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**An Integrated System for Production of Neutronics
and Photonics Calculational Constants
Volume 5, Revision 1**

**CLYDE, A CODE FOR THE PRODUCTION OF
CALCULATIONAL CONSTANTS FROM NUCLEAR DATA**

R. J. Doyas, R. E. Dye, R. J. Howerton and S. T. Perkins

September 30, 1975
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UCPL-50400 Volume 5, Revision 1

CLYDE, A CODE FOR THE PRODUCTION OF CALCULATIONAL CONSTANTS FROM NUCLEAR DATA

R. J. Doyas, R. E. Dye, R. J. Howerton and S. I. Jenkins

MS. date: September 30, 1975

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Foreword

The FCRL-50400 series describes an integrated and computer-oriented system for the production and application of neutronics and photonics calculational constants.

The system must supply reliable up-to-date data, select specific types of data on request, provide output in a variety of forms—ultimately in the form of input to other computer codes—and function rapidly and efficiently. The system has now been developed to a point where these goals are being realized.

The FCRL-50400 series, An Integrated System for Production of Neutronics and Photonics Calculational Constants, comprises the following volumes:

- Vol. 1, ECSIL: A System for Storage, Retrieval and Display of Experimental Neutron Data, March 1974.
- Vol. 2, A Bibliography of the Experimental Data of Neutron-Induced Interactions, March 1974.
- Vol. 3, An Index of the Experimental Data of Neutron-Induced Interactions, March 1974.
- Vol. 4, Evaluated Nuclear Cross-Section Library, April 1971.
- Vol. 5, CLYDE: A code for the Production of Calculational Constants from Nuclear Data, September 1975.
- Vol. 6, Photon Cross Sections 1 keV to 100 MeV, October 1968.
- Vol. 7, Graphical Experimental Data for Major Neutron-Induced Interactions, April 1974.
- Vol. 8, Graphical Experimental Data for Supplemental Neutron-Induced Interactions, October 1974.
- Vol. 9, Thresholds of Nuclear Reactions Induced by Neutrons, Photons, Deuterons, Tritons, and Alpha Particles, September 1970.
- Vol. 10, Tabulated Experimental Data for Neutron-Induced Interactions, May 1974.
- Vol. 11, Experimental Data, Indexes and Techniques of Obtaining a Selected Set of Neutron Resonance Parameters, May 1972.
- Vol. 12, An Atlas of Resolved Neutron Resonance Parameters, July 1972.
- Vol. 13, An Atlas of Unresolved Neutron Resonance Parameters, September 1972.
- Vol. 14, TARTNP: A Coupled Neutron-Photon Monte Carlo Transport Code, September 1975.
- Vol. 15, The ILL Evaluated Nuclear Data Library (ENDL): Evaluation Techniques, Graphical Displays and Descriptions of Individual Evaluations, September 1975.
- Vol. 16, Tabular and Graphical Presentation of 175 Neutron Group Constants Derived from the ILL Evaluated Neutron Data Library (ENDL), January 1975.

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Abstract

In the past several years, we have revised and modified the Lawrence Livermore Laboratory CLYDE code extensively. We have incorporated processing of photon production, and have speeded up the processing of higher-order S_n transfer matrices. A doppler broadening option has also been added. On the other hand, we have deleted the CLYDE routines that process evaporation models and cumulative probability distributions (1-5,6). The Processing of Monte-Carlo output has been spun off into a separate code, CLART.

