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LOS ALAMOS SCIENTIFIC LABORATORY
of the
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LARCA: A FORTRAN-IV CDC-6600 Program for Calculating Flux-Weighted Cross Sections

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by

R. C. Anderson

LARCA:

A FORTRAN-IV CDC-6600 PROGRAM FOR CALCULATING FLUX-WEIGHTED CROSS SECTIONS

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R. C. Anderson

ABSTRACT

LARCA is a FORTRAN-IV, CDC-6600 program which computes flux-weighted cross sections for homogeneous or heterogeneous mixtures of materials. The program also computes infinite medium fluxes, reaction rates, and other related quantities. The flux-weighted cross sections are punched in a form suitable for use in the multigroup, transport theory program DTF-IV.

INTRODUCTION

For calculation of the properties of reactors with programs such as the DTF-IV program,[1] it is often desirable, and sometimes necessary, to use the following types of multigroup cross sections: mix cross sections for frequently used compounds and mixtures, cross sections for the material in a homogeneous reactor system, and flux-weighted cross sections for each material or for the core of a heterogeneous reactor.

Hand calculation of such cross sections is tedious. The LARCA computer program has been written to calculate these cross sections and to punch cross-section decks suitable for use in DTV-IV.

In addition, since all the necessary data is available, the program can compute the infinite medium flux, the reaction rates, and such overall reactor properties as the infinite multiplication and the material buckling.

This report describes in detail the input, output, and operation of the program.

1. THE LARCA PROGRAM

1.1 General Description

The LARCA program computes the following quantities for a multigroup, multiregion model of a nuclear system:

Macroscopic cross sections (Mix cross sections) for each group in each region

Flux-weighted cross sections (LARCA cross sections) for each group in each region

Infinite medium flux in each group (optional calculation)

Reactions in each group (optional calculation)

Limitations

1-25 groups, 4-13 reaction types per group

1-20 zones

1-36 materials

Required physical quantities

Cross sections for each material in the system

Total flux (integrated over volume) in each group and each zone (supplied as input data or computed by the program)

Coordinates for the geometric boundary (right-hand boundary or outer radius) of each zone

Number density of each material in each zone

Source in each group if the infinite medium flux is calculated (supplied as input data or computed by the program)

Geometric buckling or dimensions for which leakage (DB^2) is to be calculated

Note: When leakage is calculated, the leakage is added to the flux-weighted absorption and transport cross sections.

Program output

All input data other than cross sections

Input cross sections (optional output)

Mix cross sections (optional output)

LARCA cross sections

LARCA cross sections punched on cards (optional output)

Infinite medium fluxes (if calculated)

Reactions (if calculated)

Section 1.2 lists the principal LARCA operations in the order performed for each problem and the sections of this report in which the operations are fully described.

The input cards are described in detail in Section 2; the calculations, in Section 3; and the print and punch output, in Section 4.

1.2 Principal Operations

See Attached Errata Sheet

1.	PRINT	(4.1)	Heading
2.	READ	(2.1)	Card A
3.	PRINT	(4.1)	Problem identification
4.	READ	(2.1)	Card B, card C
5.	CALCULATE	(3.1)	Quantities related to data on cards B and C
6.	PRINT	(4.1)	Indices
7.	PRINT	(4.1)	Leakage data
8.	READ	(2.1)	Card(s) D, card(s) E
~~9.~~	~~CALCULATE~~	~~(3.2)~~	~~Flux (when IF = 1, 2, 3)~~
~~10.~~	~~READ~~	~~(2.1)~~	~~Card(s) F (when IF = 4)~~
~~11.~~	~~CALCULATE~~	~~(3.3)~~	~~Total flux~~
~~12.~~	~~CALCULATE~~	~~(3.4)~~	~~Sources (when IS = 3)~~
~~13.~~	~~READ~~	~~(2.1)~~	~~Card(s) G (when IS = 4)~~

Delete

Items 14-16 occur for each set of input cross sections when NM > 0.

14.	READ	(2.1)	Cross-section deck(s) (when NM > 0)
15.	CALCULATE	(3.5)	Quantities related to data in cross-section deck (when NM > 0)
16.	PRINT	(4.1)	Cross-section header card
17.	PRINT	(4.1)	Cross-section identification (when NM < 36)
18.	PRINT	(4.2)	Input cross sections (when NM > 0 and IW = 2)
19.	PRINT	(4.1)	Zone data

Items 20-21 occur for each region.

20.	CALCULATE	(3.6)	Mix cross sections and related quantities
21.	PRINT	(4.3)	Mix cross sections and related quantities (when IW = 1,2)
22.	CALCULATE	(3.7)	LARCA cross sections and related quantities
23.	PRINT	(4.4)	LARCA cross sections and related quantities
24.	PUNCH	(4.6)	LARCA cross sections (when IP = 1)
25.	CALCULATE	(3.8)	Infinite medium fluxes (when IS = 2,3,4)
26.	CALCULATE	(3.9)	Reaction rates and related quantities (when IS > 0)
27.	PRINT	(4.5)	Reaction rates and related quantities (when IS > 0)

END OF PROBLEM

1.3 Subscript Notation

Subscripts are indicated in parentheses in the FORTRAN notation; e.g., X_i = X(I) or X(i). The uppercase indicates that the variable is subscripted in the program; the lowercase indicates that the variable depends on the subscript but is not subscripted in the program.

I: Zone subscript

Unless otherwise indicated, I = 1, NZ

J: Group subscript

Unless otherwise indicated, J = 1, NG

J = 1 is the highest energy group; J = NG is the lowest energy group

K: Reaction subscript

K = 1, NK

K = 1	Absorption
K = 2	ν * fission
K = 3	Transport
K = NS	Self-scattering (J → J)

When NS = 4

K = NS + j	Down-scattering (J-j → J) j = 1, NK-NS

When NS > 4

K = 4	Total up-scattering cross section out of group J
K = NS - j	Up-scattering (J+j → J) j = 1, NS-5
K = NS + j	Down-scattering (J-j → J) j = 1, NK-NS

M: Material subscript

M = 1, 36

Each nuclide in the system has an M number by which its cross sections are identified and selected for use in calculations

N: Cross-section index

N = 1, NX

Each cross section (and its corresponding flux) is identified by N = NK*(J-1) + K; J = 1, NG; K = 1, NK

2. INPUT DATA CARDS

Section 2.1 lists each type of required input card and gives the following information for each: the conditions for card requirement, the number of cards required, and the input quantities that go on the cards. The following information is given for each input quantity: the card columns in which the data are punched, the format in which the data are punched, the FORTRAN symbol for the input quantity, and the definition of the input quantity and limitations and restrictions on the values it may have.

