D0YAS336
 0 0 0 0 12248E-03 0 10374E-01 0 0 29769E 01 D0YAS337
 0 29549E 01 0 25832E-01 0 0 0 1 00000E-06 D0YAS338
 0 23787E-01 0 0 19671E 01 0 19363E 01 0 11684E-01 0 D0YAS339
 0 0 0 1 00000E-06 0 39803E-01 0 0 19726E 01 D0YAS340
 0 19115E 01 0 70019E-02 0 0 0 1 00000E-06 D0YAS341
 0 83375E 01 0 0 20379E 01 0 19274E 01 0 21287E-01 0 D0YAS342
 0 0 0 1 00000E-06 0 13485E-00 0 0 21170E 01 D0YAS343
 0 19603E 01 0 27169E-01 0 0 0 1 00000E-06 D0YAS344
 0 23571E-00 0 0 22411E 01 0 19779E 01 0 21870E-01 0 D0YAS345
 0 0 0 1 00000E 06 0 35581E-00 0 0 23882E 01 D0YAS346
 0 19896E 01 0 27483E 01 0 0 0 1 00000E-06 D0YAS347
 0 64260E 00 0 0 27159E 01 0 20601E 01 0 42732E-01 0 D0YAS348
 0 0 0 1 00000E-06 0 12264E 01 0 0 32882E 01 D0YAS349
 0 20618E 01 0 13124E-01 1 00000E-06 1 00000E-06 1 00000E-06 1 00000E-06 D0YAS350

C

16 9 1215 IRON MICRO 293K SPN-76 HONERTON
 0 65437E-02 0 0 22112E 01 0 88390E 00 0 0 D0YAS352
 0 0 0 0 20000E-05 0 0 22438E 01 D0YAS353
 0 14750E 01 0 54302E 00 0 0 0 D0YAS354
 0 20000E-05 0 0 18923E 01 0 14095E 01 0 36892E-00 0 44459E-00 D0YAS355
 0 0 0 0 10650E-02 0 0 25706E 01 D0YAS356

C SERIES 1200 CROSS SECTION LIBRARY - LRL F WEIGHTED

0 24066E 01 0 21262E 00 0 33167E 00 0 29452E 00 0 0 D0YAS357
 0 10274E 01 0 0 36986E 01 0 36293E 01 0 16280E 00 0 27015E 00 D0YAS358
 0 68244E 01 0 39136E 01 0 0 19652E 01 0 0 79388E 01 D0YAS359
 0 78997E 01 0 59077E 01 0 0 0 0 0 D0YAS360
 0 25573E-01 0 0 76702E 01 0 76170E 01 0 19440E-01 0 D0YAS361
 0 0 0 0 0 29986E-01 0 0 57554E 01 D0YAS362
 0 56896E 01 0 27688E 01 0 0 0 0 D0YAS363
 0 43893E 01 0 0 10051E 02 0 99810E 01 0 35864E 01 0 D0YAS364
 0 0 0 0 13870E-03 0 81908E 01 0 0 10784E 02 D0YAS365
 0 10621E 02 0 26390E 01 0 0 0 0 D0YAS366
 0 13704E 00 0 0 10893E 02 0 10654E 02 0 80600E-01 0 D0YAS367
 0 10648E 02 0 10202E 00 0 0 0 0 D0YAS369
 0 0 0 0 0 17118E-00 0 0 10899E 02 D0YAS368
 0 27118E-00 0 0 10942E 02 0 10970E 02 0 79782E-01 0 D0YAS370
 0 0 0 0 0 47935E-00 0 0 11150E 02 D0YAS371
 0 10519E 02 0 10021E-00 0 0 0 0 D0YAS372
 0 76932E 00 0 0 11440E 02 0 10623E 02 0 15097E-00 0 D0YAS373
 0 0 0 0 0 15409E 01 0 0 12256E 02 D0YAS374
 0 10715E 02 0 47208E-01 0 0 0 0 D0YAS375

C

16 9 1216 GALLIUM MICRO 293K SPN-76 HONERTON
 0 31854E 02 0 0 22659E 01 0 37496E 00 0 0 D0YAS377
 0 0 0 0 0 79600E-02 0 0 25854E 01 D0YAS378
 0 10079E 01 0 48446E-00 0 0 0 D0YAS379
 0 98932E-02 0 0 33733E 01 0 21462E 01 0 34926E-00 0 37709E-00 D0YAS380
 0 0 0 0 0 15729E-01 0 0 44901E 01 D0YAS381
 0 39507E 01 0 75182E 00 0 87852E 00 0 67441E 00 0 0 D0YAS382
 0 33122E-01 0 0 59349E 01 0 58107E 01 0 48779E-00 0 45555E-00 D0YAS383
 0 34183E-00 0 15784E-00 0 0 70906E-01 0 0 69707E 01 D0YAS384
 0 68584E 01 0 90573E 01 0 35866E 01 0 97942E-02 0 0 D0YAS385
 0 82005E-01 0 0 75671E 01 0 74512E 01 0 41408E-01 0 56710E-03 D0YAS386
 0 0 0 0 0 92113E 01 0 0 88619E 01 D0YAS387
 0 87419E 01 0 33902E-01 0 0 0 0 D0YAS388
 0 63743E-01 0 0 21126E 02 0 21047E 02 0 27932E-01 0 D0YAS389
 0 0 0 0 0 57442E 01 0 0 69299E 01 D0YAS390
 0 68429E 01 0 15302E 01 0 0 0 0 52941E-06 D0YAS391
 0 10349E 00 0 0 53946E 01 0 52451E 01 0 29593E-01 0 D0YAS392
 0 0 0 0 0 25523E 00 0 0 66880E 01 D0YAS393
 0 63922E 01 0 46028E-01 0 0 0 0 D0YAS394
 0 43716E-00 0 0 73724E 01 0 68827E 01 0 40600E-01 0 D0YAS395
 0 0 0 0 0 77000E 00 0 0 7734E 01 D0YAS396
 0 68866E 01 0 52531E 01 0 0 0 0 D0YAS397
 0 12930E 01 0 0 80939E 01 0 67772E 01 0 76812E-01 0 D0YAS398
 0 0 0 0 0 20294E 01 0 0 83114E 01 D0YAS399

C SERIES 1200 CROSS SECTION LIBRARY - LRL F WEIGHTED

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0 62800E 01 0 23618E 01 0      0      0      0      DOYAS400
C
16 9 1217 NI0BIUM 93      MICRO  293K  SPN-76      HOWERTON
1 00000E-06 0      0 28899E 01 0 80482E 00 0      0      DOYAS402
0      0      0      0 19662E-03 0      0 37622E 01 DOYAS403
0 16541E 01 0 10749E 01 0      0      0      DOYAS404
0 12300E-01 0      0 43804E 01 0 31480E 01 0 40379E-00 0 59839E 00 DOYAS405
0      0      0      0 39183E-01 0      0 56195E 01 DOYAS406
0 53791E 01 0 54029E 00 0 10755E 01 0 35327E-00 0      0      DOYAS407
0 76323E-01 0      0 75576E 01 0 74010E 01 0 16449E-00 0 55957E 00 DOYAS408
0 61857E 00 0 62727E-01 0      0 14116E-00 0      0 78012E 01 DOYAS409
0 76307E 01 0 80215E-01 0 35262E-01 0 12016E 00 0 10045E-01 0      DOYAS410
0 27851E-00 0      0 67895E 01 0 64941E 01 0 29349E-01 0      DOYAS411
0      0      0      0 92915E 00 0      0 63801E 01 DOYAS412
0 54379E 01 0 16839E-01 0      0      0      DOYAS413
0 18499E 01 0      0 72103E 01 0 53526E 01 0 13008E-01 0      DOYAS414
0      0      0 15058E-02 0 16195E 01 0      0 69799E 01 DOYAS415
0 53367E 01 0 77987E-02 0      0      0      DOYAS416
0 11000E 01 0      0 64604E 01 0 53309E 01 0 25694E-01 0      DOYAS417
0      0      0      0 11000E 01 0      0 64604E 01 DOYAS418
0 53368E 01 0 29929E-01 0      0      0      DOYAS419
0 11000E 01 0      0 64604E 01 0 53307E 01 0 25620E-01 0      DOYAS420
0      0      0      0 11000E 01 0      0 64604E 01 DOYAS421
0 53157E 01 0 29664E-01 0      0      0      DOYAS422
0 11000E 01 0      0 64604E 01 0 53465E 01 0 44677E-01 0      DOYAS423
0      0      0      0 11000E 01 0      0 64604E 01 DOYAS424
0 53604E 01 0 13944E-01 0      0      0      DOYAS425
C
16 9 1218 MOLYBDENUM      MICRO  293K  SPN-76      HOWERTON
1 00000E-06 0      0 28171E 01 0 83588E 00 0      0      DOYAS427
0      0      0      0 73218E-02 0      0 35585E 01 DOYAS428
0 18731E 01 0 11044E 01 0      0      0      DOYAS429
0 14107E-01 0      0 46390E 01 0 32063E 01 0 75132E 00 0 52787E 00 DOYAS430
0      0      0      0 23049E-01 0      0 60165E 01 DOYAS431
0 54488E 01 0 98954E 00 0 77871E 00 0 29783E-00 0      0      DOYAS432
0 31615E-01 0      0 77696E 01 0 76632E 01 0 54466E 00 0 42900E 00 DOYAS433
0 14798E-00 0 63117E 01 0      0 37325E-01 0      0 75975E 01 DOYAS434
0 75312E 01 0 74817E 01 0      0      0      DOYAS435
0 39889E-01 0      0 69101E 01 0 68510E 01 0 28911E-01 0      DOYAS436
0      0      0      0 40000E-01 0      0 66098E 01 DOYAS437
0 65505E 01 0 19197E-01 0      0      0      DOYAS438
0 40000E-01 0      0 92495E 01 0 92016E 01 0 19227E-01 0      DOYAS439
0      0      0      0 28039E 02 0      0 51143E 02 DOYAS440

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C SERIES 1200 CROSS SECTION LIBRARY LRL F WEIGHTED

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0 23081E 02 0 79448E 02 0      0      0      0 52941E 00 DOYAS441
0 11495E-00 0      0 54572E 01 0 53129E 01 0 23020E 01 0      DOYAS442
0      0      0      0 17042E-00 0      0 57991E 01 DOYAS443
0 56034E 01 0 29349E 01 0      0      0      DOYAS444
0 31204E-00 0      0 62653E 01 0 59214E 01 0 25239E-01 0      DOYAS445
0      0      0      0 52034E 00 0      0 64803E 01 DOYAS446
0 59119E 01 0 31916E-01 0      0      0      DOYAS447
0 86685E 00 0      0 68268E 01 0 59450E 01 0 48068E 01 0      DOYAS448
0      0      0      0 16731E 01 0      0 76331E 01 DOYAS449
0 59600E 01 0 15001E-01 0      0      0      DOYAS450
C
16 9 1219 EUROPIUM      MICRO  293K  SPN 76      HOWERTON
0 84803E-02 0      0 34110E 01 0 93906E 00 0      0      DOYAS452
0      0      0      0 74260E-01 0      0 45255E 01 DOYAS453
0 23820E 01 0 13064E 01 0      0      0      DOYAS454
0 13923E 00 0      0 50864E 01 0 31975E 01 0 89259E 00 0 67995E 00 DOYAS455
0      0      0      0 17666E-00 0      0 71971E 01 DOYAS456
0 61753E 01 0 12239E 01 0 99703E 00 0 39868E-00 0      0      DOYAS457
0 46041E-00 0      0 96104E 01 0 90236E 01 0 83584E 00 0 52581E 00 DOYAS458
0 18957E 00 0 13602E 00 0      0 17081E 01 0      0 11101E 02 DOYAS459
0 93630E 01 0 12589E-00 0 92900E-02 0      0      DOYAS460
0 13700E 02 0      0 22628E 02 0 89127E 01 0 28468E-01 0 50277E 03 DOYAS461
0      0      0      0 43436E 02 0      0 51983E 02 DOYAS462
0 85333E 01 0 15056E-01 0      0      0      DOYAS463
0 62345E 02 0      0 71376E 02 0 90225E 01 0 13150E-01 0      DOYAS464
0      0      0      0 13841E 03 0      0 14654E 03 DOYAS465
0 81071E 01 0 78798E 02 0      0      0      DOYAS466
0 27413E 03 0      0 28209E 03 0 79358E 01 0 21283E 01 0      DOYAS467
0      0      0 1796E-02 0 50398E 03 0      0 51194E 03 DOYAS468
0 79415E 01 0 26882E-01 0      0      0      DOYAS469
0 63678E 03 0      0 64474E 03 0 79360E 01 0 21215E 01 0      DOYAS470
0      0      0      0 17400E 04 0      0 17480E 04 DOYAS471
0 79225E 01 0 26642E-01 0      0      0      DOYAS472
0 24479E 04 0      0 24559E 04 0 79502E 01 0 40118E-01 0      DOYAS473
0      0      0      0 17513E 04 0      0 17592E 04 DOYAS474
0 79627E 01 0 12507E 01 0      0      0      DOYAS475
C
16 9 1220 GADOLINIUM      MICRO  293K  SPN 76      HOWERTON
1 00000E 06 0      0 34422E 01 0 97881E 00 0      0      DOYAS477
0      0      0      0 67644E 01 0      0 45356E 01 DOYAS478
0 23908E 01 0 13062E 01 0      0      0      DOYAS479
0 13604E 00 0      0 50897E 01 0 32079E 01 0 89052E 00 0 67995E 00 DOYAS480

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C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

0 0 0 0 17544E-00 0 0 76320E 01D0YAS481
 0 66014E 01 0 12200E 01 0 99703E 00 0 39868E-00 0 0 D0YAS482
 0 28643E-00 0 0 10173E 02 0 97605E 01 0 84586E 00 0 52581E 00D0YAS483
 0 18957E-00 0 13602E-00 0 0 92272E 00 0 0 10889E 02D0YAS484
 0 99351E 01 0 12587E-00 0 92900E 02 0 0 0 D0YAS485
 0 26145E 01 0 0 12575E 02 0 99423E 01 0 30168E-01 0 50277E-03D0YAS486
 0 0 0 0 68779E 01 0 0 16793E 02D0YAS487
 0 99010E 01 0 17724E 01 0 0 0 0 D0YAS488
 0 19504E 02 0 0 29783E 02 0 10269E 02 0 14116E-01 0 D0YAS489
 0 0 0 0 31270E 02 0 0 42510E 02D0YAS490
 0 11191E 02 0 10542E 01 0 0 0 0 D0YAS491
 0 12397E 03 0 0 15694E 03 0 32938E 02 0 49474E-01 0 D0YAS492
 0 0 0 0 11796E-02 0 35823E 02 0 0 46646E 02D0YAS493
 0 10791E 02 0 34002E 01 0 0 0 0 D0YAS494
 0 22770E 03 0 0 24521E 03 0 17478E 02 0 31975E 01 0 D0YAS495
 0 0 0 0 0 11523E 03 0 0 12798E 03D0YAS496
 0 12673E 02 0 38525E 01 0 0 0 0 D0YAS497
 0 21170E 04 0 0 21418E 04 0 24682E 02 0 72972E 01 0 D0YAS498
 0 0 0 0 0 20687E 03 0 0 20811E 03D0YAS499
 0 12460E 03 0 15103E-00 0 0 0 0 D0YAS500

16 9 1221 TANTALUM-181 MICRO 293K SPN-76 HOWERTON
 0 33937E 01 0 0 37314E 01 0 12022E 01 0 0 D0YAS502
 0 0 0 0 0 98899E-01 0 0 46962E 01D0YAS503
 0 22657E 01 0 13784E 01 0 0 0 0 D0YAS504
 0 14435E-00 0 0 50337E 01 0 26760E 01 0 97308E 00 0 66676E 00D0YAS505
 0 0 0 0 0 20884E-00 0 0 56710E 01D0YAS506
 0 44175E 01 0 16093E 01 0 11396E 01 0 38534E-00 0 0 D0YAS507
 0 39526E-00 0 0 66952E 01 0 62099E 01 0 10447E 01 0 60396E 00D0YAS508
 0 21888E-00 0 10086E-00 0 0 98276E 00 0 0 90537E 01D0YAS509
 0 80531E 01 0 90048E-01 0 0 0 0 D0YAS510
 0 39645E 01 0 0 12784E 02 0 88098E 01 0 19805E-01 0 D0YAS511
 0 0 0 0 0 14657E 02 0 0 20619E 02D0YAS512
 0 59557E 01 0 10014E-01 0 0 0 0 D0YAS513
 0 24145E 02 0 0 29221E 02 0 50722E 01 0 64052E-02 0 D0YAS514
 0 0 0 0 0 96088E 02 0 0 10107E 03D0YAS515
 0 49689E 01 0 36626E 02 0 0 0 0 D0YAS516
 0 10480E 03 0 0 11230E 03 0 72535E 01 0 11143E-01 0 D0YAS517
 0 0 0 0 0 36138E 03 0 0 40557E 03D0YAS518
 0 44182E 02 0 25374E-00 0 0 0 0 D0YAS519
 0 68038E 01 0 0 11977E 02 0 51595E 01 0 12591E 01 0 D0YAS520
 0 0 0 0 0 57511E 01 0 0 10731E 02D0YAS521
 0 49590E 01 0 13948E 01 0 0 0 0 D0YAS522
 0 74946E 01 0 0 12475E 02 0 49735E 01 0 21003E 01 0 D0YAS523

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

0 0 0 0 12372E 02 0 0 17352E 02D0YAS524
 0 49800E 01 0 65460E 02 0 0 0 D0YAS525

16 9 1222 TUNGSTEN MICRO 293K SPN-76 HOWERTON
 0 15962E-01 0 0 37190E 01 0 11443E 01 0 0 D0YAS527
 0 0 0 0 59711E-01 0 0 47572E 01D0YAS528
 0 21322E 01 0 34252E-00 0 0 0 D0YAS529
 0 49427E-01 0 0 50541E 01 0 28521E 01 0 20538E-00 0 42933E-00D0YAS530
 0 0 0 0 0 77190E-01 0 0 57377E 01D0YAS531
 0 44854E 01 0 82233E 00 0 13096E 01 0 13938E 01 0 0 D0YAS532
 0 11823E-00 0 0 74408E 01 0 70953E 01 0 11199E 01 0 10738E 01D0YAS533
 0 92266E 00 0 45213E-00 0 0 23791E-00 0 0 10731E 02D0YAS534
 0 10489E 02 0 22724E 00 0 55136E-01 0 25654E-00 0 14946E-00 0 D0YAS535
 0 16940E 01 0 0 12307E 02 0 10602E 02 0 24236E-01 0 D0YAS536
 0 0 0 0 0 95712E 01 0 0 15552E 02D0YAS537
 0 59752E 01 0 10625E-01 0 0 0 D0YAS538
 0 44814E 02 0 0 49797E 02 0 49797E 01 0 60262E-02 0 D0YAS539
 0 0 0 0 0 30898E 02 0 0 35882E 02D0YAS540
 0 49724E 01 0 36060E-02 0 0 0 D0YAS541
 0 16566E 04 0 0 16616E 04 0 49699E 01 0 10971E-01 0 D0YAS542
 0 0 0 0 0 44608E 02 0 0 49592E 02D0YAS543
 0 49724E 01 0 13858E-01 0 0 0 D0YAS544
 0 39051E 01 0 0 88884E 01 0 49696E 01 0 10936E-01 0 D0YAS545
 0 0 0 0 0 35570E 01 0 0 85393E 01D0YAS546
 0 49617E 01 0 13733E-01 0 0 0 D0YAS547
 0 59581E 01 0 0 10902E 02 0 49378E 01 0 20599E-01 0 D0YAS548
 0 0 0 0 0 11470E 02 0 0 16429E 02D0YAS549
 0 49586E 01 0 63804E-02 0 0 0 D0YAS550

16 9 1223 GOLD-197 MICRO 293K SPN-76 HOWERTON
 0 18917E-01 0 0 38017E 01 0 10336E 01 0 0 D0YAS552
 0 0 0 0 0 99218E-01 0 0 44262E 01D0YAS553
 0 19521E 01 0 21007E-00 0 0 0 D0YAS554
 0 14598E-00 0 0 42023E 01 0 23315E 01 0 18509E-00 0 38449E-00D0YAS555
 0 0 0 0 0 20419E-00 0 0 47217E 01D0YAS556
 0 35942E 01 0 65847E 00 0 12134E 01 0 15812E 01 0 0 D0YAS557
 0 38041E-00 0 0 72934E 01 0 67022E 01 0 88015E 00 0 85897E 00D0YAS558
 0 84335E 00 0 62011E 00 0 0 63949E 00 0 0 96001E 01D0YAS559
 0 89435E 01 0 21081E-00 0 43122E-01 0 20742E-00 0 13303E-00 0 D0YAS560
 0 18062E 01 0 0 99481E 01 0 81332E 01 0 17178E-01 0 D0YAS561
 0 0 0 0 0 63929E 01 0 0 11797E 02D0YAS562
 0 53998E 01 0 87748E 02 0 0 0 0 D0YAS563
 0 17274E 02 0 0 21284E 02 0 40076E 01 0 44960E 02 0 D0YAS564

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

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0 0 0 0 57459E 02 0 0 56173E 0200YAS565
0 18700E 02 0 26900E 02 0 0 0 00YAS566
0 34204E 01 0 0 12590E 02 0 91283E 01 0 14106E 01 0 00YAS567
0 0 0 0 6650E-06 0 11156E 04 0 0 12913E 0400YAS568
0 17570E 03 0 40872E-01 0 0 0 1 00000E-0600YAS569
0 35761E 02 0 0 42300E 02 0 65203E 01 0 12845E-01 0 00YAS570
0 0 0 1 00000E-06 0 22845E 02 0 0 31659E 0200YAS571
0 87750E 01 0 18442E-01 0 0 0 1 00000E 0600YAS572
0 31211E 02 0 0 41178E 02 0 99546E 01 0 38567E-01 0 00YAS573
0 0 0 1 00000E-06 0 57903E 02 0 0 67797E 0200YAS574
0 98937E 01 0 12020E-01 1 00000E-06 1 00000E-06 1 00000E-06 1 00000E-0600YAS575
C
16 9 1224 LEAD MICRO 293K SPN-76 HONERTON
1 00000E-06 0 0 40474E 01 0 19962E 01 0 0 00YAS577
0 0 0 1 00000E-06 0 0 40778E 0100YAS578
0 30753E 01 0 73899E 00 0 0 0 0 00YAS579
0 21526E-04 0 0 45602E 01 0 41584E 01 0 31539E 00 0 75072E 0000YAS580
0 0 0 0 63481E-03 0 0 0 46623E 0100YAS581
0 45340E 01 0 25530E-00 0 51070E 00 0 50095E 00 0 0 00YAS582
1 00000E-03 0 0 69354E 01 0 68952E 01 0 12227E 00 0 16643E-0000YAS583
0 17640E-00 0 12795E-00 0 1 00000E-05 0 0 99862E 0100YAS584
0 99655E 01 0 39221E-01 0 0 0 0 00YAS585
1 00000E-03 0 0 10827E 02 0 10811E 02 0 19715E-01 0 0 00YAS586
0 0 0 0 10541E-02 0 0 10964E 0200YAS587
0 10952E 02 0 14768E-01 0 0 0 0 00YAS588
0 23892E-02 0 0 10966E 02 0 10956E 02 0 11749E 01 0 00YAS589
0 0 0 0 54650E-02 0 47549E-02 0 0 10968E 0200YAS590
0 10942E 02 0 70287E-02 0 0 0 0 00YAS591
0 77869E-02 0 0 10971E 02 0 10936E 02 0 21388E-01 0 0 00YAS592
0 0 0 0 11753E-01 0 0 10975E 0200YAS593
0 10942E 02 0 27015E-01 0 0 0 0 00YAS594
0 21514E 01 0 0 10985E 02 0 10937E 02 0 21320E-01 0 0 00YAS595
0 0 0 0 35979E-01 0 0 11048E 0200YAS596
0 10971E 02 0 26772E-01 0 0 0 0 00YAS597
0 63543E-01 0 0 11072E 02 0 10996E 02 0 40589E-01 0 0 00YAS598
0 0 0 0 11500E-00 0 0 11078E 0200YAS599
0 10963E 02 0 12562E-01 0 0 0 0 00YAS600
C
16 9 1225 URANIUM 235 MICRO 293K SPN-76 HONERTON
0 17928E 01 0 54784E 01 0 43975E 01 0 10942E 01 0 0 00YAS602
0 0 0 0 20420E 01 0 53121E 01 0 46937E 0100YAS603
0 14089E 01 0 13139E-00 0 0 0 0 00YAS604
0 20569E 01 0 50004E 01 0 49808E 01 0 20020E 01 0 10061E-00 0 21414E-0000YAS605

```

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

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0 0 0 0 21745E 01 0 50609E 01 0 59146E 0100YAS606
0 33507E 01 0 36477E 00 0 63378E 00 0 88247E 00 0 0 00YAS607
0 24995E 01 0 56904E 01 0 84546E 01 0 58931E 01 0 37210E-00 0 44838E-0000YAS608
0 43942E-00 0 33678E-00 0 0 33136E 01 0 72566E 01 0 11783E 0200YAS609
0 84536E 01 0 61971E-01 0 17315E-01 0 10880E 00 0 68967E-01 0 0 00YAS610
0 58780E 01 0 130 9E 02 0 15036E 02 0 91470E 01 0 16020E-01 0 0 00YAS611
0 0 0 0 96381E 01 0 21623E 02 0 21216E 0200YAS612
0 11566E 02 0 11209E-01 0 0 0 0 00YAS613
0 18072E 02 0 41254E 02 0 30374E 02 0 12296E 02 0 11859E-01 0 0 00YAS614
0 0 0 0 39342E 02 0 99393E 02 0 51310E 0200YAS615
0 11947E 02 0 68094E-02 0 0 0 0 00YAS616
0 87147E 02 0 18262E 03 0 99115E 02 0 11942E 02 0 20724E-01 0 0 00YAS617
0 0 0 0 13608E 03 0 26877E 03 0 14805E 0300YAS618
0 11947E 02 0 26176E-01 0 0 0 0 00YAS619
0 41237E 03 0 74632E 03 0 42407E 03 0 11677E 02 0 20657E-01 0 0 00YAS620
0 0 0 0 14421E 03 0 32442E 03 0 15618E 0300YAS621
0 11929E 02 0 25940E-01 0 0 0 0 00YAS622
0 20221E 03 0 44857E 03 0 21476E 03 0 12538E 02 0 39058E 01 0 0 00YAS623
0 0 0 0 36056E 03 0 82414E 03 0 37203E 0300YAS624
0 11466E 02 0 12169E-01 0 0 0 0 00YAS625
C
16 9 1226 URANIUM-234 MICRO 293K SPN-76 HONERTON
0 15575E 01 0 47484E 01 0 42237E 01 0 11394E 01 0 0 00YAS627
0 0 0 0 15347E 01 0 39585E 01 0 45393E 0100YAS628
0 15884E 01 0 13894E 00 0 0 0 00YAS629
0 13024E 01 0 31158E 01 0 48621E 01 0 24425E 01 0 11508E-00 0 22180E-0000YAS630
0 0 0 0 98420E 00 0 20449E 01 0 56281E 0100YAS631
0 40647E 01 0 43836E-00 0 71862E 00 0 86838E 00 0 0 00YAS632
0 37396E-00 0 30158E-00 0 83139E 01 0 78602E 01 0 95298E 00 0 54740E 0000YAS633
0 50236E 00 0 32845E-00 0 0 61484E 00 0 24570E 05 0 11451E 0200YAS634
0 10817E 02 0 79792E 01 0 26165E-01 0 13145E 00 0 80150E-01 0 0 00YAS635
0 12222E 01 0 24513E 05 0 13168E 02 0 11932E 02 0 19792E-01 0 0 00YAS636
0 0 0 0 24008E 01 0 24502E 05 0 14369E 0200YAS637
0 11957E 02 0 14254E 01 0 0 0 0 00YAS638
0 42365E 01 0 24500E 05 0 16205E 02 0 11961E 02 0 11335E-01 0 0 00YAS639
0 0 0 0 69144E 01 0 24500E 05 0 18882E 0200YAS640
0 11947E 02 0 67799E 02 0 0 0 0 00YAS641
0 10222E 02 0 24500E-05 0 22190E 02 0 11942E 02 0 20634E-01 0 0 00YAS642
0 0 0 0 15464E 02 0 24500E-05 0 27432E 0200YAS643
0 11947E 02 0 26063E 01 0 0 0 0 00YAS644
0 23183E 02 0 24500E 05 0 35151E 02 0 11942E 02 0 20568E-01 0 0 00YAS645
0 0 0 0 34951E 02 0 24500E 05 0 46919E 0200YAS646
0 11929E 02 0 25828E 01 0 0 0 0 00YAS647
0 52899E 02 0 24500E 05 0 64867E 02 0 11956E 02 0 38889E 01 0 00YAS648

```

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

```

0 0 0 0 74110E 02 0 24500E-05 0 86086E 020YAS649
0 11968E 02 0 12116E 01 0 0 0 0 0 0YAS650
C
16 9 1227 URANIUM 235 MICRO 293K SPN 76 HOWERTON
0 13205E 01 0 40238E 01 0 43136E 01 0 11290E 01 0 0 0YAS652
0 0 0 0 0 0 13328E 01 0 33335E 01 0 46121E 010YAS653
0 15568E 01 0 15762E 00 0 0 0 0 0 0YAS654
0 12812E 01 0 29774E 01 0 50182E 01 0 25835E 01 0 14267E-00 0 26333E-000YAS655
0 0 0 0 0 0 13398E 01 0 28750E 01 0 56724E 010YAS656
0 0 0 0 0 0 0 0 0 0 0YAS657
0 38901E 01 0 76081E 00 0 10965E 01 0 10989E 01 0 0 0
0 17456E 01 0 33948E 01 0 86670E 01 0 68184E 01 0 40747E-00 0 38926E-000YAS658
0 48338E 00 0 41969E 00 0 0 0 31901E 01 0 56692E 01 0 12845E 020YAS659
0 96372E 01 0 68483E 01 0 23498E-01 0 34322E-02 0 0 0YAS660
0 57258E 01 0 91819E 01 0 16647E 02 0 10908E 02 0 17891E-01 0 34601E-010YAS661
0 11545E 01 0 0 0 0 10087E 02 0 16275E 02 0 21058E 020YAS662
0 10960E 02 0 13010E 01 0 0 0 0 0 0 0YAS663
0 25372E 02 0 40934E 02 0 36342E 02 0 10964E 02 0 10346E-01 0 0YAS664
0 0 0 0 0 0 48827E 02 0 78775E 02 0 59817E 020YAS665
0 10971E 02 0 61880E-02 0 0 0 0 0 0 0YAS666
0 10839E 03 0 17487E 03 0 11933E 03 0 10923E 02 0 18833E-01 0 0YAS667
0 0 0 0 0 0 11741E 03 0 17010E 03 0 12965E 030YAS668
0 12223E 02 0 23788E-01 0 0 0 0 0 0 0YAS669
0 30788E 02 0 51187E 02 0 44177E 02 0 13358E 02 0 22186E-01 0 0YAS670
0 0 0 0 0 0 76582E 02 0 16022E 03 0 90544E 020YAS671
0 13917E 02 0 30003E 01 0 0 0 0 0 0 0YAS672
0 21334E 03 0 41562E 03 0 22731E 03 0 13949E 02 0 45174E-01 0 0YAS673
0 0 0 0 0 0 38290E 03 0 78122E 03 0 39686E 030YAS674
0 13963E 02 0 14075E-01 0 0 0 0 0 0 0YAS675

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C
16 9 1228 URANIUM 236 MICRO 293K SPN-76 HOWERTON
0 10086E 01 0 30949E 01 0 42249E 01 0 11632E 01 0 0 0YAS677
0 0 0 0 0 0 82390E 00 0 21065E 01 0 45323E 010YAS678
0 15629E 01 0 17467E 00 0 0 0 0 0 0 0YAS679
0 53129E 00 0 12295E 01 0 48855E 01 0 24498E 01 0 15434E-00 0 29227E-000YAS680
0 0 0 0 0 0 13971E 00 0 11259E-00 0 55649E 010YAS681
0 41249E 01 0 71368E 00 0 10869E 01 0 12033E 01 0 0 0YAS682
0 13632E-00 0 24208E 05 0 84237E 01 0 79627E 01 0 12381E 01 0 96265E 000YAS683
0 77589E 00 0 45831E 00 0 0 0 23764E-00 0 23976E-05 0 11068E 020YAS684
0 10808E 02 0 32458E 00 0 62222E 01 0 22811E 00 0 12886E 00 0
0 15128E 01 0 23914E 05 0 13458E 02 0 11931E 02 0 20336E-01 0 0
0 0 0 0 0 0 18135E 02 0 23903E-05 0 30103E 020YAS687
0 11957E 02 0 14132E 01 0 0 0 0 0 0 0YAS688
0 26110E 02 0 23900E 05 0 38078E 02 0 11961E 02 0 11238E-01 0 0YAS689

```

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

```

0 0 0 0 32240E 02 0 23900E-05 0 44208E 020YAS690
0 11948E 02 0 67216E-02 0 0 0 0 0 0YAS691
0 35604E 01 0 23900E-05 0 15528E 02 0 11942E 02 0 20457E-01 0 0YAS692
0 0 0 0 0 0 50257E 03 0 29300E 05 0 51453E 03
0 11948E 02 0 25839E-01 0 0 0 0 0 0YAS694
0 50000E 00 0 23900E 05 0 12468E 02 0 11942E 02 0 20391E-01 0 0YAS695
0 0 0 0 0 0 50000E 00 0 23900E-05 0 12468E 020YAS696
0 11929E 02 0 25606E-01 0 0 0 0 0 0YAS697
0 50000E 00 0 23900E 05 0 12468E 02 0 11956E 02 0 38535E-01 0 0YAS698
0 0 0 0 0 0 15163E 01 0 23900E-05 0 13484E 020YAS699
0 11968E 02 0 12012E-01 0 0 0 0 0 0YAS700

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C
16 9 1229 URANIUM-238 MICRO 293K SPN-76 HOWERTON
0 61587E 00 0 18627E 01 0 41865E 01 0 11920E 01 0 0 0YAS702
0 0 0 0 0 0 49775E-00 0 11853E 01 0 46066E 010YAS703
0 17231E 01 0 19895E 00 0 0 0 0 0 0YAS704
0 18265E 00 0 90486E-01 0 49969E 01 0 28063E 01 0 17356E 00 0 33533E-000YAS705
0 0 0 0 0 0 16418E-00 0 24229E-05 0 56996E 010YAS706
0 45340E 01 0 76634E 00 0 12069E 01 0 14177E 01 0 0 0YAS707
0 16439E-00 0 23655E-05 0 83901E 01 0 78316E 01 0 95429E 00 0 99929E 000YAS708
0 86096E 00 0 54014E 00 0 0 0 39296E-00 0 23387E-05 0 12127E 020YAS709
0 11712E 02 0 39419E 00 0 47205E-01 0 24224E 00 0 14236E 00 0
0 64032E 00 0 23316E-05 0 14207E 02 0 13551E 02 0 21907E-01 0 0YAS711
0 0 0 0 0 0 16462E 01 0 23303E-05 0 16008E 020YAS712
0 14348E 02 0 16345E-01 0 0 0 0 0 0YAS713
0 67742E 01 0 23301E-05 0 23048E 02 0 16069E 02 0 14501E-01 0 0YAS714
0 0 0 0 0 0 20261E 02 0 23300E-05 0 49770E 020YAS715
0 29501E 02 0 20541E-00 0 0 0 0 0 0YAS716
0 47744E 02 0 23300E-05 0 71379E 02 0 23618E 02 0 83066E-02 0 0YAS717
0 0 0 0 0 0 15153E 03 0 23300E-05 0 16918E 03
0 17636E 02 0 17052E-01 0 0 0 0 0 0YAS719
0 36361E-00 0 23300E-05 0 93712E 01 0 89885E 01 0 15231E-01 0 0YAS720
0 0 0 0 0 0 69728E 00 0 23300E-05 0 95373E 010YAS721
0 88124E 01 0 19083E-01 0 0 0 0 0 0YAS722
0 11721E 01 0 23300E-05 0 97308E 01 0 85503E 01 0 27570E-01 0 0YAS723
0 0 0 0 0 0 16833E 01 0 23300E-05 0 10020E 020YAS724
0 85365E 01 0 84066E 02 0 0 0 0 0 0YAS725

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C
16 9 1230 PLUTONIUM-239 MICRO 293K SPN-76 HOWERTON
0 19724E 01 0 67874E 01 0 44982E 01 0 10771E 01 0 0 0YAS727
0 0 0 0 0 0 20926E 01 0 62535E 01 0 47634E 010YAS728
0 16042E 01 0 12471E-00 0 0 0 0 0 0YAS729
0 19362E 01 0 54734E 01 0 51209E 01 0 25025E 01 0 10236E-00 0 20577E-000YAS730

```

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

0	0	0	0	18705E	01	0	49594E	01	0	60220E	01	0	010YAS791
0	38194E	01	0	45663E	00	0	66853E	00	0	83878E	00	0	0YAS792
0	19462E	01	0	46766E	01	0	90035E	01	0	69556E	01	0	30085E-00
0	29568E	00	0	32119E	-00	0			0	27572E	01	0	55639E
0	10061E	02	0	67352E	-01	0	19804E	-01	0	19990E	-02	0	0YAS795
0	43876E	01	0	82962E	01	0	15842E	02	0	11441E	02	0	18737E
0	11473E	-01	0	0	0	0	0	0	0	66916E	01	0	16491E
0	11027E	02	0	12946E	-01	0	0	0	0	0	0	0	0YAS798
0	16502E	02	0	32420E	02	0	27472E	02	0	10965E	02	0	10170E
0	0	0	0	0	0	0	0	0	0	99082E	02	0	15001E
0	12465E	02	0	60830E	-02	0	0	0	0	0	0	0	0YAS740
0	19287E	03	0	26383E	03	0	21126E	03	0	18379E	02	0	18399E
0	0	0	0	0	0	0	0	0	0	97009E	02	0	13761E
0	11338E	02	0	15297E	-01	0	0	0	0	0	0	0	10836E
0	21747E	02	0	53980E	02	0	32649E	02	0	10877E	02	0	17434E
0	0	0	0	0	0	0	0	0	0	19015E	03	0	28836E
0	13191E	02	0	25477E	-01	0	0	0	0	0	0	0	16340E
0	27244E	04	0	46530E	04	0	27412E	04	0	16805E	02	0	58322E
0	0	0	0	0	0	0	0	0	0	74648E	03	0	14153E
0	96098E	01	0	94773E	-02	0	0	0	0	0	0	0	0YAS790

[illegible]

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED

```

0          0          0          0 18630E 03 0 28100E-01 0 20027E 03D0v45774
0 13963E 02 0 13777E-01 0          0          0          0D0v45775

```

[illegible][illegible]

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.	0.	0.	0.14966E-01	0.	0.34098E 01	DOYAS194
0.33324E 01	0.20685E-01	0.	0.	0.	0.	DOYAS195
0.14991E-01	0.	0.34098E 01	0.53160E 01	0.62351E-01	0.	DOYAS196
0.	0.	0.	0.14998E-01	0.	0.34098E 01	DOYAS197
0.33326E 01	0.78760E-01	0.	0.	0.	0.	DOYAS198
0.15000E-01	0.	0.34098E 01	0.53167E 01	0.62170E-01	0.	DOYAS199
0.	0.	0.	0.20403E-01	0.	0.33820E 01	DOYAS200
0.32464E 01	0.78122E-01	0.	0.	0.	0.	DOYAS201
0.30146E-01	0.	0.33319E 01	0.52660E 01	0.11522E-00	0.	DOYAS202
0.	0.	0.	0.39259E-01	0.	0.32658E 01	DOYAS203
0.32246E 01	0.35798E-01	0.	0.	0.	0.	DOYAS204

C

C

16 9 3268	RHENIUM	MICRO	295K	SPN-76	DOYAS
.154	0.	4.0503	1.1851	0.	0.
0.	0.	0.	.2138	0.	5.07084
2.1951	.5547	0.	0.	0.	0.
.2543	0.	5.03041	2.7214	.2096	.4446
0.	0.	0.	.3062	0.	5.35317
3.9987	.7847	1.3483	1.4436	0.	0.
.4216	0.	7.01241	6.3859	.9984	1.0246
.9499	.4685	0.	1.021	0.	11.17426
10.1299	.2045	.0492	.2448	.1539	0.
3.735	0.	15.70696	11.9599	.0234	0.
0.	0.	0.	11.96	0.	33.88667
21.913	0.012	0.	0.	0.	0.
38.92	0.	64.83333	25.894	.0221	0.
0.	0.	0.	91.98	0.	117.89333
25.856	.0188	0.	0.	0.	0.
66.68	0.	90.6	23.853	.057	0.
0.	0.	0.	78.6	0.	108.5
29.8343	.0665	0.	0.	0.	0.
305.39	0.	345.26667	39.756	.0656	0.
0.	0.	0.	10.0	0.	23.95333
13.895	.1099	0.	0.	0.	0.
26.0	0.	39.95333	13.934	.0577	0.
0.	0.	0.	46.0	0.	59.95333
13.953	.018	0.	0.	0.	0.

C

C

16 9 3270	I/V	MICRO	295K	SPN-76	DOYAS
7.6190E-5	0.0	7.6190E-5	0.0	0.0	0.0
0.0	0.0	0.0	0.0001141	0.0	0.0001141
0.0	0.0	0.0	0.0	0.0	0.0
0.0001507	0.0	0.0001507	0.0	0.0	0.0

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.0	0.0	0.0	0.0002067	0.0	0.0002067	5
0.0	0.0	0.0	0.0	0.0	0.0	6
0.0003462	0.0	0.0003462	0.0	0.0	0.0	7
0.0	0.0	0.0	0.0007146	0.0	0.0007146	8
0.0	0.0	0.0	0.0	0.0	0.0	9
0.001659	0.0	0.001659	0.0	0.0	0.0	10
0.0	0.0	0.0	0.003817	0.0	0.003817	11
0.0	0.0	0.0	0.0	0.0	0.0	12
0.008666	0.0	0.008666	0.0	0.0	0.0	13
0.0	0.0	0.0	0.01951	0.0	0.01951	14
0.0	0.0	0.0	0.0	0.0	0.0	15
0.03525	0.0	0.03525	0.0	0.0	0.0	16
0.0	0.0	0.0	0.06171	0.0	0.06171	17
0.0	0.0	0.0	0.0	0.0	0.0	18
0.1114	0.0	0.1114	0.0	0.0	0.0	19
0.0	0.0	0.0	0.1889	0.0	0.1889	20
0.0	0.0	0.0	0.0	0.0	0.0	21
0.3136	0.0	0.3136	0.0	0.0	0.0	22
0.0	0.0	0.0	0.6745	0.0	0.6745	23
0.0	0.0	0.0	0.0	0.0	0.0	24

C

C

16 9 1240	TRITIUM	MICRO	295K	SPN-76	HOMERTON
0.	0.	0.16083E 01	0.44451E-00	0.	DOYAS 52
0.	0.	0.	0.	0.	0.21522E 01
0.62293E 00	0.74209E 00	0.	0.	0.	DOYAS 54
0.	0.	0.19128E 01	0.38114E-00	0.52977E 00	0.37102E-00
0.	0.	0.	0.	0.	0.15947E 01
0.48535E-00	0.10071E 01	0.97329E 00	0.51720E-01	0.	DOYAS 57
0.	0.	0.11894E 01	0.69789E 00	0.11093E 01	0.52454E 00
0.26207E-01	0.83760E-03	0.	0.	0.	0.10245E 01
0.79660E 00	0.49153E-00	0.14657E-04	0.	0.	DOYAS 60
0.	0.	0.10133E 01	0.82021E 00	0.22793E-00	0.
0.	0.	0.	0.	0.	0.10133E 01
0.83852E 00	0.19307E-00	0.	0.	0.	DOYAS 63
0.	0.	0.10133E 01	0.87652E 00	0.17476E-00	0.
0.	0.	0.	0.	0.	0.10133E 01
0.64338E 00	0.13616E-00	0.	0.	0.	DOYAS 66
0.	0.	0.10133E 01	0.57671E 00	0.36494E-00	0.60540E-03
0.	0.	0.	0.	0.	0.10133E 01
0.64364E 00	0.43427E-00	0.49653E-02	0.	0.	DOYAS 69
0.	0.	0.10133E 01	0.57748E 00	0.36469E-00	0.23021E-02
0.	0.	0.	0.	0.	0.10133E 01
0.45487E-00	0.41587E-00	0.49521E-02	0.	0.	DOYAS 72
0.	0.	0.10133E 01	0.75963E 00	0.55841E 00	0.19922E-01

C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

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0 0 0 0 0 0 10133E 01DOYAS 74
0 10133E 01 0 25365E 00 0 19859E 05 0 0 DOYAS 75
C
16 9 1241 HELIUM 3 MICRO 293K SPN-76 HOWERTON
0 45949E 00 0 0 15674E 01 0 23862E-00 0 0 DOYAS 53
0 0 0 0 0 81019E 00 0 0 26189E 01DOYAS 54
0 45443E-00 0 62117E 00 0 0 DOYAS 55
0 88172E 00 0 0 27814E 01 0 29877E-00 0 56761E 00 0 21995E-00DOYAS 56
0 0 0 0 0 92294E 00 0 0 24732E 01DOYAS 57
0 39416E 00 0 11216E 01 0 76441E 00 0 28198E-01 0 0 DOYAS 58
0 13586E 01 0 0 28037E 01 0 86916E 00 0 11561E 01 0 47929E-00DOYAS 59
0 22314E 01 0 0 38096E-02 0 57411E 01 0 0 47941E 01DOYAS 60
0 84589E 00 0 57597E 00 0 92027E-05 0 0 DOYAS 61
0 88403E 01 0 0 96415E 01 0 65267E 00 0 20707E-00 0 DOYAS 62
0 0 0 0 0 19632E 02 0 0 20411E 02DOYAS 63
0 64501E 00 0 14853E-00 0 0 DOYAS 64
0 46299E 02 0 0 47078E 02 0 67424E 00 0 13443E-00 0 DOYAS 65
0 0 0 0 0 10569E 03 0 0 10643E 03DOYAS 66
0 49490E-00 0 10474E 00 0 0 DOYAS 67
0 18925E 03 0 0 19002E 03 0 44362E-00 0 28072E-00 0 46574E-03DOYAS 68
0 0 0 0 0 33156E 03 0 0 33234E 03DOYAS 69
0 49510E-00 0 33406E-00 0 38197E-02 0 0 DOYAS 70
0 59887E 03 0 0 59965E 03 0 44422E-00 0 28053E-00 0 17710E-02DOYAS 71
0 0 0 0 0 10133E 04 0 0 10140E 04DOYAS 72
0 34990E-00 0 31990E-00 0 38096E 02 0 0 DOYAS 73
0 16751E 04 0 0 16759E 04 0 58433E 00 0 42995E-00 0 15326E-01DOYAS 74
0 0 0 0 0 32345E 04 0 0 32533E 04DOYAS 75
0 77945E 00 0 19511E-00 0 15335E 05 0 0 DOYAS 76

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C
16 9 1242 HELIUM-4 MICRO 293K SPN-76 HOWERTON
0 0 0 0 12460E 01 0 32567E-00 0 0 DOYAS 81
0 0 0 0 0 0 0 26029E 01DOYAS 82
0 60891E 00 0 87102E 00 0 0 DOYAS 83
0 0 0 0 57521E 01 0 15105E 01 0 13349E 01 0 49317E-01DOYAS 84
0 0 0 0 0 0 0 28138E 01DOYAS 85
0 13203E 01 0 38356E 01 0 65910E 00 0 0 DOYAS 86
0 0 0 0 98443E 00 0 73617E 00 0 14936E 01 0 40597E-00DOYAS 87
0 0 0 0 0 0 0 68966E 00DOYAS 88
0 59517E 00 0 24825E-00 0 0 DOYAS 89
0 0 0 0 60958E 00 0 53781E 00 0 94492E-01 0 DOYAS 90
0 0 0 0 0 0 0 60829E 00DOYAS 91
0 54589E 00 0 71776E-01 0 0 DOYAS 92
0 0 0 0 60829E 00 0 56296E 00 0 64402E 01 0 DOYAS 93

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C SERIES 1200 CROSS SECTION LIBRARY LRL-F WEIGHTED

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0 0 0 0 0 0 60829E 00DOYAS 94
0 47795E-00 0 45335E-01 0 0 DOYAS 95
0 0 0 0 60829E 00 0 44359E-00 0 13034E 00 0 DOYAS 96
0 0 0 0 0 0 0 60829E 00DOYAS 97
0 47811E-00 0 16470E-00 0 0 DOYAS 98
0 0 0 0 60829E 00 0 44409E 00 0 13018E-00 0 DOYAS 99
0 36560E-00 0 16346E 00 0 0 60829E 00DOYAS100
0 0 0 0 60829E 00 0 52554E 00 0 24269E 00 0 73349E-03DOYAS102
0 0 0 0 0 0 0 60829E 00DOYAS103
0 60829E 00 0 82750E-01 0 0 DOYAS104

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C
16 9 1243 BORON-10 MICRO 293K SPN-76 HOWERTON
0 15507E-00 0 0 12179E 01 0 46728E-00 0 0 DOYAS109
0 0 0 0 0 29466E-00 0 0 19618E 01DOYAS110
0 10594E 01 0 40527E-00 0 0 DOYAS111
0 20617E 00 0 0 21330E 01 0 99253E 00 0 54621E 00 0 71531E-01DOYAS112
0 0 0 0 0 47490E-00 0 0 31609E 01DOYAS113
0 19458E 01 0 93409E 00 0 50982E-01 0 91365E-01 0 DOYAS114
0 11748E 01 0 0 45976E 01 0 31569E 01 0 74022E 00 0 19780E-03DOYAS115
0 10547E-01 0 27375E-01 0 0 29985E 01 0 0 49751E 01DOYAS116
0 18994E 01 0 26593E-00 0 0 DOYAS117
0 51148E 01 0 0 78604E 01 0 26263E 01 0 77238E-01 0 DOYAS118
0 0 0 0 0 12515E 02 0 0 16089E 02DOYAS119
0 34708E 01 0 11928E 00 0 0 DOYAS120
0 30760E 02 0 0 34483E 02 0 36558E 01 0 10385E-00 0 DOYAS121
0 0 0 0 0 71251E 02 0 0 74984E 02DOYAS122
0 35366E 01 0 66421E-01 0 0 DOYAS123
0 13299E 03 0 0 13672E 03 0 34847E 01 0 19722E 00 0 DOYAS124
0 0 0 0 0 24111E 03 0 0 24485E 03DOYAS125
0 35371E 01 0 24915E-00 0 0 DOYAS126
0 43746E 03 0 0 44120E 03 0 34864E 01 0 19674E-00 0 DOYAS127
0 0 0 0 0 72396E 03 0 0 72769E 03DOYAS128
0 33597E 01 0 24749E-00 0 0 DOYAS129
0 12081E 04 0 0 12118E 04 0 36144E 01 0 37417E-00 0 DOYAS130
0 0 0 0 0 23509E 04 0 0 23546E 04DOYAS131
0 37339E 01 0 11951E-00 0 0 DOYAS132

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C
16 9 1244 FLUORINE MICRO 293K SPN-76 HOWERTON
0 98884E 01 0 0 15347E 01 0 34344E 00 0 0 DOYAS133
0 0 0 0 0 70000E 03 0 0 24686E 01DOYAS138
0 17939E 01 0 66379E 00 0 0 DOYAS139
0 70000E 03 0 0 29042E 01 0 19563E 01 0 54524E 00 0 11371E 00DOYAS140

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C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.	0.	0.	0.13200E-01 0.	0.13309E 01D0YAS290
0.13036E 01	0.46383E-02 0.	0.	0.	0. D0YAS291
0.15996E-01 0.	0.13279E 01	0.12943E 01	0.14040E-01 0.	0. D0YAS292
0.	0.	0.20176E-01 0.	0.13291E 01D0YAS293	0.
0.12073E 01	0.17602E-01 0.	0.	0.	0. D0YAS294
0.50833E-01 0.	0.13290E 01	0.12534E 01	0.13591E-01 0.	0. D0YAS295
0.	0.	0.05159E-01 0.	0.13289E 01D0YAS296	0.
0.12193E 01	0.16801E-01 0.	0.	0.	0. D0YAS297
0.14191E-00 0.	0.13330E 01	0.11037E 01	0.24409E-01 0.	0. D0YAS298
0.	0.	0.27104E-00 0.	0.10275E 01D0YAS299	0.
0.15565E 01	0.81940E-02 0.	0.	0.	0. D0YAS300

16 9 1249	TITANIUM	MICRO	295K	SPN-76	HOWERTON
1.00000E-06 0.	0.21493E 01	0.90075E 00 0.	0.	0. D0YAS305	0.
0.	0.	1.00000E-06 0.	0.26917E 01D0YAS306	0.	0.
0.20159E 01	0.54889E 00 0.	0.	0.	0. D0YAS307	0.
0.49409E-03 0.	0.23016E 01	0.19355E 01	0.52950E 00 0.	0.13555E-00D0YAS308	0.
0.	0.	0.14675E-01 0.	0.22311E 01D0YAS309	0.	0.
0.20746E 01	0.35486E-00 0.	0.14619E-00 0.	0.40217E-00 0.	0. D0YAS310	0.
0.20000E-01 0.	0.28050E 01	0.27876E 01	0.14182E-00 0.	0.10662E-01D0YAS311	0.
0.	0.82509E-01 0.	0.20000E-01 0.	0.17456E 02D0YAS312	0.	0.
0.16611E 02	0.70216E-01 0.	0.	0.	0. D0YAS313	0.
0.21429E-01 0.	0.30711E 02	0.30659E 02	0.02564E 00 0.	0. D0YAS314	0.
0.	0.	0.28689E-01 0.	0.47926E 01D0YAS315	0.	0.
0.47438E 01	0.29927E-01 0.	0.	0.	0. D0YAS316	0.
0.54761E-01 0.	0.41960E 01	0.41292E 01	0.20022E-01 0.	0. D0YAS317	0.
0.	0.	0.13805E-06 0.	0.11934E-00 0.	0.42609E 01D0YAS318	0.
0.41047E 01	0.12049E-01 0.	0.	0.	0. D0YAS319	0.
0.23360E-00 0.	0.43740E 01	0.40931E 01	0.36511E-01 0.	0. D0YAS320	0.
0.	0.	0.38425E-00 0.	0.45255E 01D0YAS321	0.	0.
0.41040E 01	0.46110E-01 0.	0.	0.	0. D0YAS322	0.
0.66304E 00 0.	0.48042E 01	0.40935E 01	0.36399E-01 0.	0. D0YAS323	0.
0.	0.	0.11186E 01 0.	0.52598E 01D0YAS324	0.	0.
0.40723E 01	0.45721E-01 0.	0.	0.	0. D0YAS325	0.
0.10473E 01 0.	0.59885E 01	0.41196E 01	0.68891E-01 0.	0. D0YAS326	0.
0.	0.	0.35920E 01 0.	0.77340E 01D0YAS327	0.	0.
0.41412E 01	0.21550E-01 0.	0.	0.	0. D0YAS328	0.

16 9 1250	MANGANESE	MICRO	295K	SPN-76	HOWERTON
0.49419E-03 0.	0.22410E 01	0.88893E 00 0.	0.	0. D0YAS333	0.
0.	0.	0.24594E-02 0.	0.25314E 01D0YAS334	0.	0.
0.15982E 01	0.53776E 00 0.	0.	0.	0. D0YAS335	0.
0.35116E-02 0.	0.24267E 01	0.15212E 01	0.42780E-00 0.	0.46170E-00D0YAS336	0.

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.	0.	0.	0.42219E-02 0.	0.29083E 01D0YAS337
0.24701E 01	0.43804E-00 0.	0.41316E-00 0.	0.30938E-00 0.	0. D0YAS338
0.10391E-01 0.	0.35534E 01	0.33770E 01	0.14090E 00 0.	0.46398E 00
0.89727E-01 0.	0.48520E-01 0.	0.33036E-01 0.	0.90107E 01D0YAS340	0.
0.89604E 01	0.13496E 00	0.22130E 00 0.	0.	0.
0.59291E-01 0.	0.25057E 02	0.24280E 02	0.17273E-01 0.	0.31100E-01
0.71800E-01 0.	0.	0.62359E-01 0.	0.24874E 03	0.
0.24858E 03	0.71764E 00 0.	0.	0.	0. D0YAS344
0.11164E-00 0.	0.29080E 03	0.29068E 03	0.94974E-01 0.	0. D0YAS345
0.	0.	0.25583E 00 0.	0.	0.39335E 01
0.36572E 01	0.11593E-01 0.	0.	0.	0.
0.52359E 00 0.	0.30491E 01	0.25031E 01	0.20476E-01 0.	0. D0YAS348
0.	0.	0.84366E 00 0.	0.	0.30790E 01D0YAS349
0.22187E 01	0.22415E-01 0.	0.	0.	0. D0YAS350
0.15242E 01 0.	0.37711E 01	0.22243E 01	0.16646E-01 0.	0. D0YAS351
0.	0.	0.23798E 01 0.	0.46994E 01D0YAS352	0.
0.22806E 01	0.22607E-01 0.	0.	0.	0. D0YAS353
0.38115E 01 0.	0.65393E 01	0.27144E 01	0.38923E-01 0.	0. D0YAS354
0.	0.	0.78709E 01 0.	0.10861E 02D0YAS355	0.
0.29906E 01	0.13392E-01 0.	0.	0.	0. D0YAS356

16 9 1251	COPPER	MICRO	295K	SPN-76	HOWERTON
0.22804E-01 0.	0.23145E 01	0.83116E 00 0.	0.	0. D0YAS361	0.
0.	0.	0.73651E-02 0.	0.26364E 01D0YAS362	0.	0.
0.15269E 01	0.77158E 00 0.	0.	0.	0. D0YAS363	0.
0.92352E-02 0.	0.31389E 01	0.25874E 01	0.16210E-00 0.	0.40726E-00D0YAS364	0.
0.	0.	0.12485E-01 0.	0.35951E 01D0YAS365	0.	0.
0.34274E 01	0.37846E-00 0.	0.73636E 00 0.	0.25926E-00 0.	0. D0YAS366	0.
0.27479E-01 0.	0.46666E 01	0.45630E 01	0.15519E-00 0.	0.16382E-00D0YAS367	0.
0.20365E-00 0.	0.47637E-01 0.	0.39206E-01 0.	0.67725E 01D0YAS368	0.	0.
0.66635E 01	0.76136E-01 0.	0.	0.	0. D0YAS369	0.
0.98006E-01 0.	0.90973E 01	0.89737E 01	0.49777E-01 0.	0. D0YAS370	0.
0.	0.	0.10000E-00 0.	0.14836E 02D0YAS371	0.	0.
0.14692E 02	0.25587E-01 0.	0.	0.	0. D0YAS372	0.
0.10000E-00 0.	0.65443E 01	0.64289E 01	0.43850E-01 0.	0. D0YAS373	0.
0.	0.	0.67859E-06 0.	0.10000E-00 0.	0.73747E 01D0YAS374	0.
0.72257E 01	0.15364E-01 0.	0.	0.	0. D0YAS375	0.
0.12531E-00 0.	0.76396E 01	0.74521E 01	0.49056E-01 0.	0. D0YAS376	0.
0.	0.	0.23994E-00 0.	0.77389E 01D0YAS377	0.	0.
0.74698E 01	0.62210E-01 0.	0.	0.	0. D0YAS378	0.
0.43772E-00 0.	0.79567E 01	0.74573E 01	0.49098E-01 0.	0. D0YAS379	0.
0.	0.	0.73106E 00 0.	0.82500E 01D0YAS380	0.	0.
0.74260E 01	0.61667E-01 0.	0.	0.	0. D0YAS381	0.
0.12229E 01 0.	0.87419E 01	0.74899E 01	0.92897E-01 0.	0. D0YAS382	0.