Glossary

E_R	Source or incident group upper bound.
E_h	Target or emission group upper bound.
E	Incident particle energy.
E'	Emitted particle energy.
g, h	Group indices.
N	Nuclide number.
A	Atomic mass/incident particle mass.
N_R	Total number of groups in problem.
$\sigma_x(E)$	Cross section for reaction x at incident energy E .
σ_{xg}	Cross section for reaction x averaged over group g .
$\sigma_{xg \rightarrow h}$	Transfer cross section from group g to group h for reaction x .
$\sigma_x(E \rightarrow E')$	Transfer cross section from energy E to energy E' at emission cosine μ for reaction x .
$\lambda_x^{(l)}(E \rightarrow E')$	Transfer probability from energy E to energy E' for reaction x for term l of the Legendre expansion of $\sigma_x(E \rightarrow E', \mu)$.
$\bar{\sigma}_x$	Cross section for reaction x in group g weighted with $1/g$ th Legendre expansion of the flux spectrum.
$\sigma_{xg \rightarrow h}^{(l)}$	Transfer cross sections for reaction x from group g to group h for term l of the Legendre expansion of $\sigma_{xg \rightarrow h}(E)$.
$\phi(E)$	0th term of the Legendre expansion of the input flux spectrum at incident energy E .
$q^{(l)}$	l th term of the Legendre expansion of the angular distribution (center of mass; 1° in lab).
L	Maximum order of Legendre expansion requested for output transfer matrices.
N_u	Number of up-scatter terms in output transfer matrices.
N_d	Number of down-scatter terms in output transfer matrices.
$V(E)$	Speed of energy E .

CLYDE, A CODE FOR THE PRODUCTION OF CALCULATIONAL CONSTANTS FROM NUCLEAR DATA

Introduction

The CLYDE code has been developed to handle a broad range of cross section processing requirements. The present version processes neutron interactions and gamma production from neutron-induced reactions. Further generations are planned. The code is operable on the CDC-7600,* and occupies about 70 K (octal) words of SCM; 457 K (octal) words of LCM are available for storage and working arrays.

The evaluated cross sections that are input to CLYDE may appear on either cards, tape, or disc, but they must be in the format of the Evaluated Nuclear Data Library (ENDL).¹ Furthermore, the user must specify group boundaries, weighting fluxes, and the isotopes for which processed data are required.

The atomic mass for each isotope is carried with the isotope in the evaluated library. (See Appendix A for a table of these atomic masses.) A standard set of group boundaries and weighting fluxes is also maintained. (See Appendix B for a listing of those available.) A preprocessor, ENDFLL, is available to translate ENDF/B library data into the ENDL UPDATE format.

The output is flux-averaged group cross sections, transfer probabilities, energy depositions, particle and isotope production cross sections, isotope destruction cross sections, and appropriate averages of collateral quantities such as the average number of neutrons per fission. The code processes data for transport theory, diffusion theory, or Monte Carlo² applications to neutronics systems, shielding, or fusion research.

The design philosophy that defined the scope of the code is outlined below:

- The code is, for all practical purposes, unlimited in the amount of data it can handle and in the number of groups and order of transfer matrices that it can generate.
- An isotope must be calculable to a standard group structure and scattering order in a "reasonable" amount of computer time.

*Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Energy Research & Development Administration to the exclusion of others that may be suitable."

- Built-in rigidity with regard to particular models or parameters is not allowed.
- Redundant forms of input information are allowed in the evaluated library but are not processed in CLYDE.
- Output is provided in two general formats for transport diffusion codes. CLARL produces Monte Carlo output. The form is such that potential "user" codes can be readily adapted to accept the results of CLYDE.
- Since both the input data and the evaluated library are arranged in increasing energy, the code operates from low to high energy, but for the convenience of users, the code inverts all output arrays so that numbering and listing of groups and cross sections begins with the highest energy group. Card, disc, or tape output is optionally available and with each option a printout is produced that includes all pertinent information in a convenient form.