The input data are summarized in Section 2.2, and the instructions for running the program are given in Section 2.3.

2.1 Detailed List of Input Data Cards

Card A: IDENTIFICATION CARD

1 card required

1-72	A72	IDP		Problem identification Columns 1-6 are punched as identification on output cross-section cards

Card B: INDEX CARD

1 card required

See Attached Errata Sheet

1-6	I6	NZ		Number of zones $1 \le NZ \le 20$
7-12	I6	NC		Number of nonzero number densities $1 \le NC \le 36 * NZ$
13-18	I6	IF	0	Flux for LARCA cross-section calculation from previous problem
			1	Flux computed for LARCA cross-section calculation (slab geometry)
			2	Flux computed for LARCA cross-section calculation (cylindrical geometry)
			3	Flux computed for LARCA cross-section calculation (spherical geometry)
			4	Flux for LARCA cross-section calculation read from Type F cards
19-24	I6	IS	0	No reaction calculation
			1	Reaction calculation, using flux from LARCA calculation
			2	Reaction calculation, using infinite medium flux with sources from previous problem
			3	Reaction calculation, using infinite medium flux with calculated sources
			4	Reaction calculation, using infinite medium flux with sources read from Type G cards
25-30	I6	NM		Number of cross-section decks to be read in $0 \le NM \le 36$
31-36	I6	NG		Number of groups $1 \le NG \le 25$
37-42	I6	NK		Number of cross sections per group $4 \le NK \le 13$
43-48	I6	NS		Position of self-scattering cross section, σ_{gg} $4 \le NS \le NK$
49-54	I6	IW	2	Complete printout
			1	Cross sections read from cards not printed
			0	Cross sections read from cards and mix cross sections not printed
55-60	I6	IP	1	LARCA cross sections punched
			0	LARCA cross sections not punched
61-66	I6	MX		M-number of LARCA cross sections (saved for subsequent calculations) $0 \le MX \le 36$ MX = 0 implies that the cross sections are not to be saved

Card C: LEAKAGE CARD See Attached Errata Sheet

1 card required

(The dimensions listed below are those through which leakage may occur. When there is no leakage, set B1, B2, B3, B4 = 0.)

1-12	E12.4	B1	Length of slab or cylinder (cm)
13-24	E12.4	B2	Width of slab (cm)
25-36	E12.4	B3	Diameter of cylinder (cm)
37-48	E12.4	B4	Diameter of sphere (cm)
49-60	E12.4	BG	Geometric buckling (cm^{-2})

Card D: ZONE CARDS See Attached Errata Sheet

1 to 7 cards required for NZ zones at 3 zones per card

1-12	A12	IDZ(I)	I = 1, 4, 7, 10, 13, 16, 19
13-24	E12.4	R(I)	
25-36	A12	IDZ(I+1)	
37-48	E12.4	R(I+1)	
49-60	A12	IDZ(I+2)	
61-72	E12.4	R(I+2)	
		IDZ(I)	Identification of zone I

R(I)	Radius or right-hand coordinate of zone I R(I) > R(I-1) R(I) may be omitted when IF = 0 or 4 (fluxes are not calculated)

Card E: NUMBER DENSITY CARDS

1-240 cards required for NC nonzero number densities at 3 number densities per card

1-6	I6	M	1 ≤ M ≤ 36
7-12	I6	I	1 ≤ I ≤ NZ
13-24	E12.4	C(M,I)	
25-30	I6	M	
31-36	I6	I	
37-48	E12.4	C(M,I)	
49-54	I6	M	
55-60	I6	I	
61-72	E12.4	C(M,I)	
	M	M-number of material	
	I	Zone number	
	C(M,I)	Number density of material M in zone I (Atoms/b-cm, if cross sections are in barns; dimensionless, if cross sections are in cm^{-1})	

There are no restrictions on the order in which the sets of M, I, and C(M,I) are read in.

See Attached Errata Sheet

Card F: FLUX CARDS

1-6 cards for each group for NZ fluxes at 6 fluxes per card

Cards omitted unless IF = 4

1-72	6E12.4	F(I,J)	Flux in group J, zone I I = 1, NZ

The fluxes have units of n/cm-sec in slab geometry, n/sec in cylindrical geometry, and n/cm-sec in spherical geometry

The F-cards are produced by DTF-IV when the identification number (the first word on the second card of the DTF input deck) is negative

See Attached Errata Sheet

Card G: SOURCE CARDS

1-5 cards required for NG sources at 6 sources per card

Cards omitted unless IS = 4

1-72	6E12.4	S(J)	Source (n/sec) in group J J = 1, NG

CROSS-SECTION DECKS

NM decks required

The cross-section decks used in the DTF program (including the header card) are used in the LARCA program

See Attached Errata Sheet

2.2 Summary of Input Data Cards

The following input data cards are required for each problem:

Card A	Identification card		
Card B	Index card		
Card C	Leakage card		
Card(s) D	Zone card(s)		
Card(s) E	Number density card(s)		
Card(s) F	Flux card(s)	Group 1	when IF = 4
	Flux card(s)	Group 2	when IF = 4
	. . .	. . .	
	Flux card(s)	Group NG	when IF = 4
Card(s) G	Source card(s)		when IS = 4
	Cross-section decks		NM decks

2.3 Use of the Program

LARCA is written in FORTRAN-IV for the CDC-6600. The program requires 61K storage and less than 1-min running time. The deck set-up is as follows:

1. JØB card (1 min, 61K storage, * in column 63)
2. MØDE1.
3. RUN(G)
4. End of record (7-8-9 in column 1)
5. LARCA deck
6. End of record (7-8-9 in column 1)
7. Input data cards - First problem

   Input data cards - Second problem

   . . . . . .

