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OCUSOL-A, A MODIFICATION OF THE EYEWASH PROGRAM

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FROM: L. G. Alexander, D. A. Carrison, J. T. Roberts,
and R. Van Norton

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2.

OPERATING INSTRUCTIONS FOR THE UNIVAC PROGRAM OCUSOL-A
A MODIFICATION OF THE EYEWASH PROGRAM

by

L. G. Alexander, D. A. Carrison*, J. T. Roberts, and R. Van Norton**

I. Introduction

The Eyewash program, written by James H. Alexander and Nancy D. Given ^{1/}, provides solutions of reactor criticality problems in spherical geometry by means of the group diffusion method. It employs thirty lethargy groups (plus one thermal group) in nine regions. The input (See Tables III and IV) consists principally of specifying the geometrical scaling factor, boundaries and compositions of the various regions, and temperature level. The output includes the value of ν_c that would render the system critical, the relative fission density distribution, fissions, absorptions, and leakages in each lethargy group in each region, and, if desired, an edit of the flux at each space point, each lethargy, and an edit of the macroscopic cross sections for each lethargy, each region.

OCUSOL-A is a minor modification and extension of Eyewash. It provides for the computation and editing, on the supervisory control typewriter, of the total absorptions in selected nuclides in the various regions. This information is useful in the computation of breeding ratios and the preparation of detailed neutron balances, and in the estimation of flux-averaged cross sections for use in estimating the rate of change of concentration of the various nuclides with burn-up.

* Aeronutronic Systems, Incorporated (formerly of ORNL)

** Institute of Mathematics, New York University

1/ "A Machine Multigroup Calculation - The Eyewash Program for Univac", ORNL-1925

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The program also provides for saving and transferring the final fission density distribution from one computation to the next. For reactors which are similar, especially those having the same similar geometry, this procedure greatly shortens the number of iterations required for the computation to converge on ν_c . With the flat source provided in Eyewash, from seven to nine iterations are frequently required, whereas by transferring the source, usually only two, and sometimes only one, calculations will suffice.

The lethargy groups and the corresponding cross sections in OCUSOL-A have been modified from those used in Eyewash, in order to better treat intermediate reactors containing thorium. The latest cross section data were also incorporated. These matters are dealt with fully by Roberts and Alexander in ORNL-CF-57-6-5.

The modifications of the program required additional space in the fast memory of Univac. Since the reactors under consideration by the MSRP group at ORNL do not contain hydrogen, and since a large fraction of the memory in Eyewash is utilized in a Goertzel-Selengut computation for hydrogen, this part of Eyewash was sacrificed and the memory locations were used for the OCUSOL-A modifications. However, this makes position 26 in the cross section tape unavailable.

II. Preparation of Initial Conditions

In Table I is shown a format adapted from the Eyewash Program ^{2/}, and in Table II a sample of initial conditions for an OCUSOL-A case. The first column of figures on the left gives the memory location in which the corresponding word is stored. The words contain 12 bits, which may be any decimal digit or any

^{2/} op. cit.

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alphabetical available on the Univac Console Keyboard. The reactor number is stored in memory location 880, but only the second half (6 bits) is available, the first half being composed of zeros which do not print out in any edit.

Memory locations 892 through 899 contain the concentration in atoms $\times 10^{-24}/\text{cc}$ of the atomic species in the first (central-most) region of the reactor in the first 10 bits (with decimal point as indicated) of each word, together with the species code designation (jj) in the last 2 bits. Code designations are given in Table III. As of the present writing, not all of the jj positions have been assigned, and of those assigned, not all have been filled on the cross section tape (Tape 7).

In the remarks column adjacent to the jj designations of the format are listed the present contents of the species absorption selection table (jj*) which is stored in memory locations 473 through 479 at break point 6 or later (See Table IV). The computer will calculate and print out on the supervisory control typewriter (after convergence on ν_c) the sum of the absorptions in all regions for each species for which the code designation jj matches the contents of the jj* table in the corresponding location. In the example (Table II), the absorptions in Region 1 in U^{233} , U^{235} , U^{238} , Be-Li, fission fragments, and Th-B (See Table III) will be computed. The absorptions in fluorine in this region will not be computed because the code designation 05 for fluorine does not match the contents of the jj* table (24) in the corresponding location.