The second and third items above are satisfied by transferring certain on-line code calculations to pre-processor codes. These codes perform appropriate operations on basic cross section data, the results of which are stored in IBM. These results may be used as input to CLYDE directly or, in words if, for any reason, it is undesirable to place them in the library. The pre-processor functions are:

- Convert angular fluxes to Legendre coefficients, incorporating fitting and thinning procedures (UPDATE).
- Calculate Doppler broadening, including boundary motion and μ - ρ shielding of resonance reactions (SOPHIST III).
- Process scattering kernels for the more time-consuming multigroup transfer processes (e.g., n, 2n). Generate the correlated energy-angle Legendre expansions of these kernels (BOSSIE I).
- Generate thermal scattering kernels from $S(\alpha, \beta)$ data (HLS66LLL).
- Generate differential cross section data from Legendre expansion coefficients (UPDATE).
- Generate energy ($I \neq 4$) tables for the fission transfer kernel (FISPEC).
- Calculate average energy depositions from neutron induced reactions (ENDEP).
- Generate "cold" cross section data from resonance parameters (resolved and unresolved) (ENDPILL).

ENDL Format

Tables 1 through 4 summarize the reaction description scheme used in ENDL. The particle designator y (Table 1) designates an incoming or outgoing particle (v_i, v_o). Table 3 designates the reaction type, and Table 2 indicates the property of the reaction C being quantified by the associated block of data. Table 4 provides further information about the reaction in four additional words, if needed. The target nucleus is given by $ZA\ 1000*Z+A$, where Z and A are the atomic number and atomic mass, respectively. A is set to zero for naturally occurring elements with more than a single isotope. Thus, a particular set of information about a reaction is completely codified by the combination $\{A, v_i, v_o, C, 1, S, X_1, X_2, X_3, X_4\}$. For example, 8016/1/7 11-1, 1/1.5 describes tabular energy distributions for an emitted photon resulting from an n, n' reaction from the 1.5 MeV level of the target nucleus $^{16}_8\text{O}$.

Table 1. Particle designator (v_i).

	Particle
0	"not applicable" or none ^a
1	n
2	p
3	d
4	t
5	He
6	e
7	γ
8	ν

^aUsed to identify both the incident particle, v_i , and the outgoing particle, v_o to which any distribution data (e.g., energy, angle) pertains.

^bIf no property (e.g., energy distribution) is given, the v_o is zero or left blank in input.

Table 2. Reaction property designator (I).

I	Reaction property	Definition
0	Integrated cross sections (barns); also related parameters	$\sigma(E)$
1 ^a	Angular distributions, normalized probabilities (per unit cosine)	$p(E, \mu)$ or $p(E, \mu)$
2 ^a	Angular distributions, normalized Legendre coefficients, i.e., $g(E) = 1.0$	$g(E)$
4	Energy-angle distributions, normalized Legendre coefficients. Note that $\sigma(E, E') = p(E, E')$, the usual normalized energy probability (per MeV).	$\sigma(E, E')$
7	Average neutrons per fission (prompt or delayed)	$\bar{\nu}(E)$
8	Histogram form of energy distribution	$\int_{E_1}^{E_2} P(E')$
9	Multiplicity	$M(E)$
10	Total average energy deposits (MeV)	$\bar{E}(E)$
11	Local average energy deposits (MeV)	$E_{\text{loc}}(E)$
80	Maxwellian average reaction rates (barn-cm/sh) ^b	$\bar{\sigma}(kT)$
99	Supplemental parameters	See Table 33

^a Angular data are expressed in the center of mass (CM) system for all two-body breakups. Multibody breakups are, of course, in the lab (L) system.

^b $\text{sh} = 10^6 \text{ sec} = 10^{-5} \text{ yr}$.

Table 3A. Reaction descriptor (C) for I=0 through 98.