   Input data cards - Last problem
8. End of job (6-7-8-9 in column 1)

3. CALCULATIONS

3.1 Quantities Related to Data on Cards B and C

Buckling factors

BF1 =	0.0	if B1 ≤ 0
	3.141592	if B1 > 0
BF2 =	0.0	if B2 ≤ 0
	3.141592	if B2 > 0
BF3 =	0.0	if B3 ≤ 0
	4.8096	if B3 > 0
BF4 =	0.0	if B4 ≤ 0
	6.283184	if B4 > 0

Geometric buckling

BG =	Input value	if B1 + B2 + B3 + B4 ≤ 0
	0.0	if B1 + B2 + B3 + B4 > 0

Total number of cross sections per nuclide

NX = NG * NK

Miscellaneous indices

NG1 = NG + 1

NG2 = NG + 2

NM1 = NM + 1

3.2 Fluxes

Calculated when IF = 1, 2, 3

Flux in zone I, group 1

$$F(I,1) = R(I)^{**}IF - G(i,1) \qquad I = 1,\ NZ$$

$$G(i,1) = \begin{cases} R(I-1)^{**}IF & I = 2,\ NZ \\ 0 & I = 1 \end{cases}$$

Flux in zone I, group J

$$F(I,J) = F(I,1) \qquad J = 2,\ NG$$

3.3 Total Fluxes

Total flux in each group J

J = 1, NG

$$G(J) = \sum F(I,J)$$

Summation over I = 1, NZ

3.4 Sources

Calculated when IS = 3

Sources in each group J

J = 1, NG

S(1) = .204	S(5) = .090		
S(2) = .344	S(6) = .014		
S(3) = .168	S(J) = 0	J = 7, NG	
S(4) = .180			

3.5 Quantities Related to Data in Cross-Section Deck

M-number

The cross sections are identified by the number M, M = 1 for the first set read in, M = 2 for the second set, etc. Each set of cross sections retains the same M number from one problem to the next, unless new cross sections are read in or stored over it.

Cross-section identification

IDY(M) = IDX(M,8) (columns 44-49 of cross-section header card)

M = 1, 36

Cross sections for printing

Calculated when IW = 2 and NM > 0, for all input materials M = 1, NM

$$W(J,k) = X(M,N)$$

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

See Attached Errata Sheet

3.6 Mix Cross Sections and Related Quantities

Calculated for each zone I = 1, NZ

Mix cross sections

$$Y(i,N) = \sum C(M,I)^{*}X(M,N)$$

Summation over all materials M = 1, 36 for which C(M,I) > 0

N = 1, NX

Diffusion coefficient

$$D(i,J) = \begin{cases} 1.0/[3.0^{*}Y(N)] & \text{if } Y(N) > 0 \\ 0 & \text{if } Y(N) \le 0 \end{cases}$$

J = 1, NG

N = NK*(J-1) + 3

Leakage cross section

$$B(i,J) = D(i,J)\left[\left(\frac{BF1}{B1^{*}Y(N) + 1.4208}\right)^2 + \left(\frac{BF2}{B2^{*}Y(N) + 1.4208}\right)^2 + \left(\frac{BF3}{B3^{*}Y(N) + 1.4208}\right)^2 + \left(\frac{BF4}{B4^{*}Y(N) + 1.4208}\right)^2 + BG\right]$$

J = 1, NG

N = NK*(J-1) + 3

Mix cross sections for printing

Calculated when IW = 1,2

$$W(i,J,k) = Y(i,N)$$

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

Fluxes for each zone in cross-section format

$$P(i,N) = \begin{cases} F(I,L) & \text{when } 1 \le L \le NG \\ 0 & \text{when } L < 1 \text{ or } L > NG \end{cases}$$

I = 1, NZ

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

$$L = \begin{cases} J & \text{when } K \le 4 \\ J + NS - K & \text{when } K > 4 \end{cases}$$

Unnormalized LARCA cross sections

$$Z(N) = \sum Y(i,N)^{*}P(i,N)$$

Summation over I = 1, NZ

N = 1, NX

3.7 LARCA Cross Sections and Related Quantities

Total flux in cross-section format

$$P(N) = \begin{cases} G(L) & \text{when } 1 \le L \le NG \\ 0 & \text{when } L < 1 \text{ or } L > NG \end{cases}$$

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

$$L = \begin{cases} J & \text{when } K \le 4 \\ J + NS - K & \text{when } K > 4 \end{cases}$$

LARCA cross sections

$$Z(N) = \begin{cases} Z(N)/P(N) & \text{when } Z(N) \ne 0 \\ 0 & \text{when } Z(N) = 0 \end{cases}$$

N = 1, NX

Diffusion coefficient

D(J) = 1.0/[3.0*Z(N+2)]   when Z(N+2) > 0
       0   when Z(N+2) ≤ 0

J = 1, NG

N = NK*(J-1) + 1

Leakage cross section

$$B(J) = D(J)\left[\left(\frac{BF1}{B1*Z(N+2)+1.4208}\right)^2 + \left(\frac{BF2}{B2*Z(N+2)+1.4208}\right)^2 + \left(\frac{BF3}{B3*Z(N+2)+1.4208}\right)^2 + \left(\frac{BF4}{B4*Z(N+2)+1.4208}\right)^2 + BG\right]$$

J = 1, NG

N = NK*(J-1) + 1

Leakage modification to absorption and transport cross sections

Z(N) = Z(N) + B(J)

Z(N+2) = Z(N+2) + B(J)

J = 1, NG

N = NK*(J-1) + 1

Check cross section

CX(J) = Z(N+2) - Z(N) - ∑Z(L) - Z(N+3)

J = 1, NG

K = NS, NK

N = NK*(J-1) + 1

L = N + K - 1 + NK*(K-NS)

Summation over L = N+NS-1, min [NX; N-1+NK*(1+NK-NS)]

The Z(N+3) term is omitted when NS ≤ 4

Modification to the self-scattering cross section

Z(L) = Z(L) + CX(J)

J = 1, NG

N = NK*(J-1) + 1

L = N + NS - 1

Storage of LARCA cross sections

Calculated when MX > 0

X(MX,N) = Z (N)

IDY(MX) = IDP(1)

N = 1, NX

LARCA cross sections for printing

W(J,k) = Z(N)

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

LARCA cross sections for punching

Calculated when IP = 1

NG8   Octal equivalent of NG

NK8   Octal equivalent of NK

NX1 = NX+1

Z(N) = 0.0 for N = NX1,330

3.8 Infinite Medium Flux

Calculated when IS > 1

Infinite medium flux when NS ≤ 4

G(J) = S(J) + ∑Z(N)*G(L)

Summation over K = 5, NK

J = 1, NG

N = NK*(J-1) + K

L = J-K+4

When L < 0, no term is added to the summation

$$G(J) = \frac{G(J)}{Z(N) - Z(N+1)}$$

J = 1, NG

N = NK*(J-1) + 3

Infinite medium flux when NS > 4

U(J,L) = 0.0   when K ≤ 4, K > NK

U(J,L) = 1.0   when K = NS

$$U(J,L) = \frac{Z(N)}{Z(N1)-Z(N2)}$$ when K > 4, K ≤ NK, K ≠ NS

$$V(J) = \frac{S(J)}{Z(N1)-Z(N2)}$$

J = 1, NG

L = 1, NG

K = J-L+NS

N1 = NK*(J-1) + 3

N2 = NK*(J-1) + NS

N = NK*(J-1) + K

The set of equations ∑U(J,L)*G(J) = V(J), J=1, NG is solved by the LSS subroutine