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.	0.	0.	0.29556E 01 0.	0.98790E 0100YAS503					
0.75234E 01	0.29031E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
C									
16 9 1252	TIN	MICRO	293K	SPN-76	HOWERTON				
0.14376E-01 0.	0.29191E 01	0.10103E 01 0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.74009E-01 0.	0.35974E 0100YAS390					
0.24669E 01	0.10208E 01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.10060E-00 0.	0.40269E 01	0.35908E 01 0.44368E-00	0.92582E 0000YAS392						
0.	0.	0.11150E-00 0.	0.46350E 0100YAS393						
0.44273E 01	0.28386E-00	0.34937E-00	0.29886E-00 0.	0.	0.	0.	0.	0.	0.
0.11200E-00 0.	0.51382E 01	0.49820E 01 0.92935E-01	0.47173E-0100YAS395						
0.63436E-01	0.51183E-01 0.	0.11200E-00 0.	0.59887E 0100YAS396						
0.58584E 01	0.44144E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.11200E-00 0.	0.54304E 01	0.35065E 01 0.18356E-01	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.11200E-00 0.	0.50698E 0100YAS399						
0.49489E 01	0.11807E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.11200E-00 0.	0.56055E 01	0.54881E 01 0.94392E-02	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.33424E-02	0.11200E-00 0.	0.54357E 0100YAS402					
0.53082E 01	0.53790E-02 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.11200E-00 0.	0.46422E 01	0.45101E 01 0.15483E-01	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.11200E-00 0.	0.47884E 0100YAS405						
0.46602E 01	0.20180E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.11200E-00 0.	0.48401E 01	0.47077E 01 0.16179E-01	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.12061E-00 0.	0.48526E 0100YAS408						
0.47016E 01	0.20408E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.19437E-00 0.	0.48450E 01	0.46414E 01 0.30409E-01	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.37883E-00 0.	0.48035E 0100YAS411						
0.44247E 01	0.91518E-02 0.	0.	0.	0.	0.	0.	0.	0.	0.
C									
16 9 1253	URANIUM-237	MICRO	293K	SPN-76	HOWERTON				
0.81444E 00	0.25016E 01	0.43686E 01	0.11420E 01 0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.79260E 00	0.19248E 01	0.46159E 0100YAS418				
0.15414E 01	0.16265E-00 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.85501E 00	0.19070E 01	0.50889E 01	0.23019E 01	0.17199E-00	0.32206E-0000YAS420				
0.	0.	0.	0.91034E 00	0.18694E 01	0.60693E 0100YAS421				
0.36805E 01	0.12365E 01	0.14657E 01	0.14518E 01 0.	0.	0.	0.	0.	0.	0.
0.99976E 00	0.17045E 01	0.80516E 01	0.69015E 01	0.11818E 01	0.68864E 0000YAS423				
0.64428E 00	0.57846E 00	0.	0.90388E 00	0.90632E 00	0.96745E 0100YAS424				
0.87552E 01	0.29047E-00	0.16726E-00	0.68105E-02 0.	0.	0.	0.	0.	0.	0.
0.14034E 01	0.45253E-00	0.11168E 02	0.97501E 01	0.15437E-01	0.25992E-0000YAS426				
0.12945E-00 0.	0.	0.	0.30467E 01	0.36454E-00	0.6319E 0200YAS427				
0.13259E 02	0.14349E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.56557E 01	0.35401E-00	0.19627E 02	0.13964E 02	0.13154E-01 0.	0.	0.	0.	0.	0.

C SERIES 1200 CROSS SECTION LIBRARY - LRL-F WEIGHTED.

0.	0.	0.	0.68649E 01	0.35400E-00	0.20828E 0200YAS430				
0.13939E 02	0.78083E-02 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.70634E 01	0.35400E-00	0.21026E 02	0.13939E 02	0.23764E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.71216E 01	0.35400E-00	0.21084E 0200YAS433				
0.13939E 02	0.30016E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.71414E 01	0.35400E-00	0.21104E 02	0.13939E 02	0.25688E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.71471E 01	0.35400E-00	0.21110E 0200YAS436				
0.13918E 02	0.29746E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.71490E 01	0.35400E-00	0.21112E 02	0.13949E 02	0.44788E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.71498E 01	0.35400E-00	0.21112E 0200YAS439				
0.13963E 02	0.13954E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
C									
16 9 1254	URANIUM-239	MICRO	293K	SPN-76	HOWERTON				
0.32018E-00	0.99123E 00	0.43657E 01	0.11500E 01 0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.30711E-00	0.63407E 00	0.46163E 0100YAS446				
0.15429E 01	0.18950E-00 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.35021E-00	0.62407E 00	0.50843E 01	0.22997E 01	0.20105E-00	0.38274E-0000YAS448				
0.	0.	0.	0.38373E-00	0.59981E 00	0.56611E 0100YAS449				
0.33181E 01	0.15491E 01	0.17825E 01	0.17702E 01 0.	0.	0.	0.	0.	0.	0.
0.22441E-00	0.28395E-00	0.69324E 01	0.59734E 01	0.16678E 01	0.87642E 0000YAS451				
0.78290E 00	0.70533E 00	0.	0.12233E-00	0.51538E-01	0.88016E 0100YAS452				
0.86641E 01	0.38243E-00	0.17286E-00	0.87805E-02 0.	0.	0.	0.	0.	0.	0.
0.13283E-00	0.75552E-01	0.10386E 02	0.10297E 02	0.15225E-01	0.39215E-0000YAS454				
0.11856E-00 0.	0.	0.	0.17404E-00	0.16938E-00	0.14486E 0200YAS455				
0.14298E 02	0.15981E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.29308E-00	0.42014E-00	0.14560E 02	0.14259E 02	0.15410E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.55558E 00	0.85190E 00	0.14518E 0200YAS458				
0.13939E 02	0.77425E-02 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.91943E 00	0.14098E 01	0.14882E 02	0.13933E 02	0.23563E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.16890E 01	0.25898E 01	0.15683E 0200YAS461				
0.13971E 02	0.29762E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.28715E 01	0.44030E 01	0.16921E 02	0.14020E 02	0.23617E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.43300E 01	0.66394E 01	0.18342E 0200YAS464				
0.13968E 02	0.29704E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.68478E 01	0.10500E 02	0.20810E 02	0.13949E 02	0.44408E-01 0.	0.	0.	0.	0.	0.
0.	0.	0.	0.13002E 02	0.19939E 02	0.26964E 0200YAS467				
0.13963E 02	0.13836E-01 0.	0.	0.	0.	0.	0.	0.	0.	0.
C									
16 9 1255	URANIUM-240	MICRO	293K	SPN-76	HOWERTON				
0.49454E-00	0.15242E 01	0.41858E 01	0.11884E 01 0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.36480E-00	0.87109E 00	0.46098E 0100YAS474				
0.16995E 01	0.21032E-00 0.	0.	0.	0.	0.	0.	0.	0.	0.
0.93021E-01	0.10438E-00	0.49926E 01	0.28064E 01	0.18164E-00	0.35437E-0000YAS476				

C SERIES 1200 CROSS SECTION LIBRARY LRL F WEIGHTED

0 0 0 0 16221E-00 0 23691E-05 0 56990E 01D0YAS477
 0 45286E 01 0 79617E 00 0 12900E 01 0 14901E 01 0 0 D0YAS478
 0 25915E 00 0 23079E 05 0 83971E 01 0 77924E 01 0 96064E 00 0 10441E 01D0YAS479
 0 92092E 00 0 56643E 00 0 0 43952E-00 0 22793E-05 0 12150E 02D0YAS480
 0 11670E 02 0 34564E 00 0 47579E-01 0 25277E 00 0 15295E 00 0 0
 0 61717E 00 0 22717E-05 0 13877E 02 0 13245E 02 0 37777E-01 0 0
 0 0 0 0 0 73351E 00 0 22703E-05 0 12771E 02D0YAS483
 0 12028E 02 0 14309E 01 0 0 0 0 0 D0YAS484
 0 75000E 00 0 22701E-05 0 99470E 01 0 91926E 01 0 92195E-02 0 0 D0YAS485
 0 0 0 0 0 75000E 00 0 22700E 05 0 07207E 01D0YAS486
 0 79653E 01 0 44066E-02 0 0 0 0 0 D0YAS487
 0 75000E 00 0 22700E-05 0 07207E 01 0 79617E 01 0 13408E 01 0 0 D0YAS488
 0 0 0 0 0 75000E 00 0 22700E 05 0 07207E 01 0 0
 0 79653E 01 0 16935E 01 0 0 0 0 0 D0YAS491
 0 75000E 00 0 22700E 05 0 07207E 01 0 79619E 01 0 13564E-01 0 0 D0YAS492
 0 0 0 0 0 75000E 00 0 22700E 05 0 07207E 01D0YAS493
 0 79534E 01 0 16782E-01 0 0 0 0 0 D0YAS494
 0 75000E 00 0 22700E-05 0 07207E 01 0 79708E 01 0 25269E 01 0 0 D0YAS495
 0 0 0 0 0 10147E 01 0 22700E-05 0 89934E 01D0YAS496
 0 79787E 01 0 78726E 02 0 0 0 0 0 D0YAS496

16 9 1256 PLUTONIUM 238 MICRO 293K SPN-76 HOMERTON
 0 21906E 01 0 76204E 01 0 43699E 01 0 11160E 01 0 0 D0YAS501
 0 0 0 0 0 21890E 01 0 66555E 01 0 46221E 01D0YAS502
 0 15359E 01 0 75975E-01 0 0 0 0 0 D0YAS503
 0 22390E 01 0 64517E 01 0 50879E 01 0 22936E 01 0 86438E-01 0 13763E-00D0YAS504
 0 0 0 0 0 22985E 01 0 63897E 01 0 61471E 01D0YAS505
 0 36809E 01 0 23578E-00 0 45956E 00 0 64099E 00 0 0 D0YAS506
 0 26055E 01 0 69827E 01 0 91154E 01 0 64796E 01 0 16162E-00 0 25620E-00D0YAS507
 0 30682E-00 0 25818E-00 0 0 39430E 01 0 94081E 01 0 12463E 02D0YAS508
 0 85048E 01 0 30403E-01 0 59780E-02 0 62599E 01 0 44406E-01 0 0 D0YAS509
 0 59078E 01 0 11623E 02 0 15034E 02 0 91149E 01 0 15087E 01 0 0 D0YAS510
 0 0 0 0 0 11297E 02 0 15279E 02 0 22638E 02D0YAS511
 0 11328E 02 0 11185E-01 0 0 0 0 0 D0YAS512
 0 14526E 02 0 16691E 02 0 28489E 02 0 13955E 02 0 12999E 01 0 0 D0YAS513
 0 0 0 0 0 15752E 02 0 17131E 02 0 29715E 02D0YAS514
 0 13939E 02 0 77750E-02 0 0 0 0 0 D0YAS515
 0 15953E 02 0 17203E 02 0 29916E 02 0 13933E 02 0 23663E 01 0 0 D0YAS516
 0 0 0 0 0 65419E 02 0 19283E 02 0 79238E 02D0YAS517
 0 13795E 02 0 29889E-01 0 0 0 0 0 D0YAS518
 0 15086E 03 0 22851E 02 0 16443E 03 0 13540E 02 0 22993E-01 0 0 D0YAS519
 0 0 0 0 0 17539E 03 0 23875E 02 0 18888E 03D0YAS520
 0 15453E 02 0 28658E 01 0 0 0 0 0 D0YAS521
 0 18334E 03 0 24206E 02 0 19681E 03 0 13460E 02 0 43053E 01 0 0 D0YAS522

C SERIES 1200 CROSS SECTION LIBRARY LRL F WEIGHTED

0 0 0 0 26184E 03 0 32968E 02 0 27548E 03D0YAS523
 0 13640E 02 0 13399E 01 0 0 0 0 0 D0YAS524

16 9 3271 SILVER MICRO 293K SPN 76 D0YAS
 0 0525 0 3 015 1 01929 0 0 1
 0 0 0 0 0 0846 0 3 58071 2
 1 66525 0 64093 0 0 0 0 3
 0 1160 0 4 07465 2 42056 0 50152 0 46100 4
 0 0 0 0 0 1880 0 5 4150 5
 4 72335 0 88308 0 80658 0 56960 0 6
 0 3338 0 7 09436 6 66900 0 45339 0 58133 7
 0 47126 0 24840 0 0 6853 0 8 28007 8
 7 56733 0 09033 0 04801 0 07086 0 05004 0 02330 9
 1 514 0 9 76370 8 22837 0 02743 0 00119 10
 0 00175 0 00244 0 00171 3 529 0 13 24558 11
 9 69654 0 02133 0 0 00004 0 00006 0 00008 12
 7 1 0 17 03820 9 92590 0 02004 0 13
 0 0 000001 0 000002 50 0 0 58 45244 14
 8 42063 0 01230 0 0 0 0 15
 80 0 0 85 96292 5 93460 0 03181 0 16
 0 0 0 361 0 0 366 96292 17
 5 94048 0 02832 0 0 0 0 18
 16 0 0 27 96292 5 93460 0 02244 0 19
 0 0 0 14 0 0 19 96292 20
 5 91978 0 02832 0 0 0 0 21
 22 0 0 27 96292 5 94780 0 04320 0 22
 0 0 0 40 0 0 45 96292 23
 5 96292 0 01512 0 0 0 0 24

16 9 3272 HAFNIUM MICRO 293K SPN 76 D0YAS
 0 0 3 6252 7731 0 0
 0 0 0 0591 0 4 2543
 1 5959 6182 0 0 0 0
 0952 0 4 5068 2 3199 5007 6533
 0 0 0 1317 0 6 1374
 4 7796 9924 1 1418 1 0047 0 0
 202 0 7 5188 7 6428 1 0362 964
 8501 5219 0 4047 0 8 8029
 8 3818 2533 1823 1397 1029 0534
 1 53 0 9 923 8 387 0182 01
 0071 005 0033 5 193 0 13 5833
 8 3896 013 0 0003 0003 0002
 19 18 0 18 44 8 3938 0103 0

C SERIES 1200 CROSS SECTION LIBRARY LRL F WEIGHTED

0 0 0 25 0 40 40
 8 3811 062 0 0 0 0
 25 0 33 4038 8 3761 0188 0
 0 0 0 25 0 820 40
 8 3811 0238 0 0 0 0
 25 0 756 40 8 3761 0188 0
 0 0 0 25 0 81 11
 8 3636 0238 0 0 0 0
 25 0 49 59 8 3873 0363 0
 0 0 0 25 0 113 38
 8 4 0127 0 0 0 0

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

C	NUCLIDE	NUMBER	NUCLIDE	NUMBER	NUCLIDE	NUMBER
C	H-1	1601	MO	1618	H-3	1640
C	H-2	1602	EU	1619	HE-3	1641
C	LI-6	1603	GD	1620	HE-4	1642
C	LI-7	1604	TA-181	1621	B-10	1643
C	BE-9	1605	M	1622	F	1644
C	BORON	1606	AU	1623	CL	1645
C	C-12	1607	PB	1624	A	1646
C	N-14	1608	U-233	1625	CA	1648
C	O-16	1609	U-234	1626	TI	1649
C	NA-23	1610	U-235	1627	MN	1650
C	AL	1611	U-236	1628	CU	1651
C	SI	1612	U-238	1629	SN	1652
C	P-31	1613	PU-239	1630	U-237	1653
C	K	1614	PU-240	1631	U-239	1654
C	FE	1615	PU-241	1632	U-240	1655
C	GA	1616	MG	1639	PU-238	1656
C	NO-93	1617				

16 9 1601	HYDROGEN-1	THERMAL	HONERTON
0	35255E-03 0	0 55526E-00-0 60535E-00 0	0 07/3 /79
0	0	0 44611E-03 0	0 99112E-0007/3 /80
0	12511E-01 0 61801E-00 0	0 0	0 07/3 /81
0	46930E-03 0	0 13384E-01-0 19373E-01 0 80062E-00 0 19338E-0007/3 /82	0 22752E-01 0 19065E-01 0 21181E-00 0
0	0	0 48338E-03 0	0 18787E-0107/3 /83
0	20862E-01 0 18196E-01 0 80062E-00 0 19338E-00 0	0 07/3 /84	0 17400E-00 0 14014E-01 0 31103E-00 0
0	49428E-03 0	0 32342E-01-0 23231E-01 0 29733E-01 0 10917E-0107/3 /85	0 0
0	48037E-00 0 11603E-00 0	0 49898E-03 0	0 43501E-00 0 51452E-00 0
0	23526E-01 0 46122E-01 0 82261E-00 0 30205E-00 0 13290E-00 0 38675E-0107/3 /87	0 77795E-0007/3 /88	0 29837E-00 0
0	64636E-03 0	0 64545E-01-0 25815E-01 0 63062E-01 0	0 10894E-01 0 23075E-00 0 40217E-00 0 49532E-0107/3 /82
0	13875E-00 0 50948E-01 0 27221E-01 0 15128E-02 0	0 67223E-0107/3 /89	0 0 49069E-00 0
0	29335E-01 0 73789E-01 0 11036E-01 0 13614E-00 0 24282E-01 0 10917E-0107/3 /90	0 67739E-0107/3 /91	0 57542E-00 0 56026E-00 0 37163E-01 0 19379E-00 0
0	35434E-02 0	0 67641E-01 0 29262E-01 0 78990E-01 0	0 14433E-01 0
0	20270E-00 0 25006E-01 0 54510E-02 0 71925E-02 0	0 67739E-0107/3 /92	0 10371E-02 0 10319E-00 0
0	49276E-01 0 67808E-01 0 12287E-01 0 21082E-00 0 31531E-01 0 55568E-0207/3 /93	0 66668E-00 0 26499E-00 0	0 84145E-00 0
0	12839E-01 0	0 67795E-01-0 55917E-01 0 77962E-01 0 19374E-0107/3 /94	0 0 0
0	35106E-00 0 60236E-01 0 13513E-01 0 22773E-01 0	0 67894E-0107/3 /95	0 27585E-01 0 73773E-00 0 15769E-00 0
0	49359E-01 0 86509E-01 0 27287E-01 0 67808E-00 0 12287E-00 0 30118E-0107/3 /96	0 0	0 20597E-01 0 44515E-01 0
0	40773E-01 0	0 68074E-01-0 56295E-01 0 78017E-01 0 24717E-0107/3 /97	0 0
0	77962E-00 0 19374E-00 0 52660E-01 0 67031E-01 0	0 68337E-0107/3 /98	0 17824E-00 0 16519E-00 0
0	66053E-01 0 74377E-01 0 23405E-01 0 74150E-00 0 23388E-00 0 96868E-0107/3 /99	0 0	0 10425E-02 0
0	12751E-00 0	0 68942E-01 0 55716E-01 0 10029E-02 0 37188E-0107/3 /100	0 11314E-02 0 71534E-00 0 1728E-00 0
0	11703E-01 0 37075E-00 0 15592E-00 0 22842E-00 0	0 69951E-0107/3 /101	0 0 20967E-02 0
0	67667E-01 0 12338E-02 0 33430E-01 0 12396E-01 0 39009E-00 0 12358E-0007/3 /102	0 0	0 64720E-00 0 17404E-00 0

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

16 9 1602	HYDROGEN 2	THERMAL	HONERTON
0	30000E-04 0	0 10697E-01 0 13137E-00 0	0 0 MESNE27
0	0	0 0 30000E-04 0	0 21571E-01 MESNE28
0	28005E-00 0 49063E-00 0	0 0	0 MESNE29
0	30000E-04 0	0 26675E-01 0 22390E-00 0 50165E-00 0 17395E-00 MESNE30	0 28410E-01 MESNE31
0	0	0 0 30000E-04 0	0 MESNE32
0	42381E-00 0 10200E-01 0 73990E-00 0 28375E-00 0	0 19551E-01 0 14236E-01 MESNE33	0 22453E-01 MESNE34
0	30000E-04 0	0 24732E-01 0 69760E-00 0	0 33252E-03 MESNE35
0	63546E-00 0 31011E-01 0	0 30000E-04 0	0 35899E-01 MESNE36
0	92190E-00 0 17397E-01 0 46203E-00 0 21360E-04 0	0 12936E-01 0	0 22752E-01 MESNE37
0	30000E-04 0	0 22736E-01 0 92547E-00 0	0 MESNE38
0	0	0 30000E-04 0	0 35404E-01 MESNE39
0	86418E-00 0 13127E-01 0 29748E-01 0	0 13750E-01 0	0 22752E-01 MESNE40
0	30000E-04 0	0 86661E-00 0	0 MESNE41
0	0	0 30000E-04 0	0 17751E-00 MESNE42
0	48945E-00 0 12311E-01 0 35989E-01 0	0 0	0 22752E-01 MESNE43
0	30000E-04 0	0 22752E-01 0 36455E-00 0 14689E-01 0 17751E-00 MESNE44	0 22752E-01 MESNE45
0	0	0 0 38835E-04 0	0 22752E-01 MESNE46
0	48788E-00 0 16299E-01 0 31679E-00 0	0 0	0 22752E-01 MESNE47
0	69193E-04 0	0 22752E-01 0 35746E-00 0 14699E-01 0 28073E-00 MESNE48	0 22752E-01 MESNE49
0	0	0 0 11377E-03 0	0 22752E-01 MESNE50
0	17400E-00 0 14014E-01 0 31103E-00 0	0 0	0 07/3 279
0	21653E-03 0	0 22754E-01 0 36888E-00 0 18894E-01 0 51633E-00 MESNE48	0 11215E-0107/3 /200
0	63313E-02 0	0 0 38757E-03 0	0 07/3 /281
0	22752E-01 0 19065E-01 0 21181E-00 0	0 0	0 49532E-0107/3 /202
0	95955E-01 0	0 14512E-01 0 50015E-00 0	0 16195E-0107/3 /203
0	0	0 22557E-00 0	0 07/3 /284
0	43501E-00 0 51452E-00 0	0 0	0 07/3 /285
0	29837E-00 0	0 10894E-01 0 23075E-00 0 40217E-00 0 49532E-0107/3 /202	0 16195E-0107/3 /203
0	0	0 49069E-00 0	0 07/3 /284
0	57542E-00 0 56026E-00 0 37163E-01 0 19379E-00 0	0 0	0 16658E-0107/3 /286
0	14433E-01 0	0 42793E-01 0 25710E-01 0 55342E-00 0	0 07/3 /287
0	10371E-02 0 10319E-00 0	0 84145E-00 0	0 07/3 /288
0	66668E-00 0 26499E-00 0	0 0	0 53425E-0107/3 /289
0	18555E-01 0	0 27585E-01 0 73773E-00 0 15769E-00 0	0 07/3 /290
0	0	0 20597E-01 0 44515E-01 0	0 07/3 /291
0	17824E-00 0 16519E-00 0	0 0	0 21856E-0207/3 /292
0	10425E-02 0	0 11314E-02 0 71534E-00 0 1728E-00 0	0 07/3 /293
0	0	0 20967E-02 0	0 07/3 /294
0	64720E-00 0 17404E-00 0	0 0	0 67434E-0207/3 /295
0	38075E-02 0	0 38965E-02 0 61253E-00 0 24217E-00 0	0 07/3 /296
0	0	0 66545E-02 0	0 07/3 /297
0	64617E-00 0 27684E-00 0	0 0	0 07/3 /297
0	12056E-03 0	0 12145E-03 0 60967E-00 0 24321E-00 0	0 07/3 /297

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0.	0.	0.	0.19462E 03 0.	0.19551E 0307/3 298
0.55397E 00 0.27971E-00 0.	0.	0.	0.	07/3 299
0.37835E 03 0.	0.37924E 03	0.58288E 00 0.55541E-00 0.	0.	07/3 300
0.	0.	0.66656E 03 0.	0.66745E 0307/3 301	
0.88938E 00 0.30650E-00 0.	0.	0.	0.	07/3 302
16 9 1604 LITHIUM-7	THERMAL		HOWERTON	
0.21309E-00 0.	0.16144E 01 0.88398E 00 0.	0.	07/3 304	
0.	0.	0.22547E-03 0.	0.14281E 0107/3 305	
0.80592E 00 0.59564E 00 0.	0.	0.	07/3 306	
0.10001E-05 0.	0.13185E 01 0.46383E-00 0.59329E 00 0.32592E-0107/3 307	0.	0.	
0.	0.	0.10001E-05 0.	0.11584E 0107/3 308	
0.70728E 00 0.85857E 00	0.29664E-01 0.72226E-01 0.	0.	07/3 309	
0.10001E-05 0.	0.19919E 01 0.18282E 01 0.44998E-00 0.16078E-0107/3 310	0.	0.	
0.36027E-04 0.29934E-01 0.	0.10001E-05 0.	0.90982E 0007/3 311	0.	
0.76269E 00 0.16374E-00 0.	0.	0.36027E-04 0.30741E-0207/3 312	0.	
0.10001E-05 0.	0.96305E 00 0.80881E 00 0.14713E-00 0.	07/3 313	0.	
0.	0.15342E-03 0.17261E-03 0.	0.99300E 0007/3 314	0.	
0.82788E 00 0.15423E-00 0.	0.	0.	07/3 315	
0.14849E-02 0.	0.99582E 00 0.82846E 00 0.16495E-00 0.	07/3 316	0.	
0.	0.11391E-02 0.19027E-02 0.	0.99586E 0007/3 317	0.	
0.76311E 00 0.16587E-00 0.	0.	0.	07/3 318	
0.19845E-02 0.	0.99587E 00 0.72934E 00 0.23085E-00 0.	07/3 319	0.	
0.	0.	0.38391E-02 0.	0.10002E 0107/3 320	
0.76333E 00 0.26455E-00 0.	0.	0.	07/3 321	
0.56416E-02 0.	0.10045E 01 0.72967E 00 0.23303E-00 0.	07/3 322	0.	
0.	0.	0.98780E-02 0.	0.10092E 0107/3 323	
0.67612E 00 0.26914E-00 0.	0.	0.	07/3 324	
0.14983E-01 0.	0.10143E 01 0.69853E 00 0.32318E-00 0.	07/3 325	0.	
0.	0.	0.23675E-01 0.	0.10210E 0107/3 326	
0.99731E 00 0.30077E-00 0.	0.	0.	07/3 327	
16 9 1605 BE-9	THERMAL		HOWERTON	
0.66843E-01 0.	0.12817E 01 0.43581E-00 0.	0.	07/3 329	
0.	0.	0.44831E-01 0.	0.16052E 0107/3 330	
0.98684E 00 0.36987E-00 0.	0.	0.	07/3 331	
0.72993E-02 0.	0.22749E 01 0.10115E 01 0.56021E 00 0.68632E-0107/3 332	0.	0.	
0.	0.	0.42036E-02 0.	0.34627E 0107/3 333	
0.25471E 01 0.12560E 01	0.13429E-03 0.27074E-00 0.	0.	07/3 334	
0.20531E-02 0.	0.41974E 01 0.34251E 01 0.91140E 00 0.20000E-0507/3 335	0.	0.	
0.26407E-01 0.56146E 00 0.	0.11296E-02 0.	0.53522E 0107/3 336	0.	
0.46782E 01 0.77016E 00 0.	0.	0.	07/3 337	
0.10014E-02 0.	0.55487E 01 0.48728E 01 0.67290E 00 0.	07/3 338	0.	
0.	0.	0.10019E-02 0.	0.55538E 0107/3 339	
0.48423E 01 0.67498E 00 0.	0.	0.	07/3 340	
0.10020E-02 0.	0.55538E 01 0.48381E 01 0.71052E 00 0.	07/3 341	0.	
0.	0.	0.10020E-02 0.	0.55538E 0107/3 342	

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0.45542E 01 0.71473E 00 0.	0.	0.	0.	07/3 343
0.10020E-02 0.	0.55538E 01 0.44043E 01 0.99866E 00 0.	0.	07/3 344	
0.	0.	0.10020E-02 0.	0.55538E 0107/3 345	
0.45489E 01 0.11485E 01 0.	0.	0.	07/3 346	
0.10682E-02 0.	0.55539E 01 0.43832E 01 0.10040E 01 0.	0.	07/3 347	
0.	0.	0.23365E-02 0.	0.55541E 0107/3 348	
0.41492E 01 0.11646E 01 0.	0.	0.	07/3 349	
0.37252E-02 0.	0.55541E 01 0.42256E 01 0.14025E 01 0.	0.	07/3 350	
0.	0.	0.61945E-02 0.	0.55542E 0107/3 351	
0.55480E 01 0.13268E 01 0.	0.	0.	07/3 352	
16 9 1606 BORON	THERMAL		HOWERTON	
0.42456E-01 0.	0.90952E 00 0.49042E-00 0.	0.	07/3 354	
0.	0.	0.66100E-01 0.	0.18130E 0107/3 355	
0.11806E 01 0.29199E-00 0.	0.	0.	07/3 356	
0.40347E-01 0.	0.21162E 01 0.13687E 01 0.56628E 00 0.38532E-0107/3 357	0.	0.	
0.	0.	0.12252E-00 0.	0.25927E 0107/3 358	
0.16195E 01 0.70720E 00 0.	0.30277E-01 0.	0.	07/3 359	
0.30737E-00 0.	0.36135E 01 0.28216E 01 0.89069E 00 0.	0.	07/3 360	
0.	0.18549E-01 0.	0.97164E 00 0.	0.47190E 0107/3 361	
0.33639E 01 0.48437E-00 0.	0.	0.	0.19329E-0607/3 362	
0.16178E 01 0.	0.53718E 01 0.33749E 01 0.38537E-00 0.	0.	07/3 363	
0.	0.	0.23371E 01 0.	0.60910E 0107/3 364	
0.33560E 01 0.37902E-00 0.	0.	0.	07/3 365	
0.47402E 01 0.	0.84941E 01 0.33536E 01 0.39792E-00 0.	0.	07/3 366	
0.	0.	0.12190E 02 0.	0.15944E 0207/3 367	
0.31932E 01 0.40029E-00 0.	0.	0.	07/3 368	
0.25236E 02 0.	0.28990E 02 0.31065E 01 0.56067E 00 0.	0.	07/3 369	
0.	0.	0.48737E 02 0.	0.52491E 0207/3 370	
0.31911E 01 0.64740E 00 0.	0.	0.	07/3 371	
0.93778E 02 0.	0.97532E 02 0.30980E 01 0.56279E 00 0.	0.	07/3 372	
0.	0.	0.15497E 03 0.	0.15872E 0307/3 373	
0.29603E 01 0.65588E 00 0.	0.	0.	07/3 374	
0.28935E 03 0.	0.29310E 03 0.30005E 01 0.79364E 00 0.	0.	07/3 375	
0.	0.	0.52302E 03 0.	0.52677E 0307/3 376	
0.37539E 01 0.75344E 00 0.	0.	0.	07/3 377	
16 9 1607 CARBON-12	THERMAL		HOWERTON	
0.38222E-01 0.	0.14989E 01 0.10167E 01 0.	0.	07/3 379	
0.	0.	1.00000E-06 0.	0.17584E 0107/3 380	
0.12371E 01 0.43456E-00 0.	0.	0.	07/3 381	
1.00000E-06 0.	0.21729E 01 0.12905E 01 0.50131E 00 0.	0.	07/3 382	
0.	0.	1.00000E-06 0.	0.28813E 0107/3 383	
0.22560E 01 0.88239E 00 0.	0.89461E-02 0.	0.	07/3 384	
1.00000E-06 0.	0.38274E 01 0.33269E 01 0.64530E 00 0.	0.	07/3 385	
0.	0.53138E-03 0.	1.00000E-06 0.	0.43046E 0107/3 386	
0.39044E 01 0.50059E 00 0.	0.	0.	0.51560E-0607/3 387	

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

1.00000E-06 0.	0.43620E 01	0.39630E 01	0.40021E-00 0.	07/3 588
0.	0.	1.00000E-06 0.	0.43572E 0107/3 589	
0.39432E 01	0.39898E-00 0.	0.	0.	07/3 590
1.00000E-06 0.	0.43445E 01	0.39281E 01	0.41393E-00 0.	07/3 591
0.	0.	1.00000E-06 0.	0.43445E 0107/3 592	
0.37609E 01	0.41646E-00 0.	0.	0.	07/3 593
1.00000E-06 0.	0.43445E 01	0.36684E 01	0.50365E 00 0.	07/3 594
0.	0.	1.00000E-06 0.	0.44003E 0107/3 595	
0.38027E 01	0.67610E 00 0.	0.	0.	07/3 596
1.00000E-06 0.	0.44952E 01	0.37826E 01	0.59759E 00 0.	07/3 597
0.	0.	1.00000E-06 0.	0.45664E 0107/3 598	
0.36903E 01	0.71259E 00 0.	0.	0.	07/3 599
1.00000E-06 0.	0.46425E 01	0.37949E 01	0.87610E 00 0.	07/3 600
0.	0.	1.00000E-06 0.	0.47010E 0107/3 601	
0.47010E 01	0.84738E 00 0.	0.	0.	07/3 602
16 9 1608 N-14	THERMAL		HOMERTON	
0.27278E-00 0.	0.15084E 01	0.75317E 00 0.	0.	07/3 604
0.	0.	0.11307E-00 0.	0.16238E 0107/3 605	
0.10964E 01	0.26262E-00 0.	0.	0.	07/3 606
0.37585E-01 0.	0.15963E 01	0.11238E 01	0.41432E-00 0.	0.11496E-0107/3 607
0.	0.	0.40025E-01 0.	0.20504E 0107/3 608	
0.15059E 01	0.43493E-00 0.	0.73802E-02 0.	0.	07/3 609
0.16645E-02 0.	0.32713E 01	0.28705E 01	0.50441E 00 0.	07/3 610
0.	0.93127E-03 0.	0.17196E-02 0.	0.49392E 0107/3 611	
0.45060E 01	0.39920E-00 0.	0.	0.51125E-0407/3 612	
0.38376E-02 0.	0.60158E 01	0.55039E 01	0.43151E-00 0.	07/3 613
0.	0.	0.93146E-02 0.	0.75365E 0107/3 614	
0.68526E 01	0.50806E 00 0.	0.	0.	07/3 615
0.21464E-01 0.	0.88815E 01	0.81078E 01	0.67458E 00 0.	07/3 616
0.	0.	0.44175E-01 0.	0.94153E 0107/3 617	
0.82844E 01	0.75226E 00 0.	0.	0.	07/3 618
0.78296E-01 0.	0.95913E 01	0.82394E 01	0.10868E 01 0.	07/3 619
0.	0.	0.13959E-00 0.	0.98025E 0107/3 620	
0.85420E 01	0.12736E 01 0.	0.	0.	07/3 621
0.24763E-00 0.	0.99775E 01	0.84214E 01	0.11210E 01 0.	07/3 622
0.	0.	0.41938E-00 0.	0.10115E 0207/3 623	
0.81054E 01	0.13085E 01 0.	0.	0.	07/3 624
0.76729E 00 0.	0.10608E 02	0.82899E 01	0.15901E 01 0.	07/3 625
0.	0.	0.14415E 01 0.	0.11487E 0207/3 626	
0.10046E 02	0.15509E 01 0.	0.	0.	07/3 627
16 9 1609 OXYGEN-16	THERMAL		HOMERTON	
0.48937E-01 0.	0.15117E 01	0.11161E 01 0.	0.	07/3 629
0.	0.	0.20001E-05 0.	0.14571E 0107/3 630	
0.10755E 01	0.31724E-00 0.	0.	0.	07/3 631
0.20001E-05 0.	0.38314E 01	0.25071E 01	0.38165E-00 0.	0.12700E-0107/3 632

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0.	0.	0.	0.20001E-05 0.	0.40174E 0107/3 433
0.27833E 01	0.13244E 01 0.	0.16746E-01 0.	0.	07/3 434
0.20001E-05 0.	0.38916E 01	0.35934E 01	0.12341E 01 0.	07/3 435
0.	0.	0.	0.20001E-05 0.	0.33542E 0107/3 436
0.31195E 01	0.29821E-00 0.	0.	0.	0.97325E-0507/3 437
0.20001E-05 0.	0.34423E 01	0.31993E 01	0.23473E-00 0.	07/3 438
0.	0.	0.	0.20001E-05 0.	0.36246E 0107/3 439
0.33658E 01	0.24307E-00 0.	0.	0.	07/3 440
0.20001E-05 0.	0.56417E 01	0.33811E 01	0.25879E-00 0.	07/3 441
0.	0.	0.	0.20001E-05 0.	0.36417E 0107/3 442
0.32769E 01	0.26062E-00 0.	0.	0.	07/3 443
0.20001E-05 0.	0.56417E 01	0.32150E 01	0.36485E-00 0.	07/3 444
0.	0.	0.	0.20001E-05 0.	0.36417E 0107/3 445
0.32759E 01	0.42673E-00 0.	0.	0.	07/3 446
0.20001E-05 0.	0.56417E 01	0.32130E 01	0.36579E-00 0.	07/3 447
0.	0.	0.	0.20001E-05 0.	0.36417E 0107/3 448
0.31173E 01	0.42871E-00 0.	0.	0.	07/3 449
0.20001E-05 0.	0.56771E 01	0.31620E 01	0.52438E 00 0.	07/3 450
0.	0.	0.	0.20001E-05 0.	0.39211E 0107/3 451
0.39211E 01	0.51514E 00 0.	0.	0.	07/3 452
16 9 1610 SODIUM-23	THERMAL		HOMERTON	
0.89940E-02 0.	0.14495E 01	0.88773E 00 0.	0.	07/3 454
0.	0.	0.27743E-03 0.	0.	0.16371E 0107/3 455
0.11837E 01	0.40309E-00 0.	0.	0.	07/3 456
0.12491E-03 0.	0.24657E 01	0.14799E 01	0.49310E-00 0.	0.10343E-0007/3 457
0.	0.	0.	0.22500E-03 0.	0.40938E 0107/3 458
0.35320E 01	0.98610E 00 0.	0.45027E-01 0.	0.	07/3 459
0.72235E-03 0.	0.35925E 01	0.33890E 01	0.54722E 00 0.	07/3 460
0.	0.12648E-02 0.	0.13879E-02 0.	0.	0.42060E 0107/3 461
0.39960E 01	0.20278E-00 0.	0.13354E-01 0.	0.	07/3 462
0.19985E-02 0.	0.27815E 02	0.16670E 02	0.20860E-00 0.	07/3 463
0.10167E-02 0.	0.	0.24785E-02 0.	0.	0.38129E 0207/3 464
0.37981E 02	0.11143E 02 0.	0.	0.	07/3 465
0.61415E-02 0.	0.29613E 01	0.28083E 01	0.14612E-00 0.	07/3 466
0.	0.	0.72191E-07	0.15950E-01 0.	0.29813E 0107/3 467
0.27594E 01	0.14682E-00 0.	0.	0.	07/3 468
0.24153E-01 0.	0.30026E 01	0.27349E 01	0.20590E-00 0.	07/3 469
0.	0.	0.	0.48271E-01 0.	0.30338E 0107/3 470
0.27779E 01	0.24350E-00 0.	0.	0.	07/3 471
0.70307E-01 0.	0.30602E 01	0.27460E 01	0.20762E-00 0.	07/3 472
0.	0.	0.10925E-00 0.	0.30903E 0107/3 473	
0.26825E 01	0.24390E-00 0.	0.	0.	07/3 474
0.19356E-00 0.	0.31688E 01	0.26921E 01	0.29859E-00 0.	07/3 475
0.	0.	0.	0.35350E-00 0.	0.32680E 0107/3 476
0.29145E 01	0.28315E-00 0.	0.	0.	07/3 477

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

16 9 1611	ALUMINUM-27	THERMAL	HOMERTON
0 57237E-01 0	0 14864E 01 0	0 64114E 00 0	0 07/3 479
0 0	0 0	0 26828E 02 0	0 19439E 0107/3 480
0 14479E 01 0	0 38781E-00 0	0 0	0 07/3 481
0 19083E-04 0	0 23786E 01 0	0 19802E 01 0	0 45310E-00 0
0 0	0 0	0 51330E-03 0	0 75618E-0107/3 482
0 26472E 01 0	0 37833E-00 0	0 16782E 02 0	0 29785E 0107/3 483
0 20709E-02 0	0 46585E 01 0	0 44592E 01 0	0 33077E-00 0
0 38549E-01 0	0 57330E-01 0	0 60028E-02 0	0 19982E-0107/3 485
0 44965E 01 0	0 19725E-00 0	0 0	0 45387E 0107/3 486
0 47082E-02 0	0 13367E 01 0	0 12749E 01 0	0 36209E-01 0
0 0	0 0	0 50020E-02 0	0 0
0 13549E 01 0	0 57151E-01 0	0 0	0 14193E 0107/3 489
0 50020E-02 0	0 14193E 01 0	0 13543E 01 0	0 59406E-01 0
0 0	0 0	0 79877E-02 0	0 12075E-0607/3 490
0 13311E 01 0	0 60001E-01 0	0 0	0 07/3 491
0 10914E-01 0	0 14252E 01 0	0 13158E 01 0	0 83219E-01 0
0 0	0 0	0 17843E-01 0	0 14223E 0107/3 492
0 13307E 01 0	0 98462E-01 0	0 0	0 07/3 493
0 29418E-01 0	0 14437E 01 0	0 13162E 01 0	0 83584E-01 0
0 0	0 0	0 47442E-01 0	0 14617E 0107/3 498
0 12933E 01 0	0 98105E-01 0	0 0	0 07/3 499
0 92224E-01 0	0 15113E 01 0	0 13033E 01 0	0 12098E-00 0
0 0	0 0	0 16266E-00 0	0 15796E 0107/3 501
0 14170E 01 0	0 11559E-00 0	0 0	0 07/3 502
16 9 1612	SILICON	THERMAL	HOMERTON
0 94096E-01 0	0 19560E 01 0	0 54864E 00 0	0 07/3 504
0 0	0 0	0 6092E-02 0	0 21478E 0107/3 505
0 16208E 01 0	0 77282E 00 0	0 0	0 07/3 506
0 21041E-02 0	0 20958E 01 0	0 16878E 01 0	0 11741E-0007/3 507
0 0	0 0	0 32990E-02 0	0 31324E 0107/3 508
0 28589E 01 0	0 40587E-00 0	0 97095E-01 0	0 20973E 01 0
0 68274E 02 0	0 39251E 01 0	0 38725E 01 0	0 27013E-00 0
0 59096E-01 0	0 21064E-02 0	0 18061E-01 0	0 15250E 0107/3 511
0 14420E 01 0	0 45788E-01 0	0 0	0 18277E-02 0
0 24501E 01 0	0 19706E 01 0	0 18665E 01 0	0 64894E-01 0
0 0	0 0	0 83263E-02 0	0 24501E-01 0
0 19638E 01 0	0 79544E-01 0	0 0	0 20709E 0107/3 514
0 24501E-01 0	0 20709E 01 0	0 19629E 01 0	0 82692E 01 0
0 0	0 0	0 24501E-01 0	0 20709E 0107/3 517
0 19307E 01 0	0 83540E-01 0	0 0	0 07/3 518
0 24501E-01 0	0 20709E 01 0	0 19094E 01 0	0 11576E-00 0
0 0	0 0	0 24501E 01 0	0 20709E 0107/3 520
0 19301E 01 0	0 13704E-00 0	0 0	0 07/3 521
0 24501E-01 0	0 20709E 01 0	0 19100E 01 0	0 11630E 00 0

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0	0	0	0	72993E-01 0	0	21208E 0107/3 523
0	18793E 01 0	0	13649E 00 0	0	0	07/3 524
0	13685E 00 0	0	21865E 01 0	0	18896E 01 0	16857E 00 0
0	0	0	0	0	15529E-00 0	0
0	20502E 01 0	0	16009E-00 0	0	0	0
16 9 1613	P-31	THERMAL			HOMERTON	
0	11036E-00 0	0	18718E 01 0	0	60201E 00 0	0
0	0	0	0	0	20603E-01 0	0
0	15742E 01 0	0	55479E 00 0	0	0	0
0	10001E-01 0	0	16783E 01 0	0	14266E 01 0	33197E 00 0
0	0	0	0	0	10001E-01 0	0
0	20407E 01 0	0	24174E 00 0	0	13672E-00 0	34298E-00 0
0	10001E-01 0	0	0	0	30936E 01 0	29136E 01 0
0	35424E-02 0	0	96573E-01 0	0	10001E-01 0	0
0	35888E 01 0	0	17008E 00 0	0	0	0
0	10001E-01 0	0	0	0	0	0
0	0	0	42777E 01 0	0	41365E 01 0	15693E 00 0
0	0	0	10683E-06 0	0	10001E-01 0	0
0	33437E 01 0	0	13123E-00 0	0	0	1
0	10001E-01 0	0	0	0	33266E 01 0	31939E 01 0
0	0	0	1	00000E 06 0	10001E-01 0	0
0	31470E 01 0	0	12276E 00 0	0	0	1
0	10170E-01 0	0	0	0	33268E 01 0	31155E 01 0
0	0	0	1	00000E-06 0	13665E-01 0	0
0	31435E 01 0	0	20115E 00 0	0	0	1
0	25744E-01 0	0	0	0	33268E 01 0	31021E 01 0
0	0	0	1	00000E-06 0	41443E-01 0	0
0	30570E 01 0	0	19896E 00 0	0	0	1
0	80643E 01 0	0	0	0	35286E 01 0	31981E 01 0
0	0	0	1	00000E-06 0	13993E-00 0	0
0	36927E 01 0	0	24987E-00 1	0	00000E-06 1	00000E-06 1
16 9 1614	POTASSIUM	THERMAL			HOMERTON	
0	18137E-00 0	0	18241E 01 0	0	92247E 00 0	0
0	0	0	0	0	65285E 01 0	0
0	18281E 01 0	0	34991E-00 0	0	0	0
0	18565E-01 0	0	0	0	16456E 01 0	14472E 01 0
0	0	0	0	0	10007E-01 0	0
0	14363E 01 0	0	17981E 00 0	0	63518E-03 0	17724E-00 0
0	10002E-01 0	0	0	0	23503E 01 0	22726E 01 0
0	0	0	32166E-01 0	0	10002E-01 0	0
0	32047E 01 0	0	67711E 01 0	0	0	0
0	10002E-01 0	0	0	0	38188E-02 0	0
0	0	0	0	0	28320E 01 0	27250E 01 0
0	0	0	10748E 03 0	0	11402E 01 0	0
0	24589E 01 0	0	97027E-01 0	0	0	1
0	26659E-01 0	0	0	0	19673E 01 0	18836E 01 0
0	0	0	1	00000E 06 0	46192E 01 0	0
					0	19799E 0107/3 567

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0 18550E 01 0 56989E 01 0	0	0	1 00000E-0607/3 568
0 88399E-01 0	0 20464E 01 0 18636E 01 0 78641E-01 0	0 07/3 569	
0 0	1 00000E 06 0 15022E-00 0	0 21395E 0107/3 570	
0 19076E 01 0 94464E-01 0	0	1 00000E-0607/3 571	
0 25784E-00 0	0 22630E 01 0 19097E 01 0 81656E-01 0	0 07/3 572	
0 0	1 00000E-06 0 38098E-00 0	0 24248E 0107/3 573	
0 19216E 01 0 95697E 01 0	0	1 00000E-0607/3 574	
0 80296E 00 0	0 28625E 01 0 19459E 01 0 12222E-00 0	0 07/3 575	
0 0	1 00000E-06 0 14141E 01 0	0 35185E 0107/3 576	
0 21044E 01 0 11362E-00 1 00000E-06 1 00000E-06 1 00000E-06 1 00000E-0607/3 577			
16 9 1615 IRON	THERMAL	HOMERTON	
0 14824E-01 0	0 21518E 01 0 85708E 00 0	0 07/3 579	
0 0	0 20000E-05 0	0 22382E 0107/3 580	
0 14530E 01 0 52348E 00 0	0	0 07/3 581	
0 20000E-05 0	0 18930E 01 0 14144E 01 0 40814E-00 0	0 43205E-0007/3 582	
0 0	0 10779E-02 0	0 25669E 0107/3 583	
0 23996E 01 0 20774E-00 0 31686E-00 0 28467E-00 0		0 07/3 584	
0 10816E-01 0	0 38159E 01 0 37136E 01 0 16612E-00 0	0 27081E-0007/3 585	
0 60220E 01 0 41732E-01 0	0 20776E-01 0	0 89566E 0107/3 586	
0 88799E 01 0 92028E-01 0	0	0 07/3 587	
0 26411E-01 0	0 83659E 01 0 82340E 01 0 55920E-01 0	0 07/3 588	
0 0	0 31591E-01 0	0 62318E 0107/3 589	
0 60221E 01 0 10547E-00 0	0	0 07/3 590	
0 46324E 01 0	0 10442E 02 0 10175E 02 0 17804E-00 0	0 07/3 591	
0 0	0 98271E-04 0 95936E-01 0	0 10812E 0207/3 592	
0 10413E 02 0 22073E-00 0	0	0 07/3 593	
0 14095E-00 0	0 10901E 02 0 10598E 02 0 30307E-00 0	0 07/3 594	
0 0	0 18069E-00 0	0 10890E 0207/3 595	
0 10405E 02 0 36212E-00 0	0	0 07/3 596	
0 30467E-00 0	0 10975E 02 0 10515E 02 0 30444E-00 0	0 07/3 597	
0 0	0 51008E 00 0	0 11180E 0207/3 598	
0 10230E 02 0 35553E-00 0	0	0 07/3 599	
0 96647E 00 0	0 11637E 02 0 10252E 02 0 44083E-00 0	0 07/3 600	
0 0	0 17564E 01 0	0 12480E 0207/3 601	
0 10723E 02 0 41833E-00 0	0	0 07/3 602	
16 9 1616 GALLIUM	THERMAL	HOMERTON	
0 26614E 02 0	0 22218E 01 0 59185E 00 0	0 07/3 604	
0 0	0 80518E-02 0	0 25983E 0107/3 605	
0 10476E 01 0 45077E-00 0	0	0 07/3 606	
0 98918E-02 0	0 33746E 01 0 21548E 01 0 32172E-00 0	0 35670E 0007/3 607	
0 0	0 15767E 01 0	0 44961E 0107/3 608	
0 39565E 01 0 74607E 00 0 89272E 00 0 66924E 00 0		0 07/3 609	
0 35586E 01 0	0 60181E 01 0 58455E 01 0 48499E-00 0	0 45426E-0007/3 610	
0 32823E 00 0 17768E 00 0	0 72817E-01 0	0 70637E 0107/3 611	
0 68709E 01 0 13656E-00 0 38789E-01 0 96004E-02 0		0 07/3 612	

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0 84389E-01 0	0 77377E 01 0 75233E 01 0 11990E-00 0 54107E-0307/3 613		
0 0	0 89860E-01 0	0 90478E 0107/3 614	
0 88178E 01 0 12999E 00 0	0	0 07/3 615	
0 58273E-01 0	0 17195E 02 0 17006E 02 0 14016E-00 0	0 07/3 616	
0 0	0 63536E-01 0	0 58802E 0107/3 617	
0 57045E 01 0 13029E-00 0	0	0 68439E-0607/3 618	
0 11596E-00 0	0 56271E 01 0 53462E 01 0 11217E-00 0	0 07/3 619	
0 0	0 30164E-00 0	0 68626E 0107/3 620	
0 64043E 01 0 16493E-00 0	0	0 07/3 621	
0 45035E-00 0	0 74220E 01 0 67837E 01 0 15662E 00 0	0 07/3 622	
0 0	0 87545E 00 0	0 78061E 0107/3 623	
0 67042E 01 0 18798E-00 0	0	0 07/3 624	
0 13962E 01 0	0 81650E 01 0 65573E 01 0 22646E-00 0	0 07/3 625	
0 0	0 23222E 01 0	0 83528E 0107/3 626	
0 60306E 01 0 21151E-00 0	0	0 07/3 627	
16 9 1617 NIOBIUM-93	THERMAL	HOMERTON	
1 00000E-06 0	0 28350E 01 0 82606E 00 0	0 07/3 629	
0 0	0 19209E-03 0	0 37900E 0107/3 630	
0 16519E 01 0 10119E 01 0	0	0 07/3 631	
0 12330E-01 0	0 43804E 01 0 31578E 01 0 32245E-00 0	0 58139E 0007/3 632	
0 0	0 39388E-01 0	0 56285E 0107/3 633	
0 53856E 01 0 52945E 00 0 11940E 01 0 35456E-00 0		0 07/3 634	
0 78044E-01 0	0 76743E 01 0 74708E 01 0 16805E-00 0	0 56414E 0007/3 635	
0 61168E 00 0 79649E-01 0	0 15352E-00 0	0 76490E 0107/3 636	
0 74099E 01 0 12553E-00 0 34043E-01 0 11862E-00 0 98150E-02 0		0 07/3 637	
0 34967E-00 0	0 65876E 01 0 61730E 01 0 85601E-01 0	0 07/3 638	
0 0	0 12808E 01 0	0 66892E 0107/3 639	
0 53425E 01 0 64959E-01 0	0	0 07/3 640	
0 23042E 01 0	0 76646E 01 0 52933E 01 0 65945E-01 0	0 07/3 641	
0 0	0 14331E-02 0 18182E 01 0	0 71786E 0107/3 642	
0 52699E 01 0 66870E-01 0	0	0 07/3 643	
0 11000E 01 0	0 64604E 01 0 52521E 01 0 90546E-01 0	0 07/3 644	
0 0	0 11000E 01 0	0 64604E 0107/3 645	
0 52683E 01 0 10825E-00 0	0	0 07/3 646	
0 11000E 01 0	0 64604E 01 0 52533E 01 0 92133E-01 0	0 07/3 647	
0 0	0 11000E 01 0	0 64604E 0107/3 648	
0 52274E 01 0 10706E-00 0	0	0 07/3 649	
0 11000E 01 0	0 64604E 01 0 52542E 01 0 13300E 00 0	0 07/3 650	
0 0	0 11000E 01 0	0 64604E 0107/3 651	
0 53604E 01 0 12620E-00 0	0	0 07/3 652	
16 9 1618 MOLYBDENUM	THERMAL	HOMERTON	
1 00000E-06 0	0 27474E 01 0 83735E 00 0	0 07/3 654	
0 0	0 76633E-02 0	0 35792E 0107/3 655	
0 18955E 01 0 10207E 01 0	0	0 07/3 656	
0 14109E-01 0	0 46406E 01 0 32162E 01 0 78534E 00 0 50822E 0007/3 657		

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0.	0.	0.	0.23100E-01	0.	0.60241E 0107/3	698
0.54580E 01	0.98321E 00	0.74940E 00	0.31819E-00	0.	0.	07/3 699
0.32038E-01	0.	0.78411E 01	0.76919E 01	0.54304E 00	0.42705E-0007/3	660
0.14127E-00	0.11653E-00	0.	0.57887E-01	0.	0.74884E 0107/3	661
0.73661E 01	0.11711E-00	0.	0.	0.	0.	07/3 662
0.39939E-01	0.	0.68209E 01	0.67068E 01	0.84400E-01	0.	07/3 663
0.	0.	0.	0.40000E-01	0.	0.68267E 0107/3	664
0.66891E 01	0.74129E-01	0.	0.	0.	0.	07/3 665
0.40000E-01	0.	0.12785E 02	0.12676E 02	0.97582E-01	0.	07/3 666
0.	0.	0.	0.49601E 02	0.	0.87084E 0207/3	667
0.37395E 02	0.68188E-01	0.	0.	0.	0.68439E-0607/3	668
0.11528E-00	0.	0.54789E 01	0.52574E 01	0.88032E-01	0.	07/3 669
0.	0.	0.	0.19049E-00	0.	0.59069E 0107/3	670
0.56179E 01	0.10629E-00	0.	0.	0.	0.	07/3 671
0.34667E-00	0.	0.65037E 01	0.58418E 01	0.98551E-01	0.	07/3 672
0.	0.	0.	0.55739E 00	0.	0.65174E 0107/3	673
0.58186E 01	0.11528E-00	0.	0.	0.	0.	07/3 674
0.10810E 01	0.	0.70410E 01	0.58241E 01	0.14322E-00	0.	07/3 675
0.	0.	0.	0.19076E 01	0.	0.78676E 0107/3	676
0.59600E 01	0.13590E-00	0.	0.	0.	0.	07/3 677
16 9 1619	EUROPIUM					
0.78940E-02	0.	0.33367E 01	0.94648E 00	0.	0.	07/3 679
0.	0.	0.	0.77539E-01	0.	0.45702E 0107/3	680
0.24039E 01	0.11930E 01	0.	0.	0.	0.	07/3 681
0.13930E-00	0.	0.50857E 01	0.32029E 01	0.87704E 00	0.64882E 0007/3	682
0.	0.	0.	0.17684E-00	0.	0.72144E 0107/3	683
0.62186E 01	0.12197E 01	0.10184E 01	0.46522E-00	0.	0.	07/3 684
0.50993E 00	0.	0.97386E 01	0.90661E 01	0.80993E 00	0.52416E 0007/3	685
0.19325E-00	0.24810E-00	0.	0.22703E 01	0.	0.11544E 0207/3	686
0.91998E 01	0.16204E-00	0.94006E-02	0.	0.	0.	07/3 687
0.19844E 02	0.	0.28700E 02	0.87982E 01	0.72569E-01	0.57025E-0307/3	688
0.	0.	0.	0.45381E 02	0.	0.54108E 0207/3	689
0.86587E 01	0.58537E-01	0.	0.	0.	0.	07/3 690
0.73613E 02	0.	0.82779E 02	0.90966E 01	0.67493E-01	0.	07/3 691
0.	0.	0.	0.15378E 03	0.	0.16182E 0307/3	692
0.79531E 01	0.68539E-01	0.	0.	0.	0.	07/3 693
0.30556E 03	0.	0.31352E 03	0.78644E 01	0.82094E-01	0.	07/3 694
0.	0.	0.17864E-02	0.69205E 03	0.	0.70001E 0307/3	695
0.78788E 01	0.98300E-01	0.	0.	0.	0.	07/3 696
0.55772E 03	0.	0.56569E 03	0.78636E 01	0.83823E-01	0.	07/3 697
0.	0.	0.	0.51081E 04	0.	0.31160E 0407/3	698
0.78419E 01	0.97110E-01	0.	0.	0.	0.	07/3 699
0.14731E 04	0.	0.14810E 04	0.78481E 01	0.12077E-00	0.	07/3 700
0.	0.	0.	0.22788E 04	0.	0.22868E 0407/3	701
0.79627E 01	0.11459E-00	0.	0.	0.	0.	07/3 702

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

16 9 1620	GADOLINIUM					
1.00000E-06	0.	0.33625E 01	0.98024E 00	0.	0.	07/3 704
0.	0.	0.	0.71110E-01	0.	0.	07/3 705
0.24125E 01	0.11929E 01	0.	0.	0.	0.	07/3 706
0.13610E-00	0.	0.50891E 01	0.32128E 01	0.87503E 00	0.64882E 0007/3	707
0.	0.	0.	0.17562E-00	0.	0.	07/3 708
0.66496E 01	0.12160E 01	0.10184E 01	0.46522E-00	0.	0.	07/3 709
0.30943E-00	0.	0.10213E 02	0.97411E 01	0.81977E 00	0.52416E 0007/3	710
0.19325E-00	0.24810E-00	0.	0.10986E 01	0.	0.	07/3 711
0.98853E 01	0.16201E-00	0.94006E-02	0.	0.	0.	07/3 712
0.29556E 01	0.	0.12916E 02	0.98911E 01	0.77604E-01	0.57025E-0307/3	713
0.	0.	0.	0.85712E 01	0.	0.	07/3 714
0.98553E 01	0.68936E-01	0.	0.	0.	0.	07/3 715
0.24464E 02	0.	0.36005E 02	0.11449E 02	0.72501E-01	0.	07/3 716
0.	0.	0.	0.45476E 02	0.	0.	07/3 717
0.12742E 02	0.91721E-01	0.	0.	0.	0.	07/3 718
0.10580E 03	0.	0.13369E 03	0.27768E 02	0.19109E-00	0.	07/3 719
0.	0.	0.17864E-02	0.34778E 02	0.	0.	07/3 720
0.10756E 02	0.12440E-00	0.	0.	0.	0.	07/3 721
0.13811E 03	0.	0.15390E 03	0.15649E 02	0.12647E-00	0.	07/3 722
0.	0.	0.	0.16983E 03	0.	0.	07/3 723
0.12988E 02	0.14050E-00	0.	0.	0.	0.	07/3 724
0.55436E 04	0.	0.56014E 04	0.56450E 02	0.21980E-00	0.	07/3 725
0.	0.	0.	0.26755E 05	0.	0.	07/3 726
0.12848E 03	0.13847E 01	0.	0.	0.	0.	07/3 727
16 9 1621	TANTALUM-181					
0.29390E-01	0.	0.36303E 01	0.11396E 01	0.	0.	07/3 729
0.	0.	0.	0.10110E-00	0.	0.	07/3 730
0.22804E 01	0.12704E 01	0.	0.	0.	0.	07/3 731
0.14437E-00	0.	0.50335E 01	0.26800E 01	0.10327E 01	0.65575E 0007/3	732
0.	0.	0.	0.20924E-00	0.	0.	07/3 733
0.44108E 01	0.16055E 01	0.10981E 01	0.44535E-00	0.	0.	07/3 734
0.41698E-00	0.	0.68041E 01	0.62677E 01	0.10545E 01	0.60362E 0007/3	735
0.20917E-00	0.21575E-00	0.	0.11599E 01	0.	0.	07/3 736
0.82602E 01	0.11945E-00	0.	0.	0.	0.	07/3 737
0.56122E 01	0.	0.13922E 02	0.82704E 01	0.38597E-01	0.	07/3 738
0.	0.	0.	0.16455E 02	0.	0.	07/3 739
0.56609E 01	0.39003E-01	0.	0.	0.	0.	07/3 740
0.29975E 02	0.	0.34995E 02	0.49881E 01	0.32977E-01	0.	07/3 741
0.	0.	0.	0.17788E 03	0.	0.	07/3 742
0.49369E 01	0.51972E-01	0.	0.	0.	0.	07/3 743
0.14978E 03	0.	0.16358E 03	0.12882E 02	0.43083E-01	0.	07/3 744
0.	0.	0.	0.71244E 03	0.	0.	07/3 745
0.82782E 02	0.92526E 00	0.	0.	0.	0.	07/3 746
0.60427E 01	0.	0.11128E 02	0.50340E 01	0.49902E-01	0.	07/3 747