C	Reaction type	C	Reaction type	C	Reaction type	C	Reaction type
1 ^a	Total	20	(γ, n^*p)	40	(γ, p)	60	
2 ^a	Absorption	1	(γ, pn^*)	1	(γ, d)	1	
3 ^a	Nonelastic	2	(γ, nd)	2	(γ, t)	2	
4 ^a	Nonelastic neutron emission	3	($\gamma, nd2n$)	3	($\gamma, t2n$)	3	
		4	(γ, nt)	4	($\gamma, ^3\text{He}$)	4	
5 ^a	Total scattering	5	($\gamma, n^*\text{He}$)	5	(γ, α)	5	Activation
		6	(γ, n^*)	6	(γ, α)	6	Fractional yield (Z2,A2) by any fission process
6		7	(γ, n^*p)	7		7	
7		8	($\gamma, nt2n$)	8		8	
8		9		9		9	
9		30		30 ^b	(γ, Xp)		
10	Elastic	1		1 ^b	(γ, Xd)	70	Total
1	(γ, n^*p)	2		2 ^b	(γ, Xt)	1	Coherent scattering
2	($\gamma, 2n$)	3		3 ^b	($\gamma, X^3\text{He}$)	2	Incoherent scattering
3	($\gamma, 3n$)	4		4 ^b	($\gamma, X\alpha$)	3	Photoelectric
4	($\gamma, 4n$)	5		5 ^b	($\gamma, X\gamma$)	4	Pair production (nuclear)
5	(γ, Xf) (total fission)	6		6 ^b	(γ, Xn)	5	Pair production (electronic)
6	(γ, n^*f)	7		7 ^b	($\gamma, X2^+$)	6	Photoneuclear
7	($\gamma, 2nf$)	8		8		7	
8	($\gamma, 3nf$)	9		9		8	
9						9	
						80	Open
						99	

^a Not usually stored in the system, but obtained for output display by combining other data.

^b $50 \leq C \leq 59$ may have multiplicity contained in the cross section.

Table 3B. Specification of the C number for supplemental parameters (I=99).

C Interval ³	Incident particle
1 - 42	Neutrons
50 - 74	Photons
75 - 99	Charged particle

C Number	Parameters
1	Thermal scattering law, S(α, β)
10 n, el	
11 n, γ	
12 n, f	
13 n, ν	Resonance data
14 n, d	(background C/S)
15 n, t	
16 n, ^3He	
17 n, α	
18 n, x	
20	Resolved resonance parameters
21	Unresolved resonance parameters
51	Form factors (coherent scattering), G(q)
52	Form factors (incoherent scattering), K(q)

³See Table 4B, Vol. 4, for details.

Table 4. Reaction modifier, S.

S	Reaction parameter	X-field definition
00 or blank	No X-field data	—
01	Level excitation ^a	W_1 (Me V)
03	γ -ray production	E_γ (Me V)
04	Material temperature	kT (Me V) (for thermal scattering models)
05	Activation ^b	(ZA) ₂ , W_2 (Me V), τ_2 (s)
06	Bulk information for Doppler broadening or self-shielding	kT (Me V), ND ($\times 10^{-24}$), Th (cm), $\bar{v}$ (cm/shake) ^c
07	Delayed group half-lives	$\tau_{1/2}$ (s)
08	Completely correlated reaction	W_1
10	Wide level excitation	W_1, τ_1
11	Second particle from time-sequential (x,yz) reaction	W_2

^a X_1 corresponds to the initial nucleus, X_2 to the second nucleus in a sequence of de-excitations, etc.

^b(ZA)₂ = 1000Z₂ + A₂ of product nucleus.

^cThese are self-shielding and boundary motion parameters from a preprocessor code (material temperature, atom density, region thickness, and boundary speed, respectively).

Special Features and Restrictions of CLYDE

To remove most limitations on problem size, the following steps have been taken in the design of CLYDE:

- Dynamic dimensioning has been used. The POINTER statement allows the code to set up or modify storage locations of arrays as requirements develop in the course of execution of the problem. Arrays that are not needed for further processing of an isotope can be released.
- Fission distribution and total transfer arrays may be stored on disc if the storage requirements exceed the remaining available space in core at any stage in the processing. The array used least is removed first: i.e., the prompt fission, the l th total transfer array, etc., and finally, the $l = 0$ total transfer array. Once read onto disc, the arrays remain there until the OUTPUT subroutine requires them. Delayed fission matrices (if any) are always stored on disc.
- A packing algorithm is used to store the total transfer. The algorithm stores only those terms that are actually permitted by the input quantities N_U and N_D .
- The input cross section tables for a given isotope are transferred immediately to disc, and returned to core only as needed.