Infinite medium fluxes in cross-section format

P(N) = G(L)   when 1 ≤ L ≤ NG
       0   when L < 1, L > NG

J = 1, NG

K = 1, NK

N = NK*(J-1) + K

L = J   when K ≤ 4
    J + NS - K   when K > 4

3.9 Reaction Rates and Related Data

Calculated when IS > 0

Reaction rates

Y(N) = [Z(N) - B(J)]*P(N)

J = 1, NG

K = 1 and 3

N = NK*(J-1) + K

See Attached Errata Sheet

Y(N) = Z(N)*P(N)

J = 1, NG

K = 2; K = 4, NK
N = NK*(J-1) + K

Total reactions

Y(N1) = $\sum$Y(N)
Summation over J= 1, NG
J = 1, NG
K = 1, NK
N = NK*(J-1) + K
N1 = NX + K

Total flux

G(NG1) = $\sum$G(J)
Summation over J = 1, NG

See Attached Errata Sheet

Total source

S(NG1) = $\sum$S(J)
Summation over J = 1, NG

Total diffusion reactions

D(NG1) = $\sum$D(J)*G(J)
Summation over J = 1, NG

Total leakage

B(NG1) = $\sum$B(J)*G(J)
Summation over J = 1, NG

Material buckling

$$BM = \frac{Y(NX+2) - Y(NX+1)}{D(NG1)}$$

BM2 = $BM^{1/2}$ when BM > 0
0 when BM ≤ 0

Geometric buckling

BG2 = $BG^{1/2}$ when BG > 0
0 when BG < 0

Infinite multiplication

$$RINF = \frac{Y(NX+2)}{Y(NX+1)}$$

Effective multiplication

$$REFF = \frac{Y(NX+2)}{Y(NX+1) + B(NG1)}$$

Average cross sections

Y(N+1) = Y(NX+1)/G(NG1)
Y(N+2) = Y(NX+2)/G(NG1)
D(NG2) = D(NG1)/G(NG1)
Y(N+3) = Y.0/[3.0*D(NG2)]
G(NG2) = 1.0
B(NG2) = B(NG1)/G(NG1)
S(NG2) = 0.0
Y(L) = Y(N+3) - Y(N+1)
N = NX + NK
L = N + NS

Extrapolation distance

E = 0.7104/Y(N+3)

Reaction rates for printing

W(J,k) = Y(N)
J = 1, NG
K = 1, NK
N = NK*(J-1) + K

4. PRINTED OUTPUT

All of the underscored items listed below as output are printed by the program.

4.1 Input Data

Printed for each problem

LARCA CALCULATION

IDP(L) L = 1, 12

INDICES

NZ	NC	IF	IS	NM	NG	NK	NS	NX	IW	IP	MX
NZ	NC	IF	IS	NM	NG	NK	NS	NX	IW	IP	MX

LEAKAGE CONSTANTS

BKLG HEIGHT	BKLG HEIGHT	CYL BKLG DIAM	SPH BKLG DIAM	GEOM BUCKLING
B1	B2	B3	B4	BG

CROSS SECTIONS

1	IDX	(1,L)	L = 1, 12
2	IDX	(2,L)	L = 1, 12
3	IDX	(3,L)	L = 1, 12
...	...		
NM	IDX	(nm,L)	L = 1, 12
NM + 1	IDY	(NM+1)	
...	...		
36	IDY	(36)	

ZONE DATA

	ZONE	RADIUS	MATERIAL	NUMBER DENSITY
1	IDZ(1)	R(1)	M IDY(M)	C(M,1)
			(printed for all materials in zone 1)	
2	IDZ(2)	R(2)	M IDY(M)	C(M,2)
			(printed for all materials in zone 2)	
...	...	...	...	...
NZ	IDZ(NZ)	R(NZ)	M IDY(M)	C(M,NZ)
			(printed for all materials in zone NZ)	

4.2 Input Cross Sections

Printed when IW = 2 and NM > 0 for each M = 1, NM;

N = NK * (J-1) + K

M	IDY(M)			
	1	2	. . .	NG
1	X(M,N)	X(M,N)	. . .	X(M,N)
2	X(M,N)	X(M,N)	. . .	X(M,N)
. . .	. . .	. . .	. . .	. . .
NK	X(M,N)	X(M,N)	. . .	X(M,N)

See Attached Errata Sheet

4.3 Mix Cross Sections

Printed for each zone I; I = 1, NZ when IW = 1,2;

N = NK * (J-1) + K

IDP(L) L = 1,12

MIX CROSS SECTION IN ZONE I

	1	2	. . .	NG
1	Y(i,N)	Y(i,N)	. . .	Y(i,N)
2	Y(i,N)	Y(i,N)	. . .	Y(i,N)
. . .	. . .	. . .		. . .
NK	Y(i,N)	Y(i,N)	. . .	Y(i,N)
FLUX	F(I,1)	F(I,2)	. . .	F(I,NG)
DIFF COEF	D(i,1)	D(i,2)	. . .	D(i,NG)
LEAKAGE	B(i,1)	B(i,2)	. . .	B(i,NG)

See Attached Errata Sheet

4.4 LARCA Cross Sections

N = NK * (J-1) + K

LARCA CROSS SECTIONS

	1	2	. . .	NG
1	Z(N)	Z(N)	. . .	Z(N)
2	Z(N)	Z(N)	. . .	Z(N)
. . .	. . .	. . .		. . .
NK	Z(N)	Z(N)	. . .	Z(N)
FLUX	G(1)	G(2)	. . .	G(NG)
DIFF COEF	D(1)	D(2)	. . .	D(NG)
LEAKAGE	B(1)	B(2)	. . .	B(NG)
CHK X-SEC	CX(1)	CX(2)	. . .	CX(NG)

See Attached Errata Sheet

4.5 Reactions

Printed when IS > 0; Sources printed only when IS ≥ 2

N = NK * (J-1) + K

Y(NG2) printed only for K = 1, 2, 3, NS

Fluxes are the same fluxes used in the flux-weighted cross-section calculation (when IS = 1) or infinite medium fluxes (when IS = 2, 3, 4)