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0	0	0	0	60754E 01 0	0	11059E 0207/3 748
0	49166E 01 0	50969E-01 0	0	0	0	07/3 749
0	86291E 01 0	0	13609E 02 0	49198E 01 0	63402E-01 0	07/3 750
0	0	0	0	14105E 02 0	0	19085E 0207/3 751
0	49800E 01 0	60160E-01 0	0	0	0	07/3 752
16 9 1622	TUNGSTEN	THERMAL			HONERTON	
0	13336E-01 0	0	36252E 01 0	10421E 01 0	0	07/3 754
0	0	0	0	40165E-01 0	0	47774E 0107/3 755
0	21594E 01 0	23508E-00 0	0	0	0	07/3 756
0	49421E-01 0	0	50544E 01 0	28560E 01 0	24563E-00 0	56222E-0007/3 757
0	0	0	0	77565E-01 0	0	57423E 0107/3 758
0	44941E 01 0	82059E 00 0	13861E 01 0	15824E 01 0	0	07/3 759
0	12204E-00 0	0	76361E 01 0	72723E 01 0	11161E 01 0	10715E 0107/3 760
0	84996E 00 0	58842E 00 0	0	26406E-00 0	0	11038E 0207/3 761
0	10702E 02 0	24178E-00 0	54848E-01 0	25690E-00 0	98145E-01 0	07/3 762
0	29589E 01 0	0	12756E 02 0	97555E 01 0	71476E-01 0	07/3 763
0	0	0	0	10452E 02 0	0	15969E 0207/3 764
0	54859E 01 0	41391E-01 0	0	0	0	07/3 765
0	92494E 02 0	0	97478E 02 0	49518E 01 0	31035E-01 0	07/3 766
0	0	0	0	47453E 02 0	0	52436E 0207/3 767
0	49409E 01 0	31487E-01 0	0	0	0	07/3 768
0	16233E 04 0	0	16283E 04 0	49325E 01 0	42426E-01 0	07/3 769
0	0	0	0	66234E 02 0	0	71218E 0207/3 770
0	49400E 01 0	50822E-01 0	0	0	0	07/3 771
0	35428E 01 0	0	85261E 01 0	49331E 01 0	43360E-01 0	07/3 772
0	0	0	0	38171E 01 0	0	87978E 0107/3 773
0	49185E 01 0	50192E-01 0	0	0	0	07/3 774
0	74190E 01 0	0	12356E 02 0	48780E 01 0	62195E-01 0	07/3 775
0	0	0	0	13078E 02 0	0	18047E 0207/3 776
0	49697E 01 0	58652E-01 0	0	0	0	07/3 777
16 9 1624	LEAD	THERMAL			HONERTON	
1	00000E-06 0	0	39186E 01 0	18486E 01 0	0	07/3 804
0	0	0	0	1 00000E-06 0	0	40550E 0107/3 805
0	30639E 01 0	75598E 00 0	0	0	0	07/3 806
0	21104E-04 0	0	45617E 01 0	41453E 01 0	23522E-00 0	69477E 0007/3 807
0	0	0	0	63887E-03 0	0	46633E 0107/3 808
0	45345E 01 0	25060E-00 0	55875E 00 0	56775E 00 0	0	07/3 809
1	00000E-03 0	0	71999E 01 0	71373E 01 0	11867E-00 0	16580E-0007/3 810
0	19909E-00 0	20984E-00 0	1 00000E-03 0	0	0	10080E 0207/3 811
0	10021E 02 0	61622E-01 0	0	0	0	07/3 812
1	00000E-03 0	0	10888E 02 0	10830E 02 0	58219E-01 0	07/3 813
0	0	0	0	11888E-02 0	0	10965E 0207/3 814
0	10903E 02 0	57592E 01 0	0	0	0	07/3 815
0	26323E-02 0	0	10966E 02 0	10902E 02 0	60611E-01 0	07/3 816
0	0	0	0	94849E-02 0	55264E-02 0	10969E 0207/3 817

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0	10881E 02 0	61501E 01 0	0	0	0	07/3 818
0	80024E-02 0	0	10971E 02 0	10864E 02 0	82821E-01 0	07/3 819
0	0	0	0	13187E-01 0	0	10977E 0207/3 820
0	10879E 02 0	99235E-01 0	0	0	0	07/3 821
0	24625E-01 0	0	10988E 02 0	10865E 02 0	84687E-01 0	07/3 822
0	0	0	0	37827E-01 0	0	11065E 0207/3 823
0	10904E 02 0	97988E-01 0	0	0	0	07/3 824
0	74237E-01 0	0	11060E 02 0	10870E 02 0	12275E-00 0	07/3 825
0	0	0	0	13159E-00 0	0	11095E 0207/3 826
0	10963E 02 0	11568E-00 0	0	0	0	07/3 827
16 9 1625	U-235	THERMAL			HONERTON	
0	18385E 01 0	58251E 01 0	42859E 01 0	10336E 01 0	0	07/3 829
0	0	0	0	20465E 01 0	53056E 01 0	46929E 0107/3 830
0	14170E 01 0	11166E-00 0	0	0	0	07/3 831
0	20568E 01 0	49998E 01 0	49816E 01 0	20055E 01 0	11183E-00 0	18907E-0007/3 832
0	0	0	0	21754E 01 0	50620E 01 0	59201E 0107/3 833
0	33571E 01 0	36314E-00 0	65159E 00 0	88101E 00 0	0	07/3 834
0	25188E 01 0	57292E 01 0	86745E 01 0	60793E 01 0	37040E-00 0	44732E-0007/3 835
0	41351E-00 0	34159E-00 0	0	35410E 01 0	77248E 01 0	12320E 0207/3 836
0	87313E 01 0	76362E-01 0	17174E-01 0	10888E-00 0	52756E-01 0	07/3 837
0	65844E 01 0	14627E 02 0	15677E 02 0	90491E 01 0	47356E-01 0	07/3 838
0	0	0	0	10471E 02 0	23578E 02 0	22592E 0207/3 839
0	12060E 02 0	43733E-01 0	0	0	0	07/3 840
0	24257E 02 0	55457E 02 0	36409E 02 0	12092E 02 0	61274E-01 0	07/3 841
0	0	0	0	41946E 02 0	95215E 02 0	53914E 0207/3 842
0	11888E 02 0	59690E-01 0	0	0	0	07/3 843
0	10716E 03 0	21763E 03 0	11913E 03 0	11872E 02 0	80344E-01 0	07/3 844
0	0	0	0	15275E 03 0	28603E 03 0	16471E 0307/3 845
0	11886E 02 0	96285E-01 0	0	0	0	07/3 846
0	42489E 03 0	82647E 03 0	43661E 03 0	11622E 02 0	82189E-01 0	07/3 847
0	0	0	0	14786E 03 0	33257E 03 0	15983E 0307/3 848
0	11850E 02 0	95062E-01 0	0	0	0	07/3 849
0	23487E 03 0	52373E 03 0	24737E 03 0	12381E 02 0	11829E-00 0	07/3 850
0	0	0	0	41294E 03 0	94154E 03 0	42418E 0307/3 851
0	11243E 02 0	11224E-00 0	0	0	0	07/3 852
16 9 1626	U-234	THERMAL			HONERTON	
0	16111E 01 0	51246E 01 0	41262E 01 0	10732E 01 0	0	07/3 854
0	0	0	0	15341E 01 0	39446E 01 0	45393E 0107/3 855
0	15996E 01 0	12462E-00 0	0	0	0	07/3 856
0	13016E 01 0	31136E 01 0	48626E 01 0	24466E 01 0	12164E-00 0	20185E-0007/3 857
0	0	0	0	97941E 00 0	20373E 01 0	56305E 0107/3 858
0	40737E 01 0	43664E-00 0	72899E 00 0	86269E 00 0	0	07/3 859
0	36114E-00 0	26106E-00 0	85521E 01 0	80933E 01 0	55135E 00 0	54620E 0007/3 860
0	48523E-00 0	32846E-00 0	0	69577E 00 0	24558E-03 0	11811E 0207/3 861
0	11056E 02 0	97616E-01 0	26012E-01 0	13160E-00 0	69748E-01 0	07/3 862

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

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0 14509E 01 0 24510E 05 0 13407E 02 0 11900E 02 0 58508E 01 0 07/3 865
0 0 0 0 26467E 01 0 24502E 05 0 14615E 0207/3 864
0 1909E 02 0 55641E 01 0 0 0 0 07/3 865
0 45404E 01 0 24500E-05 0 16508E 02 0 11909E 02 0 58572E-01 0 07/3 866
0 0 0 0 77561E 01 0 24500E-05 0 19724E 0207/3 867
0 11888E 02 0 59435E-01 0 0 0 0 07/3 868
0 10457E 02 0 24500E-05 0 22425E 02 0 11872E 02 0 79999E-01 0 07/3 869
0 0 0 0 17433E 02 0 24500E-05 0 29401E 0207/3 870
0 11886E 02 0 95873E-01 0 0 0 0 07/3 871
0 23742E 02 0 24500E-05 0 35710E 02 0 11873E 02 0 81838E-01 0 07/3 872
0 0 0 0 38570E 02 0 24500E-05 0 50538E 0207/3 873
0 11850E 02 0 94655E-01 0 0 0 0 07/3 874
0 56438E 02 0 24500E-05 0 68406E 02 0 11856E 02 0 11778E-00 0 07/3 875
0 0 0 0 81525E 02 0 24500E-05 0 93893E 0207/3 876
0 11968E 02 0 11176E-00 0 0 0 0 07/3 877
16 9 1627 U-235 THERMAL HONERTON
0 13707E 01 0 43689E 01 0 42165E 01 0 10669E 01 0 0 07/3 879
0 0 0 0 13317E 01 0 33175E 01 0 46091E 0107/3 880
0 15700E 01 0 14004E-00 0 0 0 0 07/3 881
0 12811E 01 0 29770E 01 0 50194E 01 0 25879E 01 0 16574E-00 0 23813E-0007/3 882
0 0 0 0 13407E 01 0 28752E 01 0 56764E 0107/3 883
0 38957E 01 0 75929E 00 0 10643E 01 0 11221E 01 0 0 07/3 884
0 17851E 01 0 34682E 01 0 89534E 01 0 70546E 01 0 40485E-00 0 38771E-0007/3 885
0 47732E-00 0 43220E-00 0 0 35130E 01 0 61218E 01 0 13434E 0207/3 886
0 98681E 01 0 83511E-01 0 23512E-01 0 33643E-02 0 0 07/3 887
0 61369E 01 0 98543E 01 0 17080E 02 0 10892E 02 0 52890E-01 0 30257E-0107/3 888
0 11684E-01 0 0 0 12328E 02 0 19889E 02 0 23298E 02 7/3 889
0 10917E 02 0 50786E-01 0 0 0 0 07/3 890
0 30128E 02 0 48606E 02 0 41098E 02 0 10916E 02 0 53462E-01 0 07/3 891
0 0 0 0 54908E 02 0 88586E 02 0 65902E 0207/3 892
0 10920E 02 0 54250E-01 0 0 0 0 07/3 893
0 14212E 03 0 22932E 03 0 15304E 03 0 10833E 02 0 73019E-01 0 07/3 894
0 0 0 0 88087E 02 0 11927E 03 0 10068E 0307/3 895
0 12506E 02 0 87508E-01 0 0 0 0 07/3 896
0 41581E 02 0 73066E 02 0 55229E 02 0 13538E 02 0 88280E-01 0 07/3 897
0 0 0 0 86093E 02 0 17623E 03 0 10006E 0307/3 898
0 13826E 02 0 10996E-00 0 0 0 0 07/3 899
0 24494E 03 0 48954E 03 0 25891E 03 0 13833E 02 0 13683E-00 0 07/3 900
0 0 0 0 45307E 03 0 93352E 03 0 46704E 0307/3 901
0 13963E 02 0 12983E-00 0 0 0 0 07/3 902
16 9 1628 U-236 THERMAL HONERTON
0 10514E 01 0 33749E 01 0 41308E 01 0 10966E 01 0 0 07/3 904
0 0 0 0 81881E 00 0 20867E 01 0 45340E 0107/3 905
0 15736E 01 0 15667E 00 0 0 0 0 07/3 906
0 53079E 00 0 12282E 01 0 48867E 01 0 24544E 01 0 17746E-00 0 26562E-0007/3 907

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C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

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0 0 0 0 13892E-00 0 10985E-00 0 55704E 0107/3 908
0 41347E 01 0 71269E 00 0 11311E 01 0 12577E 01 0 0 07/3 909
0 13805E 00 0 24185E-05 0 86446E 01 0 81730E 01 0 12348E 01 0 96036E 0007/3 910
0 73387E 00 0 48273E-00 0 0 25251E-00 0 23962E-05 0 11357E 0207/3 911
0 11044E 02 0 33358E-00 0 61983E-01 0 22841E-00 0 99207E-01 0 07/3 912
0 31281E 01 0 23911E-05 0 15083E 02 0 11900E 02 0 57992E-01 0 07/3 913
0 0 0 0 20817E 02 0 23902E-05 0 32785E 0207/3 914
0 11910E 02 0 55168E-01 0 0 0 0 07/3 915
0 23792E 02 0 23900E-05 0 35760E 02 0 11909E 02 0 58075E-01 0 07/3 916
0 0 0 0 34204E 02 0 23900E-05 0 46172E 0207/3 917
0 11889E 02 0 58932E-01 0 0 0 0 07/3 918
0 17410E 01 0 23900E-05 0 13709E 02 0 11873E 02 0 79518E-01 0 07/3 919
0 0 0 0 25315E-02 0 61414E 03 0 23900E-05 0 62611E 0307/3 920
0 11887E 02 0 95058E-01 0 0 0 0 07/3 921
0 50000E 00 0 23900E 05 0 12468E 02 0 11874E 02 0 81144E-01 0 07/3 922
0 0 0 0 50000E 00 0 23900E-05 0 12468E 0207/3 923
0 11851E 02 0 93850E-01 0 0 0 0 07/3 924
0 50000E 00 0 23900E-05 0 12468E 02 0 11857E 02 0 11678E-00 0 07/3 925
0 0 0 0 25431E 01 0 23900E-05 0 14511E 0207/3 926
0 11968E 02 0 11081E 00 0 0 0 07/3 927
16 9 1629 U-238 THERMAL HONERTON
0 66296E 00 0 21139E 01 0 41022E 01 0 11246E 01 0 0 07/3 929
0 0 0 0 49612E-00 0 11742E 01 0 46146E 0107/3 930
0 17402E 01 0 17823E-00 0 0 0 0 07/3 931
0 18267E-00 0 89700E-01 0 49978E 01 0 28112E 01 0 18657E-00 0 30482E-0007/3 932
0 0 0 0 16395E-00 0 24225E-05 0 57054E 0107/3 933
0 45430E 01 0 76462E 00 0 12330E 01 0 15038E 01 0 0 07/3 934
0 17148E-00 0 23629E-05 0 86359E 01 0 80456E 01 0 95140E 00 0 99692E 0007/3 935
0 83428E 00 0 57876E 00 0 0 42783E-00 0 23372E-05 0 12587E 0207/3 936
0 12062E 02 0 41881E-00 0 46984E-01 0 24242E-00 0 12440E-00 0 07/3 937
0 72585E 00 0 23313E-05 0 14378E 02 0 13588E 02 0 64768E-01 0 07/3 938
0 0 0 0 22904E 01 0 23302E-05 0 16941E 0207/3 939
0 14576E 02 0 63812E-01 0 0 0 0 07/3 940
0 80881E 01 0 23300E-05 0 26136E 02 0 16248E 02 0 74945E-01 0 07/3 941
0 0 0 0 42973E 02 0 23300E-05 0 99997E 0207/3 942
0 56992E 02 0 17997E 01 0 0 0 0 07/3 943
0 38055E 02 0 23300E-05 0 58348E 02 0 20230E 02 0 32213E-01 0 07/3 944
0 0 0 0 32103E-01 0 12977E 03 0 23300E-05 0 14615E 0307/3 945
0 16315E 02 0 62739E-01 0 0 0 0 07/3 946
0 38527E-00 0 23300E 05 0 93893E 01 0 89341E 01 0 60616E-01 0 07/3 947
0 0 0 0 79301E 00 0 23300E-05 0 95763E 0107/3 948
0 86998E 01 0 69949E 01 0 0 0 0 07/3 949
0 12658E 01 0 23300E-05 0 97690E 01 0 84257E 01 0 83517E-01 0 07/3 950
0 0 0 0 19433E 01 0 23300E-05 0 10163E 0207/3 951
0 82399E 01 0 77556E 01 0 0 0 0 07/3 952

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C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

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16 9 1630 PU-239 THERMAL MONERTON
0 20181E 01 0 71972E 01 0 45054E 01 0 10197E 01 0 0 07/3 954
0 0 0 0 20957E 01 0 62463E 01 0 47626E 0107/3 955
0 16229E 01 0 10793E-00 0 0 0 07/3 956
0 19359E 01 0 54724E 01 0 51216E 01 0 25062E 01 0 11571E-00 0 18347E-0007/3 957
0 0 0 0 18705E 01 0 495 5E 01 0 60293E 0107/3 958
0 38271E 01 0 45485E-00 0 64231E 00 0 81883E 00 0 0 07/3 959
0 19643E 01 0 46697E 01 0 92436E 01 0 71673E 01 0 30010E-00 0 22259E-0007/3 960
0 28859E-00 0 31693E 00 0 0 27217E 01 0 57877E 01 0 15185E 0207/3 961
0 10408E 02 0 81869E-01 0 19878E 01 0 19591E-02 0 0 07/3 962
0 52165E 01 0 98457E 01 0 16591E 02 0 11324E 02 0 55399E-01 0 30023E-0107/3 963
0 11610E-01 0 0 0 96981E 01 0 18517E 02 0 20704E 0207/3 964
0 10954E 02 0 50544E-01 0 0 0 0 07/3 965
0 17814E 02 0 55120E 02 0 28785E 02 0 10917E 02 0 52567E-01 0 07/3 966
0 0 0 0 10696E 03 0 15736E 03 0 12110E 0307/3 967
0 14071E 02 0 53342E-01 0 0 0 0 07/3 968
0 26116E 03 0 39936E 03 0 27955E 03 0 18341E 02 0 71350E-01 0 07/3 969
0 0 0 0 64197E 02 0 95188E 02 0 74859E 0207/3 970
0 10592E 02 0 56292E-01 0 0 0 0 07/3 971
0 27676E 02 0 66483E 02 0 38892E 02 0 11123E 02 0 69387E-01 0 07/3 972
0 0 0 0 24980E 03 0 45927E 03 0 26383E 0307/3 973
0 13856E 02 0 9387E-01 0 0 0 0 07/3 974
0 17295E 04 0 29995E 04 0 17418E 04 0 12227E 02 0 17669E-00 0 07/3 975
0 0 0 0 79793E 03 0 15330E 04 0 80745E 0307/3 976
0 95214E 01 0 87459E-01 0 0 0 0 07/3 977
16 9 1631 PU-240 THERMAL MONERTON
0 16800E 01 0 59593E 01 0 42171E 01 0 98697E 00 0 0 07/3 979
0 0 0 0 16494E 01 0 47687E 01 0 48366E 0107/3 980
0 14886E 01 0 12597E-00 0 0 0 0 07/3 981
0 15042E 01 0 40740E 01 0 51678E 01 0 22750E 01 0 15684E-00 0 21459E-0007/3 982
0 0 0 0 90614E 00 0 20381E 01 0 54984E 0107/3 983
0 37172E 01 0 52821E 00 0 91811E 00 0 93322E 00 0 0 07/3 984
0 12937E 01 0 19799E-00 0 82395E 01 0 68028E 01 0 83375E 00 0 69457E 0007/3 985
0 56002E 00 0 35900E 00 0 0 32901E 01 0 28042E-01 0 12149E 0207/3 986
0 88139E 01 0 14290E-00 0 41311E-01 0 16582E 00 0 63606E-01 0 07/3 987
0 55114E 01 0 28068E-01 0 15877E 02 0 10510E 02 0 44829E 01 0 07/3 988
0 0 0 0 10951E 02 0 28094E-01 0 24408E 0207/3 989
0 13390E 02 0 55319E 01 0 0 0 0 07/3 990
0 15087E 02 0 28099E-01 0 29049E 02 0 13895E 02 0 66624E-01 0 07/3 991
0 0 0 0 42135E 02 0 28098E-01 0 56098E 0207/3 992
0 13872E 02 0 67607E-01 0 0 0 0 07/3 993
0 75156E 02 0 28086E 01 0 89031E 02 0 13767E 02 0 90990E-01 0 07/3 994
0 0 0 0 44377E 02 0 28082E-01 0 58340E 0207/3 995
0 13870E 02 0 10905E 00 0 0 0 0 07/3 996
0 10002E 05 0 51278E 01 0 10253E 05 0 23432E 03 0 93090E 01 0 07 3 997

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C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

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0 0 0 0 68820E 03 0 16133E 01 0 87734E 0307/3 998
0 18899E 03 0 17419E 02 0 0 0 07/3 999
0 14120E 03 0 28100E 01 0 15542E 03 0 14084E 02 0 15728E 00 0 07/31000
0 0 0 0 0 20582E 03 0 28100E-01 0 21979E 0307/31001
0 13963E 02 0 12712E 00 0 0 0 07/31002
16 9 1632 PU-241 THERMAL MONERTON
0 18106E 01 0 63436E 01 0 40727E 01 0 10133E 01 0 0 07/31004
0 0 0 0 18485E 01 0 53789E 01 0 47888E 0107/31005
0 16209E 01 0 10218E-00 0 0 0 07/31006
0 17781E 01 0 49008E 01 0 55051E 01 0 25241E 01 0 15069E 00 0 16594E 0007/31007
0 0 0 0 18550E 01 0 47569E 01 0 62653E 0107/31008
0 38251E 01 0 78215E 00 0 82153E 00 0 79301E 00 0 0 07/31009
0 26417E 01 0 61656E 01 0 98615E 01 0 71334E 01 0 53334E 00 0 41675E 0007/31010
0 36725E-00 0 30496E-00 0 0 46956E 01 0 11202E 02 0 14207E 0207/31011
0 94635E 01 0 68817E-01 0 33956E-01 0 39645E-02 0 0 07/31012
0 64023E 01 0 15225E 02 0 16330E 02 0 98823E 01 0 47414E 01 0 17666E 0107/31013
0 17831E-01 0 0 0 81421E 01 0 17108E 02 0 18109E 0207/31014
0 99193E 01 0 44903E-01 0 0 0 07/31015
0 37088E 02 0 73682E 02 0 47062E 02 0 99252E 01 0 47391E-01 0 07/31016
0 0 0 0 69861E 02 0 13885E 03 0 79834E 0207/31017
0 99086E 01 0 48090E-01 0 0 0 07/31018
0 16819E 03 0 33399E 03 0 17616E 03 0 98958E 01 0 64722E-01 0 07/31019
0 0 0 0 28689E 03 0 37064E 03 0 29686E 0307/31020
0 99071E 01 0 77567E-01 0 0 0 07/31021
0 47197E 02 0 93673E 02 0 57170E 02 0 98968E 01 0 66216E-01 0 07/31022
0 0 0 0 87891E 02 0 17475E 03 0 97864E 0207/31023
0 98780E 01 0 76580E-01 0 0 0 07/31024
0 11864E 04 0 23568E 04 0 11963E 04 0 98829E 01 0 95294E-01 0 07/31025
0 0 0 0 10164E 04 0 20226E 04 0 10264E 0407/31026
0 99733E 01 0 90420E-01 0 0 0 07/31027
16 9 1639 MAGNESIUM THERMAL MONERTON
0 28253E-01 0 0 14055E 01 0 70795E 00 0 0 MESNE 2
0 0 0 0 89738E-03 0 0 17036E 01 MESNE 3
0 12923E 01 0 51017E 00 0 0 0 MESNE 4
0 94403E-03 0 0 18950E 01 0 15240E 01 0 23461E-00 0 86948E 01 MESNE 5
0 0 0 0 97238E-03 0 0 35233E 01 MESNE 6
0 29490E 01 0 37000E 00 0 14426E 00 0 67280E-01 0 0 MESNE 7
0 99429E 03 0 0 54767E 01 0 50972E 01 0 57332E 00 0 0 MESNE 8
0 31575E-01 0 49258E-02 0 0 61130E-02 0 0 73918E 01 MESNE 9
0 71806E 01 0 37842E 00 0 0 0 0 MESNE10
0 11268E-01 0 0 35066E 01 0 33431E 01 0 20511E-00 0 0 MESNE11
0 0 0 0 57287E-07 0 14276E 01 0 0 34091E 01 MESNE12
0 32366E 01 0 15223E 00 0 0 0 0 MESNE13
0 14869E 01 0 0 34097E 01 0 32351E 01 0 15823E-00 0 0 MESNE14
0 0 0 0 14972E-01 0 0 34098E 01 MESNE15

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C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0 31720E 01 0 15970E 00 0	0	0	0	MESNE16
0 14992E 01 0	0 34090E 01 0 31325E 01 0 22204E-00 0	0	0	MESNE17
0	0	0 14999E-01 0	0 34090E 01	MESNE18
0 31719E 01 0 26226E-00 0	0	0	0	MESNE19
0 15001E-01 0	0 34090E 01 0 31332E 01 0 22200E-00 0	0	0	MESNE20
0	0	0 22367E-01 0	0 33719E 01	MESNE21
0 30344E 01 0 26163E-00 0	0	0	0	MESNE22
0 32067E-01 0	0 33220E 01 0 29945E 01 0 31514E-00 0	0	0	MESNE23
0	0	0 44227E-01 0	0 32134E 01	MESNE24
0 31692E 01 0 29541E-00 0	0	0	0	MESNE25
16 9 1640 TRITIUM	THERMAL	HOWERTON		
0	0 14793E 01 0 46222E-00 0	0	0	MESNE52
0	0	0	0 21540E 01	MESNE53
0 59956E 00 0 65890E 00 0	0	0	0	MESNE54
0	0 19126E 01 0 38031E-00 0 52372E 00 0	0 30856E-00	MESNE55	
0	0	0	0 15929E 01	MESNE56
0 48073E-00 0 10067E 01 0 10047E 01 0 53979E-01 0	0	0 11121E 01 0	0 52556E 00	MESNE57
0	0 11714E 01 0 60773E 00 0	0	0 10204E 01	MESNE58
0 25953E 01 0 34891E-02 0	0	0	0	MESNE59
0 64004E 00 0 56372E 00 0 14995E-04 0	0	0	0	MESNE60
0	0 10133E 01 0 62861E 00 0 38033E-00 0	0	0	MESNE61
0	0	0	0 10133E 01	MESNE62
0 60440E 00 0 38467E-00 0	0	0	0	MESNE63
0	0 10133E 01 0 60470E 00 0 40887E-00 0	0	0	MESNE64
0	0	0	0 10133E 01	MESNE65
0 44512E-00 0 40398E-00 0	0	0	0	MESNE66
0	0 10133E 01 0 38845E-00 0 55180E 00 0 45978E-02	MESNE67	0 10133E 01	MESNE68
0	0	0	0	MESNE69
0 44441E-00 0 61727E 00 0 16395E-01 0	0	0	0 75517E-02	MESNE70
0	0 10133E 01 0 38524E-00 0 55247E 00 0	0 10133E 01	0	MESNE71
0	0	0	0	MESNE72
0 30202E-00 0 57420E 00 0 16399E-01 0	0	0	0 53845E-01	MESNE73
0	0 10133E 01 0 39039E-00 0 71125E 00 0	0 10133E 01	0	MESNE74
0	0	0	0	MESNE75
0 10133E 01 0 62289E 00 0 60631E-05 0	0	0	0	
16 9 1641 HELIUM-3	THERMAL	HOWERTON		
0 43112E-00 0	0 14551E 01 0 27101E-00 0	0	0 07/3 104	
0	0	0 81702E 00 0	0 26429E 0107/3 105	
0 43510E-00 0 54576E 00 0	0	0	0 07/3 106	
0 88169E 00 0	0 27815E 01 0 29787E-00 0 57496E 00 0 18291E-0007/3 107	0	0 24720E 0107/3 108	
0	0	0 92322E 00 0	0 07/3 109	
0 38824E-00 0 11216E 01 0 79360E 00 0 24318E-01 0	0	0	0 48040E-0007/3 110	
0 14279E 01 0	0 28573E 01 0 75637E 00 0 11605E 01 0	0 52332E 0107/3 111	0 07/3 112	
0 22093E-01 0	0	0 42283E 01 0		
0 66527E 00 0 67303E 00 0 94151E 05 0	0	0		

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0 10214E 02 0	0 11005E 02 0 49532E-00 0 33968E-00 0	0 07/3 113
0	0 22949E 02 0	0 23729E 0207/3 114
0 46492E-00 0 29591E 00 0	0	0 07/3 115
0 57158E 02 0	0 57938E 02 0 46515E-00 0 31452E-00 0	0 07/3 116
0	0 11744E 03 0	0 11822E 0307/3 117
0 34240E-00 0 31075E-00 0	0	0 07/3 118
0 20849E 03 0	0 20926E 03 0 29881E-00 0 42446E-00 0 35371E-0207/3 119	
0	0 36965E 03 0	0 37049E 0307/3 120
0 34185E 00 0 47483E-00 0 12581E-01 0	0	0 07/3 121
0 66113E 03 0	0 66191E 03 0 29633E-00 0 42498E-00 0 58096E-0207/3 122	
0	0 10882E 04 0	0 10890E 0407/3 123
0 23232E 00 0 44169E-00 0 12615E-01 0	0	0 07/3 124
0 20749E 04 0	0 20757E 04 0 30030E-00 0 54712E 00 0 41421E-0107/3 125	
0	0 37103E 04 0	0 37111E 0407/3 126
0 77945E 00 0 47915E-00 0 46818E-05 0	0	0 07/3 127
16 9 1642 HELIUM-4	THERMAL	HOWERTON
0	0 11652E 01 0 37867E-00 0	0 07/3 129
0	0	0 26544E 0107/3 130
0 59001E 00 0 74427E 00 0	0	0 07/3 131
0	0 37600E 01 0 15093E 01 0 13740E 01 0 42269E-0107/3 132	
0	0	0 27910E 0107/3 133
0 13001E 01 0 38446E 01 0 69031E 00 0	0	0 07/3 134
0	0 95238E 00 0 64906E 00 0 14910E 01 0 40609E-0007/3 135	
0	0	0 67225E 0007/3 136
0 49619E-00 0 30332E-00 0	0	0 07/3 137
0	0 60901E 00 0 43852E-00 0 17605E-00 0	0 07/3 138
0	0	0 60829E 0007/3 139
0 42732E 00 0 17049E-00 0	0	0 07/3 140
0	0 60829E 00 0 42664E-00 0 18097E-00 0	0 07/3 141
0	0	0 60829E 0007/3 142
0 35416E-00 0 18165E-00 0	0	0 07/3 143
0	0 60829E 00 0 32113E-00 0 25413E-00 0	0 07/3 144
0 35363E-00 0 28717E-00 0	0	0 60829E 0007/3 145
0	0 60829E 00 0	0 07/3 146
0	0 60829E 00 0 31902E 00 0 25466E-00 0	0 07/3 147
0	0	0 60829E 0007/3 148
0 26520E-00 0 28673E-00 0	0	0 07/3 149
0	0 60829E 00 0 31224E-00 0 34309E-00 0 25375E-0207/3 150	
0	0	0 60829E 0007/3 151
0 60829E 00 0 29605E-00 0	0	0 07/3 152
16 9 1643 BORON-10	THERMAL	HOWERTON
0 15684E-00 0	0 11618E 01 0 45660E-00 0	0 07/3 154
0	0 30268E 00 0	0 19566E 0107/3 155
0 10321E 01 0 35407E-00 0	0	0 07/3 156
0 20604E-00 0	0 21325E 01 0 99127E 00 0 56337E 00 0 72180E-0107/3 157	

C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

0	0	0	0	47713E 00 0	0	31677E 0107/3 150
0	19430E 01 0	93500E 00 0	44952E 01 0	96878E 01 0	0	07/3 159
0	12618E 01 0	0	46149E 01 0	29673E 01 0	74760E 00 0	19920E-0307/3 160
0	13465E 01 0	25235E 01 0	0	33789E 01 0	0	52302E 0107/3 161
0	16621E 01 0	38542E 00 0	0	0	0	07/3 162
0	57039E 01 0	0	87201E 01 0	26290E 01 0	18908E-00 0	07/3 163
0	0	0	0	15306E 02 0	0	18911E 0207/3 164
0	31837E 01 0	38722E 00 0	0	0	0	33902E-0607/3 165
0	38739E 02 0	0	42469E 02 0	32985E 01 0	42055E-00 0	07/3 166
0	0	0	0	79999E 02 0	0	83733E 0207/3 167
0	31306E 01 0	43108E 00 0	0	0	0	07/3 168
0	14763E 03 0	0	15136E 03 0	30386E 01 0	60331E 00 0	07/3 169
0	0	0	0	26975E 03 0	0	27348E 0307/3 170
0	31279E 01 0	69526E 00 0	0	0	0	07/3 171
0	48254E 03 0	0	48627E 03 0	30290E 01 0	60595E 00 0	07/3 172
0	0	0	0	77868E 03 0	0	78242E 0307/3 173
0	28827E 01 0	70491E 00 0	0	0	0	07/3 174
0	15088E 04 0	0	15129E 04 0	29265E 01 0	85112E 00 0	07/3 175
0	0	0	0	26818E 04 0	0	26895E 0407/3 176
0	37339E 01 0	80734E 00 0	0	0	0	07/3 177
16 9 1644	FLOURINE-19	THERMAL				HOWERTON
0	11581E-00 0	0	15043E 01 0	34205E-00 0	0	07/3 179
0	0	0	0	70000E-03 0	0	24879E 0107/3 180
0	18233E 01 0	63374E 00 0	0	0	0	07/3 181
0	70000E-03 0	0	29008E 01 0	19537E 01 0	52688E 00 0	15866E-0007/3 182
0	0	0	0	70000E-03 0	0	38697E 0107/3 183
0	23758E 01 0	94638E 00 0	95131E-01 0	20393E-00 0	0	07/3 184
0	70000E 03 0	0	68316E 01 0	42012E 01 0	14932E 01 0	07/3 185
0	41951E-01 0	50795E-01 0	0	33656E-02 0	0	70463E 0107/3 186
0	68396E 01 0	22754E 01 0	0	0	0	07/3 187
0	27581E-02 0	0	33538E 01 0	31621E 01 0	20328E-00 0	07/3 188
0	0	0	0	43473E-02 0	0	33825E 0107/3 189
0	31647E 01 0	18893E 00 0	0	0	0	07/3 190
0	48806E-02 0	0	34384E 01 0	32331E 01 0	21346E-00 0	07/3 191
0	0	0	0	49736E-02 0	0	30741E 0107/3 192
0	28186E 01 0	20039E-00 0	0	0	0	39433E-0007/3 193
0	49918E-02 0	0	31184E 01 0	27988E 01 0	25054E-00 0	07/3 194
0	0	0	0	49974E-02 0	0	32352E 0107/3 195
0	29557E 01 0	31461E-00 0	0	0	0	07/3 196
0	49992E-02 0	0	32738E 01 0	29447E 01 0	27451E-00 0	07/3 197
0	0	0	0	49997E 02 0	0	33056E 0107/3 198
0	28980E 01 0	32411E-00 0	0	0	0	07/3 199
0	49999E 02 0	0	33571E 01 0	29635E 01 0	40261E-00 0	07/3 200
0	0	0	0	50000E-02 0	0	36425E 0107/3 201
0	36375E 01 0	38858E 00 0	0	0	0	07/3 202

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

16 9 1645	CHLORINE	THERMAL				HOWERTON
0	65403E 01 0	0	19563E 01 0	84749E 00 0	0	07/3 204
0	0	0	0	20000E 05 0	0	20953E 0107/3 205
0	16815E 01 0	47733E-00 0	0	0	0	07/3 206
0	20000E 05 0	0	19128E 01 0	16882E 01 0	25498E-00 0	40740E-0007/3 207
0	0	0	0	20000E-05 0	0	17188E 0107/3 208
0	15762E 01 0	22456E-00 0	12671E 00 0	13569E 00 0	0	07/3 209
0	66414E 02 0	0	18780E 01 0	17944E 01 0	14264E 00 0	07/3 210
0	32078E-01 0	23566E-01 0	0	28403E-01 0	0	31701E 0107/3 211
0	30649E 01 0	76955E-01 0	0	0	0	07/3 212
0	62810E 01 0	0	18689E 01 0	17649E 01 0	76765E-01 0	07/3 213
0	0	0	57287E-07 0	15952E-00 0	0	20356E 0107/3 214
0	17931E 01 0	41128E 01 0	0	0	0	07/3 215
0	38222E-00 0	0	51734E 01 0	45722E 01 0	82962E 01 0	07/3 216
0	0	0	0	75720E 00 0	0	10067E 0207/3 217
0	87956E 01 0	21896E-00 0	0	0	0	07/3 218
0	15296E 01 0	0	14412E 02 0	12157E 02 0	51423E 00 0	07/3 219
0	0	0	0	37438E 01 0	0	17478E 0207/3 220
0	13117E 02 0	72567E 00 0	0	0	0	07/3 221
0	62069E 01 0	0	19941E 02 0	13011E 02 0	61693E 00 0	07/3 222
0	0	0	0	91992E 01 0	0	22934E 0207/3 223
0	12840E 02 0	72328E 00 0	0	0	0	07/3 224
0	15008E 02 0	0	28742E 02 0	12886E 02 0	89423E 00 0	07/3 225
0	0	0	0	23994E 02 0	0	37728E 0207/3 226
0	13734E 02 0	84867E 00 0	0	0	0	07/3 227
16 9 1646	ARGON	THERMAL				HOWERTON
0	63460E 02 0	0	18789E 01 0	78084E 00 0	0	07/3 229
0	0	0	0	86599E-02 0	0	23252E 0107/3 230
0	19886E 01 0	38403E-00 0	0	0	0	07/3 231
0	92334E-02 0	0	18052E 01 0	16522E 01 0	17463E-00 0	31391E-0007/3 232
0	0	0	0	95818E-02 0	0	12095E 0107/3 233
0	11501E 01 0	14572E-00 0	55070E-02 0	36576E-00 0	0	07/3 234
0	98512E 02 0	0	14415E 01 0	13799E 01 0	49888E-01 0	07/3 235
0	0	31009E-01 0	0	99675E 02 0	0	15809E 0107/3 236
0	15279E 01 0	51727E-01 0	0	0	46829E-01 0	29732E-0407/3 237
0	99944E 02 0	0	10295E 01 0	99811E 00 0	43101E-01 0	07/3 238
0	0	0	10098E-00 0	99991E-02 0	0	72336E 0007/3 239
0	69411E 00 0	21366E 01 0	0	0	0	07/3 240
0	10986E-01 0	0	67397E 00 0	64420E 00 0	19251E-01 0	07/3 241
0	0	0	0	24549E-01 0	0	66927E 0007/3 242
0	61938E 00 0	18774E-01 0	0	0	0	07/3 243
0	31003E 01 0	0	66946E 00 0	60848E 00 0	23335E-01 0	07/3 244
0	0	0	0	49256E-01 0	0	68123E 0007/3 245
0	60692E 00 0	29973E-01 0	0	0	0	07/3 246
0	83581E-01 0	0	72002E 00 0	60642E 00 0	25055E 01 0	07/3 247

C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

0	0	0	0	13265E 00 0	0	78814E 0007/3 248
0	61722E 00 0	30018E 01 0	0	0	0	07/3 249
0	25101E 00 0	0	92779E 00 0	63855E 00 0	38284E 01 0	07/3 250
0	0	0	0	45906E 00 0	0	11335E 0107/3 251
0	67443E 00 0	58227E 01 0	0	0	0	07/3 252

16 9 1640 CALCIUM		THERMAL		HOWERTON				
1	00000E 02 0	0	18569E 01 0	11113E 01 0	0	MESNE77		
0	0	0	0	12345E 01 0	0	18989E 01 MESNE78		
0	17387E 01 0	31730E 00 0	0	0	0	MESNE79		
0	13200E 01 0	0	22391E 01 0	19095E 01 0	14780E 00 0	17682E 00 MESNE80		
0	0	0	0	13200E 01 0	0	19599E 01 MESNE81		
0	18765E 01 0	31641E 00 0	0	19082E 00 0	0	MESNE82		
0	13200E 01 0	0	32684E 01 0	31734E 01 0	70254E 01 0	MESNE83		
0	0	0	0	13200E 01 0	0	13317E 01 MESNE84		
0	12809E 01 0	81801E 01 0	0	0	0	94797E 05 MESNE85		
0	13200E 01 0	0	13309E 01 0	12818E 01 0	37601E 01 0	MESNE86		
0	0	0	0	13200E 01 0	0	13309E 01 MESNE87		
0	12803E 01 0	35850E 01 0	0	0	0	MESNE88		
0	13200E 01 0	0	13309E 01 0	12798E 01 0	37377E 01 0	MESNE89		
0	0	0	0	13200E 01 0	0	13309E 01 MESNE90		
0	12657E 01 0	37836E 01 0	0	0	0	MESNE91		
0	17645E 01 0	0	13275E 01 0	12486E 01 0	51945E 01 0	MESNE92		
0	0	0	0	32816E 01 0	0	13290E 01 MESNE93		
0	12454E 01 0	61305E 01 0	0	0	0	MESNE94		
0	62394E 01 0	0	13290E 01 0	12080E 01 0	50829E 01 0	MESNE95		
0	0	0	0	93098E 01 0	0	13292E 01 MESNE96		
0	11662E 01 0	58594E 01 0	0	0	0	MESNE97		
0	17406E 00 0	0	13545E 01 0	11093E 01 0	69898E 01 0	MESNE98		
0	0	0	0	30883E 00 0	0	20805E 01 MESNE99		
0	17716E 01 0	71166E 01 0	0	0	0	MESN100		
16 9 1649 TITANIUM		THERMAL		HOWERTON				
1	00000E 06 0	0	20678E 01 0	83265E 00 0	0	MESN102		
0	0	0	1	00000E 06 0	0	26942E 01 MESN103		
0	20244E 01 0	54955E 00 0	0	0	0	MESN104		
0	48396E 03 0	0	23003E 01 0	19401E 01 0	58882E 00 0	16455E 00 MESN105		
0	0	0	0	14765E 01 0	0	22317E 01 MESN106		
0	20733E 01 0	34919E 00 0	0	80971E 01 0	42902E 00 0	0	MESN107	
0	20000E 01 0	0	29210E 01 0	27794E 01 0	14363E 00 0	10454E 01 MESN108		
0	0	0	0	75056E 01 0	0	20000E 01 0	0	26731E 02 MESN109
0	24352E 02 0	12159E 00 0	0	0	0	0	MESN110	
0	22759E 01 0	0	27308E 02 0	27172E 02 0	23582E 01 0	0	MESN111	
0	0	0	0	30871E 01 0	0	45246E 01 MESN112		

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0	43953E 01 0	11336E 00 0	0	0	0	MESN113	
0	68830E 01 0	0	42100E 01 0	40415E 01 0	98460E 01 0	MESN114	
0	0	0	13978E 06 0	13359E 00 0	0	42748E 01 MESN115	
0	40048E 01 0	99726E 01 0	0	0	0	MESN116	
0	25064E 00 0	0	43918E 01 0	39788E 01 0	13636E 00 0	MESN117	
0	0	0	0	42614E 00 0	0	44673E 01 MESN118	
0	40035E 01 0	16240E 00 0	0	0	0	MESN119	
0	73260E 00 0	0	48738E 01 0	39802E 01 0	13770E 00 0	MESN120	
0	0	0	0	12015E 01 0	0	53427E 01 MESN121	
0	39417E 01 0	16105E 00 0	0	0	0	MESN122	
0	22871E 01 0	0	64283E 01 0	39519E 01 0	19952E 00 0	MESN123	
0	0	0	0	40962E 01 0	0	82374E 01 MESN124	
0	41412E 01 0	18934E 00 0	0	0	0	MESN125	
16 9 1650 MANGANESE-55		THERMAL		HOWERTON			
0	10024E 02 0	0	21681E 01 0	85591E 00 0	0	MESN127	
0	0	0	0	42259E 02 0	0	25297E 01 MESN128	
0	15731E 01 0	52831E 00 0	0	0	0	MESN129	
0	35125E 02 0	0	24265E 01 0	15260E 01 0	46328E 00 0	45468E 00 MESN130	
0	0	0	0	42259E 02 0	0	29140E 01 MESN131	
0	24688E 01 0	43015E 00 0	41190E 00 0	29346E 00 0	0	MESN132	
0	11162E 01 0	0	36036E 01 0	34239E 01 0	14375E 00 0	46687E 00 MESN133	
0	78904E 01 0	76800E 01 0	0	37812E 01 0	0	10011E 02 MESN134	
0	99234E 01 0	60937E 01 0	0	0	0	MESN135	
0	60054E 01 0	0	31472E 02 0	28664E 02 0	49323E 01 0	MESN136	
0	0	0	0	65596E 01 0	0	14505E 03 MESN137	
0	14451E 03 0	27478E 01 0	0	0	0	MESN138	
0	13805E 00 0	0	20922E 03 0	20899E 03 0	47175E 00 0	MESN139	
0	0	0	0	29721E 00 0	29085E 00 0	0	36351E 01 MESN140
0	32673E 01 0	96814E 01 0	0	0	0	10763E 00 MESN141	
0	56179E 00 0	0	30257E 01 0	23844E 01 0	76934E 01 0	MESN142	
0	0	0	0	94227E 00 0	0	31456E 01 MESN143	
0	21398E 01 0	79494E 01 0	0	0	0	MESN144	
0	16320E 01 0	0	39079E 01 0	21958E 01 0	63467E 01 0	MESN145	
0	0	0	0	25381E 01 0	0	49293E 01 MESN146	
0	22776E 01 0	80152E 01 0	0	0	0	MESN147	
0	48897E 01 0	0	76398E 01 0	26316E 01 0	11358E 00 0	MESN148	
0	0	0	0	89985E 01 0	0	11976E 02 MESN149	
0	29774E 01 0	11857E 00 0	0	0	0	MESN150	
16 9 1651 COPPER		THERMAL		HOWERTON			
0	29412E 01 0	0	22572E 01 0	81323E 00 0	0	MESN152	
0	0	0	0	73831E 02 0	0	26452E 01 MESN153	
0	15401E 01 0	72502E 00 0	0	0	0	MESN154	
0	92374E 02 0	0	31397E 01 0	25963E 01 0	12578E 00 0	39678E 00 MESN155	
0	0	0	0	12516E 01 0	0	35975E 01 MESN156	
0	34269E 01 0	36984E 00 0	73937E 00 0	23812E 00 0	0	MESN157	

C SERIES 1600 CROSS SECTION LIBRARY - THERMAL WEIGHTED

0 28425E-01 0	0 47553E 01 0	0 46082E 01 0	0 15008E-00 0	0 16439E-00 MESN158
0 23252E-00 0	0 76740E 01 0	0 66604E-01 0	0 74184E 01 MESN159	
0 72078E 01 0	0 11873E-00 0	0 0 0	0 MESN160	
0 98899E 01 0	0 82555E 01 0	0 80507E 01 0	0 14391E-00 0	0 MESN161
0 0 0	0 0 0	0 10000E-00 0	0 13322E 02 MESN162	
0 13006E 02 0	0 97888E-01 0	0 0 0	0 MESN163	
0 10000E-00 0	0 70273E 01 0	0 67978E 01 0	0 21624E 00 0	0 MESN164
0 0 0	0 58729E-06 0	0 10000E 00 0	0 74413E 01 MESN165	
0 71560E 01 0	0 12949E-00 0	0 0 0	0 MESN166	
0 14351E 00 0	0 76604E 01 0	0 72948E 01 0	0 18537E-00 0	0 MESN167
0 0 0	0 0 0	0 26814E 00 0	0 77871E 01 MESN168	
0 73303E 01 0	0 22209E-00 0	0 0 0	0 MESN169	
0 48539E 00 0	0 80043E 01 0	0 72990E 01 0	0 18859E-00 0	0 MESN170
0 0 0	0 0 0	0 78450E 00 0	0 83034E 01 MESN171	
0 72461E 01 0	0 21994E 00 0	0 0 0	0 MESN172	
0 15232E 01 0	0 90422E 01 0	0 72600E 01 0	0 27286E-00 0	0 MESN173
0 0 0	0 0 0	0 26858E 01 0	0 10210E 02 MESN174	
0 75242E 01 0	0 25893E-00 0	0 0 0	0 MESN175	
16 9 1652 T1N	THERMAL	HOWERTON		
0 12140E-01 0	0 28528E 01 0	0 10085E 01 0	0 MESN177	
0 0 0	0 0 0	0 75371E-01 0	0 34044E 01 MESN178	
0 24872E 01 0	0 95871E 00 0	0 0 0	0 MESN179	
0 10063E-00 0	0 40276E 01 0	0 35986E 01 0	0 44697E-00 0	0 51640E 00 MESN180
0 0 0	0 0 0	0 11152E-00 0	0 46382E 01 MESN181	
0 44285E 01 0	0 27700E-00 0	0 33453E-00 0	0 33764E-00 0	0 MESN182
0 11200E 00 0	0 52308E 01 0	0 50496E 01 0	0 94985E-01 0	0 46931E-01 MESN183
0 60273E-01 0	0 65490E-01 0	0 11200E-00 0	0 59397E 01 MESN184	
0 57739E 01 0	0 69189E-01 0	0 0 0	0 MESN185	
0 11200E-00 0	0 53256E 01 0	0 51678E 01 0	0 53806E-01 0	0 MESN186
0 0 0	0 0 0	0 11200E-00 0	0 50279E 01 MESN187	
0 48677E 01 0	0 45753E-01 0	0 0 0	0 44164E-02 MESN188	
0 11200E-00 0	0 62385E 01 0	0 60800E 01 0	0 48190E-01 0	0 MESN189
0 0 0	0 32251E-02 0	0 11200E-00 0	0 55563E 01 MESN190	
0 53848E 01 0	0 46502E-01 0	0 0 0	0 MESN191	
0 11200E-00 0	0 46759E 01 0	0 44904E 01 0	0 59475E-01 0	0 MESN192
0 0 0	0 0 0	0 11200E-00 0	0 48016E 01 MESN193	
0 46260E 01 0	0 73437E 01 0	0 0 0	0 MESN194	
0 11200E-00 0	0 48438E 01 0	0 46578E 01 0	0 63563E 01 0	0 MESN195
0 0 0	0 0 0	0 12760E-00 0	0 48513E 01 MESN196	
0 46326E 01 0	0 74065E 01 0	0 0 0	0 MESN197	
0 24119E-00 0	0 48445E 01 0	0 45200E 01 0	0 91089E-01 0	0 MESN198
0 0 0	0 0 0	0 43087E-00 0	0 47288E 01 MESN199	
0 42980E 01 0	0 83399E-01 0	0 0 0	0 MESN200	
16 9 1653 U-237	THERMAL	HOWERTON		
0 86975E 00 0	0 28105E 01 0	0 42653E 01 0	0 10866E 01 0	0 MESN202

C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

0 0 0	0 79387E 00 0	0 19196E 01 0	0 46148E 01 MESN203	
0 15539E 01 0	0 17761E-00 0	0 0 0	0 MESN204	
0 85508E 00 0	0 19070E 01 0	0 50900E 01 0	0 23056E 01 0	0 20476E 00 0
0 0 0	0 0 0	0 91065E 00 0	0 18691E 01 0	0 60759E 01 0
0 36880E 01 0	0 12370E 01 0	0 14248E 01 0	0 14751E 01 0	0 MESN207
0 99418E 00 0	0 16693E 01 0	0 81682E 01 0	0 66797E 01 0	0 11781E 01 0
0 63750E 00 0	0 56709E 00 0	0 0 0	0 92581E 00 0	0 81000E 00 0
0 89118E 01 0	0 27115E 00 0	0 16843E-00 0	0 66721E-02 0	0 MESN210
0 15880E 01 0	0 43009E-00 0	0 11818E 02 0	0 10174E 02 0	0 45639E 01 0
0 13077E-00 0	0 0 0	0 35476E 01 0	0 35965E 00 0	0 17410E 02 MESN212
0 13794E 02 0	0 56020E-01 0	0 0 0	0 0 0	0 MESN213
0 60898E 01 0	0 35401E-00 0	0 20055E 02 0	0 13897E 02 0	0 67980E 01 0
0 0 0	0 0 0	0 69155E 01 0	0 35400E-00 0	0 20878E 02 MESN215
0 13871E 02 0	0 68463E-01 0	0 0 0	0 0 0	0 MESN216
0 70775E 01 0	0 35400E-00 0	0 21040E 02 0	0 13852E 02 0	0 92146E-01 0
0 0 0	0 0 0	0 71266E 01 0	0 35400E 00 0	0 21089E 02 MESN218
0 13868E 02 0	0 11043E-00 0	0 0 0	0 0 0	0 MESN219
0 71429E 01 0	0 35400E-00 0	0 21106E 02 0	0 13854E 02 0	0 94268E 01 0
0 0 0	0 0 0	0 71475E 01 0	0 35400E-00 0	0 21110E 02 MESN221
0 13827E 02 0	0 10903E-00 0	0 0 0	0 0 0	0 MESN222
0 71493E 01 0	0 35400E-00 0	0 21112E 02 0	0 13834E 02 0	0 13567E 00 0
0 0 0	0 0 0	0 71499E 01 0	0 35400E 00 0	0 21113E 02 MESN224
0 13963E 02 0	0 2873E-00 0	0 0 0	0 0 0	0 MESN225
16 9 1654 U-239	THERMAL	HOWERTON		
0 37435E-00 0	0 12387E 01 0	0 42628E 01 0	0 10954E 01 0	0 MESN227
0 0 0	0 0 0	0 30852E-00 0	0 63221E 00 0	0 46155E 01 MESN228
0 15556E 01 0	0 20683E-00 0	0 0 0	0 0 0	0 MESN229
0 35025E-00 0	0 62409E 00 0	0 50856E 01 0	0 23035E 01 0	0 24181E-00 0
0 0 0	0 0 0	0 38390E-00 0	0 59966E 00 0	0 56637E 01 MESN231
0 33220E 01 0	0 15505E 01 0	0 17340E 01 0	0 18309E 01 0	0 MESN232
0 20729E-00 0	0 24525E-00 0	0 70795E 01 0	0 62283E 01 0	0 16636E 01 0
0 77547E 00 0	0 70490E 00 0	0 0 0	0 12289E-00 0	0 52801E-01 0
0 88138E 01 0	0 34571E-00 0	0 17414E-00 0	0 86016E-02 0	0 MESN235
0 14026E-00 0	0 92649E-01 0	0 11222E 02 0	0 11019E 02 0	0 45016E 01 0
0 12001E-00 0	0 0 0	0 18807E-00 0	0 19932E-00 0	0 14722E 02 MESN237
0 14464E 02 0	0 62394E-01 0	0 0 0	0 0 0	0 MESN238
0 31375E 00 0	0 46347E-00 0	0 14460E 02 0	0 14078E 02 0	0 69309E 01 0
0 0 0	0 0 0	0 64817E 00 0	0 99386E 00 0	0 14611E 02 MESN240
0 13871E 02 0	0 67893E 01 0	0 0 0	0 0 0	0 MESN241
0 94529E 00 0	0 14494E 01 0	0 14908E 02 0	0 13853E 02 0	0 91371E 01 0
0 0 0	0 0 0	0 19907E 01 0	0 30524E 01 0	0 15999E 02 MESN243
0 13914E 02 0	0 10950E 00 0	0 0 0	0 0 0	0 MESN244
0 29573E 01 0	0 45345E 01 0	0 17011E 02 0	0 13945E 02 0	0 93996E-01 0
0 0 0	0 0 0	0 47565E 01 0	0 72933E 01 0	0 18752E 02 MESN246
0 13861E 02 0	0 10888E-00 0	0 0 0	0 0 0	0 MESN247

C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

0	84129E	01	0	12099E	02	0	22575E	02	0	13035E	02	0	13445E	-00	0	MESN240		
0										14023E	02	0	22733E	02	0	MESN249		
0	13963E	02	0	12765E	-00	0										MESN250		
16	9	1655		U	240		THERMAL						HONERTON					
0	53126E	00	0	17319E	01	0	40990E	01	0	11212E	01	0				MESN252		
0										36079E	-00	0	85577E	00	0	46172E	01	MESN253
0	17159E	01	0	19110E	-00	0											MESN254	
0	92634E	01	0	10354E	-00	0	49935E	01	0	20115E	01	0	20915E	-00	0	32450E	-00	MESN255
0										16293E	-00	0	23687E	05	0	57049E	01	MESN256
0	45375E	01	0	79459E	00	0	13425E	01	0	15052E	01	0						MESN257
0	26382E	-00	0	23051E	-05	0	86422E	01	0	80106E	01	0	95716E	00	0	10417E	01	MESN258
0	87105E	00	0	60775E	00	0				47324E	-00	0	22777E	-05	0	12614E	02	MESN259
0	12004E	02	0	36776E	-00	0	47320E	-01	0	25299E	-00	0	11774E	-00	0			MESN260
0	64230E	00	0	22713E	-05	0	13689E	02	0	12980E	02	0	64134E	01	0			MESN261
0										74108E	00	0	22702E	05	0	12427E	02	MESN262
0	11639E	02	0	55066E	-01	0												MESN263
0	75000E	00	0	22700E	05	0	94621E	01	0	86734E	01	0	47654E	01	0			MESN264
0										75000E	00	0	22700E	-05	0	87287E	01	MESN265
0	79267E	01	0	38644E	-01	0												MESN266
0	75000E	00	0	22700E	-05	0	87287E	01	0	79164E	01	0	51993E	-01	0			MESN267
0							72341E	-01	0	75000E	00	0	22700E	-05	0	87287E	01	MESN268
0	79255E	01	0	62312E	-01	0							24492E	-02	0			MESN269
0	75000E	00	0	22700E	-05	0	87287E	01	0	79171E	01	0	53193E	-01	0			MESN270
0										75000E	00	0	22700E	-05	0	87287E	01	MESN271
0	79021E	01	0	61519E	-01	0												MESN272
0	75000E	00	0	22700E	-05	0	87287E	01	0	79060E	01	0	76593E	-01	0			MESN273
0										11611E	01	0	22700E	-05	0	91390E	01	MESN274
0	79787E	01	0	72637E	-01	0												MESN275
16	9	1656		PU	-238		THERMAL						HONERTON					
0	22162E	01	0	79609E	01	0	42676E	01	0	10567E	01	0						MESN277
0										21905E	01	0	66402E	01	0	46200E	01	MESN278
0	15482E	01	0	80184E	-01	0												MESN279
0	22398E	01	0	64314E	01	0	50891E	01	0	22973E	01	0	96758E	-01	0	12993E	-00	MESN280
0										22989E	01	0	63898E	01	0	61547E	01	MESN281
0	36891E	01	0	25377E	-00	0	47481E	-00	0	62717E	00	0						MESN282
0	26595E	01	0	70858E	01	0	93464E	01	0	66392E	01	0	16078E	-00	0	25562E	-00	MESN283
0	28091E	-00	0	24423E	-00	0				41231E	01	0	97242E	01	0	12802E	02	MESN284
0	86342E	01	0	47788E	-01	0	58762E	02	0	62642E	-01	0	28763E	-01	0			MESN285
0	69872E	01	0	12971E	02	0	15990E	02	0	89593E	01	0	44605E	-01	0			MESN286
0										11915E	02	0	15619E	02	0	24392E	02	MESN287
0	12410E	02	0	43669E	-01	0												MESN288
0	14968E	02	0	16850E	02	0	28931E	02	0	13094E	02	0	67185E	-01	0			MESN289
0										15803E	02	0	17150E	02	0	29766E	02	MESN290
0	13871E	02	0	68176E	-01	0												MESN291
0	15967E	02	0	17208E	02	0	29930E	02	0	13853E	02	0	91757E	-01	0			MESN292

C SERIES 1600 CROSS SECTION LIBRARY THERMAL WEIGHTED

0							87217E	02	0	20195E	02	0	10097E	03		MESN293		
0	13663E	02	0	10997E	00	0										MESN294		
0	15706E	03	0	23109E	02	0	17061E	03	0	13445E	02	0	91508E	01	0	MESN295		
0										17699E	03	0	23941E	-02	0	9048E	03	MESN296
0	15561E	02	0	10505E	00	0												MESN297
0	18490E	03	0	24272E	02	0	19837E	03	0	13345E	02	0	13042E	00	0			MESN298
0										30352E	03	0	37741E	02	0	31725E	03	MESN299
0	13737E	02	0	12361E	00	0												MESN300

C SERIES 2900 CROSS SECTION LIBRARY HANSEN ROACH

C	NUCLIDE	NUMBER	NUCLIDE	NUMBER	NUCLIDE	NUMBER
C	H-1	2901	GA	2916	CR	2941
C	H-2	2902	NB	2917	CO	2942
C	LI 6	2903	MO	2918	CE	2943
C	LI 7	2904	TA	2921	TH	2944
C	BE 9	2905	PB	2924	H,ANISO-1	2945
C	BORON	2906	U 235	2925	H,ANISO-2	2946
C	C-12	2907	U 235	2927	D,ANISO 1	2947
C	N 14	2908	U 238	2929	D,ANISO-2	2948
C	O 16	2909	PU-239	2930	D,1/E	2949
C	NA 23	2910	PU 240	2931	D,1/E,ANISO-1	2950
C	AL	2911	ZR	2936	D,1 E,ANISO 2	2951
C	SI,	2912	NI	2937	CL	2952
C	K	2914	F	2940	CD	2953
C	FE	2915				

16	9	2901	HYDROGEN	LAMS-2941	HANSEN							
0	0	0	6 00000E 01-0	40000E 01 0	0	HANH	1					
0	0	0	0	0	0	70000E-01HANH	2					
0	0	0	0	0	0	0	HANH	3				
9	61000E-01	7	69000E-01	0	0	0	0	HANH	4			
0	0	0	1 33000E 00-1	90600E 00 6	90000E-01	2	39000E-01HANH	5				
0	0	0	0	0	0	1	83000E 00HANH	6				
1	93750E 00	1	79600E 00	6 90000E 01 2	39000E-01	0	0	HANH	7			
0	0	0	3 00000E 00-1	86810E 00 2	82700E 00	1	07600E 00HANH	8				
4	15000E-01	1	44000E-01	0	0	5	20000E 00HANH	9				
2	09610E 00	4	04100E 00	7 81000E-01	5 00000E-01	1	16000E-01	4	90000E-02HANH	10		
0	0	0	6 33000E 00-2	69120E 00 6	02200E 00	6	84000E 01HANH	11	6 66600E 00HANH	12		
1	32000E-01	5	20000E-02	2 00000E-02	1 00023E-03	0	0	6 66600E 00HANH	13	6 66600E 00HANH	14	
2	96900E 00	7	37200E 00	1 04500E 00	1 17000E-01	2	20000E-02	1	20000E-02HANH	15	6 66600E 00HANH	16
4	00019E-03	0	0	6 66900E 00-2	94200E 00	7	88000E 00	1	34900E 00HANH	17	6 66600E 00HANH	18
1	87000E-01	2	16000E-02	5 50000E-03	8 00020E-03	0	0	6 67200E 00HANH	19	6 66600E 00HANH	20	
4	97980E 00	6	71900E 00	1 22000E 00	2 09000E-01	2	96000E-02	4	50000E-03HANH	21	6 66600E 00HANH	22
1	40002E-02	0	0	6 67600E 00-5	44890E 00	7	75700E 00	1	92000E 00HANH	23	6 66600E 00HANH	24
3	60000E-01	6	08000E-02	1 25000E-02	2 50002E-02	0	0	6 81700E 00HANH	25	6 66600E 00HANH	26	
5	04700E 00	8	49400E 00	2 71900E 00	6 80000E-01	1	22000E-01	3	04000E-02HANH	27	6 66600E 00HANH	28
4	50000E-02	0	0	6 83000E 00	5 35000E 00	7	90600E 00	2	41800E 00HANH	29	6 66600E 00HANH	30
7	80000E-01	1	92000E-01	5 20000E-02	6 99999E-02	0	0	6 84700E 00HANH	31	6 66600E 00HANH	32	
6	53900E 00	7	40900E 00	2 36400E 00	7 19000E-01	2	31900E-01	9	60000E-02HANH	33	6 66600E 00HANH	34
1	30000E 01	0	0	6 92000E 00-4	23000E 00	9	98200E 00	3	68400E 00HANH	35	6 66600E 00HANH	36
1	18200E 00	3	60000E 01	1 55900E-01	3 30000E-01	0	0	7 12000E 00HANH	37	6 66600E 00HANH	38	
6	79000E 00	1	10200E 01	3 33400E 00	1 24200E 00	3	87000E 01	1	19900E 01HANH	39	6 66600E 00HANH	40

16	9	2902	DEUTERIUM	LAMS 2941	HANSEN
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C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

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3 7000E-02 0 1 07700E-00 9 50000E-02 0 0 HAND 1
0 0 0 0 0 0 1 62300E-02 HAND 2
1 20000E-01 5 40000E-01 0 0 0 HAND 3
0 0 2 03300E-00 7 30000E-02 5 55000E-01 2 00000E-01 HAND 4
0 0 0 0 0 0 2 52100E-02 HAND 5
2 83000E-01 1 14200E-00 6 33000E-01 2 70000E-01 0 0 HAND 6
0 0 2 40500E-00 1 05700E-00 1 82600E-00 9 64000E-01 HAND 7
3 35000E-01 1 10000E-02 0 0 0 2 27000E-02 HAND 8
9 03000E-01 1 33600E-00 2 12000E-01 0 0 0 HAND 9
0 0 2 27000E-00 8 80000E-01 1 33600E-00 1 20000E-02 HAND 10
0 0 0 0 0 0 2 27000E-02 HAND 11
8 53000E-01 1 35300E-00 3 10000E-02 0 0 0 HAND 12
0 0 2 27000E-00 8 59000E-01 1 58000E-00 3 70000E-02 HAND 13
0 0 0 0 0 0 2 27000E-02 HAND 14
4 72000E-01 1 23400E-00 3 70000E-02 0 0 0 HAND 15
0 0 2 27000E-00 3 73000E-01 1 48200E-00 1 77000E-01 HAND 16
0 0 0 0 0 0 2 27000E-02 HAND 17
4 72000E-01 1 62500E-00 3 16000E-01 0 0 0 HAND 18
0 0 2 27000E-00 3 73000E-01 1 48200E-00 2 72000E-01 HAND 19
0 0 0 0 0 0 2 26710E-02 HAND 20
1 86000E-01 1 62500E-00 3 09000E-01 0 0 0 HAND 21
1 60001E-04 0 2 26716E-00 6 21000E-01 1 87700E-00 2 72000E-01 HAND 22
7 00000E-03 0 0 4 00007E-04 0 2 26740E-02 HAND 23
2 26700E-00 1 64600E-00 2 04000E-01 0 0 0 HAND 24

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C

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16 9 2903 LITHIUM-6 LAMS-2941 HANSEN
1 10000E-01 0 1 24000E-00 6 04000E-01 0 0 HANLI 1
0 0 0 2 30000E-01 0 1 02000E-02 HANLI 2
4 58000E-01 5 26000E-01 0 0 0 HANLI 3
2 60000E-01 0 1 12000E-00 2 70000E-01 2 98000E-01 0 HANLI 4
0 0 0 5 00000E-01 0 1 70000E-02 HANLI 5
7 02000E-01 5 90000E-01 3 40000E-02 0 0 HANLI 6
1 95000E-00 0 4 47000E-00 1 90900E-00 4 98000E-01 0 HANLI 7
0 0 0 8 50000E-01 0 1 65000E-02 HANLI 8
6 48000E-01 6 11000E-01 0 0 0 HANLI 9
1 40000E-00 0 2 20000E-00 6 45000E-01 1 52000E-01 0 HANLI 10
0 0 0 4 30000E-00 0 5 10000E-02 HANLI 11
6 42000E-01 1 55000E-01 0 0 0 HANLI 12
9 70000E-00 0 1 05000E-01 6 42000E-01 1 58000E-01 0 HANLI 13
0 0 0 1 99000E-01 0 2 07000E-02 HANLI 14
5 77000E-01 1 58000E-01 0 0 0 HANLI 15
3 46000E-01 0 3 54000E-01 5 55000E-01 2 23000E-01 0 HANLI 16
0 0 0 6 01000E-01 0 6 09000E-02 HANLI 17
5 77000E-01 2 45000E-01 0 0 0 HANLI 18

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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH.