Special features of CLYDE are:

- All neutron data are linearly interpolable in all dimensions.
- Transfer probabilities calculated by numerical (i.e., Simpson's) integrations are renormalized; in the case of direct scattering, only the $l = 0$ terms are renormalized:

$$x_g \cdot h = x_g \cdot h \cdot \left(\frac{x_g}{\sum_{h'} x_g \cdot h'} \right)$$

For a reaction having multiple emission (such as $[n,2n]$), the distribution(s) will be assumed to sum to the multiplicity, rather than to unity, except when $S > 1$ is present.

- The transport correction does not invoke the standard assumption of constant collision density. The effect of this is that source terms which transfer to the group in the $l + 1$ order, which are the correct

transport correction terms, are not replaced by scatter terms out of the group as is typically done. Thus, in CLYDE, the transfer term for the highest energy group will have only the higher order self-scatter term as a transport correction instead of that term, plus all down-scatter terms, as would happen in the usual approximation. The Legendre flux expansion correction to the total cross section is also calculated.

- CLYDE will use the l th coefficient of the flux expansion for weighting l th order terms, as should be done, if these are available in the problem. They can be generated from the angular fluxes from TART² or ANISN³ problems by a small preprocessor routine. If the input flux spectra do not extend to order $L+1$, the highest order flux available, $(l_{\max})$, is used for processing all l , $l_{\max} \leq l \leq L+1$. The bootstrap expression

$$\phi'(E) = \frac{\phi^{l_{\max}-1}(E)}{\sum(E) - \sum_{l=0}^{l_{\max}} \phi^l(E)}, \quad (2)$$

may be incorporated into CLYDE, but only after sufficient investigation indicates that it is warranted for systems of interest. The flux density distribution, $\phi^l(E)$, must be a continuous piecewise linear function.

- CLYDE uses an interpolation scheme which preserves linearity in interpolated areas of energy transfer tables (see section on Tabular Energy Distributions, p. 36).
- If only $l=0$ energy transfer data are available ($I=4$) and angular distribution tables are also present ($I=1$ or 2), then a pseudo-correlation of energy and angle is constructed. As shown by S.T. Perkins,⁴ age calculations can be considerably improved if, in place of using an $l=0$ transfer matrix, the product of the uncorrelated spectral and angular distributions in nonscattering emission reactions is used in the form:

$$\phi_X^l(E \rightarrow E') = \phi_X^0(E) \pi_X^0(E \rightarrow E') f^l(E). \quad (3)$$

Here $f^l(E)$ is the l th Legendre expansion coefficient of the differential cross section in the lab frame of reference. (Note that in

multibody reactions, the lab reference frame is used for all angular data in the evaluated library.) Treatment then proceeds via the TABXFR subroutine as though the $I=4$ tables were complete:

$$\pi_x^l(E \rightarrow E') = \phi_x^l(E \rightarrow E') / \sigma_x(E). \quad (4)$$

- Transfer below the lower bound of the lowest group is computed and stored in the lowest group, thus preserving particles. (The user must assure himself that his lower bound is so low that energy displacements of the above sort affect only a negligibly small proportion of his particle population.) Transfer above the upper bound of the highest energy group is likewise preserved in the upper group.

While an attempt was made to avoid restrictions on input parameters and cross sections as a general rule, some have been found to be either necessary or sufficiently desirable to merit their adoption.

These restrictions are:

- The flux spectrum must span the group bounds for all orders of l .
- The lower bound of the lowest group should be greater than zero. If input is zero, it will be set to $1.0E-10$ MeV.
- Reaction identification numbers must be in ascending numerical order.
- For multiple jobs, isotope numbers must be in monotonically non-decreasing order (repetition of isotope number is acceptable).
- Cross section arrays, distribution tables, etc., are not required to span the group bounds. If energy or angular distribution tables do not span the energy range of the appropriate reaction cross section, a flat extrapolation is made to the uppermost group boundary.
- $E_{\text{threshold}}$ (for endoergic reactions) should coincide with the initial energy of the associated cross section list. If it does not, the code will set the initial energy to that value; it will also set the cross section at that entry to zero. If $E_{\text{threshold}}$ exceeds the second energy entry in the cross section table, a comment will be issued and processing of that reaction will terminate.
- $I=0$ data (reaction cross section) are assumed to be present for each reaction to be processed.