IDP(L) L = 1, 12

REACTION RATES

COLUMN NG1 = TOTALS OVER ALL GROUPS

COLUMN NG2 = AVERAGES OVER ALL GROUPS

1	1	2	. . .	NG	NG1	NG2
1	Y(N)	Y(N)	. . .	Y(N)	Y(NG1)	Y(NG2)
2	Y(N)	Y(N)	. . .	Y(N)	Y(NG1)	Y(NG2)
. . .	. . .	. . .		. . .	. . .	. . .
NK	Y(N)	Y(N)	. . .	Y(N)	Y(N)	0.0
FLUX	G(1)	G(2)	. . .	G(NG)	G(NG1)	1.0
DIFF COEF	D(1)	D(2)	. . .	D(NG)	D(NG1)	D(NG2)
LEAKAGE	B(1)	B(2)	. . .	B(NG)	B(NG1)	B(NG2)
SOURCE	S(1)	S(2)	. . .	S(NG)	S(NG1)	S(NG2)

MATL BKLG	BM	(B = BM2)
GEOM BKLG	BG	(B = BG2)
K INFINITY	RINF	
K EFFECTIVE	REFF	
EXTN DIST	E	CM

4.6

Attached Errata Sheet

4.6 Punch Output

When IP = 1, the flux-weighted cross sections are punched

Header card

Columns 14-16	G=
Columns 17-18	NG8
Columns 19-22	L=
Columns 23-24	NK8
Columns 25-37	NUCLIDE NØ.=
Columns 44-49	IDP(1)
Columns 73-78	IDP(1)
Columns 79-80	IC (IC = 0)

Data cards

Columns 1-72	Z(N)	6 words per card	N=1,NX
Columns 73-78	IDP(1)		
Columns 79-80	IC	(IC = 1, 2, 3, . . .)	