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1 09100E-02 0 1 09900E-02 5 55000E-01 2 23000E-01 0 HANLI 19
0 0 0 1 1100E-02 0 1 71900E-02 HANLI 20
5 07000E-01 2 45000E-01 0 0 0 HANLI 21
3 09100E-02 0 3 09900E-02 6 06000E-01 2 93000E-01 0 HANLI 22
0 0 0 8 37100E-02 0 8 37900E-02 HANLI 23
8 00000E-01 1 94000E-01 0 0 0 HANLI 24

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16 9 2904 LITHIUM-7 LAMS-2941 HANSEN
4 00000E-02 0 1 21000E-00 5 54900E-01 0 0 HANLI 1
0 0 0 0 0 1 14000E-02 HANLI 2
6 76500E-01 6 15100E-01 0 0 0 HANLI 3
0 0 1 24000E-00 4 14400E-01 4 45500E-01 0 HANLI 4
0 0 0 0 0 1 11000E-02 HANLI 5
6 91300E-01 8 25600E-01 1 80000E-02 0 0 HANLI 6
0 0 2 99000E-00 2 36900E-00 4 16400E-01 0 HANLI 7
0 0 0 0 0 9 40000E-01 HANLI 8
7 87000E-01 6 21000E-01 2 30000E-03 0 0 HANLI 9
0 0 9 68100E-01 8 07500E-01 1 53000E-01 0 HANLI 10
0 0 2 00005E-04 0 9 68200E-01 HANLI 11
8 04300E-01 1 60500E-01 0 0 0 HANLI 12
3 00005E-04 0 9 68200E-01 8 05300E-01 1 63700E-01 0 HANLI 13
0 0 7 00004E-04 0 9 68200E-01 HANLI 14
7 36500E-01 1 62600E-01 0 0 0 HANLI 15
1 20001E-03 0 9 68300E-01 7 13800E-01 2 31000E-01 0 HANLI 16
0 0 2 20001E-03 0 9 68300E-01 HANLI 17
7 35500E-01 2 53300E-01 0 0 0 HANLI 18
3 80000E-03 0 9 68500E-01 7 12000E-01 2 30600E-01 0 HANLI 19
0 0 6 30001E-03 0 9 68700E-01 HANLI 20
6 60300E-01 2 52700E-01 0 0 0 HANLI 21
1 20000E-02 0 9 69300E-01 7 58400E-01 3 02100E-01 0 HANLI 22
0 0 3 30000E-02 0 9 71300E-01 HANLI 23
9 38300E-01 1 98900E-01 0 0 0 HANLI 24

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16 9 2905 BERYLLIUM LAMS-2941 HANSEN
3 09000E-01 0 1 29100E-00 4 32000E-01 0 0 HANBE 1
0 0 0 8 80000E-02 0 1 47500E-02 HANBE 2
6 34000E-01 8 18000E-01 0 0 0 HANBE 3
0 0 2 38000E-00 1 17300E-00 5 09000E-01 3 50000E-01 HANBE 4
0 0 0 0 0 3 31000E-02 HANBE 5
2 39700E-00 1 20700E-00 1 20000E-01 0 0 HANBE 6
0 0 3 94000E-00 3 30600E-00 9 13000E-01 0 HANBE 7
0 0 0 0 0 5 18000E-02 HANBE 8
4 52500E-00 6 34000E-01 0 0 0 HANBE 9

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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

0	0	5 28000E 00	4 60000E 00	6 55000E 01	0	HANBE 10
0	0	0	0	0	5 37000E 00	HANBE 11
4 66000E 00	6 80000E 01	0	0	0	0	HANBE 12
0	0	5 42000E 00	4 71000E 00	7 10000E 01	0	HANBE 13
0	0	0	0	0	5 46000E 00	HANBE 14
4 45000E 00	7 10000E-01	0	0	0	0	HANBE 15
0	0	5 46000E 00	4 35000E 00	1 01000E 00	0	HANBE 16
0	0	0	0	0	5 46000E 00	HANBE 17
4 45000E 00	1 11000E 00	0	0	0	0	HANBE 18
1 00005E-03	0	5 46000E 00	4 34900E 00	1 01000E 00	0	HANBE 19
0	0	0	2 00003E-03	0	5 45000E 00	HANBE 20
4 12800E 00	1 11000E 00	0	0	0	0	HANBE 21
4 00001E-03	0	5 46000E 00	4 37600E 00	1 33000E 00	0	HANBE 22
0	0	0	1 00001E-02	0	5 57000E 00	HANBE 23
5 56000E 00	8 80000E-01	0	0	0	0	HANBE 24

C
C

16 9 2906	BORON	LAMS-2941	HANSEN			
4 00000E-02	0	1 52000E 00	8 10000E-01 0	0	HANB 1	
0	0	0	6 00000E-02	0	1 79000E 00	HANB 2
1 31000E 00	6 70000E-01	0	0	0	0	HANB 3
4 00000E-02	0	2 14000E 00	1 22000E 00	4 20000E-01	0	HANB 4
0	0	0	8 00000E-02	0	2 27000E 00	HANB 5
1 69000E 00	8 80000E-01	0	0	0	0	HANB 6
2 70000E-01	0	3 16000E 00	2 51000E 00	5 00000E-01	0	HANB 7
0	0	0	6 10000E-01	0	4 08000E 00	HANB 8
3 11000E 00	3 80000E-01	0	0	0	0	HANB 9
1 50000E 00	0	4 97000E 00	3 10000E 00	3 60000E-01	0	HANB 10
0	0	0	3 40000E 00	0	6 87000E 00	HANB 11
3 09000E 00	3 70000E-01	0	0	0	0	HANB 12
8 00000E 00	0	1 14700E 01	3 09000E 00	3 80000E-01	0	HANB 13
0	0	0	1 64000E 01	0	1 98700E 01	HANB 14
2 94000E 00	3 80000E-01	0	0	0	0	HANB 15
2 90000E 01	0	3 24700E 01	2 89000E 00	5 30000E-01	0	HANB 16
0	0	0	5 20000E 01	0	5 54700E 01	HANB 17
2 94000E 00	5 80000E-01	0	0	0	0	HANB 18
9 20000E 01	0	9 54700E 01	2 89000E 00	5 30000E-01	0	HANB 19
0	0	0	1 51000E 02	0	1 54470E 02	HANB 20
2 77000E 00	5 80000E-01	0	0	0	0	HANB 21
2 73000E 02	0	2 76470E 02	3 01000E 00	7 00000E-01	0	HANB 22
0	0	0	6 69300E 02	0	6 72770E 02	HANB 23
3 47000E 00	4 60000E-01	0	0	0	0	HANB 24

C
C

16 9 2907	CARBON	LAMS-2941	HANSEN
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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

0	0	1 23000E 00	7 15000E-01	0	0	HANC 1
0	0	0	0	0	1 42000E 00	HANC 2
1 10600E 00	5 15000E-01	0	0	0	0	HANC 3
0	0	2 26000E 00	1 40400E 00	3 14000E-01	0	HANC 4
0	0	0	0	0	2 93000E 00	HANC 5
2 32600E 00	8 56000E-01	0	0	0	0	HANC 6
0	0	3 59000E 00	3 15700E 00	6 04000E-01	0	HANC 7
0	0	0	0	0	4 25000E 00	HANC 8
3 84900E 00	4 33000E-01	0	0	0	0	HANC 9
0	0	4 44000E 00	4 01200E 00	4 01000E-01	0	HANC 10
0	0	0	0	0	4 34000E 00	HANC 11
3 91200E 00	4 28000E 01	0	0	0	0	HANC 12
0	0	4 34000E 00	3 91200E 00	4 28000E-01	0	HANC 13
0	0	0	0	0	4 34000E 00	HANC 14
3 73700E 00	4 28000E-01	0	0	0	0	HANC 15
0	0	4 34000E 00	3 67800E 00	6 03000E-01	0	HANC 16
0	0	0	0	0	4 44000E 00	HANC 17
3 82400E 00	6 62000E-01	0	0	0	0	HANC 18
0	0	4 44000E 00	3 76300E 00	6 16000E-01	0	HANC 19
0	0	0	0	0	4 44000E 00	HANC 20
3 62700E 00	6 77000E-01	0	0	0	0	HANC 21
6 99997E-04	0	4 43870E 00	3 90200E 00	8 13000E-01	0	HANC 22
0	0	0	2 99996E-03	0	4 43900E 00	HANC 23
4 43600E 00	5 36000E-01	0	0	0	0	HANC 24

C
C

16 9 2908	NITROGEN	LAMS-2941	HANSEN			
2 50000E-01	0	9 70000E-01	3 90000E-01	0	0	HANN 1
0	0	0	1 10000E-01	0	1 48000E 00	HANN 2
1 01000E 00	3 30000E-01	0	0	0	0	HANN 3
4 00000E-02	0	1 69000E 00	1 20000E 00	3 60000E-01	0	HANN 4
0	0	0	4 00000E-02	0	2 17000E 00	HANN 5
1 78000E 00	4 50000E-01	0	0	0	0	HANN 6
2 00003E-03	0	3 29400E 00	3 12200E 00	3 30000E-01	0	HANN 7
4 99400E 00	1 70000E-01	0	0	0	0	HANN 8
4 00007E-03	0	7 35900E 00	6 74500E 00	4 40000E-01	0	HANN 9
0	0	0	7 99996E-03	0	8 09200E 00	HANN 11
7 40400E 00	6 10000E-01	0	0	0	0	HANN 12
1 89999E-02	0	8 49300E 00	7 76400E 00	6 80000E-01	0	HANN 13
0	0	0	4 00001E-02	0	9 33000E 00	HANN 14
8 18000E 00	7 10000E-01	0	0	0	0	HANN 15
7 00001E-02	0	9 59000E 00	8 28000E 00	1 11000E 00	0	HANN 16
0	0	0	1 20000E-01	0	9 64000E 00	HANN 17
8 38000E 00	1 24000E 00	0	0	0	0	HANN 18

C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

2 20000E-01 0 9 74000E 00 8 28000E 00 1 14000E 00 0 HANN 19
 0
 8 03000E 00 1 24000E 00
 6 40000E 01 0 1 01600E 01 8 53000E 00 1 49000E 00 0 HANN 22
 0
 9 52000E 00 9 90000E 01 0
 C
 C

16 9 2909 OXYGEN

LAMS-2941

HANSEN

4 00000E-02 0 1 33000E 00 8 66000E-01 0
 0
 9 89000E-01 4 24000E-01 0
 0
 0
 3 07400E 00 9 02000E-01 0
 0
 3 02900E 00 3 37000E-01 0
 0
 0
 3 37000E 00 2 55000E-01 0
 0
 0
 3 26000E 00 2 70000E-01 0
 0
 0
 3 26000E 00 4 14000E-01 0
 0
 0
 3 14200E 00 4 14000E-01 0
 0
 0
 3 64100E 00 3 31000E-01 0
 C
 C

16 9 2910 SODIUM

LAMS-2941

HANSEN

3 00000E-02 0 1 60700E 00 1 13700E 00
 0
 1 70400E 00 4 40000E-01 0
 1 99988E-04 0 2 99020E 00 1 79900E 00 5 56000E-01 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0
 2 47090E 00 1 19100E 00
 9 00030E-04 0 3 10720E 00 2 91130E 00 6 04000E 01 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0
 3 69500E 00 1 95000E-01 3 60000E 02 0
 C
 C

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

1 00005E 03 0 6 08900E 00 5 78700E 00 1 88000E-0110 00000E 09HANNA 10
 8 00000E 03 0
 4 31000E 00 3 01000E 01 0
 5 00003E-03 0 3 01000E 00 2 85000E 00 2 54000E-01 0 0 0 0 0 0 0 0 0 0 0
 0
 2 78300E 00 1 55000E-01 0
 1 80000E 02 0 3 03000E 00 2 77600E 00 2 16000E-01 0 0 0 0 0 0 0 0 0 0 0
 0
 2 81800E 00 2 36000E-01 0
 5 70000E 02 0 3 09900E 00 2 80400E 00 2 19000E 01 0 0 0 0 0 0 0 0 0 0 0
 2 0
 2 81600E 00 2 38000E-01 0
 1 90000E-01 0 3 35000E 00 2 96200E 00 2 94000E-01 0 0 0 0 0 0 0 0 0 0 0
 5 0
 3 30000E 00 1 98000E-01 0
 C
 C

16 9 2911 ALUMINUM

LAMS-2941

HANSEN

1 59000E-02 0 1 80590E 00 1 10000E 00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 0
 1 66145E 00 5 60000E-01 0
 3 80009E-04 0 2 14038E 00 1 61000E 00 2 50000E-01 1 00000E-01HANAL 4
 0
 2 47000E 00 3 80000E-01 1 10000E-01 3 00000E-02 0 0 0 0 0 0 0 0 0 0 0
 2 00000E-03 0 2 83200E 00 2 69000E 00 2 50000E-01 1 40000E-01HANAL 7
 2 00000E-02 0
 1 36000E 00 1 40000E-0110 00000E-0910 00000E-03 9 00000E-04 0 0 0 0 0 0 0
 2 00002E-03 0 1 46300E 00 1 39800E 00 7 00000E-02 0 0 0 0 0 0 0 0 0 0 0
 0
 1 30400E 00 6 30000E-02 0
 3 00002E-03 0 1 36600E 00 1 30300E 00 6 00000E-02 0 0 0 0 0 0 0 0 0 0 0
 0
 1 27600E 00 6 00000E-02 0
 1 00000E-02 0 1 36600E 00 1 26400E 00 8 40000E-02 0 0 0 0 0 0 0 0 0 0 0
 0
 1 28400E 00 9 20300E-02 0
 3 00000E-02 0 1 41000E 00 1 28600E 00 8 40000E-02 0 0 0 0 0 0 0 0 0 0 0
 0
 1 29500E 00 9 40000E-02 0
 8 00000E-02 0 1 46000E 00 1 30600E 00 1 15000E-01 0 0 0 0 0 0 0 0 0 0 0
 0
 1 34000E 00 7 40000E-02 0
 C
 C

16 9 2912 SILICON

N-2 753

MYSTIC

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

04	0 0	2 21	1 11	0 0	0 0	SI 1
0 0	0 0	0 0	0 0	0 0	2 84	SI 2
2 35	0 0	0 0	0 0	0 0	0 3	SI 3
0 0	0 0	2 95	2 40	64	0 0	SI 4
0 0	0 0	0 0	0 0	0 0	5 26	SI 5
5 08	37	0 0	0 0	0 0	0 0	SI 6
0 0	0 0	4 68	4 66	55	20	SI 7
0 0	0 0	0 0	0 0	0 0	1 49	SI 8
1 44	18	09	0 0	0 0	0 0	SI 9
0 0	0 0	2 05	1 96	02	0 0	SI 10
17	0 0	0 0	0 0	0 0	2 22	SI 11
2 13	05	0 0	03	0 0	0 0	SI 12
0 0	0 0	2 2	2 11	09	0 0	SI 13
0 0	05	0 0	0 0	0 0	2 2	SI 14
2 07	09	0 0	0 0	0 0	0 0	SI 15
01	0 0	2 2	2 05	09	0 0	SI 16
0 0	0 0	0 0	01	0 0	2 21	SI 17
2 07	13	0 0	0 0	0 0	0 0	SI 18
02	0 0	2 21	2 05	14	0 0	SI 19
0 0	0 0	0 0	05	0 0	2 18	SI 20
1 99	13	0 0	0 0	0 0	0 0	SI 21
05	0 0	2 20	2 04	14	0 0	SI 22
0 0	0 0	0 0	142	0 0	1 802	SI 23
1 66	16	0 0	0 0	0 0	0 0	SI 24

C

16 9 2914	POTASSIUM	LAMS-2941	HANSEN
0	0	2 11000E 00 1 79500E 00 0	0 HANK 1
0	0	0 0	2 22000E 00 HANK 2
2 07100E 00 3 15000E-01 0	0	0 0	0 HANK 3
0	0	1 69000E 00 1 49500E 00 1 49000E-01 0	0 HANK 4
0	0	0 0	1 84000E 00 HANK 5
1 72400E 00 1 95000E-01 0	0	0 0	0 HANK 6
0	0	1 97000E 00 1 89800E 00 1 16000E-01 0	0 HANK 7
0	0	0 1 00002E-03 0	1 86700E 00 HANK 8
1 81300E 00 7 20000E-02 0	0	0 0	0 HANK 9
3 00001E-03 0	1 42500E 00 1 38000E 00 5 30000E-02 0	0 HANK 10	
0	0	8 00000E-03 0	1 52300E 00 HANK 11
1 47000E 00 4 20000E-02 0	0 0	0 0	0 HANK 12
1 70000E-02 0	1 70000E 00 1 63500E 00 4 50000E-02 0	0 HANK 13	
0	0	3 80000E-02 0	1 86800E 00 HANK 14
1 75200E 00 5 00000E-02 0	0 0	0 0	0 HANK 15
6 80000E-02 0	1 96600E 00 1 80900E 00 7 80000E-02 0	0 HANK 16	
0	0	1 20000E-01 0	2 11000E 00 HANK 17
1 90500E 00 8 90000E-02 0	0 0	0 0	0 HANK 18

C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

2 10000E-01 0	2 26000E 00 1 95400E 00 8 50000E-02 0	0 HANK 19	
0	0	3 60000E-01 0	2 36000E 00 HANK 20
1 88800E 00 9 60000E-02 0	0	0	0 HANK 21
6 10000E 01 0	2 66000E 00 1 97500E 00 1 12000E-01 0	0 HANK 22	
0	0	1 75000E 00 0	4 00000E 00 HANK 23
2 25000E 00 7 50000E-02 0	0	0	0 HANK 24

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16 9 2915	IRON	LAMS-2941	HANSEN
7 00000E 03 0	2 24700E 00 1 44000E 00 0	0	0 HANFE 1
0	0	5 00001E 03 0	2 20000E 00 HANFE 2
1 49500E 00 5 00000E-01 0	0	0	0 HANFE 3
1 00000E-02 0	1 96000E 00 1 47000E 00 4 00000E-01 2	0 00000E-01 HANFE 4	
0	0	1 00000E-02 0	2 29000E 00 HANFE 5
2 15700E 00 2 30000E-01 2	0 00000E-01 1 00000E-01 0	0	0 HANFE 6
1 00000E-02 0	2 44000E 00 2 35900E 00 1 23000E-01 2	0 30000E-01 HANFE 7	
1 00000E-01 0	0	1 00000E-02 0	2 23000E 00 HANFE 8
2 17000E 00 7 10000E 0210	0 00000E-09 2 00000E 02 0	0	0 HANFE 9
1 00001E 02 0	5 65000E 00 5 52000E 00 5 00000E-02 0	0	0 HANFE 10
0	0	1 10000E-02 0	7 11400E 00 HANFE 11
6 95200E 00 1 20000E-01 0	0	0	0 HANFE 12
2 70001E-02 0	1 09680E 01 1 07080E 01 1 51000E-01 0	0	0 HANFE 13
0	0	5 50001E 02 0	1 13640E 01 HANFE 14
1 09770E 01 2 33000E-01 0	0	0	0 HANFE 15
9 80002E-02 0	1 13640E 01 1 09010E 01 3 32000E-01 0	0	0 HANFE 16
0	0	1 70000E-01 0	1 13700E 01 HANFE 17
1 08710E 01 3 65000E-01 0	0	0	0 HANFE 18
3 10000E-01 0	1 13700E 01 1 07020E 01 3 29000E-01 0	0	0 HANFE 19
0	0	5 10000E 01 0	1 13700E 01 HANFE 20
1 04310E 01 3 58000E-01 0	0	0	0 HANFE 21
9 10000E-01 0	1 13700E 01 1 03900E 01 4 29000E-01 0	0	0 HANFE 22
0	0	2 33000E 00 0	1 30700E 01 HANFE 23
1 05400E 01 2 70000E-01 0	0	0	0 HANFE 24

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16 9 2916	GALLIUM	LAMS-2941	HANSEN
1 00000E-02 0	2 00000E 00 1 07000E 00 0	0	0 HANFE 1
0	0	2 00000E-02 0	2 20000E 00 HANFE 2
1 51000E 00 3 00000E-01 0	0	0	0 HANFE 3
3 00000E-02 0	2 80000E 00 2 50000E 00 2 00000E-01 3	0 00000E-01 HANFE 4	
0	0	4 00000E-02 0	3 80000E 00 HANFE 5
3 70000E 00 1 50000E-01 2	5 00000E-01 2 00000E 01 0	0	0 HANFE 6
7 00001E-02 0	5 20000E 00 5 10000E 00 6 00000E-02 1	0 00000E 01 HANFE 7	
2 00000E-01 1 00000E-01 0	1 20000E 01 0	6 70000E 00 HANFE 8	
6 58000E 00 3 00000E-0210	0 00000E 09 2 00000E 02 2 00000E-02 2	0 00000E-02 HANFE 9	

C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	0	0
0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	0	0
0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	0	0
0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	0	0
0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	0	0
0	0	6 70000E 00 6 70000E 00 0	0
0	0	0	0
6 70000E 00 0	0	2 50000E 00 0	0
0	0	0	0

16 9 2917	NIOBIUM	LAMS 2941	HANSEN
1 00000E-02 0	2 40000E 00 1 39000E 00 0	0	HANNB 1
0	0	2 00000E-02 0	2 90000E 00HANNB 2
2 13000E 00 5 00000E-01 0	0	0	HANNB 3
4 00000E-02 0	3 90000E 00 3 46000E 00 4 00000E-01 0	3 00000E 01HANNB 4	
0	0	5 00000E-02 0	6 20000E 00HANNB 5
5 95000E 00 3 00000E-01 2	5 00000E-01 2 00000E-01 0	0	HANNB 6
8 00000E-02 0	8 20000E 00 7 99000E 00 2 00000E-01 1	00000E-01HANNB 7	
1 00000E-01 0	0	4 00000E-01 0	8 00000E 00HANNB 8
7 50000E 00 1 30000E-01 0	0	0	HANNB 9
1 20000E 00 0	7 20000E 00 5 92000E 00 1 00000E-01 0	0	HANNB 10
0	0	2 60000E 00 0	8 60000E 00HANNB 11
5 92000E 00 8 00000E 02 0	0	0	HANNB 12
2 80000E 00 0	8 80000E 00 5 92000E 00 8 00000E-02 0	6 40000E 00HANNB 13	
0	0	4 00000E 01 0	0
5 90000E 00 8 00000E 02 0	0	0	HANNB 15
2 00000E-02 0	6 00000E 00 5 88000E 00 1 00000E-01 0	0	HANNB 16
0	0	4 00001E 02 0	6 00000E 00HANNB 17
5 86000E 00 1 00000E 01 0	0	0	HANNB 18
6 00001E-02 0	6 10000E 00 5 93000E 00 1 00000E-01 0	0	HANNB 19
0	0	1 00000E-01 0	6 10000E 00HANNB 20
5 86000E 00 1 10000E-01 0	0	0	HANNB 21
5 70000E-01 0	6 40000E 00 5 94000E 00 1 40000E-01 0	0	HANNB 22
0	0	1 02000E 00 0	7 00000E 00HANNB 23
5 98000E 00 9 00000E 02 0	0	0	0

16 9 2918	MOLYBDENUM	LAMS 2941	HANSEN
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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

1 00000E-02 0	2 40000E 00 1 39000E 00 0	0	HANNB 1
0	0	2 00000E-02 0	2 90000E 00HANNB 2
2 13000E 00 5 00000E 01 0	0	0	HANNB 3
4 00000E-02 0	3 90000E 00 3 46000E 00 4 00000E-01 3	00000E-01	3 00000E 01HANNB 4
0	0	7 00001E 02 0	6 20000E 00HANNB 5
5 93000E 00 3 00000E-01 2	5 00000E 01 2 00000E-01 0	0	HANNB 6
9 00000E-02 0	8 20000E 00 7 98000E 00 2 00000E 01 1	00000E 01	1 00000E 01HANNB 7
1 00000E 01 0	0	1 70000E 01 0	7 90000E 00HANNB 8
7 63000E 00 1 30000E-01 0	0	0	HANNB 9
4 00000E 01 0	7 10000E 00 6 62000E 00 1 00000E-01 0	0	HANNB 10
0	0	1 50000E 00 0	8 05000E 00HANNB 11
6 47000E 00 8 00000E-02 0	0	0	HANNB 12
2 90000E 00 0	9 16000E 00 6 18000E 00 8 00000E-02 0	0	HANNB 13
0	0	1 34000E 01 0	1 93600E 01HANNB 14
5 86000E 00 8 00000E-02 0	0	0	HANNB 15
5 00000E 02 0	5 56000E 00 5 41000E 00 1 00000E-01 0	0	HANNB 16
0	0	8 00000E-02 0	5 66000E 00HANNB 17
5 48000E 00 1 00000E-01 0	0	0	HANNB 18
1 50000E-01 0	5 96000E 00 5 70000E 00 1 00000E-01 0	0	HANNB 19
0	0	2 50000E-01 0	6 46000E 00HANNB 20
6 07000E 00 1 10000E-01 0	0	0	HANNB 21
9 00000E-01 0	6 66000E 00 5 67000E 00 1 40000E-01 0	0	HANNB 22
0	0	2 50000E 00 0	7 56000E 00HANNB 23
5 06000E 00 9 00000E-02 0	0	0	0

16 9 2921	TANTALUM	LAMS-2941	HANSEN
4 00000E-02 0	3 30000E 00 1 08000E 00 0	0	HANTA 1
0	0	8 00000E-02 0	3 70000E 00HANTA 2
1 58000E 00 3 30000E-01 0	0	0	HANTA 3
1 30000E-01 0	4 40000E 00 2 82000E 00 3 50000E-01 4	6 00000E-01	4 60000E 01HANTA 4
0	0	2 00000E-01 0	5 20000E 00HANTA 5
4 42000E 00 8 00000E-01 9	6 00000E-01 7 90000E-01 0	0	HANTA 6
3 50000E-01 0	6 60000E 00 6 17000E 00 5 00000E-01 5	5 00000E-01	5 50000E 01HANTA 7
6 40000E 01 5 30000E-01 0	8 00000E-01 0	8 00000E 00HANTA 8	
7 95000E 00 8 00000E-02 8	00000E 02 1 00000E-01 9 00000E-02 7	00000E-02	7 00000E 02HANTA 9
5 00000E 00 0	1 30000E 01 7 95000E 00 5 00000E-02 0	0	HANTA 10
0	0	1 20000E 01 0	2 00000E 01HANTA 11
7 95000E 00 5 00000E-02 0	0	0	HANTA 12
2 70000E 01 0	3 60000E 01 8 95000E 00 5 00000E-02 0	0	HANTA 13
0	0	8 30000E 01 0	9 20000E 01HANTA 14
8 95000E 00 5 00000E-02 0	0	0	HANTA 15
9 90000E 01 0	1 09000E 02 9 95000E 00 5 00000E-02 0	0	HANTA 16
0	0	3 12000E 02 0	3 42000E 02HANTA 17
2 99500E 01 5 00000E 02 0	0	0	0

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

4 20000E 00 0 1 02000E 01 5 95000E 00 5 00000E-02 0 HANTA 19
 0 0 0 4 20000E 00 0 1 02000E 01 HANTA 20
 5 95000E 00 5 00000E-02 0 0 0 0 HANTA 21
 7 60000E 00 0 1 36000E 01 5 95000E 00 5 00000E-02 0 HANTA 22
 0 0 0 1 86000E 01 0 2 46000E 01 HANTA 23
 6 00000E 00 5 00000E 02 0 0 0 0 HANTA 24

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16 9 2924 LEAD H-2-753 MYSTIC
 0 0 0 2 74 90 0 0 0 0 PB 1
 0 0 0 0 0 0 0 0 2 69 PB 2
 2 02 0 0 0 0 0 0 0 0 PB 3
 0 0 0 3 73 3 43 35 0 0 PB 4
 0 0 0 0 0 0 0 0 3 88 PB 5
 3 79 14 0 0 0 0 0 0 0 0 PB 6
 0 0 0 5 97 5 95 16 42 PB 7
 0 0 0 0 0 0 0 0 9 80 PB 8
 9 75 08 29 0 0 0 0 0 0 PB 9
 0 0 0 10 83 10 77 02 12 PB 10
 67 0 0 0 0 0 0 0 11 12 PB 11
 11 06 05 01 21 0 0 0 0 PB 12
 0 0 0 11 18 11 12 06 0 0 PB 13
 02 36 0 0 0 0 0 0 11 21 PB 14
 11 12 06 0 0 0 0 0 0 PB 15
 01 0 0 11 21 11 10 06 0 0 PB 16
 0 0 0 04 01 0 0 11 21 PB 17
 11 11 09 0 0 0 0 0 0 PB 18
 02 0 0 11 29 11 17 10 0 0 PB 19
 0 0 0 0 0 0 0 11 08 PB 20
 10 94 09 0 0 0 0 0 0 PB 21
 06 0 0 10 86 10 72 10 0 0 PB 22
 0 0 0 0 15 0 0 11 15 PB 23
 11 0 11 0 0 0 0 0 0 PB 24

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16 9 2925 URANIUM-235 LAMS-2941 HANSEN
 1 79000E 00 5 28500E 00 4 29000E 00 1 19000E 00 0 0 HANU 2 1
 0 0 0 1 89000E 00 4 94100E 00 4 50000E 00 HANU 2 2
 1 55000E 00 2 00000E-01 0 0 0 0 HANU 2 3
 1 97000E 00 4 93300E 00 4 60900E 00 1 82000E 00 1 80000E-01 2 70000E-01 HANU 2 4
 0 0 0 2 05000E 00 4 98600E 00 5 30000E 00 HANU 2 5
 2 91000E 00 4 50000E-01 5 00000E-01 4 50000E-01 0 0 HANU 2 6
 2 39000E 00 5 66700E 00 8 10000E 00 5 66000E 00 2 90000E-01 3 00000E-01 HANU 2 7
 3 50000E-01 3 10000E 01 0 5 92000E 00 8 78500E 00 1 25000E 01 HANU 2 8
 8 54000E 00 5 00000E-02 5 00000E-02 6 00000E-02 5 00000E-02 4 00000E-02 HANU 2 9

C SERIES 2900 CROSS SECTION LIBRARY HANSEN ROACH

6 84000E 00 1 50600E 01 1 65000E 01 9 61000E 00 4 00000E 02 0 HANU 210
 0 0 0 1 20000E 01 2 25900E 01 2 30000E 01 HANU 211
 1 09400E 01 5 00000E-02 0 0 0 0 HANU 212
 3 20000E 01 4 76900E 01 4 40000E 01 1 19400E 01 6 00000E-02 0 HANU 213
 0 0 0 5 10000E 01 7 53000E 01 6 30000E 01 HANU 214
 1 19100E 01 6 00000E 02 0 0 0 0 HANU 215
 1 36000E 02 2 86140E 02 1 48000E 02 1 19100E 01 9 00000E 02 0 HANU 216
 0 0 0 1 21000E 02 2 56620E 02 1 33000E 02 HANU 217
 1 19100E 01 9 00000E-02 0 0 0 0 HANU 218
 4 10000E 02 7 93160E 02 4 22000E 02 1 19100E 01 9 00000E-02 0 HANU 219
 0 0 0 1 48000E 02 3 33830E 02 1 60000E 02 HANU 220
 1 18900E 01 9 00000E 02 0 0 0 0 HANU 221
 2 23000E 02 5 02000E 02 2 35000E 02 1 19200E 01 1 10000E-01 0 HANU 222
 0 0 0 5 13000E 02 1 17220E 03 5 25000E 02 HANU 223
 1 20000E 01 8 00000E-02 0 0 0 0 HANU 224

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16 9 2927 URANIUM-235 LAMS-2941 HANSEN
 1 26000E 00 3 55700E 00 4 25000E 00 1 20000E 00 0 0 HANU 2 1
 0 0 0 1 30000E 00 3 19600E 00 4 50000E 00 HANU 2 2
 1 77000E 00 2 70000E-01 0 0 0 0 HANU 2 3
 1 33000E 00 3 08700E 00 4 65000E 00 2 30000E 00 2 40000E-01 3 70000E-01 HANU 2 4
 0 0 0 1 35000E 00 2 98800E 00 5 20000E 00 HANU 2 5
 3 42000E 00 5 50000E-01 6 70000E-01 6 50000E-01 0 0 HANU 2 6
 1 66000E 00 3 51800E 00 7 90000E 00 6 16000E 00 3 50000E-01 4 00000E-01 HANU 2 7
 4 50000E-01 4 40000E 01 0 3 15000E 00 6 12500E 00 1 24000E 01 HANU 2 8
 9 20000E 00 8 00000E-02 8 00000E-02 7 00000E-02 7 00000E-02 6 00000E 02 HANU 2 9
 5 50000E 00 1 02900E 01 1 51000E 01 9 95000E 00 5 00000E-02 0 HANU 210
 0 0 0 1 11000E 01 1 93600E 01 2 11000E 01 HANU 211
 9 95000E 00 5 00000E-02 0 0 0 0 HANU 212
 2 72000E 01 4 58150E 01 3 72000E 01 9 95000E 00 5 00000E-02 0 HANU 213
 0 0 0 5 80000E 01 9 31000E 01 6 80000E 01 HANU 214
 9 95000E 00 5 00000E-02 0 0 0 0 HANU 215
 9 00000E 01 1 34750E 02 1 00000E 02 9 95000E 00 5 00000E-02 0 HANU 216
 0 0 0 8 40000E 01 1 07800E 02 9 40000E 01 HANU 217
 9 95000E 00 5 00000E-02 0 0 0 0 HANU 218
 3 90000E 01 7 35000E 01 4 90000E 01 9 95000E 00 5 00000E-02 0 HANU 219
 0 0 0 8 00000E 01 1 71500E 02 9 00000E 01 HANU 220
 9 95000E 00 5 00000E-02 0 0 0 0 HANU 221
 2 24000E 02 4 53250E 02 2 34000E 02 9 96000E 00 5 00000E-02 0 HANU 222
 0 0 0 6 11000E 02 1 26420E 03 6 21000E 02 HANU 223
 1 00000E 01 4 00000E-02 0 0 0 0 HANU 224

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16 9 2929 URANIUM-238 LAMS-2941 HANSEN

C SERIES 2900 CROSS SECTION LIBRARY HANSEN ROAD

5	66000E	01	1	72500E	00	4	00000E	00	1	25400E	00	0	0	HANJ 2 1				
0	0	0	0	0	0	0	0	0	0	0	0	0	0					
1	82500E	00	3	30000E	01	0	0	0	0	0	0	0	0	HANJ 2 2				
1	44000E	01	1	08000E	01	4	50000E	00	2	90600E	00	3	50000E	01	4	60000E	01	HANJ 2 3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	53000E	00	8	00000E	01	9	60000E	01	7	90000E	01	0	0	HANJ 2 4				
1	60000E	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	40000E	01	5	30000E	01	0	0	0	0	0	0	0	0	0	0	0	0	
1	14500E	01	8	00000E	02	8	00000E	02	1	00000E	01	9	00000E	02	7	00000E	02	HANJ 2 5
7	00000E	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	29400E	01	6	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
1	10000E	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	94000E	00	5	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
5	60000E	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	94000E	00	6	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
4	00000E	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
8	94000E	00	6	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
1	00000E	00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	00000E	00	5	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	

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16 9 2930	PLUTONIUM 239	LAMS 2941	HANSEN															
1	93000E	00	6	61200E	00	4	25000E	00	1	09000E	00	0	0	HANPU 1				
0	0	0	0	0	0	0	0	0	0	0	0	0	0					
1	42000E	00	2	00000E	01	0	0	0	0	0	0	0	0	HANPU 2				
1	90000E	00	5	47200E	00	4	80000E	00	2	09000E	00	1	80000E	01	2	70000E	01	HANPU 3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5	55000E	00	4	5000E	01	5	00000E	01	4	50000E	01	0	0	HANPU 4				
1	84000E	00	4	81000E	00	8	40000E	00	6	51000E	00	2	90000E	01	3	00000E	01	HANPU 5
5	50000E	01	3	10000E	01	0	0	0	0	0	0	0	0	0	0	0	0	
1	08500E	01	5	00000E	02	5	00000E	02	6	00000E	02	5	00000E	02	4	00000E	02	HANPU 6
3	50000E	00	7	15000E	00	1	35000E	01	9	96000E	00	5	00000E	02	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	96000E	00	4	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
2	51000E	01	4	71900E	01	3	51000E	01	9	96000E	00	4	00000E	02	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	94000E	00	4	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
1	33000E	02	2	23080E	02	1	43000E	02	9	93000E	00	6	00000E	02	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	94000E	00	7	0000E	02	0	0	0	0	0	0	0	0	0	0	0	0	

C SERIES 2900 CROSS SECTION LIBRARY HANSEN ROAD

2	30000E	01	5	72000E	01	3	30000E	01	9	93000E	00	6	00000E	02	0	0	0	HANPU 19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9	92000E	00	7	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
2	01300E	03	5	49206E	03	2	02300E	03	9	94000E	00	8	00000E	02	0	0	0	HANPU 20
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	00000E	01	6	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	HANPU 21

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16 9 2931	PLUTONIUM 240	LAMS 2941	HANSEN															
1	65000E	00	5	95200E	00	4	25000E	00	1	03000E	00	0	0	HANPU 1				
0	0	0	0	0	0	0	0	0	0	0	0	0	0					
1	62000E	00	2	40000E	01	0	0	0	0	0	0	0	0	HANPU 2				
1	50000E	00	4	58700E	00	4	65000E	00	2	24000E	00	2	20000E	01	3	30000E	01	HANPU 3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4	07000E	00	5	00000E	01	5	80000E	01	5	50000E	01	0	0	HANPU 4				
2	80000E	01	1	59000E	01	8	20000E	00	7	87000E	00	4	00000E	01	3	50000E	01	HANPU 5
4	00000E	01	4	00000E	01	0	0	0	4	50000E	01	0	0	1	14500E	01	HANPU 6	
1	09500E	01	5	00000E	02	6	00000E	02	6	00000E	02	6	00000E	02	5	00000E	02	HANPU 7
7	00000E	01	0	0	0	0	0	0	1	17000E	01	1	09500E	01	5	00000E	02	HANPU 8
0	0	0	0	0	0	0	0	0	2	00000E	00	0	0	1	30000E	01	HANPU 9	
1	09500E	01	5	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
1	10000E	01	0	0	0	0	0	0	2	20000E	01	1	09500E	01	5	00000E	02	HANPU 10
0	0	0	0	0	0	0	0	0	6	00000E	01	0	0	7	10000E	01	HANPU 11	
1	09200E	01	5	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
3	10000E	01	0	0	0	0	0	0	4	30000E	01	1	19100E	01	8	00000E	02	HANPU 12
0	0	0	0	0	0	0	0	0	2	40000E	01	0	0	3	90000E	01	HANPU 13	
1	49000E	01	9	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	
6	64140E	03	4	20000E	00	7	14940E	03	5	04140E	02	1	00000E	01	0	0	0	HANPU 14
0	0	0	0	0	0	0	0	0	8	98200E	02	6	00000E	01	9	36200E	02	HANPU 15
5	76500E	01	3	86000E	00	0	0	0	0	0	0	0	0	0	0	0	0	
1	40000E	02	0	0	0	0	0	0	1	51000E	02	1	09500E	01	3	50000E	01	HANPU 16
0	0	0	0	0	0	0	0	0	2	52030E	02	9	00000E	02	2	63030E	02	HANPU 17
1	10000E	01	7	00000E	02	0	0	0	0	0	0	0	0	0	0	0	0	

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16 9 2936	ZIRCONIUM	LAMS 2941	HANSEN															
3	00002E	03	0	2	60000E	00	1	49700E	00	0	0	0	0	HANZR 1				
0	0	0	0	0	0	0	0	0	5	00003E	03	0	0	3	10000E	00	HANZR 2	
2	39500E	00	6	00000E	01	0	0	0	0	0	0	0	0	0	0	0	0	
7	00000E	03	0	0	0	0	0	0	3	84000E	00	5	34300E	00	4	00000E	01	HANZR 3
0	0	0	0	0	0	0	0	0	1	20000E	02	0	0	6	21000E	00	HANZR 4	
5	97800E	00	3	00000E	01	2	00000E	01	2	00000E	01	0	0	0	0	0	0	
1	50000E	02	0	0	0	0	0	0	7	21000E	00	7	06000E	00	2	20000E	01	HANZR 5
1	00000E	01	0	0	0	0	0	0	1	50000E	02	0	0	7	91000E	00	HANZR 6	
7	78800E	00	35000E	01	10	00000E	09	4	00000E	02	0	0	0	0	0	0	0	

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

1 50000E-02 0	7 64400E 00	7 53300E 00	1 07000E-01 0	HANZR 10
0 0	0	1 50000E-02 0	6 55200E 00	HANZR 11
6 45300E 00	9 60000E 02 0	0	0	HANZR 12
1 50000E-02 0	6 53300E 00	6 25700E 00	8 40000E-02 0	HANZR 13
0 0	0	1 50000E-02 0	6 15500E 00	HANZR 14
6 02800E 00	8 10000E-02 0	0	0	HANZR 15
1 50000E-02 0	6 15500E 00	6 01800E 00	1 12000E-01 0	HANZR 16
0 0	0	1 50000E-02 0	6 15500E 00	HANZR 17
6 02900E 00	1 22000E-01 0	0	0	HANZR 18
2 20000E-02 0	6 15500E 00	6 01100E 00	1 11000E-01 0	HANZR 19
0 0	0	3 60000E-02 0	6 15500E 00	HANZR 20
5 97300E 00	1 22000E-01 0	0	0	HANZR 21
6 50001E-02 0	6 15500E 00	5 99400E 00	1 46000E-01 0	HANZR 22
0 0	0	1 59000E-01 0	6 15600E 00	HANZR 23
5 99700E 00	9 60000E-02 0	0	0	HANZR 24

16 9 2937 NICKEL	LAMS-2941	HANSEN
2 70000E-01 0	2 29000E 00	1 22000E 00 0
0 0	0	10 00000E-02 0
1 64000E 00	5 00000E-01 0	0
9 99999E-03 0	2 53300E 00	2 22000E 00
0 0	0	1 00000E-02 0
2 34000E 00	2 50000E-01 0	2 00000E-01 0
1 00000E-02 0	3 38000E 00	3 29000E 00
1 00000E-01 0	0	2 00000E-02 0
5 05000E 00	8 00000E-02 0	0
3 80000E-01 0	1 43800E 01	1 39100E 01
0 0	0	4 00001E-02 0
1 53200E 01	2 90000E-01 0	0
5 00000E-02 0	1 66800E 01	1 63000E 01
0 0	0	1 00000E-01 0
1 61600E 01	3 30000E-01 0	0
1 80000E-01 0	1 73000E 01	1 65900E 01
0 0	0	3 10000E-01 0
1 65200E 01	5 30000E-01 0	0
5 60000E-01 0	1 75100E 01	1 64200E 01
0 0	0	9 40000E-01 0
1 66200E 01	5 30000E-01 0	0
1 60000E 00 0	1 90000E 01	1 69700E 01
0 0	0	4 60000E 00 0
1 66100E 01	4 30000E-01 0	0

16 9 2940 FLUORINE	LAMS 2941	HANSEN
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C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

1 00000E-01 0	1 40000E 00	8 80000E-01 0	0	HANF19 1
0 0	0	0	3	1 90200E 00
1 28000E 00	4 20000E-01 0	0	0	HANF19 2
0 0	0	2 09000E 00	1 41000E 00	3 20000E-01 0
0 0	0	2 0033E-04 0	0	2 20020E 00
2 14000E 00	6 80000E-01 0	2 10000E-01 0	0	HANF19 3
2 0033E-04 0	4 61020E 00	3 95300E 00	1 06000E 00	8 00000E-01
9 00000E 02 0	0	0	0	3 78000E 00
3 53000E 00	6 50000E-01 0	0	0	HANF19 4
0 0	0	3 57000E 00	3 36000E 00	2 50000E-01 0
0 0	0	0	0	3 57000E 00
3 55000E 00	2 10000E-01 0	0	0	HANF19 5
0 0	0	3 47000E 00	3 25000E 00	2 20000E-01 0
0 0	0	0	0	3 28000E 00
2 99000E 00	2 20000E-01 0	0	0	HANF19 6
0 0	2 99000E 00	2 71000E 00	2 90000E-01 0	HANF19 7
0 0	0	0	0	3 18000E 00
2 90000E 00	2 80000E-01 0	0	0	HANF19 8
1 00002E-03 0	3 28100E 00	2 97000E 00	2 80000E-01 0	HANF19 9
0 0	0	2 00000E-03 0	0	3 28200E 00
2 91000E 00	3 10000E-01 0	0	0	HANF19 10
4 00001E-03 0	3 47400E 00	3 21000E 00	3 70000E-01 0	HANF19 11
0 0	0	8 00002E-03 0	0	3 46800E 00
3 46000E 00	2 60000E-01 0	0	0	HANF19 12

16 9 9941 CHROMIUM	LAMS-2941	AERJET
1 00000E-02 0	2 44300E 00	1 25000E 00 0
0 0	0	2 00000E-02 0
1 47000E 00	5 70000E-01 0	0
2 00000E-02 0	2 17000E 00	1 79000E 00
0 0	0	1 99999E-02 0
2 45000E 00	2 80000E-01 0	3 60000E-01 0
4 00000E-02 0	3 55000E 00	3 38000E 00
1 50000E-01 0	9 00000E 02 0	1 10000E-01 0
3 00000E 00	1 30000E-01 0	00000E-03 0
7 00001E-02 0	1 29200E 01	1 26800E 01
0 0	0	2 00000E 02 0
4 56000E 00	1 70000E-01 0	0
3 00000E-02 0	4 24000E 00	4 12000E 00
1 10000E-01 0	0	6 00001E-02 0
4 06000E 00	9 00000E-02 0	0
0 0	0	4 00000E 00
4 05000E 00	1 40000E-01 0	0

C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

3 40000E 01 0	4 47000E 00 3 99000E 00 1 30000E 01 0	AERCR 19
0 0 0	5 50000E 01 0	4 64000E 00AERCR 20
3 92000E 00 1 40000E 01 0	0 0	AERCR 21
9 90000E 01 0	5 21000E 00 4 10000E 00 1 70000E-01 0	AERCR 22
0 0 0	3 10000E 00 0	6 10000E 00AERCR 23
3 00000E 00 1 20000E-01 0	0 0 0	AERCR 24

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16 9 2942 COBALT	LAMS-2941	HANSEN
1 00000E 02 0	2 20000E 00 1 39000E 00 0	0 HANCO 1
0 0 0	5 0000E-03 0	2 50000E 00HANCO 2
1 79500E 00 5 00000E-01 0	0 0	0 HANCO 3
5 00000E 03 0	2 80000E 00 2 31500E 00 4 00000E-01 2 00000E-01HANCO 4	2 60000E-01 0
0 0 0	4 99991E-03 0	2 90000E 00HANCO 5
2 74500E 00 2 30000E 01 2 00000E-01 1 00000E 01 0	0 0	0 HANCO 6
8 00002E 03 0	3 60000E 00 3 49200E 00 1 50000E-01 2 30000E 01HANCO 7	4 30000E 00HANCO 8
1 00000E 01 0	0 9 99999E-03 0	0 HANCO 9
4 19000E 00 1 00000E 0110 00000E-08 2 00000E 02 0	0 0	0 HANCO 10
4 00001E-02 0	5 00000E 00 4 86000E 00 1 00000E-01 0	3 50000E 00HANCO 11
0 0 0	1 00000E-02 0	0 HANCO 12
3 42000E 00 1 00000E-01 0	0 0	0 HANCO 13
3 80000E 01 0	6 00000E 01 2 10000E 01 7 00000E-02 0	7 20000E 00HANCO 14
0 0 0	7 00000E-01 0	0 HANCO 15
6 30000E 00 1 00000E 00 0	0 0	0 HANCO 16
1 30000E 00 0	7 80000E 00 6 30000E 00 2 00000E-01 0	8 80000E 00HANCO 17
0 0 0	2 30000E 00 0	0 HANCO 18
6 32000E 00 2 00000E 01 0	0 0	0 HANCO 19
4 00000E 00 0	1 05000E 01 6 30000E 00 1 80000E-01 0	1 32000E 01HANCO 20
0 0 0	6 70000E 00 0	0 HANCO 21
6 26000E 00 2 00000E-01 0	0 0	0 HANCO 22
1 18000E 01 0	1 83000E 01 6 34000E 00 2 40000E-01 0	4 00000E 01HANCO 23
0 0 0	3 35000E 01 0	0 HANCO 24
6 50000E 00 1 60000E 01 0	0 0 0	

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16 9 2943 CERIUM	LAMS 2941	HANSEN
1 00000E-02 0	3 00000E 00 1 40000E 00 0	0 HANCE 1
0 0 0	4 0000E-03 0	3 70000E 00HANCE 2
2 80000E 00 8 00000E 01 0	0 0	0 HANCE 3
5 00003E 03 0	3 90000E 00 3 83500E 00 5 96000E-01 7 90000E-01HANCE 4	4 10000E 00HANCE 5
0 0 0	1 00001E-02 0	0 HANCE 6
4 03000E 00 6 00000E 02 3 00000E-01 0	0 0	0 HANCE 7
1 00000E 02 0	3 90000E 00 3 83000E 00 6 00000E-02 0	3 90000E 00HANCE 8
0 0 0	2 00000E-02 0	0 HANCE 9
3 85000E 00 6 00000E 02 0	0 0	

C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

2 00000E-02 0	4 00000E 00 3 95000E 00 3 00000E-02 0	HANCE 10
0 0 0	2 00000E-02 0	3 00000E 00HANCE 11
4 94000E 00 3 00000E-02 0	0 0	0 HANCE 12
2 00000E 02 0	4 00000E 00 3 95000E 00 4 00000E-02 0	HANCE 13
0 0 0	2 00000E-02 0	4 00000E 00HANCE 14
3 93000E 00 3 00000E-02 0	0 0	0 HANCE 15
3 00000E 02 0	4 00000E 00 3 92000E 00 5 00000E-02 0	HANCE 16
0 0 0	5 00000E-02 0	4 00000E 00HANCE 17
3 90000E 00 5 00000E-02 0	0 0	0 HANCE 18
9 00000E 02 0	4 00000E 00 3 86000E 00 5 00000E-02 0	HANCE 19
0 0 0	1 40000E-01 0	4 00000E 00HANCE 20
3 80000E 00 5 00000E-02 0	0 0	0 HANCE 21
2 60000E-01 0	4 00000E 00 3 70000E 00 6 00000E-02 0	HANCE 22
0 0 0	7 00000E-01 0	4 00000E 00HANCE 23
3 30000E 00 4 00000E-02 0	0 0	0 HANCE 24

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16 9 2944 THORIUM	LAMS-2941	HANSEN
1 80000E-01 3 84000E-01 4 00000E 00 1 64000E 00 0	0 0	0 HANTH 1
0 0 0	1 50000E-01 2 30000E-01 4 22000E 00HANTH 2	2 03000E 00 3 30000E-01 0
2 03000E 00 3 30000E-01 0	0 0	0 HANTH 3
7 90000E-02 2 07000E-02 4 32000E 00 2 79100E 00 3 50000E-01 4 60000E-01HANTH 4	0 0	5 04000E 00HANTH 5
0 0 0	1 30000E-01 0	0 HANTH 6
4 33000E 00 8 00000E-01 9 60000E-01 7 90000E-01 0	0 0	0 HANTH 7
2 10000E-01 0	7 87000E 00 7 58000E 00 5 00000E-01 5 50000E-01HANTH 8	4 80000E-01 0
6 40000E-01 5 30000E-01 0	4 80000E-01 0	1 34800E 01HANTH 9
1 29360E 01 8 00000E-02 8 00000E-02 1 00000E-01 9 00000E-02 7 00000E-02HANTH 10	0 0	1 45000E 01HANTH 11
6 00000E-01 0	1 45000E 01 1 38300E 01 6 40000E-02 0	0 HANTH 12
0 0 0	1 90000E 00 0	1 45000E 01HANTH 13
1 25360E 01 7 00000E-02 0	0 0	0 HANTH 14
2 80000E 00 0	1 48000E 01 1 19400E 01 6 40000E-02 0	1 36000E 01HANTH 15
0 0 0	1 60000E 00 0	1 25000E 01HANTH 16
1 19150E 01 6 00000E-02 0	0 0	0 HANTH 17
3 70000E 00 0	1 57000E 01 1 19060E 01 8 50000E-02 0	0 HANTH 18
0 0 0	5 00000E-01 0	1 35000E 01HANTH 19
1 19150E 01 9 40000E-02 0	0 0	0 HANTH 20
9 00000E-01 0	1 29000E 01 1 19060E 01 8 50000E-02 0	0 HANTH 21
0 0 0	1 50000E 00 0	0 HANTH 22
1 18870E 01 9 40000E-02 0	0 0	0 HANTH 23
2 70000E 00 0	1 47000E 01 1 19260E 01 1 13000E-01 0	1 96000E 01HANTH 24
0 0 0	7 60000E 00 0	0 HANTH 25
1 20000E 01 7 40000E-02 0	0 0	0 HANTH 26

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16 9 2945 HYDROGEN ANISO 1	LAMS-2941	HANSEN
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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