No absorptions will be computed for Region 2 because there is no matching. In Region 3, the absorptions for U^{233} will be computed and added to those computed for U^{233} in Region 1. The absorptions in Th-E will also be computed, and the absorptions for the components for which jj-jj* matching existed in one or more regions will be printed out on the supervisory control typewriter immediately after convergence on ν_c and prior to the editing of the output.

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Two independent copies of the initial conditions are typed on typer-tapes. These are compared on the computer, corrected, and one copy written into the next available space on the Initial Conditions Tape 2. A no-write ring is then inserted in Tape 2, and the blocks used and contents noted on the tape and in the tape log.

III. Operating Instructions

1. Tape Loading

Servo 1: OCUSOL_A Program Tape consisting of 41 blocks of program and two blocks of cross section insertion routing.

Servo 2: Initial conditions, consisting of one or two blocks per case.

Servo 3: Blank, for temporary storage.

Servo 4: OCUSOL-A Output Tape.

Servo 5: Blank, for temporary storage.

Servo 6: Blank, for temporary storage.

Servo 7: OCUSOL-A Cross Section Tape.

Servo 8: OCUSOL-A Source Function Tape.

2. Composing the Input

After the tapes are loaded, the Univac operator is instructed as follows: "Initial read servo 1, with supervisory control typewriter on normal." The first part of the program is read into memory, and the supervisory control typewriter then writes "Reactor number 000000XXXXXX" and waits for a type-in from the console keyboard. Ask the operator to depress all break points desired (See Table V), and give the operator the number of the basic case on the Initial Conditions Tape desired. The computer will then call for the date. However, any 12 symbols may be inserted here. It is recommended that only the first 6 symbols be used for inserting the date, that the initial of the person monitoring

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the computation be inserted into the seventh position, that the case number be inserted in the ninth and tenth positions, and the trial number in the twelfth. This procedure leaves the eighth and eleventh positions at the disposal of the monitor, and makes it unnecessary to alter the basic case number on break point 7 as heretofore.

After a short interval the computer will stop at break point 7, at which time the contents of any memory cell may be altered by forcing transfer. Since transfer must be forced once for each alteration, inform the operator of the number of transfers that will be needed. Forcing transfer causes the supervisory control typewriter to write "address 00000000XXX" and wait for a type-in. The address of the memory location desired is then typed in, i.e., if it is desired to change the concentration of U^{235} in Sample Case A770, one types in "00000000894". The supervisory control typewriter then types out the present contents of that cell, e.g., "000003550001", and waits for a type-in. Suppose it is desired to double the U^{235} concentration: one asks the operator to type in "000007100001". The computer will then show break point 7 again, and transfer should be forced if it is desired to make other changes. The memory locations of the initial conditions are all indicated on the input data sheets (Table I) beginning with the Reactor Number in 880 and continuing through a maximum of 120 words.

Note that changes in the contents of the jj* table, in source scaling factor, and convergence criterion cannot be made on break point 7 (See below).

3. Computation

Following the last transfer on break point 7, ask for continuous running. The computer will calculate the macroscopic cross sections and stop at break point 6, which is the cross section edit option. Forcing transfer will

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cause the cross sections to be edited provided a flux edit is also called for later on break point 5.

The contents of the jj* table may conveniently be altered at this time, regardless of whether the flux edit is desired. Ask the operator to type the new jj* code numbers desired into the appropriate memory locations (473 through 479). This is a simple and rapid operation if done correctly, but not all of the operators know how to do it; they sometimes "lose the instruction", with the result that the case is ruined and must be started over from the basic case. If in doubt about the operator's ability to perform the operation, consult the engineer on duty.

It may be possible in some cases of lost instruction or other difficulty to save the computation by transferring control manually to memory location 000. Difficulty after "generator" may sometimes be remedied by giving the operator the instruction "SCICR 88000U0001", which will transfer control to the beginning of "generator" with a forced transfer on break point 9B.

The computer next types out "generator" and stops at break point 9A. Forcing transfer brings in the source function of the previous computation from Tape 8. The source scaling factor inherent in this source cannot now be altered. Passing 9A brings the computer to break point 9B (inform operator). The computer types out "0.001 times desired source scaling", and waits for a type-in. The built-in source scaling is preserved by typing in 0000100000000*; it is reduced proportionately by typing in fractions of this number, e.g., to reduce the scaling by a factor of 100, type in 000000100000.