REFERENCE

1. K. D. Lathrop, "DTF-IV, a FORTRAN-IV Program for Solving the Multigroup Transport Equation with Anisotropic Scattering," Los Alamos Scientific Laboratory report LA-3373 (1965).

```
      PROGRAM LARCA ( INPUT,OUTPUT,PUNCH)
C
C     DIMENSION STATEMENTS
C
      DIMENSION ICP( 12),IDZ1(20),IDZ2(20),IDX( 12),IDY(36)
      DIMENSION R(20),C(36,20),S(27),F(20,25),G(27),X(36,325),W(27),
     1 Z(330),Y(351),D(27),B(27),P(325),CX(25),U(25,25),V(25)
C
C     INPUT FORMAT STATEMENTS
C
 1011 FORMAT(6A6,A7,4A6,A5)
 1012 FORMAT(12I6)
 1013 FORMAT(6E12.4)
 1031 FORMAT(3(2A6,E12.4))
 1032 FORMAT(3(2I6,E12.4))
C
C     OUTPUT FORMAT STATEMENTS
C
 2001 FORMAT(1H1,*LARCA CALCULATION*)
 2011 FORMAT(1H0,6A6,A7,4A6,A5)
 2012 FORMAT(1H0,*INDICES*//          6H    NZ,6H    NC,6H    IF,
     1 6H    IS,6H    NM,6H    NG,6H    NK,6H    NS,6H    NX,6H    IW,
     2 6H    IP,6H    MX/12I6)
 2013 FORMAT(1H0,*LEAKAGE CONSTANTS*//16H     BKLG HEIGHT,
     1 16H     BKLG HEIGHT,16H   CYL BKLG DIAM,
     2 16H   SPH BKLG DIAM,16H   GEOM BUCKLING/5F16.6)
 2091 FORMAT(1H0,*CROSS SECTIONS*//)
 2092 FORMAT(I6,6X,A6,6X,12A6)
 2093 FORMAT(I6,6X,A6)
 2094 FORMAT(1H0,11X,8I12)
 2095 FORMAT(I3,9X,8F12.6)
 2096 FORMAT(1H1,I5,6X,A6)
 2111 FORMAT(1H1,*ZONE DATA*//6X,16H            ZONE,
     1 16H          RADIUS,16H        MATERIAL,16H  NUMBER DENSITY)
 2112 FORMAT(1H0,I5,4X,2A6,F16.6)
 2113 FORMAT(38X,I6,4X,A6,F16.6)
 2241 FORMAT(1H1,6A6,A7,4A6,A5//* MIX CROSS SECTIONS IN ZONE*,I3//)
 2242 FORMAT(1H0,11HFLUX       ,8F12.6)
 2243 FORMAT(12H DIFF COEFF ,8F12.6)
 2244 FORMAT(12H LEAKAGE    ,8F12.6)
 2321 FORMAT(1H1,6A6,A7,4A6,A5//* LARCA CROSS SECTIONS*//)
 2322 FORMAT(1H0,11HCHK X-SEC   ,8F12.6)
 2651 FORMAT(1H1,6A6,A7,4A6,A5//* REACTION RATES*//
     1 6X,*COLUMN*,I3, * = TOTALS OVER ALL GROUPS*/
     2 6X,*COLUMN*,I3, * = AVERAGES OVER ALL GROUPS*//)
 2652 FORMAT(12H SOURCE     ,8F12.6)
 2653 FORMAT(1H1,11HMATL BKLG  ,F12.8,* (B =*,F12.8,* )*/
     1 12H GEOM BKLG  ,F12.8,* (B =*,F12.8,* )*/12H K INFINITY ,F12.6/
     2 12H K EFFECTIVE,F12.6/12H EXTN DIST  ,F12.6,* CM*)
C
C     PUNCH FORMAT STATEMENTS
C
 3331 FORMAT(13X,3HG= ,I2,4H L= ,I2,13H NUCLIDE NO.=,
     1 6X,A6,23X,A6,I2)
 3332 FORMAT(6E12.6,A6,I2)
C
C     PREPARATION
C
      DO1M=1,36  $  IDY(M)=6H
    1 CONTINUE
    2 PRINT 2001
C
```

```
C     GENERAL INPUT
C
      REAC 1011,(ICP(L),L=1,12)  $  PRINT 2011,(IDP(L),L=1,12)
C
      REAC 1012,NZ,NC,IF,IS,NM,NG,NK,NS,IW,IP,MX
      REAC 1013,B1,B2,B3,B4,BG
C
      BF1=0.0  $  BF2=0.0  $  BF3=0.0  $  BF4=0.0
      IF(B1.GT.0.0)BF1=3.141592  $  IF(B2.GT.0.0)BF2=3.141592
      IF(B3.GT.0.0)PF3=4.8096  $  IF(B4.GT.0.0)BF4=6.283184
      IF(B1+B2+B3+B4.GT.0.0)BG=0.0
      NX=NG*NK  $  NG1=NG+1  $  NG2=NG+2  $  NM1=NM+1
C
      PRINT 2012,NZ,NC,IF,IS,NM,NG,NK,NS,NX,IW,IP,MX
      PRINT 2013,B1,B2,B3,B4,BG
C
C     ZONE ANC MATERIAL INPUT
C
      REAC 1031,(IDZ1(I),IDZ2(I),R(I),I=1,NZ)
      DO32I=1,NZ  $  DO31M=1,36  $  C(M,I)=0.0
   31 CONTINUE
   32 CONTINUE  $  READ 1032,(M,I,C(M,I),L=1,NC)
C
C     FLUX INPUT FOR LARCA CALCULATION
C
   51 IF(IF-1)67,61,52
   52 IF(IF-3)61,61,65
C
   61 G(1)=0.0  $  DO63I=1,NZ  $  F(I,1)=R(I)**IF-G(1)
      G(1)=G(1)+F(I,1)  $  DO62J=2,NG  $  F(I,J)=F(I,1)
   62 CONTINUE
   63 CONTINUE  $  GOTO67
C
   65 DO66J=1,NG  $  READ 1013,(F(I,J),I=1,NZ)
   66 CONTINUE
   67 DO69J=1,NG  $  G(J)=0.0  $  DO68I=1,NZ  $  G(J)=G(J)+F(I,J)
   68 CONTINUE
   69 CONTINUE
C
C     REACTION INPUT
C
      IF(IS-3)81,71,73
C
   71 S(1)=.204  $  S(2)=.344  $  S(3)=.168  $  S(4)=.180  $  S(5)=.090
      S(6)=.014  $  DO72J=7,NG  $  S(J)=0.0
   72 CONTINUE  $  GOTO81
C
   73 REAC 1013,(S(J),J=1,NG)
C
C     CROSS SECTION INPUT
C
   81 PRINT 2091  $  IF(NM)93,93,91
C
   91 DO92M=1,NM  $  READ 1011,(IDX(L),L=1,12)  $  IDY(M)=IDX(8)
      PRINT 2092,M,IDY(M),(IDX(L),L=1,12)  $  READ 1013,(X(M,N),N=1,NX)
   92 CONTINUE
   93 IF(NM.LT.36)PRINT 2093,(M,IDY(M),M=NM1,36)
   94 IF(IW.LE.1.OR.NM.LE.0)GOTO99
   95 DO99M=1,NM  $  PRINT 2096,M,IDY(M)  $  J2=0
   96 J1=J2+1  $  J2=J1+7  $  IF(NG.LE.J2)J2=NG
      PRINT 2094,(J,J=J1,J2)  $  DO98K=1,NK  $  DO97J=J1,J2
      N=NK*(J-1)+K  $  W(J)=X(M,N)
   97 CONTINUE  $  PRINT 2095,K,(W(J),J=J1,J2)
   98 CONTINUE  $  IF(NG-J2)99,99,96
   99 CONTINUE
```

```
C
C     ZONE AND MATERIAL OUTPUT
C
  111 PRINT 2111  $  DO114I=1,NZ  $  PRINT 2112,I,IDZ1(I),IDZ2(I),R(I)
      DO113M=1,36  $  IF(C(M,I))113,113,112
  112 PRINT 2113,M,IDY(M),C(M,I)
  113 CONTINUE
  114 CONTINUE
C
C     CLEAR LARCA CROSS SECTIONS AND BEGIN ZONE LOOP
C
  201 DO202N=1,330 $  Z(N)=0.0
  202 CONTINUE  $  DO271I=1,NZ  $  DO203N=1,NX  $  Y(N)=0.0
  203 CONTINUE
C
C     CALCULATE MACROSCOPIC CROSS SECTIONS BY ZONE
C
      DO223M=1,36  $  IF(C(M,I))223,223,221
  221 DO222N=1,NX  $  Y(N)=Y(N)+C(M,I)*X(M,N)
  222 CONTINUE
  223 CONTINUE  $  DO233J=1,NG  $  N=NK*(J-1)+3  $  IF(Y(N))231,231,232
  231 D(J)=0.0  $  B(J)=0.0  $  GOTO233
  232 D(J)=1.0/(3.0*Y(N))  $  B(J)=(BF1/(B1+1.4208/Y(N)))**2
      B(J)=B(J)+(BF2/(B2+1.4208/Y(N)))**2 +(BF3/(B3+1.4208/Y(N)))**2
      B(J)=D(J)*(BG+B(J)+(BF4/(B4+1.4208/Y(N)))**2)
  233 CONTINUE  $  IF(IW -1)251,241,241
C
C     PRINT MACROSCOPIC CROSS SECTIONS BY ZONE