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0 0 1 45000E-0010 00000E-03 0 0 HANH A 1
0 0 0 0 0 0 2 17500E-00MANH A 2
2 44000E-01 7 69000E-01 0 0 0 0 HANH A 3
0 0 3 30000E-00 6 40000E-02 6 90000E-01 2 39000E-01MANH A 4
0 0 0 0 0 0 4 12500E-00MANH A 5
3 57000E-01 1 79600E-00 6 90000E-01 2 39000E-01 0 0 HANH A 6
0 0 6 75000E-00 1 88100E-00 2 82700E-00 1 07600E-00MANH A 7
4 15000E-01 1 44000E-01 0 0 0 1 17000E-01MANH A 8
4 40400E-00 4 04100E-00 7 81000E-01 3 00000E-01 1 16000E-01 4 90000E-02MANH A 9
0 0 1 42500E-01 5 22900E-00 6 02200E-00 6 84000E-01MANH A 10
1 32000E-01 5 20000E-02 2 00000E-02 1 00034E-03 0 1 50000E-01MANH A 11
5 36500E-00 7 37200E-00 1 04500E-00 1 17000E-01 2 20000E-02 1 20000E-02MANH A 12
4 00025E-03 0 1 50000E-01 5 38900E-00 7 88000E-00 1 34900E-00MANH A 13
1 87000E-01 2 20000E-02 6 00000E-03 8 00020E-03 0 1 50000E-01MANH A 14
3 34800E-00 6 71900E-00 1 22000E-00 2 09000E-01 5 00000E-02 5 00000E-03MANH A 15
1 40003E-02 0 1 50000E-01 2 87500E-00 7 75700E-00 1 92000E-00MANH A 16
3 60000E-01 6 10000E-02 1 20000E-02 2 50003E-02 0 1 50000E-01MANH A 17
3 13600E-00 8 49400E-00 2 71900E-00 6 80000E-01 1 22000E-01 3 00000E-02MANH A 18
4 50001E-02 0 1 50000E-01 2 62000E-00 7 90600E-00 2 41800E-00MANH A 19
7 80000E-01 1 92000E-01 5 20000E-02 7 00001E-02 0 1 80000E-01MANH A 20
4 73000E-00 7 40900E-00 2 36400E-00 7 19000E-01 2 32000E-01 9 60000E-02MANH A 21
1 30000E-01 0 2 50000E-01 1 98700E-01 9 90000E-00 3 68400E-00MANH A 22
1 18200E-00 3 60000E-01 1 56000E-01 2 90000E-01 0 4 50000E-01MANH A 23
4 47100E-01 5 00000E-00 3 30000E-00 1 24200E-00 3 87000E-01 1 20000E-01MANH A 24

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16 9 2946 HYDROGEN ANISO 2 LAMS-2941 HANSEN
-8 50000E-01 0 0 1 50000E-02 0 0 HANH A 1
0 0 0 -1 20700E-00 0 0 0 HANH A 2
1 30000E-01 5 69000E-01 0 0 0 HANH A 3
1 96700E-00 0 0 2 20000E-02 5 11000E-01 1 28000E-01MANH A 4
0 0 0 -2 29200E-00 0 0 0 HANH A 5
1 78000E-01 1 36500E-00 3 97000E-01 9 60000E-02 0 0 HANH A 6
-3 75000E-00 0 0 1 22600E-00 1 84900E-00 5 07000E-01MANH A 7
1 48000E-01 3 60000E-02 0 -6 50000E-00 0 0 HANH A 8
2 86000E-00 2 35600E-00 2 48000E-01 6 80000E-02 2 00000E-02 6 00000E-03MANH A 9
-7 91300E-00 0 0 3 41000E-00 3 37200E-00 1 35000E-01MANH A 10
1 60000E-02 5 00000E-0310 00000E-04-8 33700E-00 0 0 HANH A 11
3 52000E-00 4 15000E-00 2 48000E-01 1 20000E-0210 00000E-04 0 HANH A 12
-8 32900E-00 0 0 3 54000E-00 4 44400E-00 3 25000E-01MANH A 13
1 90000E-0210 00000E-04 0 -8 32800E-00 0 0 HANH A 14
2 18000E-00 3 99800E-00 3 10000E-01 2 30000E-0210 00000E-04 0 HANH A 15
-8 33000E-00 0 0 1 82000E-00 4 96400E-00 6 37000E-01MANH A 16
5 10000E-02 4 00000E-03 0 8 17800E-00 0 0 HANH A 17
1 91000E-00 5 44500E-00 9 87000E-01 1 28000E-0110 00000E-0310 00000E-04MANH A 18

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C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

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8 16600E-00 0 0 1 59000E-00 5 07600E-00 8 63000E-01MANH A 19
1 58000E-01 2 00000E-02 2 00000E-03 1 10000E-01 0 0 HANH A 20
4 00000E-00 4 94200E-00 8 96000E-01 1 52000E-01 2 80000E-02 6 00000E-03MANH A 21
1 20000E-01 0 0 1 00000E-01 6 40000E-00 1 47400E-00MANH A 22
2 68000E-01 4 50000E-02 1 10000E-02 1 20000E-01 0 0 HANH A 23
1 20000E-01 2 00000E-00 6 00000E-01 1 60000E-01 2 80000E-02 5 00000E-03MANH A 24

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16 9 2947 DEUTERIUM ANISO 1 LAMS-2941 HANSEN
-3 70000E-02 0 1 33200E-00 3 48000E-01 0 0 + D A 1
0 0 0 0 0 0 2 06200E-00+ D A 2
5 59000E-01 5 40000E-01 0 0 0 0 + D A 3
0 0 2 64500E-00 5 39000E-01 5 35000E-01 2 00000E-01+ D A 4
0 0 0 0 0 0 3 08300E-00+ D A 5
1 04500E-00 1 14200E-00 6 35000E-01 2 70000E-01 0 0 + D A 6
0 0 3 27800E-00 1 93000E-00 1 82600E-00 9 64000E-01+ D A 7
3 35000E-01 1 10000E-02 0 0 0 3 22300E-00+ D A 8
1 85600E-00 1 33600E-00 2 12000E-01 0 0 0 + D A 9
0 0 3 22300E-00 1 83300E-00 1 33600E-00 1 20000E-02+ D A 10
0 0 0 0 0 0 3 22300E-00+ D A 11
1 80600E-00 1 33300E-00 3 10000E-02 0 0 0 + D A 12
0 0 3 22300E-00 1 81200E-00 1 38000E-00 3 70000E-02+ D A 13
0 0 0 0 0 0 3 22300E-00+ D A 14
1 42500E-00 1 23400E-00 3 70000E-02 0 0 0 + D A 15
0 0 3 22300E-00 1 32600E-00 1 48200E-00 1 77000E-01+ D A 16
0 0 0 0 0 0 3 22300E-00+ D A 17
1 42500E-00 1 62500E-00 3 16000E-01 0 0 0 + D A 18
0 0 3 22300E-00 1 32600E-00 1 48200E-00 2 72000E-01+ D A 19
0 0 0 0 0 0 3 22310E-00+ D A 20
1 14200E-00 1 62500E-00 3 09000E-01 0 0 0 + D A 21
1 60009E-04 0 3 55756E-00 1 76340E-00 1 87700E-00 2 72000E-01+ D A 22
7 00000E-03 0 0 4 0000E-04 0 4 49200E-00+ D A 23
4 49160E-00 1 79400E-00 2 04000E-01 0 0 0 + D A 24

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16 9 2948 DEUTERIUM ANISO 2 LAMS-2941 HANSEN
2 55000E-01 0 1 60000E-01 0 0 + D A 1
0 0 0 -4 39000E-01 0 0 + D A 2
3 98000E-01 2 75000E-01 0 0 0 + D A 3
-6 12000E-01 0 0 4 56000E-01 2 87000E-01 3 10000E-02+ D A 4
0 0 0 -7 62000E-01 0 0 + D A 5
7 60000E-01 5 08000E-01 -4 60000E-02 -1 48000E-01 0 0 + D A 6
-8 73000E-01 0 0 1 09100E-00 1 38000E-01 3 52000E-01+ D A 7
2 00000E-0110 00000E-04 0 9 53000E-01 0 0 + D A 8
1 01900E-00-2 10000E-01 1 36000E-01 0 0 + D A 9

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C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH

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9 53000E-01 0 0 1 01600E 00 4 10000E 02-8 00000E-03+ D A10
0 0 0 -9 53000E-01 0 0 + D A11
1 01300E 00 3 30000E 02 2 50000E-02 0 0 + D A12
9 53000E 01 0 0 1 01400E 00-3 00000E-02 3 00000E 02+ D A13
0 0 0 9 53000E-01 0 0 + D A14
9 32000E-01 5 10000E 02-3 00000E-02 0 0 + D A15
9 53000E-01 0 0 8 98000E-01 2 08000E-01 1 12000E-01+ D A16
0 0 0 -9 53000E-01 0 0 + D A17
9 29000E-01 2 28000E-01-1 87000E-01 0 0 + D A18
9 53000E-01 0 0 8 89000E-01 2 08000E-01-1 75000E-01+ D A19
0 0 0 -9 56000E 01 0 0 + D A20
8 23000E-01 5 25000E-01 1 79000E-01 0 0 + D A21
9 25220E-01 0 0 8 17700E-01 2 77000E-01-2 61000E-01+ D A22
5 00000E-03 0 0 -8 07300E-01 0 0 + D A23
8 07300E-01 1 07520E 01-1 44000E-01 0 0 + D A24

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C
16 9 2949 DEUTERIUM 1/E LAMS-2941 HANSEN
3 70000E-02 0 1 07700E 00 9 30000E-02 0 0 + D 1 1
0 0 0 0 0 1 62300E 00+ D 1 2
1 20000E-01 5 40000E-01 0 0 0 0 + D 1 3
0 0 0 2 03300E 00-7 30000E-02 5 39000E-01 2 00000E-01+ D 1 4
0 0 0 0 0 2 47300E 00+ D 1 5
3 19000E-01 1 14200E 00 6 33000E-01 2 70000E-01 0 0 + D 1 6
0 0 2 38200E 00 6 95000E-01 1 90300E 00 9 64000E-01+ D 1 7
3 35000E-01 1 10000E-02 0 0 0 2 27000E 00+ D 1 8
9 03000E-01 1 66000E 00 2 51000E-01 0 0 0 + D 1 9
0 0 2 27000E 00 8 80000E-01 1 33600E 00 2 70000E-02+ D 110
0 0 0 0 0 2 27000E 00+ D 111
8 53000E-01 1 35300E 00 3 10000E-02 0 0 0 + D 112
0 0 2 27000E 00 8 59000E-01 1 38000E 00 3 70000E-02+ D 113
0 0 0 0 0 2 27000E 00+ D 114
4 72000E-01 1 23400E 00 3 70000E-02 0 0 0 + D 115
0 0 2 27000E 00 3 73000E-01 1 48200E 00 1 77000E-01+ D 116
0 0 0 0 0 2 27000E 00+ D 117
4 72000E-01 1 62500E 00 3 16000E-01 0 0 0 + D 118
0 0 2 27000E 00 3 73000E-01 1 48200E 00 2 72000E-01+ D 119
0 0 0 0 0 2 26710E 00+ D 120
1 86000E-01 1 62500E 00 3 09000E-01 0 0 0 + D 121
1 60001E-04 0 2 26716E 00 6 21000E-01 1 87700E 00 2 72000E-01+ D 122
7 00000E-03 0 0 4 00007E-04 0 2 26740E 00+ D 123
2 26700E 00 1 64600E 00 2 04000E-01 0 0 0 + D 124

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C
16 9 2950 DEUTERIUM 1/E ANISO 1 LAMS-2941 HANSEN

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C SERIES 2900 CROSS SECTION LIBRARY HANSEN-ROACH

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3 70000E-02 0 1 33200E 00 3 48000E 01 0 0 10 1 1
0 0 0 0 0 0 2 06200E 00 10 1 2
5 59000E 01 5 40000E 01 0 0 0 10 1 3
0 0 2 64500E 00 5 39000E 01 5 35000E-01 2 00000E-01 10 1 4
0 0 0 0 0 3 09500E 00 10 1 5
9 41000E-01 1 14200E 00 6 33000E-01 2 70000E-01 0 10 1 6
0 0 3 26900E 00 1 58200E 00 1 90300E 00 9 64000E-01 10 1 7
3 35000E 01 1 10000E-02 0 0 0 3 22300E 00 10 1 8
1 85600E 00 1 66000E 00 2 51000E-01 0 0 10 1 9
3 22300E 00 1 83300E 00 1 33600E 00 2 70000E-02 10 110
0 0 0 0 0 3 22300E 00 10 111
1 80600E 00 1 35300E 00 3 10000E-02 0 0 10 112
0 0 3 22300E 00 1 81200E 00 1 38000E 00 3 70000E-02 10 113
0 0 0 0 0 3 22300E 00 10 114
1 42500E 00 1 23400E 00 3 70000E-02 0 0 10 115
0 0 3 22300E 00 1 32600E 00 1 48200E 00 1 77000E-01 10 116
0 0 0 0 0 3 22300E 00 10 117
1 42500E 00 1 62500E 00 3 16000E-01 0 0 10 118
0 0 3 22300E 00 1 32600E 00 1 48200E 00 2 72000E-01 10 119
0 0 0 0 0 3 22300E 00 10 120
1 14200E 00 1 62500E 00 3 09000E-01 0 0 10 121
1 60009E-04 0 3 55756E 00 1 76340E 00 1 87700E 00 2 72000E-01 10 122
7 00000E 03 0 0 4 00007E-04 0 4 49200E 00 10 123
4 49160E 00 1 79400E 00 2 04000E-01 0 0 10 124

```

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C
16 9 2951 DEUTERIUM 1/E ANISO 2 LAMS-2941 HANSEN
-2 55000E-01 0 0 1 60000E-01 0 0 20 1 1
0 0 -4 39000E-01 0 0 20 1 2
3 98000E-01 2 75000E-01 0 0 0 20 1 3
6 12000E-01 0 0 4 56000E-01 2 87000E-01-3 10000E-02 20 1 4
0 0 -6 22000E-01 0 0 20 1 5
5 47000E-01 5 08000E-01-4 60000E-02-1 48000E-01 0 20 1 6
8 87000E-01 0 0 9 69000E-01 2 33000E-01 3 52000E-01 20 1 7
-2 00000E-0110 00000E-04 0 -9 53000E-01 0 0 20 1 8
1 01900E 00 6 40000E-02-1 58000E-01 0 0 20 1 9
-9 53000E-01 0 0 1 01600E 00 4 10000E-02-1 80000E-02 20 110
0 0 -9 53000E-01 0 0 20 111
1 01300E 00-3 30000E 02-2 50000E-02 0 0 20 112
-9 53000E-01 0 0 1 01400E 00 3 00000E 02 3 00000E-02 20 113
0 0 -9 53000E-01 0 0 20 114
9 32000E-01 5 10000E-02-3 00000E-02 0 0 20 115
-9 53000E-01 0 0 8 98000E-01 2 08000E-01-1 12000E-01 20 116
0 0 -9 53000E-01 0 0 20 117
9 29000E-01 2 28000E-01-1 87000E-01 0 0 20 118

```

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH.

-9.53000E-01 0. 0. 8.89000E-01 2.08000E-01-1.73000E-01. 2D 119 C
 0. 0. 0. -9.56000E-01 0. 0. . 2D 120 C
 8.23000E-01 3.25000E-01-1.79000E-01 0. 0. . 2D 121 C
 -9.25220E-01 0. 0. 8.17700E-01 2.77000E-01-2.61000E-01. 2D 122 C
 -5.00000E-03 0. 0. -8.07300E-01 0. 0. . 2D 123 C
 8.07300E-01 1.07520E-01-1.44000E-01 0. 0. . 2D 124 C

C
 C

16 9 2952 CHLORINE LAMS-2941 HANSEN
 6.00000E-02 0. 1.65000E 00 1.41700E 00 0. 0. HANCL 1 C
 0. 0. 0. 0. 0. 1.66000E 00HANCL 2 C
 1.55700E 00 1.73000E-01 0. 0. 0. 0. HANCL 3 C
 0. 0. 1.52000E 00 1.56000E 00 1.03000E-01 0. HANCL 4 C
 0. 0. 0. 0. 0. 1.66000E 00HANCL 5 C
 1.58600E 00 1.52000E-01 0. 0. 0. 0. HANCL 6 C
 0. 0. 2.02000E 00 1.99200E 00 7.40000E-02 0. HANCL 7 C
 0. 0. 0. 0. 0. 3.40000E 00HANCL 8 C
 3.29100E 00 2.80000E-02 0. 0. 0. 0. HANCL 9 C
 0. 0. 1.77000E 00 1.71300E 00 1.09000E-01 0. HANCL 10 C
 0. 0. 0. 2.00000E-03 0. 1.91200E 00HANCL 11 C
 1.84600E 00 5.70000E-02 0. 0. 0. 0. HANCL 12 C
 5.00000E-02 0. 4.28000E 00 4.04700E 00 6.40000E-02 0. HANCL 13 C
 0. 0. 0. 3.90000E-01 0. 9.83000E 00HANCL 14 C
 8.99700E 00 1.83000E-01 0. 0. 0. 0. HANCL 15 C
 9.80000E-01 0. 1.35400E 01 1.19150E 01 4.43000E-01 0. HANCL 16 C
 0. 0. 0. 2.10000E 00 0. 1.71100E 01HANCL 17 C
 1.43060E 01 6.45000E-01 0. 0. 0. 0. HANCL 18 C
 3.82000E 00 0. 1.92200E 01 1.46090E 01 7.04000E-01 0. HANCL 19 C
 0. 0. 0. 6.77000E 00 0. 2.24700E 01HANCL 20 C
 1.47320E 01 7.91000E-01 0. 0. 0. 0. HANCL 21 C
 1.21000E 01 0. 2.78000E 01 1.50520E 01 9.68000E-01 0. HANCL 22 C
 0. 0. 0. 5.00000E 01 0. 4.37000E 01HANCL 23 C
 1.57000E 01 6.48000E-01 0. 0. 0. 0. HANCL 24 C

C
 C

16 9 2953 CADMIUM LAMS-2941 HANSEN
 0. 0. 0. 0. 0. 0. HANCD 1 C
 0. 0. 0. 0. 0. 0. HANCD 2 C
 0. 0. 0. 0. 0. 0. HANCD 3 C
 0. 0. 0. 0. 0. 0. HANCD 4 C
 0. 0. 0. 0. 0. 0. HANCD 5 C
 0. 0. 0. 0. 0. 0. HANCD 6 C
 0. 0. 0. 0. 0. 0. HANCD 7 C
 0. 0. 0. 0. 0. 0. HANCD 8 C
 0. 0. 0. 0. 0. 0. HANCD 9 C

C SELF SHIELDED EUROPIUM CROSS SECTIONS

SET NO. REMARKS
 4534 COMPILED ACCORDING TO UCRL-14973. UNSHIELDED.
 4573 COMPILED AND SHIELDED FOR 0.0625 CM. ACCORDING TO UCRL-14973.
 4574 COMPILED AND SHIELDED FOR 0.1250 CM. ACCORDING TO UCRL-14973.
 4575 COMPILED AND SHIELDED FOR 0.2500 CM. ACCORDING TO UCRL-14973.
 4576 COMPILED AND SHIELDED FOR 0.5000 CM. ACCORDING TO UCRL-14973.
 FLUX WEIGHTED FOR BE0/U235 = 247/1 (UCRL-7827).
 FLUX WEIGHTED FOR BE0/U235 = 247/1 (UCRL-7827).
 FLUX WEIGHTED FOR BE0/U235 = 247/1 (UCRL-7827).
 FLUX WEIGHTED FOR BE0/U235 = 247/1 (UCRL-7827).
 FLUX WEIGHTED FOR BE0/U235 = 247/1 (UCRL-7827).

16 9 4034 EUROPIUM MICRO 293K HAMPEL
 .02219 0. 3.4406 0.94503E 00 0. 0. 00252
 0. 0. 0. .07278 0. 4.5080 00253
 0.23703E 01 0.12930E 01 0. 0. 0. 00254
 .13997 0. 5.0866 0.52040E 01 0.90557E 00 0.69800E 00 00255
 0. 0. 0. .20696 0. 7.1553 00256
 0.61399E 01 0.12189E 01 0.97801E 00 0.40536E-00 0. 0. 00257
 .46281 0. 9.527 0.89592E 01 0.80024E 00 0.52473E 00 00258
 0.18335E-00 0.12525E-00 0. 1.4681 0. 10.952 00259
 0.94670E 01 0.10470E-00 0.82295E-02 0. 0. 0. 00260
 5.0449 0. 13.993 0.89438E 01 0.15616E-01 0.37285E-03 00261
 0. 0. 0. 12.542 0. 21.063 00262
 0.85124E 01 0.45269E-02 0. 0. 0. 0. 00263
 59.593 0. 68.621 0.90205E 01 0.85045E-02 0. 00264
 0. 0. 0. 145.087 0. 151.217 00265
 0.81070E 01 0.82879E-02 0. 0. 0. 0. 00266
 198.622 0. 206.582 0.79358E 01 0.21291E-01 0. 00267
 0. 0. 0.84919E-03 382.967 0. 390.927 00268
 0.79414E 01 0.26909E-01 0. 0. 0. 0. 00269
 464.401 03 0. 472.371 0.79358E 01 0.21291E-01 0. 00270
 0. 0. 0. 2167.363 0. 2175.263 00271
 0.79217E 01 0.26909E-01 0. 0. 0. 0. 00272
 1907.259 0. 1925.259 0.79403E 01 0.41004E-01 0. 00273
 0. 0. 0. 4571.632 0. 4579.532 00274
 0.79627E 01 0.14351E-01 0. 0. 0. 0. 00275

16 9 4073 EUROPIUM MICRO 293K 0.0625 CM SHIELD HOWERTON

C SERIES 2900 CROSS SECTION LIBRARY - HANSEN-ROACH.

0. 0. 0. 0. 0. 0. HANCD 10
 0. 0. 0. 0. 0. 0. HANCD 11
 0. 0. 0. 0. 0. 0. HANCD 12
 0. 0. 0. 0. 0. 0. HANCD 13
 0. 0. 0. 0. 0. 0. HANCD 14
 0. 0. 0. 0. 0. 0. HANCD 15
 0. 0. 0. 0. 0. 0. HANCD 16
 0. 0. 0. 0. 0. 0. HANCD 17
 0. 0. 0. 0. 0. 0. HANCD 18
 0. 0. 0. 0. 0. 0. HANCD 19
 0. 0. 0. 6.00000E 01 0. 6.00000E 01HANCD 20
 0. 0. 0. 0. 0. 0. HANCD 21
 3.00000E 03 0. 3.00000E 03 0. 0. 0. HANCD 22
 0. 0. 0. 3.00000E 03 0. 3.00000E 03HANCD 23
 0. 0. 0. 0. 0. 0. HANCD 24

C SELF SHIELDED EUROPIUM CROSS SECTIONS

0 22	E 01	0	3 4245	0 93906E 00 0	0	0	DOYAS452
0	0	0	0	0 72000E-01 0	4 5377	0	DOYAS453
0 23820E 01	0 13064E 01	0	0	0	0	0	DOYAS454
0 13900E 00 0	0	5 09	0 31975E 01 0	0 89259E 00 0	0 67995E	000DOYAS455	
0	0	0	0 20600E-00 0	0	7 229	0	DOYAS456
0 61753E 01	0 12239E 01	0 99703E 00	0 39868E 00 0	0	0	0	DOYAS457
0 60100E-00 0	0	0 96104E 01	0 90236E 01 0	0 83584E 00	0 52581E	000DOYAS458	
0 18957E-00 0	0 13602E-00 0	0	0 46000E 00 0	0	10 848	0	DOYAS459
0 93630E 01	0 12589E 00	0 92900E-02 0	0	0	0	0	DOYAS460
0 50200E 01 0	0	13 948	0 89127E 01 0	0 28468E 01	0 50277E-03	000DOYAS461	
0	0	0	0 12460E 02 0	0	20 947	0	DOYAS462
0 85333E 01	0 15056E-01 0	0	0	0	0	0	DOYAS463
0 57860E 02 0	0	0 669 E 02	0 90225E 01 0	0 13150E 01	0	0	DOYAS464
0	0	0	104 12	0	112 25	0	
0 81071E 01	0 78798E-02 0	0	0	0	0	0	DOYAS466
1'5 39	0	125 35	0 79358E 01 0	0 21283E 01 0	0	0	DOYAS467
0	0	0 11796E-02	135 88	0	143 84	0	DOYAS468
0 79415E 01	0 26882E-01 0	0	0	0	0	0	DOYAS469
159 07	0	167 031	0 79360E 01 0	0 21215E-01 0	0	0	
0	0	0	0 48448E 03 0	0	492 481	0	DOYAS471
0 79225E 01	0 26642E-01 0	0	0	0	0	0	DOYAS472
0 79525E 03 0	0	767 254	0 79502E 01 0	0 40118E-01 0	0	0	DOYAS473
0	0	0	0 82947E 03 0	0	837 378	0	DOYAS474
0 79627E 01	0 12507E-01 0	0	0	0	0	0	DOYAS475

C

C

16 9 4074	EUROPIUM	MICRO	295K	0 125CM	SHIELD	HOWERTON	
0 22	E-01 0	3 4245	0 93906E 00 0	0	0	0	DOYAS452
0	0	0	0 72000E-01 0	4 5377	0	0	DOYAS453
0 23820E 01	0 13064E 01 0	0	0	0	0	0	DOYAS454
0 13900E-00 0	0	5 09	0 31975E 01 0	0 89259E 00 0	0 67995E	000DOYAS455	
0	0	0	0 20600E-00 0	0	7 229	0	DOYAS456
0 61753E 01	0 12239E 01	0 99703E 00	0 39868E-00 0	0	0	0	DOYAS457
0 60100E-00 0	0	0 96104E 01	0 90236E 01 0	0 83584E 00	0 52581E	000DOYAS458	
0 18957E-00 0	0 13602E-00 0	0	0 46000E 00 0	0	10 848	0	DOYAS459
0 93630E 01	0 12589E-00 0	0 92900E-02 0	0	0	0	0	DOYAS460
0 49900E 01 0	0	13 892	0 89127E 01 0	0 28468E-01 0	0 50277E-03	000DOYAS461	
0	0	0	0 12370E 02 0	0	20 932	0	DOYAS462
0 85333E 01	0 15056E-01 0	0	0	0	0	0	DOYAS463
0 56290E 02 0	0	0 653 E 02	0 90225E 01 0	0 13150E-01 0	0	0	DOYAS464
0	0	0	0 84940E 02 0	0	93 331	0	DOYAS465
0 81071E 01	0 78798E-02 0	0	0	0	0	0	DOYAS466
0 86790E 02 0	0	94 657	0 79358E 01 0	0 21283E-01 0	0	0	DOYAS467
0	0	0 11796E-02	0 90780E 02 0	0	98 797	0	DOYAS468
0 79415E 01	0 26882E-01 0	0	0	0	0	0	DOYAS469

C SELF SHIELDED EUROPIUM CROSS SECTIONS

0 10916E 03 0	117 381	0 79360E 01 0	0 21215E-01 0	0	0	DOYAS470
0	0	0 31939E 03 0	321 331	0	0	DOYAS471
0 79225E 01	0 26642E 01 0	0	0	0	0	DOYAS472
0 42927E 03 0	437 374	0 79502E 01 0	0 40118E-01 0	0	0	DOYAS473
0	0	0 43938E 03 0	447 088	0	0	DOYAS474
0 79627E 01	0 12507E-01 0	0	0	0	0	DOYAS475

C

C

16 9 4075	EUROPIUM	MICRO	295K	0 25CM	SHIELD	HOWERTON	
0 22	E-01 0	3 4245	0 93906E 00 0	0	0	0	DOYAS452
0	0	0	0 72000E-01 0	4 5377E	010DOYAS453		
0 23820E 01	0 13064E 01 0	0	0	0	0	0	DOYAS454
0 13900E-00 0	0	5 0864E 01	0 31975E 01 0	0 89259E 00 0	0 67995E	000DOYAS455	
0	0	0	0 20500E-00 0	0	72200E	010DOYAS456	
0 61753E 01	0 12239E 01	0 99703E 00	0 39868E-00 0	0	0	0	DOYAS457
0 45700E-00 0	0	0 96104E 01	0 90236E 01 0	0 83584E 00	0 52581E	000DOYAS458	
0 18957E-00 0	0 13602E-00 0	0	0 44440E 01 0	0	10836E	020DOYAS459	
0 93630E 01	0 12589E-00 0	0 92900E-02 0	0	0	0	0	DOYAS460
0 49360E 01 0	0	0 13836E 02	0 89127E 01 0	0 28468E-01 0	0 50277E-03	000DOYAS461	
0	0	0	0 12197E 02 0	0	20737E	020DOYAS462	
0 85333E 01	0 15056E-01 0	0	0	0	0	0	DOYAS463
0 53154E 02 0	0	0 62209E 02	0 90225E 01 0	0 13150E-01 0	0	0	DOYAS464
0	0	0	0 62183E 02 0	0	70773E	020DOYAS465	
0 81071E 01	0 78798E-02 0	0	0	0	0	0	DOYAS466
0 58953E 02 0	0	0 66823E 02	0 79358E 01 0	0 21283E-01 0	0	0	DOYAS467
0	0	0 11796E-02	0 57409E 02 0	0	65429E	020DOYAS468	
0 79415E 01	0 26882E-01 0	0	0	0	0	0	DOYAS469
0 70074E 02 0	0	0 78294E 02	0 79360E 01 0	0 21215E-01 0	0	0	DOYAS470
0	0	0	0 19081E 03 0	0	19881E	030DOYAS471	
0 79225E 01	0 26642E-01 0	0	0	0	0	0	DOYAS472
0 22009E 03 0	0	0 22819E 03	0 79502E 01 0	0 40118E-01 0	0	0	DOYAS473
0	0	0	0 22082E 03 0	0	22819E	030DOYAS474	
0 79627E 01	0 12507E-01 0	0	0	0	0	0	DOYAS475

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16 9 4076	EUROPIUM	MICRO	295K	0 50CM	SHIELD	HOWERTON	
0 22	E-01 0	3 4245	0 93906E 00 0	0	0	0	DOYAS452
0	0	0	0 71000E-01 0	4 5367	0	0	DOYAS453
0 23820E 01	0 13064E 01 0	0	0	0	0	0	DOYAS454
0 13700E-00 0	0	5 088	0 31975E 01 0	0 89259E 00 0	0 67995E	000DOYAS455	
0	0	0	0 20300E-00 0	0	7 226	0	DOYAS456
0 61753E 01	0 12239E 01	0 99703E 00	0 39868E-00 0	0	0	0	DOYAS457
0 45100E-00 0	0	9 601	0 90236E 01 0	0 83584E 00	0 52581E	000DOYAS458	
0 18957E-00 0	0 13602E-00 0	0	0 14200E 01 0	0	10 812	0	DOYAS459
0 93630E 01	0 12589E-00 0	0 92900E-02 0	0	0	0	0	DOYAS460

C SELF SHIELDED EUROPIUM CROSS SECTIONS

0 48200E 01 0	13 72	0 89127E 01 0	0 28468E-01 0	0 50277E-03	000DOYAS461		
0	0	0 11839E 02 0	20 399	0	0	0	DOYAS462
0 85333E 01	0 15056E-01 0	0	0	0	0	0	DOYAS463
0 46954E 02 0	56 009	0 90225E 01 0	0 13150E-01 0	0	0	0	DOYAS464
0	0	0 39743E 02 0	48 333	0	0	0	DOYAS465
0 81071E 01	0 78798E-02 0	0	0	0	0	0	DOYAS466
0 36089E 02 0	43 955	0 79358E 01 0	0 21283E-01 0	0	0	0	DOYAS467
0	0	0 11796E 02	0 34601E 02 0	42 621	0	0	DOYAS468
0 79415E 01	0 26882E-01 0	0	0	0	0	0	DOYAS469
0 41449E 02 0	49 669	0 79360E 01 0	0 21215E-01 0	0	0	0	DOYAS470
0	0	0 10576E 03 0	113 765	0	0	0	DOYAS471
0 79225E 01	0 26642E-01 0	0	0	0	0	0	DOYAS472
0 11005E 03 0	118 149	0 79502E 01 0	0 40118E-01 0	0	0	0	DOYAS473
0	0	0 11041E 03 0	118 112	0	0	0	DOYAS474
0 79627E 01	0 12507E-01 0	0	0	0	0	0	DOYAS475

16 9 9999 SIGMAEND

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Appendix B

DTF User's Manual: Formerly Criticality Safety Memorandum No. 21, J.J. Arcella, August 1965

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Introduction

The following pages contain a description of how to input the DTF code and also how to interpret the output from the code. The forerunner of Appendix B is the DTF Users Manual by Carlson.⁹

The DTF code is a one-dimensional multigroup program written in the FORTRAN language for use on the IBM 7094 system for solving the neutron transport equation by using the S_n differencing technique. Regular and adjoint solutions of the transport equation are available for plane, spherical, and cylindrical geometries. Isotropic or a form of linear anisotropic scattering may be considered.

Various boundary conditions are allowed so that cells or time dependent solutions may be obtained using finite as well as infinite configurations in the case of slabs or cylinders. In the case of finite configurations, the problem is handled in the usual one-dimensional manner except that the transport and absorption cross sections are corrected for leakage in the finite direction.

On the outermost boundary only perfect reflection or zero reflection is permitted. The code does not now allow a variable albedo, i.e., it is either 1.0 or 0.0.

The program also contains a number of search options whereby one can vary dimensions or concentrations in order to arrive at a predetermined eigenvalue.

Distribution or shell sources may be specified at any position within the configuration.

As output the program supplies the eigenvalue, angular fluxes, total fluxes, fission distributions, and other quantities which will be described in subsequent portions of this report. See section II OUTPUT for detailed explanation of order of printed output and also physics and units of output items.

A diffusion theory option is available in the code.

The six options available are i) fixed source, ii) reactivity (k), iii) time absorption (α), iv) concentration (c), v) zone thickness (δ), vi) critical dimension (a).

ITEMS NOT INVESTIGATED IN APPENDIX B

1. Options "Fixed source" and "Concentration source" were not documented in this report. These are options IEVT = 1 and IEVT = 3, respectively.
2. In reference to parameters IPM and IPP and thus concerning also cards SHELLI and SHELLA, the exact manner in which a shell source is entered has not been determined. Probably it is straightforward for the isotropic case, however, there is much confusion in the anisotropic case.

Input

BRIEF TABLE FOR CARD INPUT (IN ORDER OF VARIABLE AND CARD)

The following table (B-I) may be referred to for determining the input of a particular problem. It is intended to be brief and is thus only a guide to be used once the programmer is familiar with the variable names and the workings of the options. For a detailed explanation of any particular variable, see "DETAILED PARAMETER EXPLANATION WITH EXAMPLES."

The following list includes all possible cards. If an option is chosen which does not require the use of a particular card type, that card is omitted from the deck entirely—not left blank. For example, if IDFM = 1, the card labeled DENSFAC must appear in its proper place in the data deck. If IDFM = 0, the card DENSFAC is removed physically from the data deck.

The first nine cards contain various control parameters or markers. These control parameters merely define the problem by indicating which variables are needed. Thus, they indicate which cards to retain and which to remove physically from the data deck.

An explanation of the table headings is as follows:

"Card ID" is the physical identification of the card which is punched in columns 73 through 80 on the card,

"FOR Name" is the FORTRAN variable name actually used and referred to in the code,

"Definition of variable" is an extremely brief definition of the FORTRAN variable to aid the programmer in the rapid use of this table for constructing a data sheet,

"Int Dec" signifies whether the variable itself should be entered on the card as an integer (I), which corresponds to a fixed point I field in FORTRAN language, or as a decimal (D), which corresponds to a floating point F or E field in FORTRAN language,

"Limitations" is the column under which the only possible values, only meaningful values, or the recommended values for the variable are listed. For a more thorough understanding of the variable and its range of values see "DETAILED PARAMETER EXPLANATION WITH EXAMPLES." Aids are also given under this column in order to cross check values in the case that several cards are interdependent.

Table B-I. Brief table for card input.

Card ID	FOR Name	Definition of variable	Int Dec	Limitations																					
CARD 1	AID	Identification card	-	Any alpha-numeric character, "1" in column one																					
CARD 2	ID	Identification number	I	Numeric integer; operator's choice																					
	ITH	Theory	I	0 = regular; 1 = adjoint																					
	ISCT	Scattering	I	1 = isotropic; -1 = anisotropic																					
	ISN	S _n order	I	n ≤ 23 sphere and slabs; n ≤ 8 cylinders																					
	IGE	Geometry	I	1 = slab; 2 = cylinder; 3 = sphere																					
	IBL	Inner boundary condition	I	0 = no reflection (plane); 1 = total reflection (pl, sp, cy); 2 = periodic reflection (pl only); (1 is normal for sp and cy)																					
CARD 3	IBR	Outer boundary condition	I	0 = no reflection (pl, sp, cy); 1 = total reflection (pl, sp, cy); 2 = periodic reflection (pl only); (IBR is 2 if IBL is 2)																					
	IZM	Number of zones	I	≤ 75																					
	IM	Number of intervals	I	≤ 75																					
	IFN	Initial starting source	I	0 = fission density; need card FISSIO; 1 = flux input; need card FLUX; also see card 7, variable IQM																					
	IEVT	Type of calculation	I	<div style="display: flex; align-items: center;"><div style="margin-right: 10px;">0 = fixed source 1 = reactivity, k 2 = time absorption, α 3 = concentration, c 4 = zone thickness, δ 5 = critical radius, a</div><div style="border-left: 1px solid black; padding-left: 10px; margin-left: 20px;">IPVT = 0 IPVT = 1, 2</div></div>																					
	EV	First eigenvalue guess	D	Recommended table for various IEVT: <table style="margin-left: 40px; border-collapse: collapse;"><tr><th style="border-bottom: 1px solid black;">IEVT</th><th style="border-bottom: 1px solid black;">EV</th><th style="border-bottom: 1px solid black;">EVM</th></tr><tr><td>0</td><td>0.0</td><td>0.0</td></tr><tr><td>1</td><td>0.0</td><td>0.0</td></tr><tr><td>2</td><td>0.0</td><td>-0.01</td></tr><tr><td>3</td><td>1.0</td><td>-0.1</td></tr><tr><td>4</td><td>0.0</td><td>-0.1</td></tr><tr><td>5</td><td>radius</td><td>-1. or -2.</td></tr></table>	IEVT	EV	EVM	0	0.0	0.0	1	0.0	0.0	2	0.0	-0.01	3	1.0	-0.1	4	0.0	-0.1	5	radius	-1. or -2.
	IEVT	EV	EVM																						
0	0.0	0.0																							
1	0.0	0.0																							
2	0.0	-0.01																							
3	1.0	-0.1																							
4	0.0	-0.1																							
5	radius	-1. or -2.																							
CARD 4	EVM	Eigenvalue modifier	D	See IEVT and EV above																					
	EPS	Precision on eigenvalue convergence	D	Recommend 0.0001																					
	IGM	Number of neutron velocity groups	I	≤ 18; for standard library cross sections use 16																					
	IHT	Row position of transport cross section	I	For standard library cross sections use 3																					
	IHS	Row position of scattering cross section	I	For standard library cross sections use 4																					
	IHM	Maximum table length of cross section set	I	≤ 9; for standard library cross sections use 9																					
CARD 5	BF	Buckling term: not actual geometric buckling factor	D	<u>Any</u> spherical problem enter 0.0 <u>Any</u> cylindrical or plane problem enter 1.8137994.																					

Table B-I. (Continued)

Card ID	FOR Name	Definition of variable	Int Dec	Limitations								
CARD 5 (cont.)	DY	Buckling height in centimeters	D	Any spherical problem enter 0.0. Finite cylinder enter H dimension. Finite plane enter Y dimension. Infinite cylinder enter 0.0. Infinite plane in Y direction, enter 0.0.								
	DZ	Buckling depth in centimeters	D	Any spherical or cylindrical enter 0.0. Finite plane: finite in X, Y, and Z enter Z dim. finite in X, Y, enter 0.0 for $Z = \infty$.								
	MS	Mixture specifications	I	≤ 75 ; physical number of entries on MIXMB, MIXMC, or MIXMD, control "0's" counted.								
	MCR	Physical number of cross section data sets read from cards	I	} { For IHM = 9, IGM = 18: MCR + MTP $\geq$ 29 } { For IHM = 9, IGM = 16: MCR + MTP $\geq$ 32								
	MTP	Physical number of cross section data sets read from tape	I									
CARD 6	MT	Total number of nuclides plus materials	I	For IHM = 9, IGM = 18: MT $\leq$ 30 For IHM = 9, IGM = 16: MT $\leq$ 33								
	IDFM	Density factor marker	I	0 = no density changes; no card DENSFAC 1 = density changes; include DENSFAC								
	DFM1	Not presently used by code	D	Enter 0.0								
	DFM2	Not presently used by code	D	Enter 0.0								
	XNF	Source normalization factor	D	Recommend 1.0								
	IPVT	Problem type	I	0 = no parameter source (IEVT = 0, 1, 2) 1 = fixed reactivity, k_0 (IEVT = 3, 4, 5 see PV) 2 = fixed time absorption, α_0 (IEVT = 3, 4, 5 see PV)								
	CARD 7	PV	Parametric eigenvalue	D	Entered according to IPVT above <table><tr><td>IPVT</td><td>PV</td></tr><tr><td>0</td><td>0.0</td></tr><tr><td>1</td><td>k_0</td></tr><tr><td>2</td><td>α_0</td></tr></table>	IPVT	PV	0	0.0	1	k_0	2
IPVT		PV										
0		0.0										
1	k_0											
2	α_0											
	IQM	Distributed source index	I	0 = none; no card DISSOR 1 = yes, insert card DISSOR; IFN must = 1 and must have card FLUX, no card FISSIO. See IFN.								
	IPM	Shell source index	I	0 = no shell source, no cards SHELLI and SHELLA, IPP = 0 1 = isotropic shell source, insert only card SHELLI, IPP $\neq$ 0 2 = anisotropic shell source, insert cards SHELLI and SHELLA, IPP $\neq$ 0								

Table B-I. (Continued)

Card ID	FOR Name	Definition of variable	Int Dec	Limitations
CARD 7 (cont.)	IPP	Shell source position	I	0 = no shell source, IPM = 0, no cards SHELLI and SHELLA i = spatial interval where shell source is located
	FXM	Not presently used by code	D	Enter 0.0
	ILM	Maximum number of inner iterations	I	Recommend 20
CARD 8	IGS	Group skipping marker	I	0 = no group skipping, no card GRSKIP 1 = group skipping occurs, see GRSKIP
	RYF	Scattering convergence relaxation	D	Suggest 0.5
	XLXL	Lower limit $\lambda - 1$	D	Suggest 0.1
	XLAH	Upper limit $\lambda - 1$	D	Suggest 0.5
	EQL	Force asymptotic convergence	D	Suggest 0.005
	XNPM	New parameter modifier	D	Suggest 1.0 (0.75 for IEVT = 2)
CARD 9	ID1	Angular flux print	I	0 = no print; 1 = print; suggest 1
	ID2	Neutron balance table print	I	0 = no print, IZM+1 = print; suggest IZM+1
	ID3	Activity print by zone	I	0 = no print, see ID4 N $\leq$ 20, physical number of entries on card ACMAT <u>or</u> ACTYP, need ACMAT and ACTYP
	ID4	Activity print by interval	I	0 = no print, no cards ACMAT and ACTYP if ID3 = 0 also 1 = print, need cards ACMAT <u>and</u> ACTYP if <u>either</u> ID3 or ID4 $\neq$ 0
	ICM	Maximum number outer iterations	I	Suggest 100
	IDT	Diffusion theory marker	I	0 = S_n calculation for all groups 1 = diffusion theory, need card DIFMARK
RADIUS	R	Radii are entered	D	Center point is 0.0 One value for each spatial point (≤ 75) (IM + 1 spatial points) Two successive radii cannot be equal Interpolate option may be used; see "EXPLANATION OF INPUT CARD FIELDS"
ZONENU	MA	Number of intervals in each zone	I	Repeat option may be used (≤ 75 intervals)
MZ	MZ	Material used in each zone	I	Single entry per zone (≤ 40 entries)
FISFRA	XKI	Fission spectrum	D	IGM entries (≤ 18 groups) Standard for library cross sections

Table B-I. (Continued)

Card ID	FOR Name	Definition of variable	Int Dec	Limitations
VELOCI	VE	Neutron velocities	D	IGM entries (≤ 18 groups) Standard for library cross sections
W	W	S_n weights	D	$\left\lceil \frac{ISN(ISN + 4)}{4} \right\rceil$ for cylinder See ISN. (ISN + 1) for sphere entries. Standard for specific order of S_n .
$\pm D$	D	S_n direction cosines $D \neq 0$.	D	$\left\lceil \frac{ISN(ISN + 4)}{4} \right\rceil$ for cylinder See ISN. (ISN + 1) for sphere entries. Standard for specific order of S_n
FISSIO	F	Source start—fission densities	D	Single value for each interval. See IFN. Repeat option may be used. Suggest 1.0 for all intervals if IFN = 0. No cards FLUX.
FLUX	XN	Source start—fluxes	D	Single values for each interval and for each energy group. Only used if IFN = 1. No cards FISSIO.
MIXMB	MB	Assign mixture identification numbers	I	"MS" entries in number. (Maximum number of entries is 75.)
MIXMC	MC	Mix nuclides to form materials	I	"MS" entries in number. Control 0's on this card.
MIXMD	XMD	Atom densities of nuclides in makeup of materials	D	"MS" entries in number. Control 0.0's on this card. All densities must be > 0 .
RADMOD	RM	Radial modifiers for each zone	D	One value for each zone. Use only if IEVT = 2 (≤ 75 entries). "IZM" entries in number.
DISSOR	Q	Distributed source terms	D	One value for each spatial interval and each energy group. Use only if IQM = 1. "IM $\times$ IGM" entries in number.
DENSFAC	DF	Density factors for each interval	D	One value for each spatial interval. Use only if IDFM = 1. "IM" entries in number.
NUCLNO	MTT	Nuclide numbers for tape only	I	Use only if data is read from tape. Use only if MTP $\neq 0$. "MTP" entries in number.
DIFMARK	IGT	Diffusion group markers	I	One value for each energy group. Use only if IDT = 1. "IGM" entries in number. 0 = S_n calculation for corresponding group. 1 = diffusion calculation for corresponding group.
GRSKIP	IZI	Group skipping markers	I	One value for each energy group. "IGM" entries in number. Use only if IGS = 1. Group one cannot be skipped. 0 = do not skip; 1 = skip.
XSEC	C	Microscopic nuclide cross section block here	D	Regular format is not followed. A 6E12.6 field is followed. Use Hansen 16 group cross section sets in library. "MCR $\times$ IGM $\times$ IHM" entries in number.

Table B-I. (Continued)

Card ID	FOR Name	Definition of variable	Int Dec	Limitations
ACMAT	J3	Material ID numbers for activity prints	I	One material identification number for each activity type $ID3 \leq 20$ entries in number
ACTYP	J4	Activity types for ACMAT	I	Corresponding activity type for each material identification above. $ID3 \leq 20$ entries in number. Same number of entries as ACMAT. Types of activities as follows: 1 = σ_a 2 = $\nu\sigma_f$ 3 = σ_{tr} 4 = σ_{gg}

ADD TWO BLANK CARDS AT THE END OF THE DATA SET. If jobs are stacked and there are several data sets following one source program, include the two blank cards after only the last data set.

RECOMMENDED VALUES FOR VARIOUS OPTIONS

The following table of FORTRAN variables includes those variables which are either fixed for any option or have an optimum value to use. The values for these variables are listed for each of the possible options of the code. Those FORTRAN variables which have an asterisk (*) by them are fixed values and cannot be changed from the given value for that particular option. Those without an asterisk are recommended values to use.

Table B-II. FORTRAN variables.

FORTRAN variable	Fixed source	Reactivity (k)	Time absorption (α)	Concentration (c)	Zone thickness (δ)	Critical dimension (α)
IEVT*	0	1	2	3	4	5
EV	0.0	0.0	0.0	1.0	0.0	Outermost radius
EVM	0.0	0.0	-0.01	-0.1	-0.1	-1. or -2.
EPS		0.0001	0.0001		0.0001	0.0001
DFM1*	0.0	0.0	0.0	0.0	0.0	0.0
DFM2*	0.0	0.0	0.0	0.0	0.0	0.0
XNF		1.0	1.0		1.0	1.0
IPVT*	0	0	0	1, 2	1, 2	1, 2
PV*	0.0	0.0	0.0	k_0 or α_0	k_0 or α_0	k_0 or α_0
FXM*	0.0	0.0	0.0	0.0	0.0	0.0
IIM	20	20	20	20	20	20
RYF		0.5	0.5		0.5	0.5
XLAL		0.01 or 0.1	0.01 or 0.1		0.01 or 0.1	0.01 or 0.1
XLAH		0.05 or 0.5	0.05 or 0.5		0.05 or 0.5	0.05 or 0.5
EQL		0.005	0.005		0.005	0.005
XNPM	1.0	1.0	0.75	1.0	1.0	1.0
ICM	100	100	100	100	100	100

EXPLANATION OF INPUT CARD FIELDS

There are four types of input fields to be used by the programmer in the data deck. They are as follows:

1. 6(I1, I2, I9)
2. 6(I1, I2, F9.4)
3. 6(I1, I2, E9.4)
4. 6(12.6)

Type 1 is used with all integer numbers on Card 1 through Card 9, ZONENU, MZ, MIXMB, MIXMC, NUCLNO, DIFMARK, GRSKIP, ACMAT, and ACTYP. Type 2 is used

on all decimal numbers on Card 1 through Card 9, type 3 is used on cards RADIUS, FISFRA, VELOCI, W, D, FISSIO, FLUX, MIXMD, RADMOD, DISSOR, SHELLI, SHELLA, and DENSFAC. Type 4 is used only in one place and that is in the actual microscopic cross section data input. Type 4 is in the exact form of the library card and tape cross section data.

The following explanation is for the use of format types 1, 2, and 3. It will use the type 3 format so that the interpolation option may be explained also. The interpolation option may not be used with the type 1 format. See below.

Each card consists of 6 fields of 12 digits each, the first 3 digits of each field being reserved for integer control numbers explained below. Digits 73 through 80 are reserved for the identification of the card, i.e., Card 3, FISSIO, DENSFAC, etc. For the purpose of this paper the representation of an IBM card with the various fields will be as follows:

The following is the configuration for a single field:

Possible values for the I1 field: b, 0, 1, 2, 3 where "b" represents a blank digit. Possible values for the I2 field: bb, 00 through 99.

The operation of the control parameters can best be explained by observing two consecutive fields of 12 digits, each of which has the first 3 digits reserved for the control parameters: The last 9 digits are reserved for the variable to be entered, which in this example case have been arbitrarily chosen as an E9.4 field. In the control parameter digits a zero (numeric) and a blank are equivalent. In the variable digits, the same is true.

0	bb	normal, input a single value x
1	nm	repeat input of value x nn times
2	nm	interpolate between the values x and y nn times: i.e., $(y - x)/(nm + 1)$. The interval $(y - x)$ is divided into $(nm + 1)$ equal segments to make $(nm + 1)$ points $(nm + 2)$ points the first time the interpolation occurs). See examples below.
3	bb	terminate input for specific variable name, such as ZONENU, DENSFAC, FISSIO, etc.

The following examples will aid in the proper use of the input using control parameters:

EXAMPLE ONE: Read into the computer the values 0.0, 3.0, 3.0, 8.9

/ / / 0.0 / 1 / 02 / 3.0 / 1 / / 8.9 / 3 / / / / / / / / / .
 ↑ terminate

EXAMPLE TWO: Read in the value 1.34 six times, i.e., 1.34, 1.34, 1.34, 1.34, 1.34, 1.34.

/ 1 / 6 / 1.34 / 3 / / / / / / / / / / / / / .
 ↑ terminate

EXAMPLE THREE: Read in the values 0.0, 1.5, 3.0, 4.5, 6.0, 6.666, 7.333, 8.0.

/ 2 / 3 / 0.0* / 2 / 2 / 6.0 / / / 8.0 / 3 / / / / / / / / / .
 ↑ means four intervals between 0.0 and 6.0 and thus five points, including points 0.0 and 6.0.
 ↑ means three intervals between 6.0 and 8.0 and thus three points, not including the point 6.0.
 ↑ terminate

EXAMPLE FOUR: Example three may also be read in as follows:

/ / / 0.0 / / / 1.5 / / / 3.0 / / / 4.5 / / / 6.0 / / / 6.666.
 / / / 7.333 / / / 8.0 / 3 / / / / / / / / / / / .
 ↑ terminate

In the above example there are only 6 fields to the IBM card, and thus two cards are necessary for the complete input.

EXAMPLE FIVE: Read in the values 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

/ 2 / 09 / 0.0 / / / 20.0 / 3 / / / / / / / / / / / .
 ————
 ———— interpolate between 0.0 and 20.0 ten times in order to make 10 intervals (uniform) and 11 points including the first point 0.0. In this case the variable IM equals 10.

Note that the same configuration with a "1" in digit one would input nine values of zero and one value of 20.0. The repeat option cannot be used with the radius input, for no two consecutive radii may be equal.

*Note: for a radius input, 0.0 must be the first point entered, the center.

EXAMPLE SIX: A radius input for an assembly with two zones, IZM = 2.

Zone one has five spatial intervals. . . . 6 points	} IM = 9, where IM is the total number of intervals
Zone two has four spatial intervals . . . 4 points	

The geometry of the assembly is as follows:

The card is as follows:

/ 2 / 04 / 0.0 / 2 / 03 / 10.0 / / / 18.0 / 3 / / / / / / / .

The values read in are 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0.

An easy check on the number of input intervals on a radius input is as follows:

$$\left(\sum_i nm_i \right) + IZM = IM$$

i.e., (4 + 3) + 2 = 9 = IM.

When interpolating, always enter one less than the number of intervals wanted for the value nn.

DETAILED PARAMETER EXPLANATION WITH EXAMPLES

The following table is a more thorough explanation of the Table B-I Brief table for card input. The format is the same in that the order of the parameters and the cards follows that of an actual data deck, those cards not necessary being physically excluded from the deck.

Along with the more detailed explanation are examples when it is thought necessary for clarity. Although some portions of the explanation may seem verbose or trivial, this path was thought to be much more advantageous than being brief or elusive. If after reading the explanation for a specific variable there still seems to be some doubt, bear in mind that there are no double meanings or trick phrases implied in the explanation.

An explanation of the headings for this table are as follows:

"FOR Name" is the actual FORTRAN name of the variable used in the code. The order of the variables appears as the variables appear in the data deck.

"Card ID" is the actual identification which is punched in columns 73 through 80 on the card on which the variable appears, i.e., Card 1, FISSIO, etc.

"Poss Values" lists the possible values which the variable may take. In some cases the variable may take practically any value but there are recommended or "most

meaningful" values for it. In this case the value(s) will be followed by an asterisk (*) and the basis of the choice will be explained under the heading "Explanation."

"Inp Fld" indicates whether or not the variable is an integer (I field) or a decimal (E or F field) and tells how long the input field is. Refer to "EXPLANATION OF INPUT CARD FIELDS" for the use of the first three control digits of each variable field. The fields listed here exclude those three digits and refer only to those digits actually occupied by the variable itself.

"Card Digit" refers to the actual digits occupied by the specific variable on the input IBM card. The numbers are inclusive, i.e., 16-24 means that digits 16 and 24 are also part of the field which may be occupied by the variable.

"Explanation and Examples" is as the heading states.

Table B-III. Detailed parameter explanation with examples.

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
AID	Card 1	Alpha-num	12A6	1-72	Alpha-numeric identification card. 72 characters or less of English text using any character available on the IBM keypunch. Printed at the top of the first data output page if a "1" is punched in digit one of the IBM card. In the case of a stacked job (two or more succeeding data decks) a "1" in the first column of each of the CARD 1's for each data set will assure that the output for each new problem will begin at the top of a new page.
ID	Card 2	Numeric	I9	4-12 ^a	Any numeric program identification may be used here. This number is the programmer's choice.
ITH	Card 2	0, 1	I9	16-24	This control parameter indicates the theory to be used in the transport equation solution. The option has been tried, however, the actual values of the fluxes, etc., have not been investigated to see if indeed it is the adjoint solution. 0 = regular solution 1 = adjoint solution
ISCT	Card 2	-1, 1	I9	28-36	Indicates type of scattering to be used. -1 = anisotropic 1 = isotropic ISCT must be -1 if any material contains anisotropic cross sections. See "Special section on anisotropic materials."

^aAll integer numbers are stacked to the right. Floating point numbers are entered according to the F or E9.4 fields, where a punched decimal point overrides the four place fraction implied in the F or E9.4. Where exponents are punched on the card, they are stacked right (right adjusted).

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
ISN	Card 2	2, ..., 23	I9	40-48	Order of the S_n to be used. This is the number of angular segments assigned to the angular fluxes. $n \leq 23$, spheres and slabs $n \leq 8$, cylinders Usually even orders of S_n are used (n even). The constants must be read in on cards W and D and are readily available for even orders in Carlson. ⁹
IGE	Card 2	1,2,3	I9	52-60	Geometry index. In general in the plane and cylindrical cases the geometry is semi-infinite in the Y and Z directions, and the H dimension, respectively. It is possible to run a finite geometry problem by using correction factors for leakage. These factors are BF, DY, and DZ. For finite geometry see these variables. For infinite or finite geometry one of the following specifications must be used: 1 = plane (slab) 2 = cylinder 3 = sphere
IBL	Card 2	0,1,2	I9	64-72	Left boundary condition index. The left boundary is considered the physical geometrical center of the assembly in spherical, cylindrical (radial center), and <u>symmetric</u> plane geometry, i.e., $r = 0$ or $x = 0$.

The following is a diagram of an r, μ mesh for an S_4 calculation. Directions 1, 2, and 3 indicate that the angular fluxes labeled 1, 2, and 3 are directed toward the center of the assembly from the outer physical boundary. Those labeled 4, and 5 are directed toward the outer physical boundary from the center. Variables IBL and IBLR (to follow) indicate the boundary conditions in each place. The μ values refer to the 5 angular directions assigned to the four segments in an S_4 calculation.

The control parameter IBL governs only the inner physical boundary and thus the diagrams will indicate the conditions for only the boundary concerned.

0 = no reflection. This means that the directional fluxes at the center of the assembly are set equal to zero for the outgoing directions, i.e., directions 4 and 5 for an S_4 calculation. IBL = 0 has meaning only for asymmetric plane geometry, where IBL then also refers to an outer boundary. For spherical and cylindrical geometries this option is meaningless.

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IBL (cont.)					<p>The code runs, but in essence $IBL = 0$ for spheres and cylinders means that there is a neutron sink at $r = 0.0$.</p> <p>1 = total (100%) reflection. Mirror reflection of the angular fluxes is assumed about the angular directions, i.e., the iteration is begun at the outer physical boundary and the fluxes are directed toward the center of the assembly. These directions are 1, 2, and 3. Once the fluxes are propagated along the radius by the difference equations and reach the center of the assembly, they are mirror reflected (changed to directions 4 and 5) and directed toward the outer boundary. This is equivalent to allowing the fluxes to pass through the entire assembly along a length equivalent to the diameter (for a sphere). However, since the code uses $r = 0.0$ as its center or coordinates, only half the dimension (the radius and not the diameter) of the assembly is used. Thus the reflection or change of direction at the center point.</p> <p>2 = periodic reflection. This refers to being periodic in space as opposed to being periodic in time. This option can only be used with plane geometry and IBR must also be 2. The plane or slab is treated as one of a group of parallel planes, where each plane acts as a source (flux) for the immediately adjacent plane. Thus, the outgoing fluxes from the <u>left</u> boundary are used for the incoming fluxes on the <u>right</u> boundary. The outgoing fluxes from the <u>right</u> boundary are used for the incoming fluxes on the <u>left</u> boundary. In this manner a series of slabs is approximated by using a single assembly and allowing its right boundary to be used as the right boundary of the fictitious assembly to the left of the assembly in question. Thus, its own right boundary feeds its own left boundary (flux-wise), and vice-versa.</p> <p>The normal spherical and cylindrical value to use for IBL is 1.</p>

IBR	Card 3	0,1,2	I9	4-12	Right boundary condition index. The right boundary is considered the outermost physical boundary of the assembly.

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IBR (cont.)					The control parameter IBR governs only the outer physical boundary and thus the diagrams will indicate the conditions for only the boundary concerned. See IBL for general S_4 r - μ mesh.

0 = no reflection (albedo = 0.0). The directional fluxes coming into the assembly (directions 1, 2, and 3 for an S_4 calc.) are set equal to zero. The condition IBR = 0 implies a perfect absorber or a vacuum at the outer boundary of the assembly.

1 = total (100%) reflection (albedo = 1.0). Mirror reflection about the directional fluxes at the outermost boundary is assumed. The incoming fluxes at the outer boundary (directions 1, 2, and 3) are set equal to the outgoing fluxes at the outer boundary (directions 4, and 5). IBR = 1 implies a perfect reflector at the outer physical boundary.

SPECIAL NOTE: When a vacuum exists in the outermost zone and perfect reflection is imposed (IBR = 1) on the outermost boundary (past the vacuum), the problem is the same as if no vacuum zone were present and perfect reflection were imposed (still) on the outermost physical boundary. These two configurations will yield the same results.