* Down by a factor of 10 from Eyewash

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The computer next types out "OCUSOL-A XXXXXX" and proceeds with the iterative calculation of ν_c . The absorptions in the species matched in the jj* table are then typed out on the supervisory control typewriter, following which the total neutron absorptions ("balance") is typed.

The computer then stops at break point 5. Forcing transfer cause, the flux to be edited onto Tape 4, and also the cross sections if transfer was previously forced on break point 6 (See above). The number of output blocks is then typed out and the computer calls for the next reactor number.

If, for any reason, it is desired to terminate the computation before convergence, this can be done conveniently by setting the output break point switch on the console after the "OCUSOL-A XXXXXX" type-out. The computer will stop just before the ν_c type-out. The value of ν_c is available at this time in memory cell 898, and may be examined. Convergence is forced by typing 099999999999 into memory cell 997. The permanent value of the convergence criterion stored in 997 is, in the OCUSOL-A program, 019999999999 (compared to 010000000000 in Eyewash and Murine-1).

In cases where convergence (and the accompanying edits) is not desired or not possible, the computation may be terminated by stopping the computer, re-winding all tapes except Tape 4 (best to turn servo off), and giving "initial read 1, supervisory control typewriter on normal". The output on Tape 4 will not be lost by this procedure.

IV. Acknowledgment

The assistance of J. H. Alexander in planning the modifications is gratefully acknowledged.

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FORMAT FOR INPUT

Page 1 of 1 Pages

880	0							X X X X X X	Reactor Number
	1							X	Number of regions, ≤ 9
	2	0	X	X	X	X	X		Scaling factor, Δr , cm
	3							X X	Outside boundary, ≤ 60
	4								z = 1, Region fissionable
	5								z = 0, Region non-fissionable
	6								
	7								
	8								
	9								
89	0							X X	Outer boundary at Region 1
	1								
	2							X	Number of nuclides in region, ≤ 7
	3	0	N	N	N	N	N	J J	00 (473) U-233
	4								01 (474) U-235
	5								02 (475) U-238
	6								03 (476) Be-Li
	7								04 (477) Fission Products
	8								24 (478) Th-E
	9								21 (479) Th-B
	0							X X	Outer boundary of Region 2
	1								
	2								
	3								
	4								
	5								
	6								
	7								
	8								
	9								

PROBLEM OCUSOL-A Table II (continued)
 PREPARED BY

DATE 11.

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0						60	Blanket 13" thick
1							
2						7	Four species
3					465	00	= 00 U-233
4						17	≠ 01 Li
5						00	≠ 02
6							≠ 03
7							= 04
8			66	4		24	= 24 Th-E
9			465			05	≠ 21 F
0							Fill to BE
1							
2							
3							
4							
5							
6							
7							
8							
9							
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							✓

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Table III

NUCLIDE CODE NUMBERS IN OCUSOL-A

Code Number	Nuclide or Mixture	Date Edited on Tape 7
<u>jj</u>		
00	U-233	2-25-57
01	U-235	"
02	U-238	"
03	Be + 2.3 Li (See text)	"
04	Two fission products (See text)	"
05	F	"
06	Li ⁶	
07	Li ⁷	
08	Na	
09	Be	
10	Cl	
11	Pu	
12	Fe	2-25-57
13	Ni	"
14	Cr	"
15	Not available	
16	Pa	
17	0.9999 Li ⁷ + 0.0001 Li ⁶	2-25-57
18	C	
19		
20	Th-A (with no self-shielding)	2-25-57
21	Th-B (in 67 LiF - 32 BeF ₂ - 1 ThF ₄) at 1150°F	"
22	Th-C (in 68 LiF - 28 BeF ₂ - 4 ThF ₄) at 1150°F	"
23	Th-D (in 70 LiF - 20 BeF ₂ - 10 ThF ₄) at 1150°F	"
24	Th-E (in 75 LiF - 25 ThF ₄) at 1150°F	"
25		
26	Not available	
27		
28		
29		
30		