C
  241 PRINT 2241,(ICP(L),L=1,12),I  $  J2=0
  242 J1=J2+1  $  J2=J1+7  $  IF(NG.LE.J2)J2=NG
      PRINT 2094,(J,J=J1,J2)  $  DO244K=1,NK  $  DO243J=J1,J2
      N=NK*(J-1)+K  $  W(J)=Y(N)
  243 CONTINUE  $  PRINT 2095,K,(W(J),J=J1,J2)
  244 CONTINUE  $  PRINT 2242,(F(I,J),J=J1,J2)
      PRINT 2243,(D(J),J=J1,J2)  $  PRINT 2244,(B(J),J=J1,J2)
      IF(NG-J2)251,251,242
C
C     ARRANGE ZONE FLUXES
C
  251 DO258J=1,NG  $ DO257K=1,NK  $ N=NK*(J-1)+K  $ IF(K-4)252,252,253
  252 L=J  $  GOTO255
  253 L=J+NS-K  $  IF(L)256,256,254
  254 IF(NG-L)256,255,255
  255 P(N)=F(I,L)  $  GOTO257
  256 P(N)=0.0
  257 CONTINUE
  258 CONTINUE
C
C     ACCUMULATE LARCA CROSS SECTIONS
C
  261 DO262N=1,NX  $  Z(N)=Z(N)+Y(N)*P(N)
  262 CONTINUE
C
C     END ZONE LOOP
  271 CONTINUE
C
C     ARRANGE FLUX
C

  281 DO288J=1,NG  $ DO287K=1,NK  $ N=NK*(J-1)+K  $ IF(K-4)282,282,283
  282 L=J  $  GOTO285
  283 L=J+NS-K  $  IF(L)286,286,284
  284 IF(NG-L)286,285,285
  285 P(N)=G(L)     $  GOTO287
  286 P(N)=0.0
  287 CONTINUE
  288 CONTINUE
```

```
C
C      CALCULATE LARCA CROSS SECTIONS
C
      DO292N=1,NX   $   IF(Z(N).NE.0.0)Z(N)=Z(N)/P(N)
  292 CONTINUE   $   DO297J=1,NG   $   N=NK*(J-1)+1
      IF(Z(N+2))293,293,294
  293 D(J)=0.0   $   B(J)=0.0   $   GOTO295
  294 D(J)=1.0/(3.0*Z(N+2))   $   B(J)=(BF1/(B1+1.4208/Z(N+2)))**2
      B(J)=B(J)+(BF2/(B2+1.4208/Z(N+2)))**2 +(BF3/(B3+1.4208/Z(N+2)))**2
      B(J)=D(J)*(BG+B(J)+(BF4/(B4+1.4208/Z(N+2)))**2)
      Z(N)=Z(N)+B(J)   $   Z(N+2)=Z(N+2)+B(J)
  295 CX(J)=Z(N+2)-Z(N)   $   DO296K=NS,NK
      L=N+K-1+NK*(K-NS)   $   IF(NX.GE.L)CX(J)=CX(J)-Z(L)
  296 CONTINUE   $   IF(NS.GT.4)CX(J)=CX(J)-Z(N+3)
      L=N+NS-1   $   Z(L)=Z(L)+CX(J)
  297 CONTINUE   $   IF(MX)321,321,311
C
C      STORE LARCA CROSS SECTIONS
C
  311 DO312N=1,NX   $   X(MX,N)=Z(N)
  312 CONTINUE   $   IDY(MX)=IDP(1)
C
C      PRINT LARCA CROSS SECTIONS
C
  321 PRINT 2321,(IDP(L),L=1,12)   $   J2=0
  322 J1=J2+1   $   J2=J1+7   $   IF(NG.LE.J2)J2=NG
      PRINT 2094,(J,J=J1,J2)   $   DO324K=1,NK   $   DO323J=J1,J2
      N=NK*(J-1)+K   $   W(J)=Z(N)
  323 CONTINUE   $   PRINT 2095,K,(W(J),J=J1,J2)
  324 CONTINUE   $   PRINT 2242,(G(J),J=J1,J2)
      PRINT 2243,(D(J),J=J1,J2)   $   PRINT 2244,(B(J),J=J1,J2)
      PRINT 2322,(CX(J),J=J1,J2)   $   IF(NG-J2)331,331,322
C
C      PUNCH LARCA CROSS SECTIONS
C
  331 IF(IP )343,343,332
C
  332 NG8=NG   $   IF(NG.GT.7)NG8=NG+2   $   IF(NG.GT.15)NG8=NG+4
      IF(NG.GT.23)NG8=NG+6   $   NK8=NK   $   IF(NK.GT.7)NK8=NK+2
C
  341 IC=0   $   PUNCH 3331,NG8,NK8,IDP(1),IDP(1),IC   $   N2=0
  342 N1=N2+1   $   N2=N1+5   $   IC=IC+1
      PUNCH 3332,(Z(N),N=N1,N2),IDP(1),IC   $   IF(NX-N2)343,343,342
  343 IF(IS-1)701,601,501
C
C      CALCULATION OF INFINITE MEDIUM FLUXES
C
  501 IF(NS-4)511,511,521
C
  511 DO513J=1,NG   $   G(J)=S(J)   $   DO512K=5,NK   $   N=NK*(J-1)+K
      L=J-K+4   $   IF(L.GT.0)G(J)=G(J)+Z(N)*G(L)
  512 CONTINUE   $   N1=NK*(J-1)+3   $   N2=N1+1   $   G(J)=G(J)/(Z(N1)-Z(N2))
  513 CONTINUE   $   GOTO531
  521 DO528J=1,NG   $   N1=NK*(J-1)+3   $   N2=NK*(J-1)+NS
      DO527L=1,NG   $   K=J-L+NS   $   IF(K-4)524,524,522
  522 IF(K-NS)523,525,523
  523 IF(K-NK)526,526,524
  524 U(J,L)=0.0   $   GOTO527
  525 U(J,L)=1.0   $   GOTO527
  526 N=NK*(J-1)+K   $   U(J,L)=-Z(N)/(Z(N1)-Z(N2))
  527 CONTINUE   $   V(J)=S(J)/(Z(N1)-Z(N2))
  528 CONTINUE   $   L=1   $   CALL LSS(NG,L,NG,L,V,D,DET)
      DO529J=1,NG   $   G(J)=V(J)
  529 CONTINUE
```

```
C
C     ARRANGE INFINITE MEDIUM FLUXES
C
  531 DO538J=1,NG  $ DO537K=1,NK  $ N=NK*(J-1)+K  $ IF(K-4)532,532,533
  532 L=J  $  GOTO535
  533 L=J+NS-K  $  IF(L)536,536,534
  534 IF(NG-L)536,535,535
  535 P(N)=G(L)    $  GOTO537
  536 P(N)=0.0
  537 CONTINUE
  538 CONTINUE
C
C     CALCULATION OF REACTION RATES
C
  601 NK1=2*NK  $  DO602K=1,NK1  $  N=NX+K  $  Y(N)=0.0
  602 CONTINUE  $  G(NG1)=0.0  $ S(NG1)=0.0  $ D(NG1)=0.0  $ B(NG1)=0.0
C
      DO612J=1,NG  $  DO611K=1,NK  $  N=NK*(J-1)+K
      IF(K.EQ.1)Y(N)=(Z(N)-B(J))*P(N) $ IF(K.EQ.3)Y(N)=(Z(N)-B(J))*P(N)
      Y(N)=Z(N)*P(N)  $  N1=NX+K  $  Y(N1)=Y(N1)+Y(N)
  611 CONTINUE  $  G(NG1)=G(NG1)+G(J)  $  S(NG1)=S(NG1)+S(J)
      D(NG1)=D(NG1)+D(J)*G(J)  $  B(NG1)=B(NG1)+B(J)*G(J)
  612 CONTINUE  $  BM=(Y(NX+2)-Y(NX+1))/D(NG1)  $ BM2=0.0  $  BG2=0.0
      IF(BM.GT.0.0)BM2=BM**.5  $  IF(BG.GT.0.0)BG2=BG**.5
      RINF=Y(NX+2)/Y(NX+1)  $  REFF=Y(NX+2)/(Y(NX+1)+B(NG1))
      N=NX+NK  $                    Y(N+1)=Y(NX+1)/G(NG1)
      Y(N+2)=Y(NX+2)/G(NG1)  $  D(NG2)=D(NG1)/G(NG1)
      Y(N+3)=1.0/(3.0*D(NG2))  $  G(NG2)=1.0  $  B(NG2)=B(NG1)/G(NG1)
      S(NG2)=0.0  $  E=.7104/Y(N+3)  $  L=N+NS  $  Y(L)=Y(N+3)-Y(N+1)
C
C     PRINT REACTION RATES
C
      PRINT 2651,(ICP(L),L=1,12),NG1,NG2  $  J2=0
  651 J1=J2+1  $  J2=J1+7  $  IF(NG2.LE.J2)J2=NG2
      PRINT 2094,(J,J=J1,J2)  $  DO653K=1,NK  $  DO652J=J1,J2
      N=NK*(J-1)+K  $  W(J)=Y(N)
  652 CONTINUE  $  PRINT 2095,K,(W(J),J=J1,J2)
  653 CONTINUE  $  PRINT 2242,(G(J),J=J1,J2)
      PRINT 2243,(D(J),J=J1,J2)  $  PRINT 2244,(B(J),J=J1,J2)
      IF(IS.GE.2)PRINT 2652,(S(J),J=J1,J2)  $  IF(NG2-J2)654,654,651
  654 PRINT 2653,(BM,BM2,BG,BG2,RINF,REFF,E)
C
C     END OF PROBLEM
C
  701 GOTO2
      END
```