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IBR (cont.)					<p>2 = periodic reflection. Left boundary feeds right boundary and right boundary feeds left boundary. Can only be used for plane geometry. See IBL for explanation.</p> <p>Normal values for IBR are as follows: IBR = 0 no reflection IBR = 1 perfect reflection</p>
IZM	Card 3	1,...,75	I9	16-24	<p>Number of spatial material zones, where a zone refers to an area, or essentially a volume, which is of a single homogeneous composition. (A zone may be occupied by a vacuum—see card DENSFAC.) Example:</p> <p>In this example there are four zones, each composed of a single material whether it be a mixture or a single nuclide. Note: Each zone may be further divided into spatial intervals. See IM below.</p>
IM	Card 3	1,...,75	I9	28-36	<p>Total number of spatial intervals, where an interval refers to a smaller division of a zone. Uniform or nonuniform intervals may be chosen within each zone according to the input control numbers. (See card RADIUS for input explanation. See "EXPLANATION OF INPUT CARD FIELDS" for explanation of uniform and nonuniform interval input.) The physical boundaries of the intervals do not contain zone boundaries, i.e., the two boundaries coincide:</p>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Input fld	Card digit	Explanation and examples
IM (cont.)					
<p>The diagram shows a sector of a circle divided into 10 radial intervals, numbered 1 to 10 from the innermost (r = 0.0) to the outermost. The intervals are grouped into two zones: Zone 1 (intervals 1-4) and Zone 2 (intervals 5-10). The total number of intervals is IM = 10, and the total number of zones is IZM = 2.</p>					

In the code the intervals are numbered consecutively from 1 to IM (starting with the innermost one, $r = 0.0$) and the numbering does not start at unity again upon reaching a zone boundary.

IFN	Card 3	0, 1	I9	40-48	<p>Index which defines how the initial source conditions shall be entered. Each new problem must be given either an initial fission density at each spatial interval or an initial flux for each energy group and spatial interval. This source condition is not the same as a distributed source. It is only temporary and immediately changes upon operation of the code. <u>Either</u> the fission densities or the fluxes must be entered to start the problem.</p> <p>0 = load the fission densities, a single value for each spatial interval. A value must be supplied for each interval regardless of whether or not a fissionable isotope occupies that specific interval. See card FISSIO for fission density input.</p> <p>1 = load scalar fluxes for each energy group and for each spatial interval. If a distributed source option</p>
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Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples																					
IFN (cont.)					(IQM = 1) is used, the initial source IFN = 1 option MUST be used. (The combination IQM = 1, IFN = 0 will not operate correctly.) See card FLUX for flux input. SPECIAL NOTE FOR IFN = 1 OPTION: If sense switch one on the computer console is in the ON position, at the termination of a problem, the scalar fluxes will be punched onto IBM cards in the same format as the input format for the fluxes for option IFN = 1. These punched fluxes may be used as an initial flux distribution for a similar problem, <u>provided</u> the same number of energy groups and intervals is employed.																					
IEVT	Card 3	0, 1, 2, 3, 4, 5	I9	52-60	This control parameter indicates which types of calculation is sought. 0 = fixed source (inhomogeneous form of transport equation) 1 = reactivity, k 2 = time absorption, α 3 = concentration search, c 4 = zone thickness search, δ 5 = critical radius search, a																					
EV	Card 3	Suggested	F9.5	64-72	First eigenvalue guess, which is an initial guess of each of the values sought depending upon the value of IEVT above. The suggested values which are listed below are chosen so that various problems concerning convergence, etc., will be bypassed. Therefore, it is recommended that these values be used. <table><tr><th>IEVT</th><th>EV</th></tr><tr><td>0</td><td>0.0</td></tr><tr><td>1</td><td>0.0</td></tr><tr><td>2</td><td>0.0</td></tr><tr><td>3</td><td>1.0</td></tr><tr><td>4</td><td>0.0</td></tr><tr><td>5</td><td>radius (outermost of assembly)</td></tr></table>	IEVT	EV	0	0.0	1	0.0	2	0.0	3	1.0	4	0.0	5	radius (outermost of assembly)							
IEVT	EV																									
0	0.0																									
1	0.0																									
2	0.0																									
3	1.0																									
4	0.0																									
5	radius (outermost of assembly)																									
EVM	Card 4	Suggested	F9.5	4-12	Eigenvalue modifier. Likewise as the EV above there are suggested values to use depending upon the value of IEVT. It is recommended that these values be used. <table><tr><th>IEVT</th><th>EV</th><th>EVM</th></tr><tr><td>0</td><td>0.0</td><td>0.0</td></tr><tr><td>1</td><td>0.0</td><td>0.0</td></tr><tr><td>2</td><td>0.0</td><td>-0.01</td></tr><tr><td>3</td><td>1.0</td><td>-0.1</td></tr><tr><td>4</td><td>0.0</td><td>-0.1</td></tr><tr><td>5</td><td>radius</td><td>-1. or -2.</td></tr></table> The new eigenvalue which is calculated after each total iteration (if convergence is not complete) is calculated by $EV \pm EVM$,	IEVT	EV	EVM	0	0.0	0.0	1	0.0	0.0	2	0.0	-0.01	3	1.0	-0.1	4	0.0	-0.1	5	radius	-1. or -2.
IEVT	EV	EVM																								
0	0.0	0.0																								
1	0.0	0.0																								
2	0.0	-0.01																								
3	1.0	-0.1																								
4	0.0	-0.1																								
5	radius	-1. or -2.																								

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Input fld	Card digit	Explanation and examples
EVM (cont.)					where the code chooses the sign depending upon which direction leads to convergence of the problem. For example, if the radius of a certain critical system is 6.17 cm and an intermediate calculation in the code results in a dimension of 5.0 cm (EV in the case of a critical radius calculation), then the sign of the EVM will be chosen so that the radius will be increased. Comparison of successive values of EV determine what the value of lambda (XLA) is, total convergence of the problem occurring as lambda approaches unity (as lambda is within EPS of unity).
EPS	Card 4	Fractions	F9.5	16-24	Precision on the eigenvalue lambda (XLA). The total problem terminates when lambda is within EPS of unity. Fractional values are entered with a recommended value of 0.0001. If an error occurs in Subroutine S841 at 6, <u>sometimes</u> the error can be avoided by <u>reducing</u> the precision EPS to 0.001 or 0.01.
IGM	Card 4	1, ..., 18	I9	28-36	The number of neutron velocity groups, "1" being the highest velocity in magnitude. The number of fission fractions, velocities, cross section groups, etc., must correspond to this number.
IHT	Card 4	3, ..., 9	I9	40-48	Row position in the cross section table of the transport cross section. Variables IHT, IHS, and IHM are closely coordinated. On paper the cross section data for a single isotope (nuclide) is viewed in a number (IGM) of columns, one column for each velocity group. Each column consists of IHM rows. Row 1 contains the microscopic absorption cross section, σ_a ; row 2 contains the value ν times the microscopic fission cross section, $\nu\sigma_f$; etc.; row i (i is the value entered for IHT) contains the microscopic transport cross section, σ_{tr} ; etc. See example under IHS below. In any event, the value for IHT is chosen first and the rest of the cross section entries are centered about this value, i.e., IHT is the row position of the transport cross section. Then $\nu\sigma_f$ and σ_a MUST be in positions IHT-1 and IHT-2, respectively. IHT + 1, etc., are reserved for scattering cross sections. For the standard 16 group library cross sections use the value IHT = 3.
IHS	Card 4	4, ..., 9	I9	52-60	Row position of the self scattering microscopic cross section in the input cross section table. After having chosen the

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Input fld	Card digit	Explanation and examples																																								
IHS (cont.)					<p>position of the transport cross section (the value IHT) the value for the self scattering term is chosen. If there are no upscattering terms (i.e., from group 4 to 3, or 4 to 2, etc.), then the row position of the self scattering cross section is $IHS = IHT+1$. If there are three upscattering terms, then three terms must be entered between the transport cross section and the self scattering cross section and the value of IHS will then be $IHS = IHT+4$. Thus it is seen that upscattering cross sections appear in positions $IHT+1$ through $IHS-1$. The self scattering cross section appears in position IHS. Down-scattering cross section terms appear in positions $IHS+1$ through IHM.</p> <p>In the following two examples, the symbol $\sigma_{g'g}$ represents scattering from group g' to group g.</p> <p><u>EXAMPLE ONE:</u> $IHT = 3$, $IHM = 9$, $IHS = 6$, cross section column for group 4 is used, $g = 4$.</p> <table><tr><th>ROW</th><th>CROSS SECTION</th></tr><tr><td>1</td><td>σ_a</td></tr><tr><td>2</td><td>$\nu\sigma_f$</td></tr><tr><td>IHT = 3</td><td>σ_{tr}</td></tr><tr><td>4</td><td>σ_{64}</td></tr><tr><td>5</td><td>σ_{54}</td></tr><tr><td>IHS = 6</td><td>σ_{44}</td></tr><tr><td>7</td><td>σ_{34}</td></tr><tr><td>8</td><td>σ_{24}</td></tr><tr><td>IHM = 9</td><td>σ_{14}</td></tr></table> <p><u>EXAMPLE TWO:</u> $IHT = 3$, $IHM = 9$, $IHS = 5$, cross section column for group 4 is used, $g = 4$.</p> <table><tr><th>ROW</th><th>CROSS SECTION</th></tr><tr><td>1</td><td>σ_a</td></tr><tr><td>2</td><td>$\nu\sigma_f$</td></tr><tr><td>IHT = 3</td><td>σ_{tr}</td></tr><tr><td>4</td><td>σ_{54}</td></tr><tr><td>IHS = 5</td><td>σ_{44}</td></tr><tr><td>6</td><td>σ_{34}</td></tr><tr><td>7</td><td>σ_{24}</td></tr><tr><td>8</td><td>σ_{14}</td></tr><tr><td>IHM = 9</td><td>blank</td></tr></table>	ROW	CROSS SECTION	1	σ_a	2	$\nu\sigma_f$	IHT = 3	σ_{tr}	4	σ_{64}	5	σ_{54}	IHS = 6	σ_{44}	7	σ_{34}	8	σ_{24}	IHM = 9	σ_{14}	ROW	CROSS SECTION	1	σ_a	2	$\nu\sigma_f$	IHT = 3	σ_{tr}	4	σ_{54}	IHS = 5	σ_{44}	6	σ_{34}	7	σ_{24}	8	σ_{14}	IHM = 9	blank
ROW	CROSS SECTION																																												
1	σ_a																																												
2	$\nu\sigma_f$																																												
IHT = 3	σ_{tr}																																												
4	σ_{64}																																												
5	σ_{54}																																												
IHS = 6	σ_{44}																																												
7	σ_{34}																																												
8	σ_{24}																																												
IHM = 9	σ_{14}																																												
ROW	CROSS SECTION																																												
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2	$\nu\sigma_f$																																												
IHT = 3	σ_{tr}																																												
4	σ_{54}																																												
IHS = 5	σ_{44}																																												
6	σ_{34}																																												
7	σ_{24}																																												
8	σ_{14}																																												
IHM = 9	blank																																												

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples																															
IHS (cont.)					<p>Note that IHS and IHT may be shifted to any position to include more or less up-scatter terms; however, at each change of IHT or IHS, a new data card must be made (a physical change in input cards) for the repositioning of the cross sections for every energy group for every nuclide. Note that blank fields are taken to be zero. Thus in general the positioning of the cross sections is as follows:</p> <table><tr><th>ROW</th><th>CROSS SECTION</th><th></th></tr><tr><td>IHT-2</td><td>σ_a</td><td rowspan="12">This is the cross section order. Note the position of the upscatter terms: by row σ_{g+1-g} is preceded by σ_{g+2-g}, etc. Also note order of downscatter terms. See examples above.</td></tr><tr><td>IHT-1</td><td>$\nu\sigma_f$</td></tr><tr><td>IHT</td><td>σ_{tr}</td></tr><tr><td>.</td><td>.</td></tr><tr><td>.</td><td>.</td></tr><tr><td>IHS-2</td><td>$\sigma_{g+2,g}$</td></tr><tr><td>IHS-1</td><td>$\sigma_{g+1,g}$</td></tr><tr><td>IHS</td><td>$\sigma_{g,g}$</td></tr><tr><td>IHS+1</td><td>$\sigma_{g-1,g}$</td></tr><tr><td>.</td><td>$\sigma_{g-2,g}$</td></tr><tr><td>.</td><td>.</td></tr><tr><td>.</td><td>.</td></tr><tr><td>IHM</td><td>$\sigma_{g-g+1,g}$</td><td></td></tr></table> <p>For this standard 16 group library cross sections use IHS = 4.</p>	ROW	CROSS SECTION		IHT-2	σ_a	This is the cross section order. Note the position of the upscatter terms: by row σ_{g+1-g} is preceded by σ_{g+2-g} , etc. Also note order of downscatter terms. See examples above.	IHT-1	$\nu\sigma_f$	IHT	σ_{tr}	.	.	.	.	IHS-2	$\sigma_{g+2,g}$	IHS-1	$\sigma_{g+1,g}$	IHS	$\sigma_{g,g}$	IHS+1	$\sigma_{g-1,g}$	.	$\sigma_{g-2,g}$	.	.	.	.	IHM	$\sigma_{g-g+1,g}$	
ROW	CROSS SECTION																																			
IHT-2	σ_a	This is the cross section order. Note the position of the upscatter terms: by row σ_{g+1-g} is preceded by σ_{g+2-g} , etc. Also note order of downscatter terms. See examples above.																																		
IHT-1	$\nu\sigma_f$																																			
IHT	σ_{tr}																																			
.	.																																			
.	.																																			
IHS-2	$\sigma_{g+2,g}$																																			
IHS-1	$\sigma_{g+1,g}$																																			
IHS	$\sigma_{g,g}$																																			
IHS+1	$\sigma_{g-1,g}$																																			
.	$\sigma_{g-2,g}$																																			
.	.																																			
.	.																																			
IHM	$\sigma_{g-g+1,g}$																																			
IHM	Card 4	4, . . . , 9	I9	64-72	<p>Maximum length of the microscopic cross section table. The maximum possible value for IHM in the DTF code at present is 9, however, lower values may be used. If σ_a, $\nu\sigma_f$, and σ_{gg} and five downscattering terms are supplied for every velocity group IHM = 9. However for each velocity group "IHM" entries in number must be supplied even if it is necessary to input a value of zero (or a blank). The lower value of IHM = 4 is necessary, for at least σ_a, $\nu\sigma_f$, σ_{tr}, and one scattering term must be supplied (for each isotope and group) in order that IHT, IHS, and IHM will perform properly in the code.</p> <p>For the standard 16 group library cross sections use a value of IHM = 9.</p>																															
BF	Card 5	0.0 or 1.8137994	F9.5	4-12	<p>This is not the actual geometric buckling but is a fixed value. In the case of finite geometries this term corrects the absorption and transport cross sections. The fixed value for BF is $\pi/\sqrt{3}$ or 1.8137994. The correction is as follows to the cross sections:</p> $\Sigma = \Sigma' + DB^2.$																															

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
BF (cont.)					<p>The value for BF is nested in the following equation from subroutine S816:</p> $SRI = \left(\frac{BF}{\Sigma' \cdot DY + 1.42} \right)^2 \cdot \Sigma' = DB^2$ <p>or</p> $\left(\frac{\pi/\sqrt{3}}{\Sigma' \cdot DY + 1.42} \right)^2 \frac{\Sigma'^2}{\Sigma'}$ $= \left(\frac{\pi}{DY + 1.42\lambda_{tr}} \right)^2 \frac{1}{3\Sigma'} = B^2 D$ <p>$\therefore$,</p> $\underline{\underline{BF = \pi/\sqrt{3}}}$ <p>For <u>any</u> spherical problem enter 0.0. For <u>any</u> cylindrical or plane problem enter $\pi/\sqrt{3}$, which is 1.8137994.</p>
DY	Card 5	Decimal	F9.5	16-24	<p>Buckling height in centimeters. For <u>all</u> spherical problems enter 0.0. For <u>infinite</u> cylindrical problems enter 0.0. For <u>plane</u> geometries that are infinite in Y and Z enter 0.0. For plane geometries finite in X and Y but infinite in Z, enter the Y dimension. For a finite cylinder, enter the buckling height H. This buckling height is the finite dimension of the cylinder. In the case of a finite plane in two dimensions the dimensions X and Y are chosen. Thus the value for DY is the dimension Y in this case. In the case of a plane of two finite dimensions a value of 0.0 for DY and a nonzero value for DZ below will not work; i.e., chose finite dimensions in the order X, Y, Z.</p>
DZ	Card 5	Decimal	F9.5	28-36	<p>Buckling depth in centimeters. This value is only used for finite plane geometry. For spherical, cylindrical, and <u>infinite</u> plane geometries enter DZ = 0.0. For finite plane geometries enter the Z dimension of the plane, DZ = Z dimension.</p>
MS	Card 5	1, ..., 75	I9	40-48	<p>Number of mixture specification entries. Count the physical number of single entries (including control zeros) of either of the cards MIXMB, MIXMC, or MIXMD (there is the same number of entries on each of these cards). This number is entered for the value of MS. See the example under the card MIXMC.</p>
MCR	Card 5	0, ..., 29	I9	52-60	<p>This is the total number (the counted number, NOT the corresponding identification number) of nuclides which will be used for composition purposes to be read in from</p>

Table B-III. (Continued)

FOR Name	Card ID	Pass values	Inp fld	Card digit	Explanation and examples
MCR (cont.)					<p>cards. This number of cross section data sets must be placed in the data deck.</p> <p>If some cross section data sets are on cards and some are on tape, all cross section data cards will be read in first, THEN the cross section data from tape. See MTP for cross section data on tape.</p> <p>The reason for the upper limit of 29 is as follows. A table of cross section values of length IHM must be read for each energy group IGM and for each nuclide. The total space saved for cross sections is 4860 spaces. This space includes nuclide cross section storage AND mixture storage. Using the maximum values of IHM = 9 and IGM = 18, the total number of nuclides it is possible to read from cards is $4860/(9 \times 18) = 4860/162 = 30$. But with 30 nuclides there is no room for a single mixture. Thus with 29 nuclides, at least one mixture is possible.</p> <p>It is to be noted, however, that with the standard library cross section data, which has IHM = 9 and IGM = 16, there is room enough for 32 nuclides to be read in with the possibility of at least one mixture.</p> <p>Thus the limiting factors are as follows for the reading in of cross sections and the formation of mixtures:</p> <p>For IHM = 9, IGM = 18: $MT \leq 30$, $MCR + MTP \leq 29$ $MT_{\max} = 30$</p> <p>For IHM = 9, IGM = 16: $MT \leq 33$, $MCR + MTP \leq 32$ $MT_{\max} = 33$</p> <p>In general the maximum number of mixtures possible is</p> $\text{maximum number mixtures} = MT_{\max} - (MCR + MTP).$ <p><u>EXAMPLE:</u> Suppose the nuclides C, O, ^{235}U, Be, and H are read from cards; and H, Zr, Nb, and D are read from tape. And also suppose that the mixtures to be formed are combinations consisting of the following groups of nuclides:</p> <ol style="list-style-type: none"> mixture 1: C, O 2: H, O 3: Be 4: ^{235}U, C 5: D, O 6: Zr, Nb 7: C <p>By using the library cross section data, the following values are used:</p>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
MCR (cont.)					$\begin{aligned} &\left. \begin{array}{l} \text{MCR} = 5 \\ \text{MTP} = 4 \end{array} \right\} \text{MCR} + \text{MTP} = 9 \\ &\text{max possible MT} = \text{MT}_{\text{max}} - (\text{MCR} + \text{MTP}) \\ &\quad = 33 - 9 \\ &\quad = 24 \end{aligned}$ <p>However, only 7 mixtures are used here. Thus MT = 16 (nuclides + mixtures) is a legitimate number. If it happened that 24 mixtures were formed from these same 9 nuclides, then MT would be 33 and would still be legitimate. However if 25 or more mixtures were formed from these same 9 nuclides, then MT would exceed 33 and this value is invalid due to the fact that the storage available in the code for cross section input is exceeded.</p> <p>In general to determine the maximum possible value of MT the following relationship can be used: $4860 / [\text{IHM} \times \text{IGM} \times (\text{MCR} + \text{MTP})]$ where this number is rounded off to the nearest lower integer, i.e., 32.6 would be 32.</p>
MTP	Card 5	0, ..., 29	I9	64-72	<p>Number (counted number and not corresponding identification number) of nuclide cross section data sets to be read from tape for the purpose of forming mixtures.</p> <p>Note that all cross section data sets on cards will be read in before data sets on tape.</p> <p>See MCR for detailed explanation of interplay of MCR and MTP and also the limiting factors.</p>
MT	Card 6	1, ..., 30	I9	4-12	<p>Total number of materials including isolated nuclides and mixtures used in the assembly. See the explanation under MCR for a better understanding of the limiting features of the value MT.</p> <p><u>EXAMPLE:</u> If C, O, N, Al, and ^{235}U are the nuclides used and the following mixtures are formed from them</p> <p style="margin-left: 40px;">mixture 1 C, O mixture 2 ^{235}U, O, Al,</p> <p>then by the following configuration it is seen that the value to enter for MT is 7:</p> <div style="display: flex; align-items: center; margin-left: 40px;"> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="display: flex; flex-direction: column; align-items: center;"> <div>1 C</div> <div>2 O</div> <div>3 N</div> <div>4 Al</div> <div>5 ^{235}U</div> </div> <div style="font-size: 3em; margin: 0 10px;">}</div> <div style="display: flex; flex-direction: column; align-items: center;"> <div>6 C, O</div> <div>7 ^{235}U, O, Al</div> </div> </div> <div style="margin-left: 20px;"> <p>five nuclide cross section data sets are read in</p> <p>two mixtures are internally computed from the above five nuclides and are used in the assembly</p> </div> </div>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples																				
MT (cont.)					<p>Note that if three zones are to be used (as opposed to the two zones above, one with mixture 6, the other with mixture 7) the first of which has the mixture C, O; the second of which has the mixture ^{235}U, Al, O; and the third of which has the material ^{235}U alone; then the ^{235}U which is now used separately as a single "mixture" or material must be renamed as a material and given a separate identification number from its identification number as a nuclide. In this case the input arrangement is as follows:</p> <table><tr><td>1</td><td>C</td><td rowspan="5">}</td><td rowspan="5">five nuclide cross section data sets are read in</td></tr><tr><td>2</td><td>O</td></tr><tr><td>3</td><td>N</td></tr><tr><td>4</td><td>Al</td></tr><tr><td>5</td><td>^{235}U</td></tr><tr><td>6</td><td>C, O</td><td rowspan="3">}</td><td rowspan="3">three mixtures are internally computed from the above five nuclides and are used in the assembly</td></tr><tr><td>7</td><td>^{235}U, O, Al</td></tr><tr><td>MT = 8</td><td>^{235}U</td></tr></table>	1	C	}	five nuclide cross section data sets are read in	2	O	3	N	4	Al	5	^{235}U	6	C, O	}	three mixtures are internally computed from the above five nuclides and are used in the assembly	7	^{235}U , O, Al	MT = 8	^{235}U
1	C	}	five nuclide cross section data sets are read in																						
2	O																								
3	N																								
4	Al																								
5	^{235}U																								
6	C, O	}	three mixtures are internally computed from the above five nuclides and are used in the assembly																						
7	^{235}U , O, Al																								
MT = 8	^{235}U																								
					<p>Now the value for MT will be 8. In other words, the value for MT is the total number of cross section data sets read in (by cards and tape) plus the total number of mixtures formed from these nuclides, a single nuclide being renamed (given a new identification number) as a mixture if it is to occupy a region alone in the assembly.</p>																				
IDFM	Card 6	0, 1	I9	16-24	<p>Density factor marker. This control parameter merely prepares the program to read in density factors or not to read in density factors. The actual values for the density factors appear later in the data deck on a card called DENSFAC.</p> <p>If IDFM = 0, no changes in the densities of the materials will take place and the card DENSFAC should not appear in the data deck.</p> <p>If IDFM = 1, then certain changes will take place in the densities of certain materials as specified by the actual values of the density factors on card DENSFAC. Card DENSFAC must appear in the data deck.</p> <p>See DENSFAC for the operation of the density factors.</p>																				
DFM1	Card 6	0.0	F9.5	28-36	<p>This parameter is not presently used by the code, and a value of 0.0 is entered for every case.</p>																				
DFM2	Card 6	0.0	F9.5	40-48	<p>This parameter is not presently used by the code, and a value of 0.0 is entered for every case.</p>																				

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples								
XNF	Card 6	Decimal	F9.5	52-60	Normalization factor. The source terms will be normalized to the value of XNF. Any value may be used here with the normal value of 1.0 used.								
IPVT	Card 6	0, 1, 2	I9	64-72	Indicates the type of problem being run. 0 = no parameter source (IEVT = 0, 1, 2) 1 = fixed reactivity, k_0 (IEVT = 3, 4, 5) 2 = fixed time absorption, α_0 If a search option (search options are indicated by IEVT 3, 4, or 5) is chosen, either 1 or 2 must be used for IPVT and a value for k_0 or α_0 must be given in PV below. For example, if a critical radius calculation is being run (IEVT 5), the value for IPVT must be 1 and the value for PV will be $k_0 = 1.0$. However, if it is then desired to find the radius of the system which corresponds to a supercritical system or $k = 1.2$, then the value for IPVT must be 1 and the entry for PV will be $k_0 = 1.2$.								
PV	Card 7	Decimal	F9.5	4-12	Parametric eigenvalue. Whether or not a value is given for PV is determined by the value of IPVT above. See IPVT above. <table><tr><td>IPVT</td><td>PV</td></tr><tr><td>0</td><td>0.0</td></tr><tr><td>1</td><td>k_0</td></tr><tr><td>2</td><td>α_0</td></tr></table>	IPVT	PV	0	0.0	1	k_0	2	α_0
IPVT	PV												
0	0.0												
1	k_0												
2	α_0												
IQM	Card 7	0, 1	I9	16-24	Distributed source index. The distributed source corresponds to a fixed source in space and time. It is constant at its assigned position throughout the problem. The control parameter IQM merely indicates whether or not to read in any distributed source terms and does not read the terms themselves. The distributed source terms are located on card DISSOR. 0 = no distributed source. No card DISSOR. 1 = supply a distributed source on card DISSOR. A single value is entered for each energy group and for each spatial interval. <u>SPECIAL NOTE:</u> For the option IQM = 1, the parameter IFN on CARD 3 must be 1 and both cards FLUX and DISSOR must be used. In other words, with a distributed source the problem cannot be started with fission densities. The combination IQM = 1, IFN = 0 will not operate correctly. See parameter IFN.								
IPM	Card 7	0, 1, 2	I9	28-36	Shell source index. A shell source corresponds to an area source located on the								

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IPM (cont.)					<p>outermost boundary of the interval in which it is specified. If a shell source is used, it may be emitted isotropically or anisotropically (i.e., directed). The options for IPM are as follows:</p> <p>0 = no shell source. No cards SHELLI, SHELLA. The variable IPP below must be 0.</p> <p>1 = isotropic shell source. { IPP below must have a value other than zero and card SHELLI must be supplied. For IPM = 2, card SHELLA must also be supplied along with card SHELLI.</p> <p>2 = anisotropic shell source.</p>
IPP	Card 7	0, i	I9	40-48	<p>Shell source position. See IPM above. If a shell source is present (IPM = 1 or 2), the position of the source is specified by IPP.</p> <p>0 = no shell source (IPM must be 0. No cards SHELLI or SHELLA.)</p> <p>1 = the spatial interval where the shell source is located. Note that the shell source is an area source and is located at the outermost radius of the interval specified. Either card SHELLI or SHELLA or both must be supplied depending on the value of IPM above.</p>
FXM	Card 7	0.0	F9.5	52-60	This parameter is not presently used by the code, and a value of 0.0 is entered for every case.
IIM	Card 7	Approx 20	I9	64-72	This is the maximum number of inner iterations. A suggested value is 20. Rarely if ever will this number have to be increased.
IGS	Card 8	0, 1	I9	4-12	Group skipping marker. If after executing a particular type of problem it is found that the flux distributions for two or more velocity groups have similar shapes, those velocity groups of similar shape may be combined in order to skip an inner iteration over those particular groups. For example, if the distribution of group 3 is the same or similar to that of group 2, then inner iterations for the duration of the problem over the fluxes of group three will be skipped and the values found for group 2 will be correspondingly assigned to those of group 3. The only advantage to this is that computation time is saved on very long problems. The parameter IGS is merely a marker which indicates whether or not

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IGS (cont.)					<p>this option is to be used. The actual use of the option is prescribed by the group skipping markers read in on card GRSKIP.</p> <p>0 = no groups are to be skipped; no card GRSKIP.</p> <p>1 = group skipping option will be used; read in card GRSKIP in proper place in data deck. See card GRSKIP.</p>
RYF	Card 8	Decimal	F9.5	16-24	<p>Diamond method limit. This is a relaxation for the convergence criterion for scattering. The convergence is $E3 - EPS > 0$, where the value $E3 = RYF \times 1 - ALA$. (The variables E3, EPS, and ALA are all variables which are used in the code. These are the actual FORTRAN names of the variables.) Convergence occurs when this first inequality is satisfied. Thus it is seen that for similar values of $1 - ALA$ the variable E3 is strongly dependent on the value of RYF. Increasing RYF from unity essentially forces convergence since E3 is correspondingly increased (EPS remains fixed for the duration of the problem), and this allows the problem to terminate sooner (in time) with a slight loss of accuracy. Decreasing the value of RYF from unity will in turn decrease the value of E3 and thus more inner iterations must be performed before the convergence criterion will be met.</p> <p>For example: A spherical, 16-group, S₄, 5-nuclide, 2-mixture, k calculation was performed with the value of RYF first set at 0.1, and then the same problem was run with the value RYF set at 2.0. The difference between the eigenvalue, k, of the two problems was a change in the fifth decimal place. The problem with RYF set equal to 0.1 ran 4 seconds longer than the problem with RYF set equal to 2.0.</p> <p>A suggested value for RYF is 0.5.</p>
XLAL	Card 8	Decimal	F9.5	28-36	<p>The lower limit of $\lambda - 1$ or XLA - 1, where λ is used to terminate the problem. See XLAH below for further details.</p> <p>A suggested value is XLAL = 0.1.</p>
XLAH	Card 8	Decimal	F9.5	40-48	<p>Upper limit of $\lambda - 1$ or XLA - 1, where λ is used to terminate the problem. The value λ (XLA) referred to is a value which is calculated by comparing two successively computed eigenvalues. When this value of λ approaches unity (comes within EPS of unity) the best eigenvalue will have been determined within the precision cited (value of EPS) and the total problem will</p>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
XLAH (cont.)					<p>terminate. Depending on whether the value of two successive λ's indicates that λ is approaching or diverging from unity, a new value of the eigenvalue will be computed (see EV and EVM for the procedure). The function of the values XLAL and XLAH is to define a range close to unity so that each new value of λ may be tested to see how far from this range it is. The range is defined by the lower and upper values of $1 + \text{XLAL}$ and $1 + \text{XLAH}$, respectively. Two adjustments of the eigenvalue are blindly made initially in order to obtain the values of two successive λ's. These two λ's are compared to see which direction the value of λ is going (toward or away from unity). After this initial determination of the direction of λ, a very rapid (and large, if necessary) change of the value of the eigenvalue is made in order to bring the value of λ within this defined range. Each value of λ hereafter will systematically approach unity. This initial "jump" of λ is made in order to reduce the running time necessary for the problem. Once the value of λ falls below the value of the upper limit of the range (defined by $1 + \text{XLAH}$), it can not exceed this value. Therefore, the upper limit confines the value of λ. The lower limit is used simply to define this range and make the initial adjustment on the eigenvalue.</p> <p>The values of XLAL and XLAH remain unchanged for the duration of the problem. They are fixed.</p>

The above schematic shows that on a linear scale λ is changed rapidly at first (corresponding to the initial jumps) and then once within the range defined by XLAL and XLAH it changes systematically as it approaches unity (convergence).

A suggested value is $\text{XLAH} = 0.5$.

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
EQL	Card 8	Decimal	F9.5	52-60	<p>EQ limit. EQ is a test of the rate of change of the eigenvalue. EQL represents the lower limit of the slope (rate of change) of the eigenvalue search. The code checks the successive changes of the eigenvalue and forces convergence if the successive changes are very small. This corresponds to a situation where the problem is asymptotically converging upon and eigenvalue. Instead of allowing the problem to get caught in this type of neverending loop, the value of EQL tests the rate of convergence and terminates the problem accordingly.</p> <p>A suggested value for EQL is 0.005.</p>
XNPM	Card 8	Decimal	F9.5	64-72	<p>New parameter modifier. This value is used as a multiplier of the eigenvalue modifier (EVM) and is used in computing new values of the eigenvalue.</p> <p>Suggested values are XNPM = 1.0 for IEVT = 0, 1, 3, 4, 5. XNPM = 0.75 for IEVT = 2.</p> <p>In the case of a time absorption problem oscillations of the eigenvalue about a critical condition may occur and this value of 0.75 for XNPM prevents this from occurring.</p>
ID1	Card 9	0, 1	I9	4-12	<p>Printing index for the angular flux.</p> <p>0 = no print 1 = print angular fluxes</p> <p>Angular fluxes are printed in table form, one table corresponding to one energy group. The first vertical column in a table corresponds to angular direction 1 (toward the center of the core) with fluxes listed for spatial points 1 through IM + 1 in a vertical column. Spatial point 1 corresponds to the geometrical center of the assembly and spatial point IM + 1 corresponds to the outer physical boundary. The next vertical column to the right is similarly listed for the fluxes of direction 2, etc.</p> <p>It is to be noted for mirror reflection at the center of the assembly (IBL = 1; this condition corresponds to spatial point 1) that the values for fluxes whose directions are 3 and 4 are the same, and also the values of the fluxes with directions 2 and 5 are the same (for an S_4 calculation). The values from 2 and 3 have been transferred to the values for 5 and 4, respectively, for spatial point 1. This is the definition</p>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Infld	Card digit	Explanation and examples
ID1 (cont.)					<p>of mirror reflection at the center of the assembly. See diagrams under IBL and IBR.</p> <p>It is to be noted that for perfect reflection at the outer boundary of the assembly (IBR = 1; corresponding to spatial point IM + 1) the fluxes for directions 1, 2, and 3 have been set equal to the fluxes from directions 6, 5, and 4, respectively.</p> <p>For perfect absorption at the outer boundary (or a vacuum) it is to be noted that the fluxes at directions 1, 2, and 3 (IBR = 0; corresponding to spatial point IM + 1) are set equal to zero.</p> <p>See section on OUTPUT.</p>
ID2	Card 9	0, ..., 76	I9	16-24	<p>Printing index for neutron balance table.</p> <p>0 = no table printed</p> <p>IZM + 1 = neutron balance table printed.</p> <p>In order to print, the value of the number of zones plus "1" must be entered for ID2.</p> <p>See section on OUTPUT.</p>
ID3	Card 9	0, ..., 20	I9	28-36	<p>Activity print by zone. An activity print by zone also means an activity print by material, since each zone is occupied by a single material.</p> <p>0 = no print (see ID4).</p> <p>N = print, where N is the physical number of entries on either card ACMAT or ACTYP (each has the same number of entries). See cards ACMAT and ACTYP. Cards ACMAT and ACTYP must be supplied.</p> <p>Also see section on OUTPUT.</p>
ID4	Card 9	0, 1	I9	40-48	<p>Activity print by interval.</p> <p>0 = no print (omit cards ACMAT and ACTYP <u>only</u> if <u>both</u> ID3 and ID4 are zero)</p> <p>1 = print activities. Supply cards ACMAT and ACTYP if <u>either</u> ID3 or ID4 is <u>not</u> zero.</p>
ICM	Card 9	Approx 100	I9	52-60	<p>Maximum number of outer iterations. The suggested value is 100. Rarely if ever will this number be changed.</p>
IDT	Card 9	0, 1	I9	64-72	<p>Diffusion theory option. Instead of using the difference calculation, diffusion theory may be chosen for any energy group. IDT merely indicates whether or not any selections of this type will be used. The actual selections are read in on card DIFMARK.</p> <p>0 = no diffusion calculations; omit card DIFMARK</p>

Table B-III. (Continued)

FOR Name	Card ID	Poss values	Inp fld	Card digit	Explanation and examples
IDT (cont.)					1 = a diffusion calculation will be made for one or more energy groups. The groups for which this is to be done are indicated on card DIFMARK. Include card DIFMARK in the data deck.

The above parameters are all parameters which are more on the order of control parameters and not actual pieces of data. They are all read in on the first nine cards of the data deck.

The following cards read in actual pieces of data different from control parameters. The headings for Table B-IV change slightly from those used above. In order that there be no doubt as to what each one signifies, each heading will be defined again for the table that follows.

"FOR Name" is the actual FORTRAN name of the variable used in the code. Also included in the column is the maximum dimension for which the code is suited.

"Card ID" is the actual identification punched in columns 73 through 80 of the IBM card

"Units" give the exact units of the variable for input purposes. The symbol "-" means that the variable is a pure number, i.e., no units.

"Inp Fld" tells what the field format is for input. There are two types of input field for the input variables to follow. They are as follows: 6(I1,I2,I9) and 6(I1,I2,E9.4). In this column an "I" will indicate that the first field is applicable and an "E" will indicate that the second field is applicable.

"Explanation and examples" is as the heading states. Suggested values to use, hints, and aids will be given in this column along with examples.

Table B-IV. Data input

FOR Name	Card ID	Units	Inp fld	Explanation and examples
R(76)	RADIUS	Centimeters	E	<p>The radii for each spatial point are read in. The number of intervals determines how many points there will be. If there are 3 intervals (IM = 3), then there will be 4 spatial points (IM + 1 = 4).</p> <p>Conditions:</p> <ul style="list-style-type: none"> Center point must have radius of 0.0, A single value must be supplied for each spatial point, Two successive radii cannot be equal, Interpolation option may be used to form uniform intervals. <p>See "EXPLANATION OF INPUT CARD FIELDS" examples three, four, five, and six for radius input examples.</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples																
MA(75)	ZONENU	—	I	<p>The total number of intervals is given by zone. For each zone the total number of spatial intervals in that zone is specified, starting with zone 1 which is immediately adjacent to the center of the assembly.</p> <p><u>EXAMPLE:</u> With 6 zones (IZM = 6) and 30 total intervals (IM = 30), the distribution of the intervals is as follows:</p> <table><thead><tr><th>Zone</th><th>Intervals</th></tr></thead><tbody><tr><td>1 contains</td><td>1</td></tr><tr><td>2 contains</td><td>1</td></tr><tr><td>3 contains</td><td>5</td></tr><tr><td>4 contains</td><td>3</td></tr><tr><td>5 contains</td><td>19</td></tr><tr><td>6 contains</td><td>1</td></tr><tr><td></td><td><u>30</u> total intervals</td></tr></tbody></table>	Zone	Intervals	1 contains	1	2 contains	1	3 contains	5	4 contains	3	5 contains	19	6 contains	1		<u>30</u> total intervals
Zone	Intervals																			
1 contains	1																			
2 contains	1																			
3 contains	5																			
4 contains	3																			
5 contains	19																			
6 contains	1																			
	<u>30</u> total intervals																			

Card configuration is as follows:

```

/ / / 1 / / / 2 / 1 / 05 / 3 / 1 / 03 / 4 / 1 / 19 / 5 / / / 6
/ 3 / / etc.
      ^ a new card was necessary to
      terminate the input for MA.
                                repeat 19
                                intervals in
                                zone 5.

```

MZ(40)	MZ	—	I	<p>This card specifies the material or mixture used in each zone by its identification number. Each mixture (even if composed of only a single nuclide) is given an identification number for reference purposes in the code. (Cards MIXMB and MIXMC will later show how this is done. Examples are also shown under parameter MT previously discussed.) Each zone consists of a single material, and therefore the corresponding identification number for each material used must be entered in the proper zone. The material identification numbers are entered starting with the one corresponding to zone one.</p> <p><u>EXAMPLE:</u> Using a two zone system (IZM = 2), five nuclides read in (MCR + MTP = 5), and two mixtures formed from these 5 nuclides (the nuclides are numbered 1 through 5 and the two mixtures formed are numbered 6 and 7; see example one under MT), and with the following assembly: zone 1 contains material with ID number 7 zone 2 contains material with ID number 6, then the card configuration is as follows:</p>
--------	----	---	---	--

```

/ / / 7 / / / 6 / 3 / / / / / / / / / .
      ^ terminate MZ input
      material 7 material 6
      is placed in is placed in
      zone one    zone two

```

The cross section input for the case of an anisotropic material

SPECIAL NOTE: Certain nuclides have anisotropic cross section sets available. The only two nuclides

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples										
is a special case. For greater details see Special Section on Anisotropic Materials.				<p>that do in the standard library cross section data are hydrogen (H) and deuterium (D). If any material is formed using the anisotropic cross section set, then whatever the identification number is for that material, when it is placed on card MZ a negative sign must precede it. If the isotropic cross section sets are used for H and D, this negative sign is not necessary.</p> <p><u>EXAMPLE TWO:</u> With no connection to the materials of example one, suppose material 7 is to be placed in zone 2 and material 8 is to be placed in zone 1 of a 2 zone assembly. Also suppose that material 8 contains anisotropic hydrogen. The card configuration is as follows:</p> <div><div>/ / / 8 / / / 7 / 3 / / / / / / / / / .</div><div><div>material 8 (anisotropic) is placed in zone 1</div><div>material 7 is placed in zone 2</div><div>└ terminate input of MZ</div></div></div>										
XKI(18)	FISFRA	-	E	<p>Fission fraction corresponding to the fission spectrum. The spectrum corresponds to the number of energy groups being used for the problem (IGM).</p> <p>One value is entered for each energy group, with 1 (unity) corresponding to the highest energy group and being entered first.</p> <p><u>EXAMPLE:</u> For a four group calculation (IGM = 4) and the fission spectrum given as follows:</p> <table><thead><tr><th>Energy group No.</th><th>XKI</th></tr></thead><tbody><tr><td>1</td><td>0.3</td></tr><tr><td>2</td><td>0.2</td></tr><tr><td>3</td><td>0.4</td></tr><tr><td>4</td><td>0.1</td></tr></tbody></table> <p>$E_1 > E_2 > E_3 > E_4$</p> <p>the card configuration is as follows:</p> <div><div>/ / / 0.3 / / / 0.2 / / / 0.4 / / / 0.1 / 3 / / / / / .</div><div><div>enter 0.3 for energy group 1</div><div>etc. ...</div><div>└ terminate XKI input</div></div></div>	Energy group No.	XKI	1	0.3	2	0.2	3	0.4	4	0.1
Energy group No.	XKI													
1	0.3													
2	0.2													
3	0.4													
4	0.1													
VE(18)	VELOCI	cm/shake	E	<p>Neutron velocities corresponding to the number of energy groups being used for the problem (IGM). A single value must be entered for each energy group. The highest velocity corresponds to energy group one and is read in first.</p> <p>The units are in cm/shake, where a shake is equivalent to 10^{-8} cm/sec.</p> <p><u>EXAMPLE:</u> For a four group calculation (IGM = 4) and the velocities corresponding to the fission spectrum and energy groups as follows:</p>										

Table B-IV. (Continued)

FOR Name	Card ID	Units	Input fld	Explanation and examples		
VE(18) (cont.)				Energy group No.	XKI	VE
				1	0.3	28.0×10^{-8} cm/sec
				2	0.2	14.0
				3	0.4	6.7
				4	0.1	0.3

the configuration for the input card is as follows:

/ / /28.0 / / /14.0 / / /6.7 / / /0.3 / 3 / / / / / .
 ↑ terminate VE input

W(24) W - E These values correspond to the S_n constants which are the weights. For a spherical S_n calculation there are $(n + 1)$ weights. The weight for direction number one (direction cosine equals -1) is read in first and then 2, etc. For an S_4 calculation directions 1, 2, and 3 are directed toward the inward direction, while directions 4 and 5 are toward the outward direction.

EXAMPLE: The following diagram holds for a spherical S_4 calculation, where the numbers refer to the number of the direction cosine (the direction number):

The following table gives values for the S_4 weights (W) and the direction cosines (D, see below):

Direction No.	Weight (W)	Direction cosine (D)
1	0.0	-1.0
2	0.1667	-0.881
3	0.3333	-0.333
4	0.3333	0.3333
5	0.1667	0.8819

The weights (W) are entered on cards in the following manner (see below for cosines):

/ / /0.0 / / /0.1667 / / /0.3333 / / /0.3333 / / /0.1667 / 3 / / .

D(24) D - E These values correspond to the S_n constants which are the direction cosines. The table above gives the values of the direction cosines for an S_4 calculation. The direction cosines are entered in a

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
D(24) (cont.)				<p>similar manner to the direction weights, the first entry corresponding to direction number 1.</p> <p><u>EXAMPLE:</u> See W above for the values of the direction cosines corresponding to an S_4 calculation. The card configuration for input is as follows:</p> <p style="text-align: center;">/ / /-1.0 / / /-0.881/ / /-0.333/ / /0.3333/ / /0.8819/3/ / .</p> <p>S_n constants (weights and direction cosines) for all geometries and S_n orders $n = 2, 4, 8, 16, 24$ may be found in Appendix C.</p> <p>NOTE: In general S_4 calculations are sufficient for most problems run on DTF. Rarely is it necessary to resort to higher orders except for shielding calculations. However, the user should verify that the order retained is acceptable in the "asymptotic" sense.</p>
F(75)	FISSIO	n/cm^3	E	<p>This is an initial guess to start the problem. Refer to control parameter IFN. The problem may be started by supplying either fission densities or an initial flux distribution. This card supplies the fission density if that option is chosen. If the control parameter is zero (IFN = 0) card FISSIO is supplied in the data deck.</p> <p>A single value must be supplied for <u>each</u> spatial interval, regardless of whether or not a source or fissionable isotope is present in all intervals. This initial fission density guess is not permanent and changes after each iteration. Thus it will be reduced to zero by successive iterations in intervals where no fissions occur. This stipulation assures that the difference equations will operate properly.</p> <p><u>EXAMPLE:</u> Consider a two zone assembly, the first zone containing Uranium with 20 spatial intervals, and the second zone containing H_2 with 30 spatial intervals. A total of 50 spatial intervals is present. The geometric configuration is as follows:</p>

A suggested value for the fission density for each interval is unity. The normalization factor XNF will normalize whatever value is inserted for the fission densities to XNF, however.

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
XN(1350) (cont.)				<div><div>/ / /1.0 /1 /02/2.0 /1 /02/3.0 / / /4.0 /1 /03/1.0 / / /3.0 .</div><div>/ 3 / / / / / / / / / / / /</div></div> <div>A new card must be used to terminate the flux input.</div>
MB(75)	MIXMB	—	I	The order of these cards in the data set in MIXMB, MIXMC, and MIXMD. These three cards are very closely coordinated. They form the materials (mixtures and single nuclides) to be used and assign identification numbers to the newly formed materials.
MC(75)	MIXMC	—	I	
XMD(75)	MIXMD	atoms/ 10 ²⁴ -cc	E	

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
MB(75) MC(75) XMD(75) (cont.)				<p>components of one material, then another control 0 followed by the identification numbers of the nuclide of the next material, etc. Use a 3 to terminate MIXMC input.</p> <p>The card configuration for forming materials 6 and 7 is as follows: (Card MIXMC)</p> <pre> / / / 0 / / / 1 / / / 2 / / / 0 / / / 5 / / / 2 . / / / 4 / 3 / / / / / / / / / / / / / . </pre> <p>This means that nuclides 1 and 2 form <u>a</u> material, and nuclides 5, 2, and 4 form <u>another</u> material. (The reason that "a" and "another" are underlined is that card MIXMC merely forms the materials. Card MIXMB will assign the identification numbers to these materials.)</p> <p>Card MIXMB assigns identification numbers to these materials which have been formed by card MIXMC. This is done by writing the material identification numbers (must continue consecutively after the last nuclide number) as many times as fields occupied on card MIXMC by control 0 and nuclide component identification numbers. For example in reference to card MIXMC the first material formed will be called material 6 and the second one formed will be called material 7. The card configuration for card MIXMB is as follows: (terminate MIXMB input with a 3)</p> <pre> / / / 6 / / / 6 / / / 6 / / / 7 / / / 7 / / / 7 . / / / 7 / 3 / / / / / / / / / / / / / . </pre> <p>The three 6's on card MIXMB show that nuclides 1 and 2 make up material 6. One 6 is included for the initial control 0 and another for each component in material 6. The next four 7's show that nuclides 5, 2, and 4 make up material 7. Also include one 7 for the initial control 0 and one for each component in material 7. (For the actual placement of these materials in the zones of the assembly see card MZ.)</p> <p>Card(s) MIXMD reads in the atom densities (in units atoms/10^{24}-cc) for each nuclide corresponding to the correct material. These densities must appear precisely in the order and position of the nuclide identification numbers on card MIXMC. For example, card MIXMC shows that nuclides 1 and 2 form <u>a</u> material. Card MIXMB shows that it is material <u>6</u>. With "0.0" in the corresponding place of "0" on card MIXMC, card MIXMD should read in the atom densities of each nuclide in material 6 in the order that the nuclide identification number appears on card MIXMC. Immediately following on card MIXMD is another control "0.0" and the atom densities of the nuclides forming material</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples																
MB(75)				7 are read in—using the same order as the nuclide																
MC(75)				identification numbers appear on card MIXMC.																
XMD(75)				See example below.																
(cont.)				All densities must be greater than zero, e.g., 10^{-20} .																
				<u>EXAMPLE TWO:</u> The nuclides C, O, N, Al, and ^{235}U are read in. Material 6 is formed: C, O.																
				Material 7 is formed: ^{235}U , O, Al.																
				<table><tr><th>ID No.</th><th>Nuclide or material</th></tr><tr><td>1</td><td>C</td></tr><tr><td>2</td><td>O</td></tr><tr><td>3</td><td>N</td></tr><tr><td>4</td><td>Al</td></tr><tr><td>5</td><td>^{235}U</td></tr><tr><td>6</td><td>C, O</td></tr><tr><td>7</td><td>^{235}U, O, Al</td></tr></table>	ID No.	Nuclide or material	1	C	2	O	3	N	4	Al	5	^{235}U	6	C, O	7	^{235}U , O, Al
ID No.	Nuclide or material																			
1	C																			
2	O																			
3	N																			
4	Al																			
5	^{235}U																			
6	C, O																			
7	^{235}U , O, Al																			
				Material 6 consists of C and O with atom densities:																
				$N_{\text{C}} = 0.0031 \times 10^{24}$ atoms/cc																
				$N_{\text{O}} = 0.0062 \times 10^{24}$ atoms/cc																
				Material 7 consists of ^{235}U , O, and Al with atom densities:																
				$N_{^{235}\text{U}} = 0.048 \times 10^{24}$ atoms/cc																
				$N_{\text{O}} = 0.0058 \times 10^{24}$ atoms/cc																
				$N_{\text{Al}} = 0.018 \times 10^{24}$ atoms/cc																
				All 5 nuclide cross section data sets are on cards so MCR = 5, MTP = 0.																
				Cards MIXMB appear as:																
				<pre> / / / 6 / / / 6 / / / 6 / / / 7 / / / 7 / / / 7 . / / / 7 / 3 / / / / / / / / / / / / / .</pre>																
				Cards MIXMC appear as follows:																
				<pre> / / / 0 / / / 1 / / / 2 / / / 0 / / / 5 / / / 2 . / / / 4 / 3 / / / / / / / / / / / / / .</pre>																
				Cards MIXMD appear as follows:																
				<pre> / / / 0.0 / / / 0.0031 / / / 0.0062 / / / 0.0 / / / 0.048 / / / 0.0058. / / / 0.018 / 3 / / / / / / / / / / / / / .</pre>																
				In this case MS = 7, the physical number of entries on card MIXMB (or MIXMC or MIXMD) including control zeros.																
				In this case MT = 7, the total number of nuclides plus materials.																
				<u>EXAMPLE THREE:</u> Consider a problem similar to the one in example two above except that one wants																

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples	
MB(75)				to use ^{235}U alone as a material. In this case the	
MC(75)				nuclide ^{235}U will have to be renamed as a material	
XMD(75)				and given a separate identification number.	
(cont.)				Nuclides or	
				ID No.	material
				1	C
				2	O
				3	N
				4	Al
				5	^{235}U
				6	C, O
				7	^{235}U , O, Al
				8	^{235}U
				} nuclides read in	
				} materials formed	
				$\text{N}_{^{235}\text{U}} = 0.048 \times 10^{24}$	
				atoms/cc for material 8.	

Cards MIXMB appear as follows:

```

/ / / 6 / / / 6 / / / 6 / / / 7 / / / 7 / / / 7 .
/ / / 7 / / / 8 / / / 8 / 3 / / / / / / / / / / .

```

Cards MIXMC appear as follows:

```

/ / / 0 / / / 1 / / / 2 / / / 0 / / / 5 / / / 2 .
/ / / 4 / / / 0 / / / 5 / 3 / / / / / / / / / / .

```

Cards MIXMD appear as follows:

```

/ / / 0.0 / / / 0.0031 / / / 0.0062 / / / 0.0 / / / 0.048 / / / 0.0058.
/ / / 0.018 / / / 0.0 / / / 0.048 / 3 / / / / / / / / / / .

```

In this case MS = 9, the physical number of single entries on cards MIXMB (or MIXMC or MIXMD) including control zeros.

In this case MT = 8, the total number of nuclides plus materials.

RM(75)	RADMOD	—	E	<p>Radial modifiers. Card RADMOD is included in the data deck for only the zone thickness search, i.e., IEVT = 4. The radial modifiers determine the manner in which the radii of the intervals within each zone are to be changed. In essence, they determine whether or not the zone thickness (of each separate zone) is to be changed in the assembly. It is possible to hold the thickness of any zone(s) constant while changing the overall size of the assembly.</p> <p>One radial modifier (RM) must be entered for each zone. The repeat input option may be convenient to use.</p> <p>If a radial modifier (RM) equals 0.0, this means that the thickness of that particular zone for which RM = 0.0 was entered cannot change no matter how the dimensions of the entire assembly change (i.e., since the thickness of the zone remains constant</p>	
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Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
RM(75) (cont.)				<p>and not the relative position of the zone in the assembly, the mass is not conserved.)</p> <p>If a radial modifier (RM) equals 1.0 then the new thickness of the zone for which RM = 1.0 was entered will be $(1.0 + EV)$ times the original input thickness. After each outer iteration a new eigenvalue is computed and the zone thicknesses are scaled from the initial input zone thicknesses. The flux distribution from the previous calculation is used to test the new dimensions, however, since the closer to the correct dimensions one is the successively better is the computed flux distribution. When there is little change in successive eigenvalues, the dimensions of the systems corresponding to these successive eigenvalues are only slightly different. Thus any further dimension changes are superfluous and the problem terminates.</p> <p>The radial modifiers may assume any positive or negative decimal number. However, 0.0 and 1.0 are the most meaningful values. The effect of values other than 0.0 or 1.0 may be investigated with the following equation.</p> <p>In any event the radii for each interval are adjusted in each zone using the radial modifier entered for that zone. The overall dimensions of the entire assembly (outermost dimension of each zone) are adjusted proportionally. That is, if there are three zones, 1, 2, and 3, and the center zone, 2, is to remain the same thickness, then upon changing the overall dimensions of the assembly the change in thickness of zones 1 and 3 is proportional, while the thickness of zone 2 remains constant.</p> <p>The equation used for changing the indicated zone thicknesses after each outer iteration is as follows:</p> $RA_{i+1} = RA_i + (R_{i+1} - R_i) \times (1.0 + EV \times RM_k)$ <p>for $i = 1$ through IM $k = 1$ through IZM</p> <p>where i = interval number k = zone number.</p> <p>R_i correspond to the original input dimensions and remain fixed throughout the problem. Each time the eigenvalue changes (corresponding to an outer iteration over all energy groups and spatial directions), the new dimensions of the assembly are rescaled (using the latest eigenvalue) from the original input dimensions.</p> <p>RM_k correspond to the original input radial modifiers and remain fixed throughout the problem.</p> <p>RA_i correspond to the latest dimensions of the assembly which are calculated from the original dimensions immediately upon obtaining a new eigenvalue.</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Input fld	Explanation and examples
RM(75) (cont.)				<p>$RA_1 = R_1 = 0.0$: the center of the assembly remains fixed at 0.0.</p> <p>Note that the radii are computed starting at $r = 0.0$ and working toward the outer boundary. Each new value of RA_i is immediately used to calculate RA_{i+1}. All the latest values of RA are immediately used.</p> <p><u>EXAMPLE ONE</u>: For a 3 zone assembly, zone number 2 is not to change thickness. Thus the radial modifiers are $RM_1 = 1.0$, $RM_2 = 0.0$, and $RM_3 = 1.0$.</p> <p>The input card configuration for RADMOD is as follows:</p>

/ / /1.0 / / /0.0 / / /1.0 /3/ / / / / / / / / .

This means that in searching for the proper zone thicknesses for zones 1, 2, and 3, although the overall dimensions of the assembly are changed during the search, the relative thickness ($R_3 - R_2$) remains constant.

The figures below show that R_1, R_2, R_3 , and R_4 are changed to RA_1, RA_2, RA_3 , and RA_4 , respectively; and then RA_1, RA_2, RA_3 , and RA_4 are changed to RA'_1, RA'_2, RA'_3 , and RA'_4 , respectively.

In showing that $RM_2 = 0.0$ keeps the thickness of zone 2 constant, i.e., the relative thickness along a radius it remains to be proved that

$$(RA'_3 - RA'_2) = (RA_3 - RA_2) = (R_3 - R_2).$$

Using the iterative equation above and the values $RM_1 = 1.0$, $RM_2 = 0.0$, $RM_3 = 1.0$, and $R_1 = RA_1 = RA'_1 = 0$, where the latest RA values computed are immediately used:

Table B-IV. (Continued)

FOR Name	Card ID	Units	Input fld	Explanation and examples
RM(75) (cont.)				<p>(i) $RA'_2 = RA'_1 + (R_2 - R_1)(1 + EV \cdot RM_1)$</p> <p>(ii) $RA'_3 = RA'_2 + (R_3 - R_2)(1 + EV \cdot RM_2)$</p> <p>Since $RM_2 = 0.0$ it immediately follows from equation (ii)</p> <p>(iii) $RA'_3 - RA'_2 = R_3 - R_2$.</p> <p>thus it is seen that the thickness of zone 2 does not change.</p> <p>It is also shown that at the same time the thickness of zone 2 remains constant, the thickness of zone 3 does NOT remain constant</p> <p>(iv) $RA'_4 = RA'_3 + (R_4 - R_3)(1 + EV \cdot RM_3)$</p> <p>since $RM_3 = 1.0$</p> <p>$RA'_4 = RA'_3 + (R_4 - R_3)(1 + EV)$</p> <p>$(RA'_4 - RA'_3) = (R_4 - R_3)(1 + EV)$</p> <p>$\therefore (RA'_4 - R'_3) \neq (R_4 - R_3);$</p> <p>i. e., zone 3 thickness changes, as specified.</p> <p><u>EXAMPLE TWO:</u> Suppose there are four total zones. The innermost three zones are to remain the same thickness and the outer zone (a reflector) is to change thickness to determine the lower limit (dimension) beyond which the reflector acts as an infinite reflector.</p> <p>The card configuration for card RADMOD is as follows:</p> <p>/ 1 / 03 / 0.0 / / / 1.0 / 3 / / / / / / / / / .</p> <p>This means that $RM_1 = RM_2 = RM_3 = 0.0; RM_4 = 1.0$.</p>
Q(1350)	DISSOR	n/cm ³ -sec	E	<p>Distributed source terms. If the control parameter IQM = 1, then a distributed source is present and card DISSOR contains the distributed source terms. The distributed source terms remain constant in space and time throughout the problem.</p> <p>A value must be entered for each energy group and for each spatial interval. Spatial intervals vary first, i.e., all values for group one are entered first starting with spatial interval 1, then spatial interval 2, etc., through spatial interval IM. Then all source terms of energy group 2 are entered, starting with spatial interval 1, then spatial interval 2, etc.</p> <p><u>EXAMPLE:</u> Suppose there are 3 intervals and the number of groups is 2 (IGM = 2). The sources are as follows:</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Imp fld	Explanation and examples		
Q(1350) (cont.)				<u>Group</u>	<u>Interval</u>	<u>Source (n/cc-sec)</u>
				1	1	1.0
					2	1.0
					3	3.0
				2	1	7.0
					2	1.0
					3	3.0

The card configuration for card DISSOR is as follows:

/ 1 / 02 / 1.0 / / / 3.0 / / / 7.0 / / / 1.0 / / / 3.0 / 3 / / .

This space is being left for explanation of the shell source input. Cards SHELLI and SHELLA. This has not been completed.