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Table III Nuclide Code Numbers in OCUSOL-A (continued)

<u>Code Number</u>	<u>Nuclide or Mixture</u>	<u>Date Edited</u> <u>on Tape 7</u>
jj		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		

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Table IV

SPECIES ABSORPTION SELECTION TABLE

<u>Memory Location</u>	<u>jj*</u>	<u>Nuclide</u>
473	00	U-233
474	01	U-235
475	02	U-238
476	03	Be-Li
477	04	Fission Products
478	24	Thorium-E
479	21	Thorium-B

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Table V

BREAK POINTS FOR OCUSOL-A

<u>Break Point No.</u>	<u>Remarks</u>
1.	Not assigned
2.	Not assigned
3.	Not assigned
4.	To end continuous running or to change output tape; force transfer. Computer will type out "New Tape 4" and come to a stop. All tapes are rewound at this time. To continue running, merely hit start bar. Be sure to label Tape 4.
5.	Force transfer to obtain flux edit. Will also give a cross section edit provided transfer was forced previously on break point 6.
6.	Force transfer to obtain cross section edit on break point 5.
7.	Force transfer to alter initial conditions. Computer will call for address of initial condition to be changed. After this is typed in, computer will type out present contents of cell, and wait for a type-in. Continue to force transfer until all the desired changes have been made.
8.	Force transfer to change A or P scaling.
9A	Force transfer to bring in from Tape 8 source distribution generated during previous case.
9B	Force transfer to change flux dependent scaling (see text).

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Table VI

LETHARGY GROUPS FOR OCUSOL-A

<u>Group 1</u>	<u>Energy</u>	<u>ΔU</u>	<u>Lethargy</u>	<u>T^oF</u>
0	1×10^7	--	0.0	
1	6.065×10^6	0.5	0.5	
2	3.679	0.5	1.0	
3	2.231	0.5	1.5	
4	1.353	0.5	2.0	
5	8.208×10^5	0.5	2.5	
6	3.876	0.75	3.25	
7	1.830	0.75	4.00	
8	6.733×10^4	1.0	5.00	
9	2.478	1.0	6.00	
10	9.118×10^3	1.0	7.00	
11	3.355	1.0	8.00	
12	1.234	1.0	9.00	
13	4.540×10^2	1.0	10.00	
14	3.199	0.35	10.35	
15	2.255	0.35	10.70	
16	1.120	0.70	11.40	
17	61.47	0.60	12.00	
18	33.74	0.60	12.6	
19	15.15	0.80	13.4	
20	10.16	0.40	13.8	
21	4.564	0.80	14.6	
22	1.375	1.20	15.8	
23	0.9214	0.40	16.2	
24	0.6716	0.40	16.6	
25	0.4140	0.40	17.0	
26	0.2775	0.40	17.4	
27	0.1523	0.40	17.8	
28	0.1021	0.40	18.2	1704
29	0.07735	0.48	18.68	1180
30	0.07595	0.018	18.698	1150

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UNIVAC TYPING FORMS

UNITYPING REQUEST			REMARKS		
Date: _____	Typed by Self :	☐			
Time: _____	Type Once :	☐			
Req. By: _____	Type Twice :	☒			
Site: ORNL	Code-Edit :	☐			
Prob: OCUSOL-A	Sample Wd.: :	☐			
Date Needed: _____		No. of Blks.: _____			
TO BE FILLED IN BY TYPIST					
DATE	TIME ON	TIME OFF	TAPE NO.	BLOCKS	Sign.
Notations of Typist:					
F-132					

UNIPRINTER TYPE OUT REQUEST			
Date:	Time:	Tape No:	
Req. by:	Site: ORNL	Prob.: OCUSOL-A	
Type of Paper: W	Line Space: 1	Carbons: 1	
Margin: Left	Heading: OCUSOL-A		
Tabs: M+12 , T1+ 15 , T2+ 15 , T3+ 15 , T4+ 15 , T5+12 , T6+ , T7+ , T8+ , T9+ , T10+			
No. of Pages:	No. of Blocks:		
Put on Printer No.	Time:	Date:	By:
Off--	Time:	Date:	By: Reason:
Remarks on Back	Request No. _____		
FILL OUT FORM COMPLETELY PLEASE!			
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