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IN REPLY
REFER TO: To Holders of LA-3873-MS October 1, 1969

SUBJECT: Addendum to LA-3873-MS - LARCA: A FORTRAN-IV CDC-6600 Program for Calculating Flux-Weighted Cross Sections by R. C. Anderson

Since the publication of LA-3873-MS, changes and additions, which are listed below, have been made to the LARCA program.

Section 1.1 General Description

Add to the subsection Program Output:

Damage flux

Average scattering cross section per atom (if calculated).

Section 1.2 Principal Operations

Delete items 9-13, inclusive, and insert after item 8:

9.	READ	(2.1)	Card(s) H (when IDF > 0)
10.	CALCULATE	(3.4)	Sources (when IS = 3)
10a.	READ	(2.1)	Card(s) G (when IS = 4)
11.	CALCULATE	(3.2)	Flux (when IF = 1,2, or 3)
11a.	READ	(2.1)	Card I (when IF = 5)
11b.	READ	(2.1)	Card(s) F (when IF = 4 or 5)
12.	CALCULATE	(3.3)	Total flux

Section 2.1 Detailed List of Input Data Cards

Card B: INDEX CARD

13-18	I6	IF	5	Flux for LARCA calculation read from Type I and Type F cards.
67-72	I6	NLAST	0	After completing the calculation of the problem the program reads the input data for the next problem and terminates by reading the END ØF JØB card after the last problem.
			1	After completing the calculation of the problem the program returns control to the monitor.

Card C: LEAKAGE CARD

The card is changed as follows:

1-6	I6	IDF	0	Damage Flux computed using standard damage flux coefficients.
			> 0	Damage Flux coefficients for groups 1-IDF, inclusive, to be read from Type H cards.
7-9	I3	ISP1		
10-12	I3	ISP2	The average resonance scattering cross section per atom will be computed for groups ISP1 - ISP2, inclusive. If ISP1 = 0, the calculation is omitted.	
13-24	E12.4	B1	As defined in LA-3873-MS.	
25-36	E12.4	B2	As defined in LA-3873-MS.	
37-48	E12.4	B3	As defined in LA-3873-MS.	
49-60	E12.4	B4	As defined in LA-3873-MS.	
61-72	E12.4	BG	As defined in LA-3873-MS.	

Card D: ZONE CARDS

Change last entry to read:

The quantity R(I) may be omitted when IF = 0, 4, or 5 (fluxes not calculated).

Card F: FLUX CARDS

These cards are unchanged, but are required when IF = 4 or 5.

Card G: SOURCE CARDS

These cards are unchanged, but, if used, must precede the Type I and Type F cards.

Card H: DAMAGE FLUX CARDS

These cards have been added to the input, and, if used, follow Card(s) E. 1-5 cards required for IDF damage flux coefficients at 6 coefficients per card.

Cards omitted unless IDF > 0.

1-72	6E12.4	DFC(J)	Damage Flux coefficient in group J. J = 1, IDF.

Card I: FLUX HEADER CARD

This card has been added to the input and, if used, precedes the Type F card(s).

1 card required.

Card omitted unless IF = 5.

An I card is produced by DTF-IV when the F cards are produced.

1-72	A72	IDD	Flux header card information.

Section 2.2 Summary of Input Data Cards

The revised list reads as follows:

Card A	Identification card	
Card B	Index card	
Card C	Leakage card	
Card(s) D	Zone card(s)	
Card(s) E	Number density card(s)	
Card(s) H	Damage flux card(s)	when IDF > 0
Card(s) G	Source card(s)	when IS = 4
Card I	Flux header card	when IF = 5
Card(s) F	Flux card(s) Group 1	when IF = 4,5
	Flux card(s) Group 2	when IF = 4,5
	... ...	
	Flux card(s) Group NG	when IF = 4,5
	Cross-section decks	NM decks

Section 3.6 Mix Cross Sections and Related Quantities

The following are added to this section:

Damage flux

DF(i) - $\sum$DFC(J) *F(I,J)

Summation over all J = 1, NG.

DFT = $\sum$DF(i)

Summation over all I = 1, NZ.

The standard damage flux coefficients are:

DFC(1) = 6.5	DFC(6) = .0585	
DFC(2) = 2.2	DFC(7) = .010175	
DFC(3) = 1.15	DFC(8) = .001902	
DFC(4) = .65	DFC(9) = .000258	
DFC(5) = .25	DFC(J) = 0	J = 10,25

Average scattering cross section per atom

Calculated when ISP1 > 0 for each material M in each zone I for groups ISP1, ISP2 (inclusive).

SPR(i) = $\sum$(Y(JK+2) - Y(JK))

Summation over J = ISP1, ISP2

JK = (J-1) *NK + 1

SP(i,m) = SPR(i)/C(M,I)/DSP

where DSP = ISP2 - ISP1 + 1

Section 3.9 Reaction Rates and Related Data

The following is added to this section:

Damage Flux

$$DF = \sum DFC(J) * G(J)$$

Summation over all J = 1, NG.

Section 4.1 Input Data

Under the heading CROSS SECTIONS, IDX(M,L), L = 1, 12, is printed for all cross-section sets.

Under the heading ZØNE DATA, the damage flux in each zone is printed, and IDX(M,L), L = 1,12, is printed for each material in each zone.

Section 4.3 Mix Cross Sections

When calculated, the average scattering cross section (SIGMA P) is printed for each material in each zone. This is printed even when the mix cross sections are not printed.

Section 4.4 LARCA Cross Section

The damage flux (totaled over all zones) is printed.

Section 4.5 Reactions

The damage flux is printed.

Section 4.6 Punch Output

The header card format has been changed as follows:

Columns 13-36	IDP(L) L = 1,4
Columns 40-42	NG
Columns 43-45	NK
Columns 73-78	IDP(1)
Columns 79-80	IC (IC = 0)