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
DF(75)	DENSFAC	—	E	<p>Density factors. The density factors are convenient for changing the density of a material according to spatial interval. See control parameter IDFM. The card DENSFAC is supplied in the data deck only if IDFM = 1.</p> <p>A value is read in for each spatial interval. Reading in density factors of 1.0 for all intervals and reading in no density factors (IDFM = 0 and no card DENSFAC) have the same effect.</p> <p>The code reads in microscopic cross sections and atom densities of the nuclides for each material. Thus, it computes the macroscopic cross sections internally. The density factor operates on the macroscopic cross sections of the materials in specific intervals. The macroscopic cross section is computed in the following manner:</p> $\Sigma = N\sigma d,$ <p>where Σ = macroscopic cross section (cm^{-1}) σ = microscopic cross section (barns) N = atom density (atoms/10^{24}-cc) d = density factor (-).</p> <p>Suppose $N_1 = 2.0$ atoms/10^{24}-cc $\sigma_1 = 1.0$ barn $d_1 = 1.0$,</p> <p>then $\Sigma_1 = 2.0 \text{ cm}^{-1}$.</p> <p>Now suppose $N_2 = \frac{1}{2} N_1 = 1.0$ atom/10^{24}-cc $\sigma_2 = \sigma_1 = 1.0$ barn $d_2 = 2d_1 = 2.0$,</p> <p>then $\Sigma_2 = 2.0 \text{ cm}^{-1}$.</p> <p>Although the two microscopic cross sections have the same values and the atom densities have different values, the macroscopic cross sections are the same. It is seen that d (the density factor) may be used to change atom densities of a material by multiplying the macroscopic cross section of each nuclide as it is combined to make a material. However a density factor works for each spatial interval. Thus adjacent intervals may be made more or less dense by assigning the proper value to the density factor—by interval.</p> <p>See examples below.</p> <p><u>EXAMPLE ONE:</u> Three intervals all have the same material and the same density.</p> <p>(i) Set IDFM = 0 and omit card DENSFAC OR (ii) Set IDFM = 1 and include card DENSFAC as follows: (It is convenient to use the input repeat option.)</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
		/ 1 / 03 / 1.0 / 3 / / / / / / / / / / / .		<p>This means that the number 1.0 will be read in three times corresponding to intervals 1, 2, and 3 in that order. The material macroscopic cross sections in intervals 1, 2, and 3 will be multiplied by 1.0 for those intervals, i.e., no density changes.</p> <p><u>EXAMPLE TWO:</u> Three intervals all have the same material, but the interval 2 has 1/3 the density of intervals 1 and 3.</p> <p>Set IDFM = 1, include card DENSFAC.</p> <p>The configuration for card DENSFAC is as follows:</p>
		/ / / 1.0 / / / 0.3333 / / / 1.0 / 3 / / / / / / / .		<p><u>EXAMPLE THREE:</u> How to insert a VACUUM. Suppose the assembly has 30 total intervals. The intervals have any combination of materials in them. For example, the first 10 intervals have material 8, the next 2 intervals have material 12, the next four have material 10, etc. However, intervals 17, 18, and 19 have a vacuum in them. An arbitrary material is entered for these three intervals (see sample problem 601); however, the density factors are set equal to 0.0. This makes all macroscopic cross sections for the material zero only in intervals 17, 18, and 19. (This is the reason any material cross sections can be placed in these three intervals. They will eventually be multiplied by zero anyway.) The card DENSFAC configuration for placing a vacuum in intervals 17, 18, and 19 is as follows: (It is convenient to use the input repeat option.)</p>
		/ 1 / 16 / 1.0 / 1 / 03 / 0.0 / 1 / 11 / 1.0 / 3 / / / / / / / .		<p>three entries of 0.0 in the 17, 18, and 19th place produce the vacuum in those intervals.</p> <p>The values of 1.0 entered for all other intervals essentially leave those densities untouched (multiplied by 1.0).</p>
MTT(25) NUCLNO	—	I		<p>Nuclide numbers. This card must be supplied only if cross section data is to be read from tape. (Not <u>exclusively</u> from tape. Some may be from cards and some may be from tape, but any time there are some read from tape, card NUCLNO must be included.) Thus use NUCLNO any time MTP > 0.</p> <p><u>EXAMPLE:</u> If the nuclide cross section sets are entered on tape in the order C, O, Zr, ²³⁸U, ²⁴⁰Pu, Fe and the tape is used for storing them, then to use any of the sets the number corresponding to the nuclide's order on tape must be supplied. For example, if one needs cross section sets for</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
MTT(25) (cont.)				<p>Fe, C, and ^{238}U (MTP = 3), the numbers 6, 1, 4 must be given on NUCLNO. However, the nuclides must be called for in the order of increasing identification number on tape. In other words one must use the numbers in the order 1, 4, 6 corresponding to C, ^{238}U, Fe, respectively. (The tape does not back up or reverse and thus must read the identification numbers in increasing order. Be certain to keep the identification numbers of these nuclides straight on cards MIXMC when calling for the cross section sets to form mixtures.)</p> <p>The card configuration for card NUCLNO is as follows:</p> <p>/ / / 1 / / / 4 / / / 6 / 3 / / / / / / .</p> <p><u>HOW TO MAKE A PERMANENT LIBRARY TAPE OF CROSS SECTIONS.</u> The field on the first card of each cross section set (before any cards are read onto a permanent reference library tape) corresponding to digits 40 through 44 is reserved for the sequence number (order in which entered on tape) in octal. For example, the following nuclide cross section data sets are on cards: C, N, O, Fe, Zr, Al, ^{235}U, ^{239}Pu, Nb, H, D, ^6Li. They are put on tape in that same order: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 (in decimal notation). Then the first card of each set (see CROSS SECTIONS in Carlson⁹) must have in digits 40 through 44 the same corresponding sequential numbers in octal notation, i.e., 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, respectively. Thus in using a certain cross section set from this tape, the octal number in digits 40 through 44 is compared sequentially until all the cross section sets desired (specified by nuclide numbers on card NUCLNO) have been extracted.</p>
IGT(18)	DIFMARK	—	I	<p>Diffusion group markers. The control parameter IDT which was previously discussed indicates whether or not a diffusion calculation is to be performed (IDT = 1). The card DIFMARK indicates which group (or groups) is to have this diffusion calculation.</p> <p>One value must be supplied for each energy group, beginning with energy group 1, the highest group.</p> <p>0 = no diffusion calculation for this group 1 = use diffusion calculation for this group</p> <p>Supply card DIFMARK only if IDT = 1.</p> <p><u>EXAMPLE:</u> Using 16 groups, a diffusion calculation is desired for groups 3 and 12. The regular S_n calculation is desired for all other groups.</p> <p>The card configuration for card DIFMARK is as follows:</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
IGT(18) (cont.)				<div> <div>/1/02/ 0</div> <div>/ / / 1</div> <div>/1/08/ 0</div> <div>/ / / 1</div> <div>/1/04/ 0</div> <div>/3/ /</div> </div> <div> <div>S_n for groups 1 and 2</div> <div>diffusion for group 3</div> <div>S_n for groups 4 through 11</div> <div>diffusion for group 12</div> <div>S_n for groups 13 through 16</div> <div>terminate DIFMARK input</div> </div> <p><u>EXAMPLE:</u> Using 16 groups, group 16 requires a diffusion calculation.</p> <p>The card configuration for card DIFMARK is as follows:</p> <div> <div>/1/15/ 0</div> <div>/ / / 1</div> <div>/3/ /</div> <div>/ / /</div> <div>/ / /</div> <div>/ / /</div> </div> <div> <div>S_n for groups 1 through 15</div> <div>diffusion for group 16</div> <div>terminate DIFMARK input</div> </div>
IZI(75)	GRSKIP	—	I	<p>Group skipping markers. Card GRSKIP is to be supplied only if control parameter IGS = 1. These markers may be used in long problems to save time. If a certain type of problem always shows the group 1 and 2 (for example) flux distributions to be very similar then the inner iterations over group 2 may be skipped. The corresponding (in direction and interval) flux values for group 1 will be assigned to group 2 also. In this manner the iterations for group 2 are skipped and this time in computation is saved.</p> <p>One value must be read for each energy group, starting with energy group 1, the highest group.</p> <p>Group 1 may <u>not</u> be skipped.</p> <p><u>EXAMPLE:</u> Using 5 total groups (IGM = 5), it is desired to skip groups 2 and 4, i.e., assign flux distribution of group 1 to that of group 2 thus skipping the inner iteration over group 2 fluxes; and assign the flux distribution from group three to that of group 4, thus skipping the inner iteration over group 4 fluxes.</p> <p>The card configuration for card GRSKIP is as follows:</p> <div> <div>/ / / 0</div> <div>/ / / 1</div> <div>/ / 0</div> <div>/ / / 1</div> <div>/ / / 0</div> <div>/3/ /</div> </div> <div> <div>skip iteration over group 2</div> <div>skip iteration over group 4</div> </div>
C(4860)	HANx	barns	E12.6	<p>Gross section data sets for nuclides in units barns. If all cross section data sets are to be read from tape, the cross section cards HANx (reference is made to standard library cross section sets, Hansen 16 group cross sections, where "x" is the chemical symbol for the nuclide) will be omitted from the card data deck.</p>

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
C(4860) (cont.)				See MCR and MTP. If $MTP > 0$, also see NUCLNO. If standard 16 group library cross sections are not used, see parameters IHT, IHS, IHM, and card NUCLNO, "HOW TO MAKE A PERMANENT LIBRARY TAPE OF CROSS SECTIONS." See MCR for maximum number of nuclide cross section sets which are possible for each problem, depending on the values of IHM, IGM, and MT.
<u>SPECIAL NOTE</u> : The case of input for an anisotropic material is a special case and further details should be obtained under SPECIAL SECTION ON ANISOTROPIC MATERIALS.				
J3(75)	ACMAT	—	I	These two cards are the activity print cards and appear immediately following the cross section card block only if <u>either</u> ID3 <u>or</u> ID4 is NOT zero. These two cards are closely coordinated and are similar in arrangement to the MIXMB and MIXMC cards. Either option ID3 (print activities by zone) or ID4 (print activities by interval) may be used or both may be used. Whichever combination is used, if <u>either</u> print option is called, cards ACMAT and ACTYP must appear in the card data deck. Card ACMAT lists the materials (by identification number) for which an activity print will occur (whichever print option is called for, ID3 or ID4). Here a material and zone mean the same thing since a zone contains a single homogeneous material. The activity print over each material is referred to by zone number. In other words, if material number 7 has been placed in zone number 3, on the card ACMAT the activity print for material number 7 is asked for. However, on the output sheet, the activity print for material number 7 is referred to as the activity print for zone 3. Thus one must be careful when the same material occupies two different zones. To avoid complications it would be wise to rename and recompose the same material twice (on cards MIXMB, MIXMC, and MIXMD) before placing it in these two separate zones. See example three below. Card ACTYP tells what type of activity is to be printed for the materials listed on card ACMAT. These types are referred to by number: 1 = σ_a activity 2 = $\nu\sigma_f$ activity 3 = σ_{tr} activity 4 = σ_{gg} activity The total number of physical entries on cards ACMAT and ACTYP must coincide, and the maximum number of physical entries on one card is 20. First one lists the types of activities desired on card ACTYP. Then the corresponding material identification numbers for which the activities are desired are listed. <u>EXAMPLE ONE</u> : Zones 1, 2, and 3 contain materials 8, 9, and 10, respectively. It is desired to print only $\nu\sigma_f$ activities for materials 8, 9, and 10.
J4(75)	ACTYP	—	I	

Table B-IV. (Continued)

FOR Name	Card ID	Units	Infld	Explanation and examples
J3(75)				The card configurations for cards ACMAT and ACTYP are as follows:
J4(75)				
(cont.)				
ACMAT	/ / / 8 / / / 9 / / / 10 / 3 / / / / / / .			
ACTYP	/ / / 2 / / / 2 / / / 2 / 3 / / / / / / .			

In this case ID3 = 3, the physical number of entries on either one of the cards.

EXAMPLE TWO: Zones 1,2, and 3 contain materials 8,9, and 10, respectively. It is desired to print σ_a , ν_{of} , and σ_{gg} activities for material 8 and σ_a and σ_{gg} activities for materials 9 and 10.

The card configurations for cards ACMAT and ACTYP are as follows:

ACMAT1	/ / / 8 / / / 8 / / / 8 / / / 9 / / / 9 / / / 10 .
ACMAT2	/ / / 10 / 3 / / / / / / / / / / / / .
ACTYP1	/ / / 1 / / / 2 / / / 4 / / / 1 / / / 4 / / / 1 .
ACTYP2	/ / / 4 / 3 / / / / / / / / / / / / .

In this case ID3 = 7, the physical number of entries on cards ACMAT or ACTYP.

EXAMPLE THREE: Suppose there are three zones and they contain the following materials:

Zone No.	Material	Material No.
1	⁶ Li,D	9
2	²³⁵ U	10
3	⁶ Li,D	9

In order to print the activities for each zone a change must be made in identification or an error will occur. The activities in zones 1 and 3 will be different even though the materials are the same. Simply calling the identification number of the material in this case will not specify whether the activities of zone 1 or 3 are desired. The following card configuration is INCORRECT and will not operate correctly for this case (print σ_a activities for each zone):

INCORRECT CARD SETUP:

ACMAT	/ / / 9 / / / 10 / / / 9 / 3 / / / / / / .
ACTYP	/ / / 1 / / / 1 / / / 1 / 3 / / / / / / .

The correct manner for printing the activities for zones containing the same material is to first rename the material in zone 3 as number 11 even though it is the same as material 9. (Changes must occur on cards MIXMB, MIXMC, MIXMD, MZ, and variables MT, and MS must change.) After these changes have been made the correct card configuration for printing the σ_a activities for each zone are as follows:

Table B-IV. (Continued)

FOR Name	Card ID	Units	Inp fld	Explanation and examples
J3(75)				
J4(75)				
(cont.)				
CORRECT CARD SETUP:				
ACMAT	/ / /	9 / / /	10 / / /	11 / 3 / / / / / .
ACTYP	/ / /	1 / / /	1 / / /	1 / 3 / / / / / .

where ID3 = 3.

Add 2 blank cards at the end of the data set. If several data sets are stacked behind a single source deck, then 2 blank cards are placed after only the last data set.

END INPUT DATA

ORDER OF INPUT CARDS

The following table supplies the order of the input deck along with the conditions for removal of any specific card or cards. The order of the data deck is given in terms of the actual identification associated with the card and punched in columns 73 through 80 on the card.

Table B-V. Order of input deck.

Order of cards by card ID	Conditions for removal from deck
Source DTF deck	As compiled this deck will run on the IBM 7094 system. Appropriate monitor control cards should be included, along with the * CHAIN(1, 3) and * CHAIN(2, 3) cards and the * DATA card at the end of the source deck.
CARD 1	Always included
CARD 2	Always included
CARD 3	Always included
CARD 4	Always included
CARD 5	Always included
CARD 6	Always included
CARD 7	Always included
CARD 8	Always included
CARD 9	Always included
RADIUS	Always included
ZONENU	Always included
MZ	Always included
FISFRA	Always included
VELOC	Always included
W	Always included
D	Always included
FISSIO	Omit only if IFN = 1
FLUX	Omit only if IFN = 0
MIXMB	Always included

Table B-V. (Continued)

Order of cards by card ID	Conditions for removal from deck
MIXMC	Always included
MIXMD	Always included
RADMOD	Omit only if IEVT $\neq$ 4
DISSOR	Omit only if IQM = 0
SHELLI	Omit only if IPM = 0
SHELLA	Omit only if IPM = 0
DENSFAC	Omit only if IDFM = 0
NUCLNO	Omit only if MTP > 0
DIFMARK	Omit only if IDT = 0
GRSKIP	Omit only if IGS = 0
HANx, cross sections	Omit only if MCR = 0
ACMAT	Omit only if ID3 <u>and</u> ID4 = 0
ACTYP	Omit only if ID3 <u>and</u> ID4 = 0
2 blank cards	Omit only if data is stacked; place after last data set.

SPECIAL SECTION ON ANISOTROPIC MATERIALS

In the case where it is desired to place one or more anisotropic materials in an assembly, a special input procedure must be used. In general, the data deck will be in the same order as for the isotropic problem. When using anisotropic materials the following cards must be given special attention:

- CARD 2: control parameter ISCT must be -1
- CARD 5: parameters MS and MCR are recorded in the usual manner, where the two cross section sets for an anisotropic nuclide are considered as separate entities.
- CARD 6: control parameter MT must also include the fictitious material formed by the second cross section set entered for an anisotropic nuclide.
- MIXMB }
MIXMC: } the same characteristics apply; they have simply been rearranged.
MIXMD }

These items to which special attention must be given for the anisotropic case will be discussed individually below:

ISCT: The control parameter ISCT merely indicates that anisotropic scattering theory is to be used in the code. Depending on the value of ISCT a separate set of scattering equations is used. This parameter does NOT indicate to the code which of the materials is anisotropic or how to read in the cross section data. (ISCT = -1)

MS: (See page 198.) This parameter is still entered as the physical number of entries on either of the cards MIXMB, MIXMC, or MIXMD. Upon including an anisotropic material the configuration of cards MIXMB, MIXMC, and MIXMD is changed, however, the value for MS is arrived at in the same manner as the isotropic case.

MCR: (See page 198.) In the case of an anisotropic material an anisotropic nuclide must be supplied. In fact, this anisotropic nuclide has associated with it two sets of

cross sections which must be read in. These two sets are treated as separate cross section sets when entering them. MCR is still the physical number of cross section sets which are entered by cards. MCR is arrived at in the same manner as the isotropic case.

MT: (See page 200.) This parameter is the total of the number of nuclides used and the number of materials formed from these nuclides. It will be noted under the explanation of the cards MIXMB, MIXMC, and MIXMD that a fictitious material is formed from the second cross section set associated with the anisotropic nuclide. Although this material is not used explicitly in the code, it still must be given an identification number and also must be counted as a separate material in the determination of the parameter MT.

MZ: (See page 209.) As in the usual case card MZ contains a list of the materials by identification number to be used in the assembly. They are entered by zone, zone 1 first, etc. A material which contains an anisotropic nuclide is termed an anisotropic material. When the material identification number for this anisotropic material appears on card MZ in order to place it in the proper zone, a negative sign must precede the identification number. This will allow the anisotropic scattering equations to be used with the anisotropic materials. However, those materials which are isotropic in the same assembly will be unaffected and the usual isotropic scattering equations will apply to them.

MIXMB, MIXMC, MIXMD: (See page 214.) As stated above, two microscopic cross section sets are associated with each anisotropic nuclide. The two sets are labeled ANISO 1 and ANISO 2. When a nuclide having these anisotropic cross section sets is used—but it is desired that the nuclide be isotropic, a separate cross section set other than either ANISO 1 or ANISO 2 is used.

When a nuclide is to be used in its anisotropic form, both of the cross section sets ANISO 1 and ANISO 2 are placed in the data deck. They are treated as two separate entities and thus are each given a separate nuclide identification number according to the sequence in which they have been entered. Upon mixing the cross sections to form a material on card MIXMC, the set labeled ANISO 1 is used in the mixture which is to be termed anisotropic. Immediately following the mixture in which cross sections ANISO 1 appear, a separate fictitious material is formed in the usual manner using a control zero on card MIXMC and the identification number of the nuclide corresponding to the cross section set ANISO 2. Only that single cross section set ANISO 2 appears in this material. This fictitious material is also given a proper identification number which is in sequence with the other material identification numbers. On card MIXMB this fictitious material formed from cross sections ANISO 2 is assigned the appropriate material identification number which is next in sequence. Any other materials which are formed after this anisotropic material has been formed are combined in the usual manner by continuing on card MIXMC. The anisotropic material does not necessarily have to be the first one formed. It may be formed in any order on the card MIXMC. The only stipulation is that the fictitious material formed with the cross section set ANISO 2 must immediately follow

and be numbered in sequence the material in which cross section set ANISO 1 was placed. The material identification number associated with the material in which cross section set ANISO 1 appears is used on card MZ to place the anisotropic material in the proper zone.

On the card MIXMD the atomic densities of cross section sets ANISO 1 and ANISO 2 are exactly the same. It is the total atomic density of the anisotropic nuclide appearing in the material which is entered for each atomic density, NOT half that value for each.

NOTE: If two anisotropic materials are to be formed each containing a different anisotropic nuclide, in each case the fictitious material formed with the ANISO 2 portion of the cross section sets must appear immediately following that material which contains the respective ANISO 1 portion.

No investigation has been made in the case that an anisotropic material using two different anisotropic nuclides in combination is used. The configuration for the input cards MIXMB, MIXMC, and MIXMD is unknown.

EXAMPLE ONE: Consider a 2 zone assembly with a ^{239}Pu core and a CH_2 reflector. It is desired to use anisotropic hydrogen instead of isotropic hydrogen. Compare sample problems 600 and 602 (see SAMPLE PROBLEMS) for the difference in input. Problem 600 is the normal problem using isotropic hydrogen. Problem 602 is the identical problem with the only change that of using anisotropic hydrogen in the CH_2 .

Output

ORDER, UNITS, AND PHYSICS OF PRINT ITEMS

An explanation of what to expect and how to interpret items appearing on the printed output sheet is shown in Table B-VI. The output is explained in a similar manner to that of the input data deck. Many items may be printed but it is possible that some may not appear in the output because of the fact that they were not used in the program. The explanation of the output printings that follow will take every item in order of its possible appearance. For example, activity prints are possible although the programmer may not ask for this option in the actual problem he is running. Activity prints will be explained below in the proper order as they are called for in the program.

Most items that are printed have a title so that they may be identified. However, the titles need some explanation with respect to units and also the physics involved in obtaining the item. Each printed item will be explained below in the order of its appearance and by its title. The table below has the following explanations for its headings:

"ORD APP" gives the number of the order of appearance on the output sheet of the item in question. This is the relative order, only used for the purposes of this table. When several consecutive titles (see TITLE below) appear with the same number for the order of appearance, this means that they are side by side from left to right on the output sheet,

"TITLE" gives the actual printed title that appears on the output sheet,

"COMMENTS" gives explanations, units, and physics of the printed items under the corresponding title.

For a better understanding of the output sheet it is recommended that a sample problem (appearing under SAMPLE PROBLEMS in this report) be submitted and the printed output from this problem be used in conjunction with the following guide.

Table B-VI. Output parameters.

Ord app	Title	Comments
1	CARD 1	That which has been entered on CARD 1 is printed—at the top of a new page if "1" has been entered in the first digit of CARD 1.
2	CARD 2 through CARD 9	The control parameters on these cards are reproduced and listed in the order of their appearance. The actual FORTRAN name of each variable is printed alongside its value.
3	RADIUS nm	(Units, centimeters.) The number "nm" is the total number of radial points or entries. If the interpolate input option has been used, then the interpolation is performed and the actual values of these radial points are printed. The first point listed is the center, 0.0. In the same row the value to the right is the radius corresponding to spatial point 2 and the outer radius of interval 1, etc.

Radii are listed in the order:

$r_1 = 0.0, r_2, r_3, r_4, r_5, r_6, r_7$ etc.

4	ZONENU nm	The number "nm" is the total number of entries on the card ZONENU. This is a reproduction of the card ZONENU. If 10 intervals appear in zone 1, then the number "1" will appear 10 times from left to right on the page. If then 5 intervals appear in zone 2, the number "2" will appear five times: <div style="display: flex; justify-content: space-around; width: 100%;"> 1111111111 </div> <div style="display: flex; justify-content: space-around; width: 100%;"> 22222 </div>
5	MATNUM nm	The number "nm" is the total number of entries on card MZ. This is a reproduction of the card MZ. It gives the material identification number for each zone. If material 6 appears in zone 1 and material 7 in zone 2, then the numbers will be printed from left to right: <div style="display: flex; justify-content: space-around; width: 100%;"> 67 </div>
6	FISFRA nm	The number "nm" is the number of entries on the card FISFRA, or the number of energy groups. The fission fractions read from left to right beginning with the fission fraction for energy group 1, the highest energy group.

Table B-VI. (Continued)

Ord app	Title	Comments
7	VELOCI nm	(Units: cm/shake. 1 shake = 10^{-8} sec.) The number "nm" in the total number of entries on card VELOCI, or the number of energy groups. The velocities are entered beginning with velocity group 1 corresponding to the highest energy group and read from left to right beginning with velocity group 1.
8	W nm	The number "nm" is the total number of entries on card W. This is a reproduction of the card W, the weights corresponding to the S_n order. The weight for direction 1, corresponding to the direction cosine that is -1 is printed first with direction 2 weight printed immediately to the right, etc.
9	D nm	The number "nm" is the total number of entries on the card D. This is a reproduction of the card D, the direction cosines of the S_n order. Direction cosine for direction 1 is printed first and that for direction 2 immediately to the right, etc.
10	FISSIO nm	(Units: n/cc.) The number "nm" is the total number of entries on card FISSIO. One value is printed for each spatial interval, starting with spatial interval 1. Immediately to the right is the value for spatial interval 2, etc. This printing will not appear if IFN is 1. Instead the values for the FLUX will appear.
11	FLUX nm	(Units: n/cm ² -sec.) The number "nm" is the total number of entries on card FLUX. The fluxes are printed exactly as given on card FLUX. For energy group 1 the flux for interval 1 is printed, followed immediately to the right by the value for interval 2, etc. After fluxes for group 1 have been printed, then the flux for group 2, interval 1 is printed, immediately followed to the right by the flux for group 2 interval 2, etc. This printing will not appear if IFN is 0.
12	MIXMB nm	The number "nm" is the total number of entries on card MIXMB. This is a reproduction of the card MIXMB.
13	MIXMC nm	The number "nm" is the total number of entries on card MIXMC. This is a reproduction of the card MIXMC.
14	MIXMD nm	(Units: atoms/ 10^{24} -cc, or atoms-barn/cc.) The number "nm" is the total number of entries on card MIXMD. This is a reproduction of the card MIXMD.
15	RADMOD nm	Reproduction of input card RADMOD (only appears for IEVT = 4).
16	DISTSO nm	Reproduction of input card DISSOR (only appears for IQM = 1).
17	SHISOT nm	Reproduction of card SHELLI (only appears for IPM $\neq$ 0).
18	DENFAC nm	Reproduction of card SHELLA (only appears for IPM = 2).
19	DENFAC nm	Reproduction of card DENSFAC (only appears for IDFM = 1).
20	NUFRTH nm	Reproduction of card NUCLNO (only appears for MTP > 0).
21	IGT nm	Reproduction of card DIFMARK (only appears if IDT = 1).
22	IZI nm	Reproduction of card GRSKIP (only appears if IGS = 1).
23	No title	The first card or identification card at the beginning of each cross section card set for each nuclide is printed in the order that the nuclides are entered. This card is printed for each nuclide on tape as well as on cards.
24	RADIUS VOLUME AREA	(Units: cm, cc, cm ² .) Beneath these headings are listed the appropriate item. These radii are the same items entered and printed under item 3 above. In a vertical column the radii appear, one value for each spatial point. The volumes and areas correspond to

Table B-VI. (Continued)

Ord app	Title	Comments																				
24 (cont.)		<p>the radii. Each is a cumulative value. These radii, volumes, and areas correspond to initial dimensions as entered in the input. They are computed in the following manner:</p> <p><u>Radii:</u></p> <p>(i) $RA_{i+1} = R_{i+1}$ for IEVT = 0, 1, 2, or 3</p> <p>where RA = actual radius R = initial radius i = spatial point subscript.</p> <p>(ii) $RA_{i+1} = RA_i + (R_{i+1} - R_i) \cdot (1 + EV \cdot RM_k)$ for IEVT = 4</p> <p>where EV = eigenvalue RM = radial modifier k = zonal subscript.</p> <p>(iii) $RA_i = (R_i/R_{outer}) \cdot EV$ For IEVT = 5</p> <p>where R_{outer} = outermost radius of the assembly.</p> <p><u>Areas:</u></p> <p>(i) $AA_i = AF_m \cdot RA_i^2$ for spheres</p> <p>where AA = area AF = area factor m = geometry indicator.</p> <p>(ii) $AA_i = AF_m \cdot RA_i$ for cylinders</p> <p>(iii) $AA_i = AF_m$ for slabs</p> <p>where the geometry factors are as follows:</p> <table><tr><td>spheres</td><td>m = 3</td><td>4π</td></tr><tr><td>cylinders</td><td>m = 2</td><td>2π</td></tr><tr><td>slabs</td><td>m = 1</td><td>1</td></tr></table> <p><u>Volumes:</u></p> <p>$V_i = VF_m \cdot (AA_{i+1} \cdot RA_{i+1} - AA_i \cdot RA_i)$</p> <p>where V = volume elements VF = volume factor and the volume factors are</p> <table><tr><td>spheres</td><td>m = 3</td><td>$1/3$</td></tr><tr><td>cylinders</td><td>m = 2</td><td>$1/2$</td></tr><tr><td>slabs</td><td>m = 1</td><td>i</td></tr></table> <p>In a vertical column to the right of the area elements are located the corresponding spatial point numbers.</p>	spheres	m = 3	4π	cylinders	m = 2	2π	slabs	m = 1	1	spheres	m = 3	$1/3$	cylinders	m = 2	$1/2$	slabs	m = 1	i		
spheres	m = 3	4π																				
cylinders	m = 2	2π																				
slabs	m = 1	1																				
spheres	m = 3	$1/3$																				
cylinders	m = 2	$1/2$																				
slabs	m = 1	i																				
25	W D WD MR	<p>In vertical columns the S_n weights, direction cosines, and their products are printed corresponding to W, D, and WD, respectively. Immediately to the right of the products (WD) is a column of numbers referred to as the mirror reflection numbers. And then to the right of these mirror reflection numbers (MR) is a column which prints the direction numbers. For an S_4 calculation the last two columns are as follows:</p> <table><tr><td>5</td><td>1</td><td>MR</td><td>Note that the heading MR is displaced too far to the right.</td></tr><tr><td>5</td><td>2</td><td></td><td></td></tr><tr><td>4</td><td>3</td><td></td><td></td></tr><tr><td>3</td><td>4</td><td></td><td></td></tr><tr><td>2</td><td>5</td><td></td><td></td></tr></table> <p>By matching these numbers one can tell how the fluxes are reflected around the boundaries according to direction. In the above example</p>	5	1	MR	Note that the heading MR is displaced too far to the right.	5	2			4	3			3	4			2	5		
5	1	MR	Note that the heading MR is displaced too far to the right.																			
5	2																					
4	3																					
3	4																					
2	5																					

Table B-VI. (Continued)

Ord app	Title	Comments
25 (cont.)		<p>the right column of direction numbers might be thought of as the "receiving" column and the left column of mirror reflection numbers the "donating" column. The receiving column contains the number of the directions which must be assigned a value upon reaching a boundary. The directions 1, 2, and 3 are directed inward toward the center of the assembly and must be assigned values at the outer boundary. At the center of the assembly values have already been computed for these direction numbers. Thus by matching these two columns one sees that at the outer boundary the value of the flux at direction 5 is given to the inward directions 1 and 2. The outward value of the flux at 4 is likewise given to the directional flux at 3. The last two direction numbers (4 and 5) receive values at the center of the assembly. Directions 4 and 5 receive flux values from directions 3 and 2, respectively.</p> <p>The reflecting conditions on the inner and outer boundaries are independent of one another and both or either may occur. However, whether both, one, or none occur, these mirror reflection numbers are still printed. See IBL and IBR under Detailed Parameter Explanation with Examples for an explanation with diagrams.</p>
26	XKI XKE	<p>In a vertical column the fission fractions are printed under the heading XKI. These are the input fission fractions. Under the heading XKE are printed the modified fission fractions. The modified fission fractions are simply the input fission fractions divided by the parametric eigenvalue. (Recall that the parametric eigenvalue takes on the value of k_0 or α_0 for a search option.) Suppose a "critical" dimension search is called for with a k of 1.2. The parametric eigenvalue is $k_0 = 1.2$. The fission spectrum (fractions) is divided by 1.2, and the radius for a k of 1 is computed with these reduced fission fractions. This radius computed is just critical ($k = 1$) for the sealed down fission fractions. However, it corresponds to the radius of a supercritical system with $k = 1.2$ with the original unscaled fission fractions.</p> <p>To the right of column XKE is a column listing the energy group numbers corresponding to the fission fractions, 1 being the highest energy group.</p> <p>The last number in each column corresponding to energy group IGM + 1 is the sum of all the above values (fission fractions).</p>
27	MIX-NO MIX-COM DENSITY	<p>The vertical columns formed under these three headings are reproductions of cards MIXMB, MIXMC, and MIXMD respectively. The densities are listed in units atoms/10^{24}-cc. The column of numbers to the right of heading DENSITY is merely a consecutively numbered listing of the entries in the three columns.</p>
28	X-SECT MT nm	<p>(Units: barns or cm^{-1}.) The cross section tables for all the nuclides and materials are located here listed one after the other, each nuclide or material having this heading. The number "nm" indicates the identification number of the nuclide or the material (recall that they have been numbered consecutively). The cross section tables of the nuclides have the units barns and the cross sections of the materials have the units cm^{-1}. The printing arrangement for the cross section sets (both microscopic and macroscopic) is as follows. Starting with the first row and the first column and reading from left to right the cross sections are printed in the same manner in which they were entered on cards. The cross sections in the first row from left to right correspond to the cross sections for the first</p>

Table B-VI. (Continued)

Ord app	Title	Comments
28 (cont.)		<p>(highest) energy group. Then dropping down to the second row, from 1 left to right are the cross sections for the second energy group. The cross sections in each row from left to right correspond to the following order (where Σ is used for microscopic OR macroscopic cross sections, i.e., the order is the same for the nuclides and the materials):</p> $\Sigma_c, \nu_o \Sigma_f, \Sigma_{tr}, \Sigma_{g,g}, \Sigma_{g-1,g}, \Sigma_{g-2,g}, \Sigma_{g-3,g}, \Sigma_{g-4,g}, \Sigma_{g-5},$ <p>(This is the order for the standard library cross sections.)</p>
29	ID IC LC XMB(GP) EPS EQ EV XLA	<p>A row of values, one under each of these headings, is printed for each completed outer iteration. A column of these values will be printed for each outer iteration until the problem converges and terminates. By examining these successive numbers from outer iteration to outer iteration one can determine the rate of convergence and the path by which the problem converged. An explanation of the headings is as follows:</p> <p>ID—is the identification number of the problem entered as control parameter ID on CARD 2. It remains constant.</p> <p>IC—is the cumulative sum of outer iterations of the problem. The maximum number has been set by control parameter ICM of CARD 9.</p> <p>LC—is the cumulative sum of inner iterations of the problem. The maximum number has been set by control parameter IDM of CARD 7. The value IDM is the maximum value for a single group. The values LC corresponding to each outer iteration are the total number of iterations over all groups for that specific outer iteration.</p> <p>XNB(GP)^a—is the neutron balance over all groups for the problem. Ideally this value should be zero, which accounts for all neutrons.</p> <p>EPS—is the precision on the convergence of XLA which has been entered as control parameter EPS on CARD 4.</p> <p>EQ—is the derivative of the ratio of the desired eigenvalue to reactivity. It is a check of the rate of convergence of the problem and terminates the problem by the value EQL entered on CARD 8 when the solution is being approached asymptotically and thus little is gained by allowing the problem to continue to operate since very slight changes are occurring. Ideally upon convergence of a problem successive values of EQ should either be the same or change only very slightly. This means that the rate of change (convergence) is slow, i.e., asymptotic.</p> <p>EV—The latest successive value of the eigenvalue is printed here. In an eigenvalue calculation the number in the EV column is the eigenvalue being sought, i.e., it is k for a k calculation, the critical radius for a critical dimension calculation, and α for a time absorption calculation; with the units "no unit" centimeters, and 1/shake, respectively. Recall that a shake is 10^{-8} seconds.</p> <p>XLA—is a parameter which shows the rate of convergence of the problem. The precision on XLA is given by EPS. Ideally XLA will be unity for absolute convergence, however, when XLA is within EPS of unity the problem converges.</p>

^aThe neutron balance has units "neutrons" and is obtained by summing the following parameters: distributed source + fission source + In-scatter (change of energy) - net leakage (physical boundary) - absorption - slowing down.

Table B-VI. (Continued)

Ord app	Title	Comments																																										
29 (cont.)		NOTE: One more row of these values is printed later on under the heading *****FINAL PRINT***** along with their corresponding headings explained above. This last row is the row of values corresponding to those which the problem has converged upon.																																										
30	NEUTRON FLUX BY RADIUS AND DIRECTION, GROUP = nm	<p>These values are the directional or angular fluxes which have been computed by the S_n difference equations. The units are n/cm^2-sec. A separate table of these fluxes is printed for each energy group. The number "nm" indicates which energy group is printed below the heading. The fluxes are printed in columns starting with the fluxes at spatial point 1 at the top of each column and ending with the fluxes for spatial point IM+1 at the bottom of the vertical columns. The first column of numbers (under the word "NEUTRON" of the heading) is a list of the numbers corresponding to the spatial points, listed vertically from 1 through IM+1. The column immediately to the right of this column contains the angular fluxes for direction number 1 (direction cosine of -1; the inward angular ray). The value at the top of the column corresponds to the spatial point number 1, or is the flux at the center ($r=0.0$) of the assembly. The value at the bottom of the column corresponds to spatial point with number IM+1, which is the outer boundary of the assembly. The next vertical column to the right lists fluxes for direction number 2, etc.</p> <p>Note the following for an S_4 calculation: Output table configuration:</p> <p>NEUTRON FLUX BY RADIUS AND DIRECTION, GROUP = nm</p> <table><tr><td>1</td><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td></td></tr><tr><td>2</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>where a, b, c, d, e, v, w, x, y, and z</td></tr><tr><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>are angular flux values. Values a,</td></tr><tr><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>b, c, d, and e are for spatial point 1</td></tr><tr><td>IM</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>and directions 1, 2, 3, 4, 5, respec-</td></tr><tr><td>IM + 1</td><td>v</td><td>w</td><td>x</td><td>y</td><td>z</td><td>tively. Values v, w, x, y, and z are</td></tr></table> <p>For IBL = 0, d = e = 0.0 directions 1, 2, 3, 4, 5, respectively.</p> <p>For IBR = 0, v = w = x = 0.0</p> <p>For IBL = 1, b $\rightarrow$ e, c $\rightarrow$ d Recall that IBL controls the</p> <p>For IBR = 1, z $\rightarrow$ v, z $\rightarrow$ w, y $\rightarrow$ x inner boundary and IBR the</p> <p>For IBL = IBR = 2, e $\rightarrow$ a, v $\rightarrow$ z right.</p> <p>This table is followed by the neutron balance table for energy group 1, and then the angular flux table for energy group 2 is printed, followed by the neutron balance table for energy group 2, etc.</p>	1	a	b	c	d	e		2	.	.	.	.	.	where a, b, c, d, e, v, w, x, y, and z	.	.	.	.	.	.	are angular flux values. Values a,	.	.	.	.	.	.	b, c, d, and e are for spatial point 1	IM	.	.	.	.	.	and directions 1, 2, 3, 4, 5, respec-	IM + 1	v	w	x	y	z	tively. Values v, w, x, y, and z are
1	a	b	c	d	e																																							
2	.	.	.	.	.	where a, b, c, d, e, v, w, x, y, and z																																						
.	.	.	.	.	.	are angular flux values. Values a,																																						
.	.	.	.	.	.	b, c, d, and e are for spatial point 1																																						
IM	.	.	.	.	.	and directions 1, 2, 3, 4, 5, respec-																																						
IM + 1	v	w	x	y	z	tively. Values v, w, x, y, and z are																																						
31	BALANCE FOR GROUP nm	<p>The balance table for each energy group will follow the angular flux table for each group. This balance table consists of many items with the following headings: FIXED SOURCE, FISSION IN, IN SCATTER, SELF SCATTER, OUT SCATTER, ABS. NEUTRONS, NET LEAKAGE, TOTAL DENSITY, TOT. FLUX, NEUTRON BALANCE, ZONE NO., RIGHT FLUX, RIGHT FLOW, RIGHT CURRENT, RIGHT LEAKAGE, and FISSION DENSITY.</p> <p>The headings are listed from left to right on the output sheet, one row immediately following the other (2 rows). The values printed below these headings are printed in rows of two also, corresponding to the headings. The values listed in each set of two rows are those values corresponding to the material in the zone specified, i.e., see the zone number under the heading ZONE NO. The last set of two rows is the arithmetic sum of the appropriate values listed in those rows above. For example, if an assembly consists of 3 zones, there will be four entries of two rows each (for each energy group this table is printed). The fourth entry of two rows will contain the</p>																																										

Table B-VI. (Continued)

Ord app	Title	Comments
31 (cont.)		<p>arithmetic sums of those values in the other three entries of two rows each. The heading ZONE NO. in the last entry will also contain an arithmetic sum of the zone numbers above and will be $1 + 2 + 3 = 6$. Thus it is seen that some of the values in this last entry are somewhat useless since they are arithmetic sums. Care should be used in the interpretation of this last entry.</p> <p>The headings for this table listed above are explained below with the physics and units used when applicable:</p> <p>Definition of some symbols which applies to all variables explained below.</p> <p>i —the subscript for spatial intervals g —the subscript for energy groups n —the subscript for the direction numbers of the S_n constants imax —the spatial interval subscript corresponding to the maximum radius of the zone in question imin —the spatial interval subscript corresponding to the minimum radius of the zone in question N —the order of the S_n calculation, or ISN in the code.</p> <p>Note that for a steady state problem the units "n/sec" and "neutrons" have the same meaning.</p> <p>FIXED SOURCE (FS_g): $FS_g = \sum_{i=imin}^{imax} Q_{gi} \cdot V_i \quad \text{n/sec}$</p> <p>where FS_g —is the fixed source for group g (n/sec) Q_{gi} —is the distributed source for group g and spatial interval i (n/cc-sec) V_i —is the volume element for interval i (cc)</p> <p>FISSIONS IN (FI_g):</p> <p>regular theory: $FI_g = \sum_{i=imin}^{imax} V_i \cdot F_i \cdot XKE_g \quad \text{n/sec}$</p> <p>adjoint theory: $FI_g = \sum_{i=imin}^{imax} V_i \cdot F_i \cdot CE_{gi}$</p> <p>where CE_{gi} is the product $\nu\Sigma_f$ for the zone in question (1/cm). F_i is the fission density at interval i and XKE_g is the fission fraction for group g.</p> <p>INSCATTER (IS_g):</p> <p>shell source: $IS_g = ST_g - SS_g - FI_g - FS_g \quad \text{n/sec}$ no shell source: $IS_g = ST_g - SS_g - FI_g \quad \text{n/sec}$ where</p> <p>regular theory: $ST_g = \sum_{i=imin}^{imax} V_i (XNN_{gi} \cdot CS_{gi} + XKE_g \cdot F_i + SR_{gi})$</p>

Table B-VI. (Continued)

Ord app	Title	Comments
31 (cont.)	adjoint theory: $ST_g = \sum_{i=imin}^{imax} V_i (XNN_{gi} \cdot CS_{gi} + CF_{gi} \cdot F_i + SR_{gi})$	
	and $SR_{gi} = \begin{cases} 0.0 & \text{if no distributed source, } Q_{gi} \\ Q_{gi} & \text{if distributed source, } Q_{gi}, \text{ is present.} \end{cases}$	
	where SS_g is defined below	
	CS_{gi} are scattering cross sections (1/cm)	
	FI_g and FS_g are defined above.	
	XNN_{gi} are neutron fluxes (n/cm ² -sec)	
	SELF SCATTER (SS_g):	
	$SS_g = \sum_{i=imin}^{imax} V_i \cdot CSS_{gi} \cdot XNN_{gi} \text{ n/sec}$	
	where CSS_{gi} is the self scattering cross section for interval i (1/cm).	
	OUT SCATTER (OS_g): $OS_g = TR_g - SS_g - AB_g \text{ n/sec}$	
	where AB_g is defined below	
	$TR_g = \sum_{i=imin}^{imax} V_i \cdot CS_{gi} \cdot XNN_{gi} \text{ n/sec}$	
	CS_{gi} are upscattering and downscattering cross section terms (1/cm).	
	ABS. NEUTRONS (AB_g):	
	$AB_g = \sum_{i=imin}^{imax} V_i \cdot CA_{gi} \cdot XNN_{gi} \text{ n/sec}$	
	where CA_{gi} are absorption cross section terms (1/cm).	
	NET LEAKAGE (NL_g): $NL_g = RL_{gimax} - RL_{gimin} \text{ n/sec}$	
	or $NL_g = A_{imax} \sum_{i=imin}^{imax} XND_{g,imax,n} \cdot WD_n$	
	$- A_{imin} \sum_{i=imin}^{imax} XND_{g,imin,n} \cdot WD_n$	
	where $XND_{g,i,n}$ is the directional flux at position i for group g and for direction n (n/cm ² -sec)	
	A_i is the area on the radial surface at interval i (cm ²)	
	WD_n is the product of the direction cosines and the weights for direction number n for an S_n calculation.	

Table B-VI. (Continued)

Ord app	Title	Comments
31 (cont.)	<p>NOTE: The net leakage for the zone in question is computed by subtracting the leakage into the zone at the lowest value of the radius for the zone from the leakage out of the zone at the highest value of the radius for the zone.</p> <p>TOTAL DENSITY (TD_g):</p> $TD_g = \left(\sum_{i=imin}^{imax} V_i \cdot XNN_{gi} \right) / VE_g \quad \text{neutrons}$ <p>where VE_g is the velocity for energy group g (cm/shake)</p> <p>TOTAL FLUX (TF_g):</p> $TF_g = \sum_{i=imin}^{imax} V_i \cdot XNN_{gi} \quad \text{n-cm/sec}$ <p>NEUTRON BALANCE (NB_g):</p> $NB_g = FS_g + FI_g + IS_g - NL_g - AB_g - OS_g \quad \text{n/sec}$ <p>ZONE NO. (ZN):</p> <p>ZN = whichever zone is being considered. Under this heading the number of the zone which the two rows of values correspond to will appear. If the number is greater than the maximum number of zones in the problem, this means that the values of the corresponding two rows are the arithmetic sums of the values for all the other zones.</p> <p>RIGHT FLUX (RF_g):</p> $RF_g = \sum_{n=1}^{N+1} XND_{g,imax,n} \cdot WD_n \text{ n/cm}^2\text{-sec}$ <p>NOTE: This is the flux being emitted from the outermost radius of a zone. Thus only the directional fluxes at that outermost boundary are used for the calculation. Also since the sum is over all directions at that boundary, the value computed is a net value, including both negative and positive directions for the fluxes.</p> <p>W_n is a weight corresponding to direction n</p> <p>RIGHT FLOW (RFL_g):</p> $RFL_g = \sum_{n=\frac{N}{2}+1}^{N+1} XND_{g,imax,n} \cdot WD_n \text{ n/cm}^2\text{-sec}$ <p>NOTE: This is the flux of neutrons being directed away from the center of the assembly computed at the boundary or outermost radius of a zone. It is not a net value since only directional fluxes directed away from the center of the assembly are used. (The net value of this flow over all directions is found under RIGHT CURRENT below.)</p>	

Table B-VI. (Continued)

Ord app	Title	Comments
31 (cont.)		<p>RIGHT CURRENT (RC_g):</p> $RC_g = \sum_{n=1}^{N+1} XND_{g,imax,n} \cdot WD_n \quad n/cm^2\text{-sec}$ <p>NOTE: This is a net value since the sum is over all directions. Only the directional fluxes at the outermost boundary of the zone is used, seen by the interval subscript "imax."</p> <p>RIGHT LEAKAGE (RL_g): $RL_g = A_{imax} \cdot RC_g \quad n/sec$</p> <p>or $RL_g = A_{imax} \sum_{n=1}^{N+1} XND_{g,imax,n} \cdot WD_n \quad n/sec$</p> <p>NOTE: This value is a net value since it is a sum over all directions, n.</p> <p>FISSION DENSITY (FD_g):</p> $FD_g = \sum_{i=imin}^{imax} V_i \cdot XNN_{gi} \cdot CE_{gi} \quad n/sec$ <p>where CE_{gi} is the product of $\nu\Sigma_f$ (1/cm).</p> <p>Items 30 and 31 above are alternated until each of the two tables (explained under items 30 and 31) has been printed for each energy group. Immediately following this printout will be a table with the same heading as item 31. Only two rows of values will be found under the appropriate headings. The main heading for this table will say BALANCE FOR GROUP nm, where the number "nm" will be one more than the total number of energy groups being used in the problem. This set of values is the sum of the appropriate values (under each heading) over all spatial intervals and all energy groups. It is a total sum.</p>
32	No title	<p>The table which appears in this position on the printout sheet has no title, however various headings are placed above each vertical column of values for identification purposes. The headings are as follows: DIST SOURCE, FISS DENSITY, SCATT-IN, SELF-SCAT, NET LEAKAGE, ABSORBS, N-BALANCE, R-LEAKAGE, FISSION-NEUTRONS, NEUTRON DENSITY, and NEUTRON FLUX.</p> <p>This table is essentially a summary of the neutron balance table explained under item 31 above. A value for each of these headings is given for each energy group and the last value of each vertical column is the sum over all energy groups. Thus this value found in the last position of each vertical column is a sum over all spatial intervals and all energy groups. It may also be found in the table with the heading BALANCE FOR GROUP nm, where nm is IM + 1. The other values (for each energy group) of item 32 may be found in the balance tables for each group (item 31) in the last two rows of values representing the sum over all zones (which in turn is a sum over all intervals).</p> <p>The units and physics of the values under each heading are explained below:</p>

Table B-VI. (Continued)

Ord app	Title	Comments
32 (cont.)		DIST SOURCE (n/sec): see FIXED SOURCE FISS DENSITY (n/sec): see FISSIONS IN SCATT-IN (n/sec): see INSCATTER SELF-SCATT (n/sec): see SELF SCATTER NET LEAKAGE (n/sec): see NET LEAKAGE ABSORBS (n/sec): see ABSORPTION N BALANCE (n/sec): see NEUTRON BALANCE R LEAKAGE (n/sec): see RIGHT LEAKAGE FISSION NEUTRONS (n/sec): see FISSION DENSITY NEUTRON DENSITY (neutrons): see TOTAL DENSITY NEUTRON FLUX (n-cm/sec): see TOTAL FLUX
		} under item 31 above
33	***FINAL PRINT***	The final row of values under item 29 is printed. The headings listed under item 29 are also printed so that the values printed may be easily identified. The eigenvalue (EV) in this line is the final eigenvalue on which the program has converged for the problem. See item 29 for an explanation of the headings.
34	ZONE FINAL RADII RAV FISSIONS VOLUME	The units for these headings are "no units," centimeters, centimeters, n/cm ³ -sec, and cm ³ , respectively. The items listed under each of these headings are explained below: ZONE: In a vertical column the identification number of the zone will be repeated for each spatial point in the zone up to but not including the spatial point which is the outermost boundary of that zone. This outermost point of the first zone will mark the lower boundary of the next zone and thus the number corresponding to the next zone will appear in this position. FINAL RADII: These values are listed vertically and correspond to the radii for each spatial point of the assembly. If a critical dimension or zone thickness search has been called for, these radii are the final dimensions of the assembly. These may be different from the initial input radii in the case of an option which changes the original input dimensions. RAV: These are the radii of the center points of the intervals corresponding to the final assembly dimensions. They are merely arithmetic averages of the consecutive radii appearing under the heading FINAL RADII in the column to the left. The center points of the intervals are computed in the following manner: $RAV_i = \frac{1}{2} \cdot (RA_{i+1} + RA_i)$ where RAV = center point of the interval RA = actual radii i = spatial point subscript FISSIONS: (Units: n/cm ³ -sec.) The values for the fissions are given for each spatial interval and thus correspond to the average radii (RAV) in the column to the left. VOLUME: (Units: cm ³ .) The values for the volumes are cumulative values which are values for the sum of volume of all intervals up to and including the one for which the value is listed, i.e., the value listed for interval 3 is the total volume of intervals 1, 2 and 3.
35	ENERGY GROUP nm	The scalar fluxes are printed for each spatial interval. There is a separate table for each energy group, the number "nm" indicating which energy group fluxes follow. Units: n/cm ² -sec.

Table B-VI. (Continued)

Ord app	Title	Comments
35 (cont.)		<p>For each energy group the fluxes are printed by row. The value for spatial interval one is followed by the value for spatial interval two to the right. To the right of that value is the value for spatial interval 3, etc.</p> <p>The FORTRAN name for the scalar fluxes is XN_{gi}.</p> <p>N. B. To obtain $Q(E)dE$ divide XN_{gi} by Eg.</p>
36	ACTIVITIES BY ZONE	<p>(Units: n/sec.) The control parameter ID3 on CARD 9 of the input data deck is the trigger for the printing of the activities by zone. The type of activity and the zone for which the activity is to be printed are specified by cards ACMAT and ACTYP of the input data deck (see ACMAT and ACTYP explanation under Detailed Parameter Explanation with Examples).</p> <p>On a single line the number of the zone will be printed, followed by the activities specified on cards ACMAT and ACTYP and also in the same order as specified on these cards. The values are printed by row and follow from left to right in the order given on cards ACMAT and ACTYP. The places on the printout sheet which correspond to activities of a material in zone two are replaced by a zero under the heading of activities for zone one. Next a heading is printed for zone 2, the number 2. The activities for the material in zone 2 follow, but a zero appears in those places under zone 2 where activities were printed under zone 1. See a sample problem for clarification.</p> <p>The activities by zone are computed by the following relationship:</p> $ACZ_k = \sum_{g=1}^{IGM} \sum_{i=imin}^{imax} XN_{gi} \cdot V_i \cdot C_{gi} \quad \text{n/sec}$ <p>where</p> <ul style="list-style-type: none"> k is the zone subscript i is the interval subscript g is the group index XN_{gi} is the scalar fluxes printed in item 35 above V_i is the volume element of interval i (cc) C_{gi} is the macroscopic cross section corresponding to the activity type desired. See cards ACMAT and ACTYP under Detailed Parameter Explanation with Examples. (1/cm) IGM is the maximum number of energy groups being used imin is the interval number corresponding to the lowest space point of the zone; the lower zone boundary imax is the interval number corresponding to the highest space point of the zone; the highest zone boundary. <p>It is to be noted that after the desired activities have been printed for each zone, each set of activities is labeled by the number of the zone followed by the appropriate activities, another set of values will be printed. This set will have the number IZM + 1 as a heading. The values that follow this number are the arithmetic sums of the corresponding values above.</p>
37	ACTIVITIES BY INTERVAL	<p>(Units: n/cc-sec.) The printing of these activities is done in the same manner as the activities by zone above. The format is also the same. The only difference is that values will appear for each spatial interval instead of a value for each zone. The appropriate</p>

Table B-VI. (Continued)

Ord app	Title	Comments
37 (cont.)		<p>interval number is first printed on a line of its own and is followed by the activity values called for on cards ACMAT and ACTYP.</p> <p>The following relationship is used to compute the activities by interval:</p> $ACI_i = \sum_{g=1}^{IGM} XN_{gi} \cdot C_{gi} \quad \text{n/cc-sec}$ <p>where i is the interval subscript g is the group subscript XN_{gi} is the scalar fluxes printed in item 35 above C_{gi} is the appropriate macroscopic cross section for the type of activity desired (1/cm) (in the case of fission activity this is the product $\nu\Sigma_f$) IGM is the number of energy groups being used</p> <p>This print option is controlled by the parameter ID4.</p> <p>TERMINATION OF PRINT OPTIONS</p>

ERROR MESSAGES

Throughout the code are various checks for inconsistencies. Most of these checks have to do with the input data. The control parameters listed on cards 1 through 9 indicate what types of data are required in the following data deck and how much is required. If the proper amount is not supplied an error will occur and one of the error messages will be printed. The message will include the name of the subroutine in which the error occurs and the statement number within the subroutine. The error messages are as follows:

Table B-VII. Error messages.

Subroutine	Statement number	Explanation
REAG	9	Incorrect number of input items
REAI	5	Attempting to interpolate between integers
RECS	10	Nuclide requested not on tape or nuclide numbers out of order
S804	8	Incorrect direction cosines
S804	14	Angular ray index exceeds maximum
S804	20	Incorrect angular weights
S810	16	Negative final radius for zone thickness search option
S810	41	Zero radius at other than midpoint
S810	51	Two successive equal radii
S811	16	Incorrect volume fractions
S813	9	No fixed source for inhomogeneous solution
S813	12	No parametric eigenvalue for fixed reactivity option
S813	20	Zero group velocity
S814	18	No distributed source
S815	27	No shell source

Table B-VII. (Continued)

Subroutine	Statement number	Explanation
S822	29	No distributed source or fission sum
S822	34	No fission sum
S841	6	Neutron balance for the group is larger than epsilon for the group (make EPS larger and try again)
S842	24	Left boundary condition not specified

DTF Data Sheet

Problem ID 100

Date _____

Type of Calculation SAMPLE K CALCULATION

Zone Radii	cm	No. Zones = 2 #
$r_0 = 0.0$		$r_9 =$
$r_1 = 25.4$		$r_{10} =$
$r_2 =$		$r_{11} =$
$r_3 =$		$r_{12} =$
$r_4 =$		$R = 39.9$
$r_5 =$		Spherical, 2 zone assembly known to be critical at $r_1 = 25.4$ cm $R = 39.9$ cm 16 group, S_4
$r_6 =$		
$r_7 =$		
$r_8 =$		

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24} cc)													
Nuclides and Materials	ID No	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
N	1	0 00003444											
O	2	0 00000753											
U235y	3		0 007879										
U238y	4		0 03111										
Mo	5 *		0 01073										
AIR	6	X											
U-Mo	7 +		X										
	8												
	9												
	10												
	11			Air — 20-80 mixture of O-N									
	12			U-Mo — 10-90 mixture of Mo-U									
	13			<div> <div>10 w/o Mo</div> <div>18 w/o U235</div> <div>72 w/o U238</div> </div> <div> <div>U-Mo (10)</div> <div>$\rho = 17.08$ g/cc</div> </div>									
	14												
	15												
	16												
	17			* MCR = 5									
	18			+ MT = 7									
	19			$\pm$ IM = 40									
	20			# IZM = 2									
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID	
SAMPLE		REACTIVITY		PROBLEM		ID = 100												CARD 1
ID	100		ITH	0		ISCT	1		ISN	4		IGE	3		IBL	1	CARD 2	
IBR	0		IZM	2		IM	40		IFN	0		IEVT	1		EV	0.0	CARD 3	
EVM	0.0		EPS	0.0001		IGM	16		IHT	3		IHS	4		IHM	9	CARD 4	
BF	0.0		DY	0.0		DZ	0.0		MS	7		MCR	5		MTP	0	CARD 5	
MT	7		IDFM	0		DFMI	0.0		DFM2	0.0		XNF	1.0		IPVT	0	CARD 6	
PV	0.0		IQM	0		IPM	0		IPP	0		FXM	0.0		IIM	20	CARD 7	
IGS	0		RYF	0.5		XLAL	0.1		XLAH	0.5		EQL	0.005		XNPM	1.0	CARD 8	
IDI	1		ID2	3		ID3	8		ID4	1		ICM	100		IDT	0	CARD 9	
2	19	0.0	2	19	25.4		39.9	3									RADIUS $\frac{1}{2}$	
1	20		1	20	2	3											ZONENU	
		6			7	3											MZ	
Standard 16 Group																	FISFRA AND VELOC	
S ₄ Calculation																	W AND D	
1	40	1.0	3														FISSIO OR FLUX	
		6			6		6		7			7				7	MIXMB $\frac{1}{2}$	
		7	3														$\frac{3}{4}$	
		0			1		2		0			3				4	MIXMC $\frac{1}{2}$	
		5	3														$\frac{3}{4}$	
		0.0			0.00003441		0.00000753		0.0			0.007879			0.03111		MIXMD $\frac{1}{2}$	
		0.01073	3														$\frac{3}{4}$	
																	RADMOD	
																	DISSOR	
																	SHELL I	
																	SHELLA	
																	DENSFAC	
																	NUCLNO	
																	DIFMARK	
																	GRSKIP	
Cross Section Data Sets Are Entered Here																	XSEC	
		6			6		6		6			7				7	ACMAT $\frac{1}{2}$	
		7			7	3											$\frac{3}{4}$	
		1			2		3		4			1				2	ACTYP $\frac{1}{2}$	
		3			4	3											$\frac{3}{4}$	

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 200

Date _____

Type of Calculation TIME ABSORPTION
CALCULATION

Zone Radii cm No. Zones = 1 #

$r_0 = 0.0$	$r_9 =$
$r_1 =$	$r_{10} =$
$r_2 =$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R = 8.738$
$r_5 =$	
$r_6 =$	
$r_7 =$	
$r_8 =$	

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24} cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
U235y	1	0.04493											
U238y	2 *	0.00299											
Oy	3 +	X											
	4												
	5												
	6												
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

* MCR = 2
 $\pm$ IM = 20
+ MT = 3
IZM = 1

4		12	13	16		24	25	29		36	37	40		48	49	52		60	61	64		72	CARD ID
SAMPLE		PROBLEM		TIME		ABSORPTION		ID = 200														CARD 1	
ID		ITH		ISCT		ISN		IGE		IBL												CARD 2	
200		0		1		4		3		1												CARD 3	
IBR		IZM		IM		IFN		IEVT		EV												CARD 4	
0		1		20		0		2		0.0												CARD 5	
EVM		EPS		IGM		IHT		IHS		IHM												CARD 6	
-0.01		0.0001		16		3		4		9												CARD 7	
BF		DY		DZ		MS		MCR		MTP												CARD 8	
0.0		0.0		0.0		3		2		0												CARD 9	
MT		IDFM		DFMI		DFM2		XNF		IPVT												CARD 10	
3		0		0.0		0.0		1.0		0												CARD 11	
PV		IQM		IPM		IPP		FXM		IIM												CARD 12	
0.0		0		0		0		0.0		20												CARD 13	
IGS		RYF		XLAL		XLAH		EQL		XNPM												CARD 14	
0		0.5		0.1		0.5		0.005		0.75												CARD 15	
IDI		ID2		ID3		ID4		ICM		IDT												CARD 16	
1		2		0		0		200		0												CARD 17	
2	19	0.0		8.738	3																	RADIUS $\frac{1}{2}$	
1	20		1	3																		ZONENU	
			3	3																		MZ	
					Standard 16 Group																FISFRA AND VELOC		
					S ₄ Calculation																W AND D		
1	20	1.0	3																			FISSIO OR FLUX	
			3		3			3	3													MIXMB $\frac{1}{2}$	
																						$\frac{3}{4}$	
			0		1			2	3													MIXMC $\frac{1}{2}$	
																						$\frac{3}{4}$	
																						MIXMD $\frac{1}{2}$	
																						$\frac{3}{4}$	
																						RADMOD	
																						DISSOR	
																						SHELL I	
																						SHELL A	
																						DENSFAC	
																						NUCLNO	
																						DIFMARK	
																						GRSKIP	
					Cross Section Data Sets Are Entered Here																XSEC		
																						ACMAT $\frac{1}{2}$	
																						$\frac{3}{4}$	
																						ACTYP $\frac{1}{2}$	
																						$\frac{3}{4}$	

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 400

Date _____

ZONE SEARCH

Type of Calculation CALCULATION

Zone Radii cm No. Zones = 2 #

$r_0 = 0.0$	$r_9 =$
$r_1 = 25.4$	$r_{10} =$
$r_2 =$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R = 47.8$
$r_5 =$	Spherical, 2 zone assembly known to be critical at $r_1 = 25.4$ cm $R = 39.9$ cm 16 gr, S_4 .
$r_6 =$	
$r_7 =$	
$r_8 =$	

Only dimension of zone 2 allowed to vary.

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24} cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
N	1	0.00003444											
O	2	0.00000753											
U235y	3		0.007879										
U238y	4		0.03111										
Mo	5 *		0.01073										
AIR	6	X											
U-Mo	7 +		X										
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

Air — 20-80 mixture of O-N
U-Mo — 10-90 mixture of Mo-U10 w/o Mo } U-Mo (10)
18 w/o U235 } $\rho = 17.08$ g/cc
72 w/o U238 }

* MCR = 5

+ MT = 1

± IM = 40

IZM = 2

1	4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID
SAMPLE		PROBLEM			ZONE		SEARCH			ID = 400						CARD 1		
ID	400			ITH	0		ISCT	1		ISN	4		IGE	3		IBL	1	CARD 2
IBR	0			IZM	2		IM	40		IFN	0		IEVT	4		EV	00	CARD 3
EVM	-01			EPS	00001		IGM	16		IHT	3		IHS	4		IHM	9	CARD 4
BF	00			DY	00		DZ	00		MS	7		MCR	5		MTP	0	CARD 5
MT	7			IDFM	0		DFMI	00		DFM2	00		XNF	10		IPVT	0	CARD 6
PV	00			IQM	0		IPM	0		IPP	0		FXM	00		IIM	20	CARD 7
IGS	0			RYF	05		XLAL	01		XLAH	05		EQL	0005		XNPM	10	CARD 8
IDI	1			ID2	3		ID3	0		ID4	0		ICM	100		IDT	0	CARD 9
2	19	00		2	19	25 4		47 8	3									RADIUS $\frac{1}{2}$
1	20		1	1	20	2	3											ZONENU
		6				7	3											MZ
Standard 16 Group																		FISFRA AND VELOC
S ₄ Calculation																		W AND D
1	40	10	3															FISSIO OR FLUX
		6			6			6		7			7			7		MIXMB $\frac{1}{2}$
		7	3															$\frac{3}{4}$
		0			1			2		0			3			4		$\frac{1}{2}$
		5	3															MIXMC $\frac{1}{2}$
																		$\frac{3}{4}$
	00			000003444			000000753		00			0007879		003111				MIXMD $\frac{1}{2}$
	001073	3																$\frac{3}{4}$
	00			10	3													RADMOD
																		DISSOR
																		SHELLI
																		SHELLA
																		DENSFAC
																		NUCLNO
																		DIFMARK
																		GRSKIP
Cross Section Data Sets Are Entered Here																		XSEC
																		ACMAT $\frac{1}{2}$
																		$\frac{3}{4}$
																		ACTYP $\frac{1}{2}$
																		$\frac{3}{4}$

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 500

Date _____

SAMPLE CRITICAL
DIMENSION

Type of Calculation _____

Zone Radii cm No. Zones = 2 #

$r_0 = 0.0$	$r_9 =$
$r_1 = 30.48$	$r_{10} =$
$R = r_2 = 47.88$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R =$
$r_5 =$	Spherical, 2 zone assembly known to be critical at $r_1 = 25.4$ cm $R = 39.9$ cm
$r_6 =$	
$r_7 =$	
$r_8 =$	

16 group, S_4

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24} cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
N	1	0 00003444											
O	2	0 00000753											
U235y	3		0 007879										
U238y	4		0 031111										
Mo	5*		0 01073										
AIR	6	X											
U-Mo(10)	7+		X										
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

Air ~ 20-80 mixture of O-N
U-Mo ~ 10-90 mixture of Mo-U

* MCR = 5

+ MT = 7

± IM = 40

IZM = 2

4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID
1	SAMPLE		CRITICAL		DIMENSION		PROBLEM		ID = 500								CARD 1
	ID 500		ITH 0		ISCT 1		ISN 4		IGE 3						IBL 1		CARD 2
	IBR 0		IZM 2		IM 40		IFN 0		IEVT 5						EV 47.88		CARD 3
	EVM 1.0		ESP 0.0001		IGM 16		IHT 3		IHS 4						IHM 9		CARD 4
	BF 0.0		DY 0.0		DZ 0.0		MS 7		MCR 5						MTP 0		CARD 5
	MT 7		IDFM 0		DFMI 0.0		DFM2 0.0		XNF 1.0						IPVT 1		CARD 6
	PV 1.00		IQM 0		IPM 0		IPP 0		FXM 0.0						IIM 20		CARD 7
	IGS 0		RYF 0.5		XLAL 0.1		XLAH 0.5		EQL 0.005						XNPM 1.0		CARD 8
	IDI 1		ID2 3		ID3 8		ID4 1		ICM 100						IDT 0		CARD 9
2	19	0.0	2	19	30.48		47.88	3									RADIUS $\frac{1}{2}$
1	20		1	20	2	3											ZONENU
			6		7	3											MZ
							Standard 16 Group										FISFRA AND VELOC
							S ₄ Calculation										W AND D
1	40	1.0	3														FISSIO OR FLUX
			6		6		6		7		7		7		7		MIXMB $\frac{1}{2}$
			7	3													$\frac{3}{4}$
																	$\frac{3}{4}$
			0		1		2		0		3		4		4		MIXMC $\frac{1}{2}$
			5	3													$\frac{3}{4}$
	0.0			0.0003444		0.0000753		0.0		0.007879		0.03111					MIXMD $\frac{1}{2}$
	0.01073	3															$\frac{3}{4}$
																	RADMOD
																	DISSOR
																	SHELLI
																	SHELLA
																	DENSFAC
																	NUCLNO
																	DIFMARK
																	GRSKIP
							Cross Section Data Sets Are Entered Here										XSEC
			6		6		6		6		7		7		7		ACMAT $\frac{1}{2}$
			7		7	3											$\frac{3}{4}$
																	$\frac{3}{4}$
			1		2		3		4		1		2		2		ACTYP $\frac{1}{2}$
			3		4	3											$\frac{3}{4}$

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 501

Date _____

SAMPLE CRITICAL
DIMENSION

Type of Calculation _____

Zone Radii	cm	No. Zones = 1#
$r_0 = 0.0$		$r_9 =$
$r_1 = 7.8$		$r_{10} =$
$r_2 =$		$r_{11} =$
$r_3 =$		$r_{12} =$
$r_4 =$		$R =$
$r_5 =$		
$r_6 =$		
$r_7 =$		
$r_8 =$		

Spherical, 1 zone,
bare 239Pu Critical
radius of bare 239Pu
+ 240Pu assembly is
 ~ 5.0 cm (~ 10 kg).

16 gr., S_4

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24}cc)													
Nuclides and Materials	ID No	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
Pu 239	1 *	0.049295											
Pu 240	2 +	X											
	3												
	4												
	5												
	6												
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

* MCR = 1
+ MT = 2
 $\pm$ IM = 30
IZM = 1

Although the critical dimension is close to
5.0 cm, the radius has purposely been set
equal to 7.8 cm to test the convergence
Thus first eigenvalue guess is 7.8 cm

4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID
1 SAMPLE		CRITICAL			DIMENSION			PROBLEM			ID = 501					CARD 1	
ID	501		ITH	0		ISCT	1		ISN	4		IGE	3		IBL	1	CARD 2
IBR	0		IZM	1		IM	30		IFN	0		IEVT	5		EV	7.8	CARD 3
EVM	1.0		ESP	0.0001		IGM	16		IHT	3		IHS	4		IHM	9	CARD 4
BF	0.0		DY	0.0		DZ	0.0		MS	2		MCR	1		MTP	0	CARD 5
MT	2		IDFM	0		DFM1	0.0		DFM2	0.0		XNF	1.0		IPVT	1	CARD 6
PV	1.0		IQM	0		IPM	0		IPP	0		FXM	0.0		IIM	20	CARD 7
IGS	0		RFY	0.5		XLAL	0.1		XLAH	0.5		EQL	0.005		XNPM	1.0	CARD 8
IDI	1		ID2	2		ID3	4		ID4	1		ICM	100		IDT	0	CARD 9
2	29	0.0		7.8	3												RADIUS $\frac{1}{2}$
1	30		1	3													ZONENU
			2	3													MZ
						Standard 16 Group										FISFRA AND VELOC	
						S ₄ Calculation										W AND D	
1	30	1.0	3														FISSIO OR FLUX
			2		2	3											MIXMB $\frac{1}{2}$
																	$\frac{3}{4}$
			0		1	3											$\frac{1}{2}$
																	$\frac{3}{4}$
																	$\frac{1}{2}$
																	$\frac{3}{4}$
																	MIXMD
																	$\frac{1}{2}$
																	$\frac{3}{4}$
																	$\frac{1}{2}$
																	$\frac{3}{4}$
																	RADMOD
																	DISSOR
																	SHELLI
																	SHELLA
																	DENSFAC
																	NUCLNO
																	DIFMARK
																	GRSKIP
					Cross Section Data Sets Are Entered Here										XSEC		
			2		2		2		2	3							ACMAT $\frac{1}{2}$
																	$\frac{3}{4}$
																	$\frac{1}{2}$
			1		2		3		4	3							ACTYP $\frac{1}{2}$
																	$\frac{3}{4}$
																	$\frac{1}{2}$
																	$\frac{3}{4}$

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 600

Date _____

REACTIVITY
CALCULATION

Type of Calculation _____

Zone
Radii cm

No. Zones = 2 #

$r_0 = 0.0$	$r_9 =$
$r_1 = 3.32175$	$r_{10} =$
$r_2 =$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R = 4.8385$
$r_5 =$	Spherical 2 zone, reflected assembly k unknown. Isotropic hydrogen is used.
$r_6 =$	
$r_7 =$	
$r_8 =$	

Atomic Densities of Nuclides in Each Zone (atoms / 10 ²⁴ cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
Pu239	1	0.049295											
H	2		0.07901										
C	3*		0.039505										
Pu239	4	X											
CH ₂	5+		X										
	6												
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

	4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID	
1	SPECIAL			SAMPLE			PROBLEM			FOR VACUUM			INPUT			ID = 600			CARD 1
	ID	600		ITH	0		ISCT	1		ISN	4		IGE	3		IBL	1	CARD 2	
	IBR	1		IZM	2		IM	50		IFN	0		IEVT	1		EV	0.0	CARD 3	
	EVM	0.0		EPS	0.0001		IGM	16		IHT	3		IHS	4		IHM	9	CARD 4	
	BF	0.0		DY	0.0		DZ	0.0		MS	5		MCR	3		MTP	0	CARD 5	
	MT	5		IDFM	0		DFMI	0.0		DFM2	0.0		XNF	1.0		IPVT	0	CARD 6	
	PV	0.0		IQM	0		IPM	0		IPP	0		FXM	0.0		IIM	20	CARD 7	
	IGS	0		RYF	0.5		XLAL	0.1		XLAH	0.5		EQL	0.005		XNPM	1.0	CARD 8	
	IDI	1		ID2	3		ID3	0		ID4	0		ICM	100		IDT	0	CARD 9	
2	19	0.0		2	29	332175		1.8385	3									RADIUS $\frac{1}{2}$	
1	20		1	1	30	2	3											ZONENU	
			4			5	3											MZ	
								Standard 16 Group										FISFRA AND VELOC	
								S ₄ Calculation										W AND D	
1	50	1.0		3														FISSIO OR FLUX	
			4		4		5		5		5	3						MIXMB $\frac{1}{2}$	
																		$\frac{3}{4}$	
			0		1		0		2		3	3						MIXMC $\frac{1}{2}$	
																		$\frac{3}{4}$	
	0.0				0.049295		0.0		0.07901		0.039505	3						MIXMD $\frac{1}{2}$	
																		$\frac{3}{4}$	
																		RADMOD	
																		DISSOR	
																		SHELLI	
																		SHELLA	
																		DENSFAC	
																		NUCLNO	
																		DIFMARK	
																		GRSKIP	
								Cross Section Data Sets Are Entered Here										XSEC	
																		ACMAT $\frac{1}{2}$	
																		$\frac{3}{4}$	
																		ACTYP $\frac{1}{2}$	
																		$\frac{3}{4}$	

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 601

Date _____

REACTIVITY
CALCULATION

Type of Calculation _____

Zone Radii cm No. Zones = 3 #

$r_0 = 0.0$	$r_9 =$
$r_1 = 3.32175$	$r_{10} =$
$r_2 = 4.02175$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R = 5.53850$
$r_5 =$	
$r_6 =$	
$r_7 =$	
$r_8 =$	

This problem is the same as problem 601 with a 0.7 cm vacuum inserted between the ^{239}Pu and CH_2 . Only necessary changes from 600 are listed on next page.

Atomic Densities of Nuclides in Each Zone (atoms/ 10^{24}cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
Pu 239	1	0.049295											
H	2		1.0	0.07901									
C	3*			0.039505									
Pu 239	4	X											
CH ₂	5			X									
H	6+		X										
	7												
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

H was arbitrarily placed in zone 2 with an atom density of unity — also arbitrarily chosen. A material must be placed there to begin the problem. However, the density factors for all intervals in zone 2 will be set equal to zero. The cross sections will be multiplied by the zero density factors (only in zone 2) and thus the material acts as a perfect void. Density factors of unity must be supplied for all other intervals, i.e., those for zones 1 and 3, in order for these materials to act in a normal manner.

ONLY CHANGES NECESSARY IN PRODUCING THIS VACUUM CONDITION FROM PROBLEM 600 ARE LISTED ON THE FOLLOWING DATA PAGE.

* MCR = 3
+ MT = 6
± IM = 55
IZM = 3

	4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID
I	SPECIAL			SAMPLE		PROBLEM			VACUUM		INSERTED		ID=60I					CARD 1
	ID 601			ITH		ISCT			ISN		IGE		IBL					CARD 2
	IBR			IZM 3		IM 55			IFN		IEVT		EV					CARD 3
	EVM			EPS		IGM			IHT		IHS		IHM					CARD 4
	BF			DY		DZ			MS 7		MCR		MTP					CARD 5
	MT 6			IDFM 1		DFMI			DFM2		XNF		IPVT					CARD 6
	PV			IQM		IPM			IPP		FXM		IIM					CARD 7
	IGS			RYF		XLAL			XLAH		EQL		XNPM					CARD 8
	IDI			ID2 4		ID3			ID4		ICM		IDT					CARD 9
2	19	0.0		2 04 3.32175		2 29 4.02175			5.63850	3								RADIUS $\frac{1}{2}$
1	20		1	1 05	2	1 30	3	3										ZONENU
			4		6		5	3										MZ
																		FISFRA AND VELOC
																		W AND D
1	55	1.0		3														FISSIO OR FLUX
			4		4		5		5		5		6					MIXMB $\frac{1}{2}$
			6	3														$\frac{3}{4}$
			0															$\frac{3}{4}$
			2	3		1	0		2		3		0					MIXMC $\frac{1}{2}$
																		$\frac{3}{4}$
	0.0			0.049295		0.0			0.07901		0.039505		0.0					MIXMD $\frac{1}{2}$
	1.0		3															$\frac{3}{4}$
																		RADMOD
																		DISSOR
																		SHELLI
																		SHELLA
1	20	1.0	1	05 0.0	1	30 1.0	3											DENSFAC
																		NUCLNO
																		DIFMARK
																		GRSKIP
																		XSEC
																		ACMAT $\frac{1}{2}$
																		$\frac{3}{4}$
																		ACTYP $\frac{1}{2}$
																		$\frac{3}{4}$

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

DTF Data Sheet

Problem ID 602

Date
REACTIVITY
CALCULATION

Type of Calculation

Zone Radii cm No. Zones = 2#

$r_0 = 0.0$	$r_9 =$
$r_1 = 3.32175$	$r_{10} =$
$r_2 =$	$r_{11} =$
$r_3 =$	$r_{12} =$
$r_4 =$	$R = 4.8385$
$r_5 =$	This is the same as problem 600, however, the CH_2 is anisotropic. For anisotropic cross sections ISCT must be -1.
$r_6 =$	
$r_7 =$	
$r_8 =$	

Atomic Densities of Nuclides in Each Zone (atoms / 10^{24} cc)													
Nuclides and Materials	ID No.	Zone											
		1	2	3	4	5	6	7	8	9	10	11	12
Pu 239	1	0.049295											
H-1	2		0.07901										
H-2	3												
C	4 *		0.039505										
Pu 239	5	X											
CH ₂	6		X										
H-2	7 +		0.07901										
	8												
	9												
	10												
	11												
	12												
	13												
	14												
	15												
	16												
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	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												

Note that material #6 and not material #7 is assigned to zone 2.

* MCR = 4
+ MT = 7
± IM = 50
IZM = 2

4	12	13	16	24	25	29	36	37	40	48	49	52	60	61	64	72	CARD ID
I SPECIAL		SAMPLE			PROBLEM			ANISOTROPIC			MATERIAL			ID = 602			CARD 1
ID 602		ITH 0			ISCT -1			ISN 4			IGE 3			IBL 1			CARD 2
IBR 1		IZM 2			IM 50			IFN 0			IEVT 1			EV 0.0			CARD 3
EVM 0.0		EPS 00001			IGM 16			IHT 3			IHS 4			IHM 9			CARD 4
BF 0.0		DY 0.0			DZ 0.0			MS 7			MCR 4			MTP 0			CARD 5
MT 7		IDFM 0			DFMI 0.0			DFM2 0.0			XNF 1.0			IPVT 0			CARD 6
PV 0.0		IQM 0			IPM 0			IPP 0			FXM 0.0			IIM 2.0			CARD 7
IGS 0		RYF 0.5			XLAL 0.1			XLAH 0.5			EQL 0.005			XNPM 1.0			CARD 8
IDI 1		ID2 3			ID3 0			ID4 0			ICM 100			IDT 0			CARD 9
2	19	0.0	2	29	3.32175		4.8385	3									RADIUS $\frac{1}{2}$
1	20		1	30	2	3											ZONENU
		5		-6	3												MZ
Standard 16 Group																	FISFRA AND VELOC
S ₄ Calculation																	W AND D
1	50	1.0	3														FISSIO OR FLUX
		5		5		6		6		6		6		7			MIXMB $\frac{1}{2}$
		7	3														$\frac{3}{4}$
		0		1		0		2		4		0					MIXMC $\frac{1}{2}$
		3	3														$\frac{3}{4}$
	0.0			0.049295		0.0		0.07901		0.032505		0.0					MIXMD $\frac{1}{2}$
	0.07901	3															$\frac{3}{4}$
Cross Section Data Sets Are Entered Here																	RADMOD
																	DISSOR
																	SHELLI
																	SHELLA
																	DENSFAC
																	NUCLNO
																	DIFMARK
																	GRSKIP
																	XSEC
																	ACMAT $\frac{1}{2}$
																	$\frac{3}{4}$
																	ACTYP $\frac{1}{2}$
																	$\frac{3}{4}$

ADD TWO BLANK CARDS AT END OF DATA SET (ONLY AFTER LAST SET IF DATA IS STACKED)

Appendix C

Carlson S_N Discrete Ordinate Angular Quadrature

Introduction

To establish a common basis for discussion, a few statements are in order. It is hoped the points made will become self evident as the text unfolds, otherwise there arises significant opportunity for confusion:

1. The " S_N quadrature" is nonunique and nonoptimum. It varies with the problem under consideration.
2. The selection of a quadrature set described as " S_N " is based on the principle of geometrical invariance, i. e., the set of direction cosines and associated point weights (p_s) and (w_m) are the same for any geometry (rectangular, cylindrical, or spherical).
3. For a chosen S_N quadrature set the calculational weights (v_m) to be associated with a particular direction cosine set vary with the calculational geometry.

A thorough justification or development of Carlson's general calculational procedure for numerical integration of the transport or diffusion equation is not intended here. This has been done in rather great detail.¹⁰ The purpose of this appendix is only to make reasonable the origin of direction cosines and associated calculational (level) weights given that an S_N order and a geometry have been selected (in particular, cylindrical geometry).

At the present time we are using a modified version of the transport code DTF-II¹¹ in S_4 cylindrical geometry, and this order of approximation is entirely suited to the optimization, scoping type studies required to date. It is clear that as one narrows system parameter choices, increasingly accurate calculational estimates will be desired. This will justify the expenditure of computer time through higher order approximations. While it is doubtful that calculations beyond S_8 will be necessary, belief in analytical comparisons to experimental results (e. g., crits) may require calculational "overshoot." For this purpose parameters for orders beyond 8 may be readily developed. Note also that while the current "running" code is one dimensional, (WDTF), a switch can be made to a two dimensional S_N cylindrical code (DOT).

Solution of the neutron Boltzmann equation in closed form is a seldom realized ambition. The inherent difficulty is implicit in the dependent variable $\psi = \psi(\underline{r}, E, \underline{\Omega}, t)$. Even for stationary, monoenergetic, one dimensional systems the angular dependence of ψ through the integral thermalization operator ξ requires some sort of approximation be applied in the transport equation solution. Perhaps the best known scheme is the P_N (spherical harmonics) method¹² which expands all functions of the angular variable in terms of spherical harmonics and approximates to a solution through truncation of the resulting infinite but exact set of equations. Although an excellent technique for

total flux description within a reactor interior it has inherent difficulties near boundaries or absorbers where the flux exhibits a higher order of anisotropy. To improve this situation Yvon¹³ developed the double P_N method which uses separate expansions over the regions which exhibit step flux changes. Alternate to these schemes is the general technique of quadrature which approximates, e.g., the $\xi \psi$ integral by the discrete angle expansion

$$\xi \psi(\underline{r}, E, \underline{\Omega}, t) = \sum_p w_p \psi_p(\underline{r}, E, \underline{\Omega}_p, t)$$

where the w_p are suitable weighting functions. Of the many quadrature formulas used for transport equation solution the most common is the Legendre Gauss (suggested by Wick).¹⁴ This approach enjoys a high order truncation error,^{*} but suffers from a lack of symmetry (nonuniform spacing) of interpolation points. This does not allow projection invariance and thus makes questionable differencing approximations utilizing such a scheme.^{**} This brings us to the Carlson S_N approach.

Completely Symmetric Quadrature Sets

This Carlson S_N method is a quadrature technique which obtains projection invariance by systematizing the selection of symmetric points and the quadrature weights associated with these points on an octant of the unit sphere. Coordinates systems for the three geometries (spherical, cylindrical and rectangular) are shown in Fig. 1C. The common factor in these is the vector $\underline{\Omega}$. This is defined with respect to an orthogonal rectangular frame (μ, η, ξ) which is in turn locally aligned with respect to the unit vectors of the geometrical coordinate system. To obtain complete symmetry the chosen (μ, η, ξ) coordinates of points on the unit sphere must be invariant to all 90° rotations about the μ, η , or ξ axis. Thus it follows that

- a) each coordinate set must be symmetric with respect to the origin,
- b) the set of points on each axis must be the same,
- c) a description of one octant is sufficient to describe the point array on a unit sphere.

The triangular point direction mesh scheme developed by Carlson is depicted for S_2 through S_8 in Fig. 2C. The j^{th} level from the side opposite any pole is defined to have

*For an m point formula the truncation error is $O(2m)$.

**This apparently has not prevented its frequent use.

Fig. 1C. Coordinate systems for rectangular, cylindrical, and spherical geometries.

Fig. 2C. Carlson S_N direction mesh for unit sphere octants; $N = 2, 4, 6$, and 8 .

$\frac{N}{2} - j + 1$ points. The direction cosine indices are given in the circle and the corresponding point weight indices located under the circles. Thus in example it is clear that for S_8 ,

$$\mu_4^2 + \mu_1^2 + \mu_1^2 = \mu_1^2 + \mu_2^2 + \mu_3^2 = 1 \quad (1C.1)$$

since for any order

$$\mu_\ell^2 + \mu_m^2 + \mu_n^2 = 1. \quad (1C.2)$$

This also implies that $\mu_j = \xi_j = \eta_j$. Regarding the numerology of the S_n points,

- d) there are $N(N+2)/8$ points per octant,
- e) there are $N/2$ μ levels per octant and thus $N\mu$ -levels per quadrant
- f) in general $\mu_\ell^2 + \mu_m^2 + \mu_{N/2-\ell-m+2}^2 = 1$ where $\ell = 1, 2, 3, \dots, N/2$ and $m = 1, 2, 3, \dots, N/2-\ell+1$.
- g) the sum of the μ indices $= N/2 + 2$.
- h) there are but three classes of points regardless of order N : A, B and C:

A - all indices different ($\ell \neq m \neq n$). There will always be six of these when they exist.

B - two indices equal ($\ell = m \neq n$, $\ell \neq m = n$, $\ell = n \neq m$). There will always be three of these when they exist.

C - all indices equal ($\ell = m = n$). This (a center point) occurs only if $\frac{N+4}{6}$ is integral and thus there is a maximum of one to a set.

- i) the range of each index is $1, 2, 3, \dots, N/2$.

The determination of the interrelation between the μ 's is straightforward. By g) above and Eq. (1C.2), $\ell + m + n = N/2 + 2$. Thus by choosing one index, say ℓ , the remaining two vary according to $m + n = N/2 + 2 - \ell$. If $\ell \rightarrow \ell - 1$ then

$$\mu_{\ell-1}^2 + \mu_{m+1}^2 + \mu_n^2 = 1 \quad (1C.3)$$

and similarly

$$\mu_{\ell-1}^2 + \mu_m^2 + \mu_{n+1}^2 = 1. \quad (1C.4)$$

Eliminating $\mu_{\ell-1}^2$ from Eq. (1C.3) and (1C.4) obtains

$$\mu_{n+1}^2 - \mu_n^2 = \mu_{m+1}^2 - \mu_m^2 \quad (1C.5)$$

Now Eq. (1C.5) must hold for every allowable (n,m) constrained by $m + n = N/2 + 2 - \ell$. Further permutation of the indices must yield an invariant description.

$$\begin{aligned} \mu_{N/2}^2 - \mu_{N/2-1}^2 &\equiv \mu_{N/2-j}^2 - \mu_{N/2-j-1}^2 \\ &\vdots \\ &\equiv \mu_2^2 - \mu_1^2 \\ &\equiv \Delta \end{aligned} \quad (1C.6)$$

By ascension therefore,

$$\mu_2^2 = \mu_1^2 + \Delta$$

$$\mu_3^2 = \mu_1^2 + 2\Delta$$

and

$$\mu_j^2 = \mu_1^2 + (j - 1)\Delta, \quad j = 1, 2, \dots, N/2 \quad (1C.7)$$

where μ_1^2 is arbitrary. Using Eqs. (1C.2) and (1C.7),

$$\begin{aligned} 1 &= \mu_1^2 + \mu_1^2 + (m - 1)\Delta + \mu_1^2 + (n - 1)\Delta \\ &= 3\mu_1^2 + (N/2 - 1)\Delta \end{aligned}$$

so

$$\Delta = \frac{2}{N - 2} \left(1 - 3\mu_1^2 \right) \quad (1C.8)$$

It is clear that direction cosines computed by Eqs. (1C.7) and (1C.8) exhibit the required symmetry but depend upon the choice of μ_1 for degree of "clustering." The point weights p_s to be associated with the points S [which implies $\Omega_s(\mu_\ell, \mu_m, \mu_n)$] possess the same symmetry as the directions Ω_s . As seen in Fig. 2C for $N = 6$, the point weights p_2 should all be the same, similarly the point weights p_1 should be equal.

In this methodology another set of weights, the level weights (w_j), are defined as the latitude sums of the points weights. Thus for $N = 6$ and Fig. 2C,

$$w_1 = p_1 + 2p_2$$

$$w_2 = 2p_1$$

$$w_3 = p_2$$

At this point it remains to define conditions on the w and μ_1 . This is where the non-uniqueness of the S_N quadrature sets arise. In general one of two methods is applied. The first is a weighted area condition consistent with the following definitions of numerical integration:

$$n(\underline{R}) = \int d\Omega n(\underline{R}, \underline{\Omega}) \doteq \sum_s p_s n(\underline{R}, \Omega_s)$$

$$M_{2q}(\underline{R}) = \int d\Omega \Omega^{2q} n(\underline{R}, \underline{\Omega}) \doteq \sum_s p_s \Omega_s^{2q} n(\underline{R}, \Omega_s)$$

so that

$$M_0(\underline{R}) \equiv n(\underline{R})$$

and

$$M_2(\underline{R}) \equiv J(\underline{R})$$

That this also satisfies the diffusion theory condition, i. e., $n(\underline{R}, \underline{\Omega})$ is linear in $\underline{\Omega}$, is self evident if the condition on the point weights p_s

$$\sum_s p_s \Omega_s^2 = \frac{1}{3}$$

or

$$\sum_{m=1}^{N/2} w_m \mu_m^2 = \frac{1}{3} \text{ is satisfied.}^*$$

*Except for a constant.

Lee¹⁵ has demonstrated this to be a direct consequence of the invariance condition. Additionally the level weights are normalized so that

$$\sum_{m=1}^{N/2} w_m = 1 \quad (1C.9)$$

We will not develop the level weights by Lee's rather lengthy and rigorous method but will instead derive them by a more direct method suggested by Carlson in Alder et al.¹⁶ Examining the relation between the w_i and p_j we reuse the example for $N = 6$ above and note that

$$w_1 + w_2 + w_2 = 3p_1 + 3p_2$$

which is to say the p_j 's are both class B points (two indices equal) and by inference

$$\sum_{m=1}^{N/2=3} w_m = \sum_{s=1}^{S=1} n_s p_s = 1 .$$

In general this is found to be true so that

$$\sum_{s=1}^S n_s p_s = \sum_{m=1}^{N/2} w_m = 1 \quad (1C.10)$$

where n_s is the number of points with index s ($n_s = 6$ for Class A, $n_s = 3$ for Class B, $n_s = 1$ for Class C).

It will now be shown that

$$\sum_{m=1}^{N/2} (m-1) w_m = \frac{N-2}{6} \text{ for } \sum_{m=1}^{N/2} w_m \mu_m^2 = \frac{1}{3} .$$

Using Eqs. (1C.7) and (1C.8) in direct substitution,

$$\begin{aligned} \sum_{m=1}^{N/2} w_m \mu_m^2 &= \mu_1^2 + \Delta \sum_{m=1}^{N/2} w_m (m-1) \\ &= \mu_1^2 + \frac{2}{N-2} (1 - 3\mu_1^2) \sum_{m=1}^{N/2} w_m (m-1) \\ &= \frac{1}{3} \end{aligned} \quad (1C.11)$$

Solving for the sum,

$$\sum_{m=1}^{N/2} w_m (m-1) = \left(\frac{1}{3} - \mu_1^2 \right) / \frac{2}{N-2} \left(1 - 3\mu_1^2 \right)$$

$$= \frac{N-2}{6} \quad (1C.12)$$

To obtain another relation on the w_m

$$\text{define } W_m \doteq w_1 + w_2 + \dots + w_m$$

then

$$\sum_{m=1}^{N/2} W_m = \frac{N}{2} w_1 + \left(\frac{N}{2} - 1 \right) w_2 + \dots + w_{N/2}$$

and

$$\sum_{m=1}^{N/2} (m-1) w_m = w_2 + 2w_3 + \dots + \left(\frac{N}{2} - 1 \right) w_{N/2}$$

so that

$$\sum_{m=1}^{N/2} \left[W_m + (m-1) w_m \right] = \frac{N}{2} \sum_{m=1}^{N/2} w_m = \frac{N}{2}$$

finally

$$\sum_{m=1}^{N/2} W_m = \frac{N}{2} - \frac{N-2}{6}$$

$$= \frac{N+1}{3} \quad (1C.13)$$

where we have used Eq. (1C.12).

Additionally we may write

$$\begin{aligned}
 \sum_{m=1}^{N/2-1} W_m &= \sum_{m=1}^{N/2} W_m - 1 \\
 &= \frac{N+1}{3} - 1 \\
 &= \frac{N-2}{3}
 \end{aligned} \tag{1C.14}$$

In analogy to Eq. (1C.7), since the μ_j^2 are linear we write

$$W_m^2 = W_1^2 + (m-1)\Delta, \quad m = 1, 2, \dots, \frac{N}{2} - 1. \tag{1C.15}$$

Carlson then anticipates the asymptotic form for Δ as $\Delta \cong 2/(N-1)$ which leads [through Eq. (1C.14)] to expression of W_1 as

$$W_1^2 = (4 + \epsilon_N)/3(N-1) \tag{1C.16}$$

also

$$\begin{aligned}
 \mu_1^2 &= W_1^2 - \Delta/2 \\
 &\cong \frac{1}{3(N-1)}
 \end{aligned} \tag{1C.17}$$

and

$$\Delta \cong \frac{2}{N-1} \tag{1C.18}$$

where

N	$\epsilon_n \times 10^3$
4	0.0
6	4.16667
8	5.39164
12	5.92059
16	5.83892

I. The direction cosines μ_j and level and points weights (w_j and p_s) based on the above scheme are listed in Table C-I. These represent the sets often taken as the Carlson S_N sets.

Table C-I. Completely symmetric S_N sets Set I - area method (even)

N	m	w_m	μ_m	p_s	Point class	v_m
2	1	1	0.57735027	1	C	0.50000000
4	1	2/3	1/3	1/3	B	0.16666667
	2	1/3	0.88191710	—		0.16666667
6	1	0.51666667	0.25819889	0.15000000	B	0.08611111
	2	0.30000000	0.68313005	0.18333333	B	0.07500000
	3	0.18333333	0.93094934	—		0.09166667
8	1	0.43672981	0.21821790	0.07075470	C	0.05459122
	2	0.25352175	0.57735027	0.09138352	A	0.04225362
	3	0.18276705	0.78679579	0.12698139	B	0.04569176
	4	0.12698139	0.95112972	—		0.06349070

Note that the point weights and the level weights are connected by Eq. (1C.10). The v_m are the one dimensional calculational weights for cylindrical geometry and will be discussed later.

II. A second possible set is, in a sense, an "odd" approximation corresponding to $n - 1 = 3, 5, 7, \dots$. It is constructed in a manner similar to Set I except that for a particular N, the point pattern of Set I for $N + 2$ is used with the corner points deleted (which omits one μ level). Since no allowance for $n = 2$ is made the relation

$$\sum_{m=1}^N w_m \mu_m = \frac{1}{2} \quad (2C.1)$$

is satisfied supplementary to Eq. 1C.11. For this case Carlson obtains

$$\mu_m^2 = \mu_1^2 + (m - 1) \Delta \quad (2C.2)$$

$$\Delta = 2 \left(1 - 3\mu_1^2 \right) / n \quad (2C.3)$$

$$\sum_m w_m = (n - 3)/3 \quad (2C.4)$$

corresponding to Eqs. (1C.7), (1C.8) and (1C.14) of Set I. Using $W_m^2 = W_1^2 + (m - 1) \Delta'$ where $\Delta' = 2/N, W_1$ is determined using Eq. (2C.4) and from this μ_1 is found by substituting Eq. (2C.2) in Eq. (2C.1). Table C-II lists the "odd" S_N set derived by this procedure. This set was suggested by Carlson¹⁶ as offering better accuracy in application than Set I and indeed in application to the small fast systems under current investigation, this has been found to be the case.

Table C-II. Completely symmetric S_N sets.
Set II - odd approximation

N	m	w_m	μ_m	p_s	Point class	v_m
4	1	1/3	0.09175171	1/3	B	0.08333333
	2	2/3	0.70412415	—		1/3
6	1	1/3	0.11417547	0	C	0.05555556
	2	1/3	0.57735027	1/6	A	0.08333333
	3	1/3	0.80847425	—		1/6
8	1	0.30807338	0.11104445	0.02525996	B	0.03850917
	2	0.27921634	0.50307327	0.07937696	B	0.04653606
	3	0.18401386	0.70273364	0.11434821	A	0.04600346
	4	0.22869642	0.85708017	—		0.11434821

Note that the point weights and the level weights are connected by Eq. (1C.10). The v_m are the one dimensional calculational weights for cylindrical geometry and will be discussed later.

III. A third completely symmetric set satisfying even moment conditions is produced by choosing μ_1 and the w_m to satisfy the $N/2 + 1$ conditions

$$\frac{1}{2} \int_{-1}^1 \mu^{2i} d\mu = \int_0^1 \mu^{2i} d\mu = \frac{1}{2i+1}$$

$$= \sum_{m=1}^{N/2} w_m \mu_m^{2i} \quad (3C.1)$$

for $i = 0, 1, 2, \dots, N/2$ where the μ_m^2 are defined by the earlier equations

$$\mu_m^2 = \mu_1^2 + (m - 1)\Delta, \quad m = 1, 2, \dots, N/2 \quad (1C.7)$$

$$\Delta = \frac{2}{N-2} \left(1 - 3\mu_1^2 \right) \quad (1C.8)$$

The quadrature sets produced using these constraints are listed in Table C-III.

Table C-III. Completely symmetric S_N sets
Set III - even moment matching

N	m	w_m	μ_m	p_s	Point class	v_m
4	1	2/3	0.3500212	1/3	B	0.1666667
	2	1/3	0.8688903	—		0.1666667
6	1	0.5094594	0.2666355	0.1572071	B	0.0849099
	2	0.3144142	0.6815076	0.1761262	B	0.0786036
	3	0.1761262	0.9261808	—		0.0880631
8	1	0.4234566	0.2182179	0.1209877	B	0.0705761
	2	0.2740740	0.5773503	0.0907407	A	0.0456790
	3	0.1814814	0.7867958	0.0925926	C	0.0453704
	4	0.1209876	0.9511897	—		0.0604938

Note that the point weights and the level weights are connected by Eq. (1C.10). The v_m are the one dimensional calculational weights for cylindrical geometry and will be discussed later.

IV. A fourth set may be chosen by matching all half range moments through the $\frac{N}{2} + 1$ conditions

$$\int_0^1 \mu^i d\mu = \frac{1}{i+1} = \sum_{m=1}^{N/2} w_m \mu_m^i \quad (4C.1)$$

As before the μ satisfy Eqs. (1C.7) and (1C.8). These quadrature sets are listed in Table C-IV. This procedure produces some negative weights for $N \geq 12$ and therefore is rather undesirable.

Table C-IV. Completely symmetric S_N sets.
Set IV - half range moment matching

N	m	w_m	μ_m	p_s	Point class	v_m
4	1	2/3	0.2958759	1/3	B	0.1666667
	2	1/3	0.9082483	—		0.1666667
6	1	0.4357984	0.1838670	0.1024651	B	0.0726331
	2	0.4617364	0.6950514	0.2308682	B	0.1154341
	3	0.1024651	0.9656013	—		0.0512326
8	1	0.3443658	0.1422555	0.1090122	B	0.0430457
	2	0.4202804	0.5773503	0.0631708	A	0.0700467
	3	0.1263416	0.8040087	0.2939388	C	0.0315854
	4	0.1090122	0.9795543	—		0.0545061

Note that the point weights and the level weights are connected by Eq. (1C.10). The v_m are the one dimensional calculational weights for cylindrical geometry and will be discussed later.

In addition there are sets produced by

- half range level moment matching (these do not lead to negative weights as in Set IV above)
- holding the point and level arrangement to complete symmetry while allowing the points on each axis to be chosen from an independent set, i. e. ,

$$\alpha_m^2 = \alpha_1^2 + (m - 1) \Delta$$

where $\alpha_m \Rightarrow \mu_m, \eta_m, \text{ or } \xi_m$

and

$$\Delta = \frac{2}{N - 2} \left(1 - \mu_1^2 - \eta_1^2 - \xi_1^2 \right)$$

c) Tschebyshev and Legendre quadrature combined.
These schemes are all discussed in Lathrop and Carlson.¹⁷

Application of an S_N Quadrature Set

Quadrature simply implies an integration approximation using some discrete area summation scheme. This in turn suggests the need for some orderly procedure of performing the necessary summation. Figure 3C shows the direction mesh applied in the Carlson method on the upper front quadrant of the unit sphere for $N = 6$. The triangularly patterned direction mesh previously discussed are indicated by the $P_{\ell m}$ with $N \geq \ell$, $m \geq 1$ and are shown as open circles. The filled circles ($P_{\ell 0}$) represent the starting points (in cylindrical geometry) for μ with constant ξ . Unprimed points indicate negative μ ; primed points have positive μ . Due to the symmetry of the mesh the ξ levels are simply related to the μ levels through the relation*

$$\xi_m = -\mu_m, \quad m = 1, 2, \dots, N/2 \quad (5C.1)$$

Further, the μ starting points ($P_{\ell 0}$) are related to their ξ_ℓ level by the equation

$$\mu_{\ell 0} = -\sqrt{1 - \xi_\ell^2} \quad (5C.2)$$

where we have used Eq. (5C.1).

Earlier we listed several different " S_N " quadrature sets and tabulated the level weights (w_m), the corresponding direction cosines (μ_m), and the point weights (p_s); neither the $\mu_{\ell 0}$ nor the ξ_ℓ were tabulated. They are now set out in Table C-V for completeness of the four enumerated S_N sets.

*Consideration of Fig. 2C will clarify this relation.

Fig. 3C. Direction mesh on upper front quadrant of unit sphere for $N = 6$.

Table C-V. The levels of ξ and the cylindrical geometry μ starting values for S_N Sets I - IV.

Set I - Even (Area)				Set II - Odd (Area)			
N	ℓ	ξ_ℓ	$-\mu_{\ell 0}$	N	ℓ	ξ_ℓ	$-\mu_{\ell 0}$
4	1	1/3	0.94280904	4	1	0.09175171	0.99578192
	2	0.88191710	0.47140453	4	2	0.70412415	0.71007688
6	1	0.25819889	0.96609178	6	1	0.11417547	0.99346060
	2	0.68313005	0.73029674	6	2	0.57735027	0.81649658
	3	0.93094934	0.36514836	6	3	0.80847425	0.58853155
8	1	0.21821790	0.97590007	8	1	0.11104445	0.99381544
	2	0.57735027	0.81649658	8	2	0.50307327	0.86424376
	3	0.78679579	0.61721340	8	3	0.70273364	0.71145304
	4	0.95118972	0.30860673	8	4	0.85708017	0.51518306

Set III - Even (Moment)				Set IV - Odd (Moment)			
N	ℓ	ξ_ℓ	$-\mu_{\ell 0}$	N	ℓ	ξ_ℓ	$-\mu_{\ell 0}$
4	1	0.3500212	0.9367418	4	1	0.2958759	0.9552264
	2	0.8688903	0.4950047	4	2	0.9082483	0.4184316
6	1	0.2666355	0.9637974	6	1	0.1838670	0.9829511
	2	0.6815076	0.7318110	6	2	0.6950514	0.7189600
	3	0.9261808	0.3770797	6	3	0.9656013	0.2600272
8	1	0.2182179	0.9759001	8	1	0.1422555	0.9898300
	2	0.5773503	0.8164966	8	2	0.5773503	0.8164966
	3	0.7867958	0.6172134	8	3	0.8040087	0.5946175
	4	0.9511897	0.3086068	8	4	0.9795543	0.2011800

Calculational Weights

The calculational weights which are to be applied to the μ_m direction cosines are a function of

- the S_N quadrature set chosen,
- the geometry of the system under consideration.

The first condition is a natural consequence of the numerology used to derive the weights and direction cosines. The second condition arises from the method by which the mesh is swept to obtain geometrical consistency. This determines the number of points to be involved which in turn establishes the number of times a particular value of μ_m is used (and thus the number of w_m 's). The value of calculational weight (defined as v_m) to be associated with each μ_m used, say b times, is then given by

$$v_m = \frac{w_m}{b}$$

which satisfies the normalization requirement

$$\sum_{m=1}^{N/2} w_m = 1 .$$

All points with ℓ or $m = 0$ carry zero weight.

The remainder of this appendix will be specialized by enumerating only the weights and point patterns associated with cylindrical geometry and the various S_N sets discussed earlier. This specialization is considered valid since all anticipated S_N calculational effort (DTF or DOT) in the SPR program is concerned with cylindrical systems and deviations from this geometry, particularly in the case of DOT, which would require more exposition than is implicit here. For information regarding rectangular and spherical geometry the reader is directed to Lee.¹⁵ A note of caution however is advised since the spherical mesh-sweeping scheme of Lee¹⁵ appears to differ from that of Carlson.^{10,16} No effort has been expended by the author to resolve the difference at this time.

Returning to cylindrical geometry point patterns, it will be of aid to define three new point quantities* related to the $P_{\ell m}$

$\bar{P}_{\ell m} \doteq P_{\ell m}$ points reflected across the local x-z plane (see Fig. 3c) to the upper back quadrant

$\tilde{P}_{\ell m} \doteq P_{\ell m}$ points reflected across the local x-y plane to the lower front quadrant

$\hat{P}_{\ell m} \doteq \bar{P}_{\ell m}$ points reflected across the local x-y plane to the lower back quadrant

The index ranges on ℓ and m are

$$0 \leq \ell \leq \frac{N}{2}$$

$$m = 0, \quad \ell \leq m \leq N + 1 - \ell$$

Table C-VI lists the point types for 1, 2 and 3 dimensional cylindrical geometry, relative calculational weights, v_m , and the corresponding order of evaluation of the $P_{\ell m}$. Other order of approximation proceed in the same manner.

*These follow the notation of Lee¹⁵ and are valid for all three geometries.

Table C-VI. Cylindrical geometry point patterns and order of evaluation for S_6 .

Functional	Points	Relative weights v_m	Evaluation order for S_6
$n(r)$	P_{lm}	v_m	P_{10} to P'_{16} along ξ_1 . P_{20} to P'_{25} along ξ_2 . P_{30} to P'_{34} along ξ_3 .
$n(r, \theta)$	$P_{lm}, \bar{P}_{lm}$	$\frac{1}{2} v_m$	P_{10} to P'_{16} along ξ_1 . P_{20} to P'_{25} along ξ_2 . P_{30} to P'_{34} along ξ_3 . $\bar{P}_{10}$ to $\bar{P}'_{16}$. $\bar{P}_{20}$ to $\bar{P}'_{25}$. $\bar{P}_{30}$ to $\bar{P}'_{34}$.
$n(r, z)$	$P_{lm}, \tilde{P}_{lm}$	$\frac{1}{2} v_m$	P_{10} to P'_{16} along ξ_1 . P_{20} to P'_{25} along ξ_2 . P_{30} to P'_{34} along ξ_3 . $\tilde{P}_{10}$ to $\tilde{P}'_{16}$. $\tilde{P}_{20}$ to $\tilde{P}'_{25}$. $\tilde{P}_{30}$ to $\tilde{P}'_{34}$.
$n(r, \theta, z)$	$P_{lm}, \bar{P}_{lm}$ $\tilde{P}_{lm}, \hat{P}_{lm}$	$\frac{1}{4} v_m$	P_{10} to P'_{16} . P_{20} to P'_{25} . P_{30} to P'_{34} . $\bar{P}_{10}$ to $\bar{P}'_{16}$. $\bar{P}_{20}$ to $\bar{P}'_{25}$. $\bar{P}_{30}$ to $\bar{P}'_{34}$. $\tilde{P}_{10}$ to $\tilde{P}'_{16}$. $\tilde{P}_{20}$ to $\tilde{P}'_{25}$. $\tilde{P}_{30}$ to $\tilde{P}'_{34}$. $\hat{P}_{10}$ to $\hat{P}'_{16}$. $\hat{P}_{20}$ to $\hat{P}'_{25}$. $\hat{P}_{30}$ to $\hat{P}'_{34}$.

To make explicit the above considerations, Table C-VII lists (for S_6) the coordinates and v for all points in cylindrical geometry on the upper front quadrant (1 dimensional) and a representative point (P_{12}) for 2 and 3 dimensions. These were taken from S_N Set I.

Table C-VII. The $P_{\ell m}$ coordinates (μ, η, ξ) and calculational weights $v_{\ell m}$ for S_6 ,
Set I.

Functional	$P_{\ell m}$	$\mu_{\ell m}$	$\eta_{\ell m}$	$\xi_{\ell m}$	$v_{\ell m}$
n(r) ↓	P_{10}	-0.96609178	0	0.25819889	0
	P_{11}	-0.93094934	0.25819889		0.09166667
	P_{12}	-0.68313005	0.68313005		0.07500000
	P_{13}	-0.25819889	0.93094934		0.08611111
	P_{14}	0.25819889	0.93094934		0.08611111
	P_{15}	0.68313005	0.68313005		0.07500000
	P_{16}	0.93094934	0.25819889		0.09166667
	P_{20}	-0.73029674	0	0.68313005	0
	P_{22}	-0.68313005	0.25819889		0.07500000
	P_{23}	-0.25819889	0.68313005		0.08611111
	P_{24}	0.25819889	0.68313005		0.08611111
	P_{25}	0.68313005	0.25819889		0.07500000
	P_{30}	-0.36514836	0	0.93094934	0
	P_{33}	-0.25819889	0.25819889		0.08611111
	P_{34}	0.25819889	0.25819889		0.08611111
n(r, θ)	P_{12}	-0.68313005	0.68313005	0.25819889	0.03750000
n(r, z)	P_{12}	-0.68313005	0.68313005	0.25819889	0.03750000
n(r, θ , z)	P_{12}	-0.68313005	0.68313005	0.25819889	0.01875000

Commentary on Errors

A fundamental consideration regarding use of quadrature lies in the ability of refined approximation representations to converge to analytic solutions of the transport equation. This is considerably complicated by a current lack of any judgment other than an empirical affirmative. Since quadrature is nothing more than an approximate integration any problem solution obtained by this technique* should be checked for convergence by varying the quadrature order. A comment here by Carlson¹⁰ is,

*Regardless of S_N quadrature set used.

however, pertinent in that it exposes the interdependence of spatial and angular quadrature in producing a calculational result which is in error.*

"However, solutions of the transport equation are more complicated because spatial, as well as angular, quadrature is involved. Experience has shown that errors involved in spatial and angular quadrature are interdependent. Qualitatively, the error surface is like a valley between two ridges. If error is plotted against order-of-angular-quadrature along one axis and order-of-spatial-quadrature along an orthogonal axis, the ridges of the surface lie above these axes. Hence, if a calculation gives a result in the error valley, both quadratures must be refined to remain in this error valley. On the other hand, for a given spatial mesh, refining the angular quadrature may actually increase the error, and conversely."

*The way this error may be defined is however that "something else" they talk about and properly should relate to experimental reality.

Appendix D

Flux Weighting and Group Size

Whenever group cross sections are generated from basic data an approximation is involved if subsequent calculations are done for systems (or regions) which have neutron energy spectra different from that used in flux weighting the pointwise data. It is evident however, that as the number of energy groups used in a calculation increases, the uncertainty due to an improper guess of the local neutron energy spectrum becomes of decreasing importance.

Four neutron energy spectrums are shown in Figs. 1D and 2D. Two of these, "Godiva" and "LRL-F", were used to produce 16-group cross section libraries of interest to the LRL programmatic work. As discussed in Appendix A, the 1100 series used "Godiva" weighting and the 1200 series used "LRL-F." A third energy spectrum corresponding to a Be/U = 3000:1 system was used to develop a library (1600 series) of more general applicability over the neutron energy range $1 \text{ eV} < E < 10 \text{ MeV}$. The fourth spectrum (fission) is included for purposes of comparison.

A preliminary study was made¹⁸ of the effects of group structure and energy spectra on predicting k_{eff} for a wide range of Be/U ratio. The results of using increasingly coarse group cross sections (90, 30, 18, and 6 groups) are compared to 180 group calculations as a standard in a series of bare Be-U crits and are shown in Fig. 3D. The basic 180-group library used approximately equal lethargy spacing over the entire energy range; the collapsed groups were also formed so as to be approximately equal in lethargy. Cross sections were collapsed from the 180 group set with flux weightings appropriate to Be/U = 0:1 (Godiva) and Be/U = 3000:1 systems, and k_{eff} for a range of systems was determined with each cross section set using DTF. Note in Fig. 3D the ability of the Be/U = 3000:1 weighted sets to calculate the entire range of bare, one-region systems with reasonable accuracy and the corresponding failure of the Be/U = 0:1 weighted sets to handle these unreflected systems with spectra even slightly different from those used in the initial weighting.

To evaluate the dependency of the eigenvalue on the region spectrum, region-dependent cross sections were generated for the SPR-6, 10 MWe design (UCRL-50382); these data are not included here because of their specialized nature. However, a reduction in k_{eff} of ~2% was found by a recalculation of the reflector worth of the SPR-6 with these constants, so that the basic set (series 1200) overpredicts a thick reflector worth by about 20%.

A representative plot of the variation in median energy of neutrons causing fission across a two region system of ^{235}U and Be using region weighting is shown in Fig. 4D. Clearly, for multiregion systems in general, either region-dependent or very fine group cross sections will be necessary for high accuracy. This plot is, however, representative of that obtained using the 1200 series library even in a water

Fig. 1D. Energy spectrums used for cross section weighting.

Fig. 2D. Thermal energy flux spectrum (Be/U = 3000:1).

Fig. 3D. Effect of group size and flux weighting on $k_{\text{effective}}$ calculations for bare O Be region systems.

flooded system (UCRL-50459),⁶ because of the high percentage of dense refractory metals included. The effect on k_{eff} of varying the group structure from the basic 180-group library while retaining the region weighting was compared to Godiva (Be/U = 0:1) and thermal (Be/U = 3000:1) weighting. The results are shown in Table D-I for the two region system of Fig. 4D. As expected, region weighting is superior for all group structures although even here the Be/U = 3000:1 set is an excellent approximation.

In view of the above results a thermally weighted, 16 group cross section library (1600 series) was generated which should be applicable in surveys over a wide energy range. Use of this set should also improve the results for reflected fast systems. Both the 1200 and 1600 series cross section sets were used to evaluate the water safety eigenvalue for a (UCRL-50459)⁶ type system. The results were effectively identical.

Fig. 4D. Median energy of neutrons causing fission as a function of spatial position in a two region system using region dependent weighting. (In the reflector the median fission energy is that for a trace quantity of fuel material.)

Table D-I. A comparison of k_{eff} as a function of group structure and weighting spectrum for a two-region system.^a

No. of groups	Be/U ^b 0:1	Be/U ^c 3000:1	Region ^d weighted
6	0.9690	1.0547	1.0199
18	0.9784	1.0047	1.0004
30	0.9886	1.0013	1.0008
90	0.9986	1.0001	0.9995
180	1.0000	1.0000	1.0000

^aSee Fig. 4D. Core o.d. = 0.285 reflector o.d.

^bSeries 1100 "Godiva" spectrum.

^cSeries 1600 spectrum.

^dBased on UCRL-50382²¹

Appendix E

Interim Set of One-Group Cross Sections

An interim set of one-group cross sections are listed in Table E-I. They are weighted with the LRL-F spectrum shown in Appendix D. These data have proven useful not only in 1-speed diffusion calculations, but also in computing fissile species-daughter relationships in the reactor lifetime analysis.

Table E-I. Interim neutron cross sections—one-group library (LRL-F flux weighting).

Material	Ref. ^a No.	ν	σ_f	σ_c^b	σ_s	$\bar{\mu}$	σ_{tr}
Hydrogen	01001	—	—	4.72×10^{-4}	6.821	0.6667	2.274
Deuterium	01002	—	—	3.00×10^{-5}	2.884	0.1705	2.390
Tritium	01003	—	—	0	1.634	0.0498	1.553
Helium-3	02003	—	—	1.393	1.922	0.2154	2.903
Helium-4	02004	—	—	0	2.718	0.1642	2.271
Lithium-6	03006	—	—	0.7157	1.829	0.1447	2.281
Lithium-7	03007	—	—	0.0149	1.688	0.0985	1.522
Beryllium-9	04009	—	—	0.0169	3.770	0.1408	3.212
Boron	05000	—	—	0.2376	2.856	0.1182	2.756
Boron-10	05010	—	—	0.9073	2.756	0.1273	3.313
Carbon-12	06012	—	—	1.96×10^{-3}	3.162	0.0844	2.897
Nitrogen-14	07014	—	—	0.0610	2.633	0.0755	2.495
Oxygen-16	08016	—	—	3.66×10^{-3}	3.585	0.0897	3.267
Fluorine-19	09019	—	—	9.50×10^{-3}	4.911	0.0947	4.456
Sodium-23	11023	—	—	7.55×10^{-4}	3.814	0.1284	3.325
Magnesium	12000	—	—	2.62×10^{-3}	4.921	0.1875	4.001
Aluminum-27	13027	—	—	5.65×10^{-3}	3.892	0.1725	3.227
Silicon	1400	—	—	9.80×10^{-3}	3.338	0.1643	2.814
Phosphorus-31	15031	—	—	0.0209	3.146	0.2130	2.497
Chlorine	17000	—	—	0.0101	2.501	0.2007	2.009
Argon	18000	—	—	9.25×10^{-3}	2.121	0.2358	1.630
Potassium	19000	—	—	0.0339	2.625	0.2146	2.095
Calcium	20000	—	—	0.0128	2.943	0.2391	2.252
Titanium	22000	—	—	0.0113	5.056	0.1009	4.557
Manganese-55	25055	—	—	8.95×10^{-3}	4.594	0.1133	4.082
Iron	26000	—	—	5.96×10^{-3}	3.832	0.1332	3.328
Nickel ^c	None	—	—	0.0538	4.796	0.0	4.850

Table E-I. (Continued)

Material	Ref. ^b No.	ν	σ_f	σ_c^a	σ_s	$\bar{\mu}$	σ_{tr}
Copper	29000	—	—	0.0222	4.388	0.1008	3.967
Gallium	31000	—	—	0.0239	4.505	0.0	4.529
Zirconium ^c	None	—	—	0.0105	7.402	0.0	7.413
Niobium-93	41093	—	—	0.0506	6.913	0.1860	5.677
Tin	50000	—	—	0.0956	6.118	0.2818	4.489
Molybdenum	42000	—	—	0.0214	7.096	0.1854	5.801
Silver	None	—	—	0.2761	6.559	0.2391	6.678
Europium	63000	—	—	0.6044	7.621	0.0991	7.465
Europium ^d	None	—	—	0.4399	7.620	0.0989	7.306
Gadolinium	64000	—	—	0.2849	8.008	0.0952	7.526
Gadolinium ^d	None	—	—	0.2306	8.007	0.0949	7.478
Tantalum-181	73181	—	—	0.3636	7.021	0.1974	5.996
Tungsten	74000	—	—	0.1235	7.518	0.1662	6.387
Rhenium ^c	None	—	—	0.2036	10.593	0.0	10.797
Gold-197	79197	—	—	0.2841	6.776	0.1859	5.796
Lead	82000	—	—	5.38×10^{-4}	6.933	0.1708	5.746
Uranium-233	92233	2.576	2.194	0.1731	6.096	0.2578	6.887
Uranium-234	92234	2.689	0.7536	0.2156	7.556	0.2689	6.659
Uranium-235	92235	2.529	1.421	0.2778	7.086	0.2506	7.002
Uranium-236	92236	2.760	0.2901	0.1346	8.107	0.2306	6.656
Uranium-237	92237	2.537	0.6993	0.2085	7.347	0.2324	6.538
Uranium-238	92238	2.816	0.1316	0.1616	8.511	0.2335	6.807
Uranium-239	92239	2.551	0.1937	0.0944	7.392	0.2201	6.039
Uranium-240	92240	2.811	0.1034	0.1740	8.512	0.2322	6.803
Plutonium-238	94238	2.996	2.369	0.2049	6.329	0.2701	7.189
Plutonium-239	94239	2.984	1.824	0.2355	6.912	0.2562	7.197
Plutonium-240	94240	3.059	0.7647	0.7731	6.835	0.2447	6.697
Plutonium-241	94241	2.896	2.088	0.2627	6.950	0.2538	7.531

^aFirst two digits are the element number Z, and the last three digits the atomic weight, A. The atomic weight of the natural element is entered by three zeros, e. g., Boron (05000).

^bRadiative capture only; no contribution from n-2n reaction included.

^cPreliminary estimate by R. Doyas (from BNL-325)¹⁸ and Howerton's UCRL-5351.¹⁹

^dLike 63000 and 64000, respectively, except with capture cross sections according to V. E. Hampel.²⁰

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