Input Preparation

OPERATING INSTRUCTIONS

To run CLYDE from teletype, the TTY line is:

CLYDE infil box outop library filetype1 outfile filetype2 / t v

where:

infil is the file name of the input deck (described below)

box is a 3-character output box number

outop = HSP high-speed printer

= FR80 fiche

= OLP printer

= DEBUG HSPO, etc., files remain on disc at end of job

library = evaluated library file name* or tape vault number

filetype1 = 0 disc file for evaluated library

= 1 tape for evaluated library

outfile = output file name, or tape vault number, or "NONE" if no
output file requested

filetype2 = 0 disc file or none for CLYDE output

= 1 tape for CLYDE output

= 2 create output disc file of 10^6 decimal words

= nnn create output disc file of nnn decimal words

To run from batch processing, set up the following control cards ahead

of the problem deck:

*ID	Acct. No.	Name	Box nnn
*V	LE609		
*B	PLEASE RUN UNDER ORDER.		
*	XLO MCT		
*	XEQMES ELF RDS .239700: PROGRAMS CLYDE END		
*	NXT		
*	XEQ		
*		CLYDE	
*	XEQMES	infil box outop	LE609 1
		outfile filetype2	

LE609 is the floor ENDL library tape. To run the CFART code, replace

*Floor and experimental library files may be obtained from the Physical Data Group.

CLYDE with CTART in the above instructions. CLYDE and CTART are in photostore under 2239700: PROGRAMS and can be obtained with MCT for TTY operation.

INPUT DECK

A problem may ordinarily be completely defined on only one card (card type 1). More cards are required to define a problem only when special card input features of the code are to be used, such as card input of group bounds or flux spectra. This section describes the format of each type of input card, and explains what each field means and how each could affect the running of the program.

Card type 1. General parameters.

1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85															

Variable	Columns	Description
NNZA	1-6	Descriptor telling which isotope or element to run. If NNZA = 999999, then the user is running an isotope that is not in the library, and all input is from cards. NNZA = $1000 \times Z + A$ where Z is the nuclear charge and A is either the isotopic mass or zero if the material is a natural mixture of isotopes in an element.
IYI	8-9	Incident particle descriptor. The possible values are described in Table 1. At present, only IYI = 1 (indicating an incident neutron) can be used.
IYO	11-12	Outgoing particle descriptor. The possibilities for this are those described in Table 1. The restriction described under IYI does not apply here.
NGP	14-15	Defines which group structure of those listed in Appendix A is to be used for this calculation. If NGP = 0, the group bounds are expected to be read from cards according to card type 2. If NGP = -1, then the code uses the group structure specified for the previous isotope.
NFLX	17-18	Defines which flux spectrum of those listed in Appendix A is to be used for this calculation. If NFLX = 0, the flux

Card type 1 (continued).

Variable	Columns	Description
		spectrum is expected to be read from cards according to card type 3. If NFLX = -1, then the code uses the flux spectrum specified for the previous isotope. Note that NFLX must not be equal to -1 if NGP is not equal to -1 or if the order of i has increased.
N1(NLIST)	20-21	Defines the number of reaction properties (1's) to be processed for this isotope. This number is used in reading card type 4. If NLIST = 0, the list of reactions and associated reaction properties carried on the library tape will be used. This option should be used only when a subset of the reactions present is to be processed. NLIST must be less than or equal to 40.
N2(NRCTSL)	23-24	Defines the number of reaction selector cards (card type 5) present for this isotope. The reaction selector cards are used to select a reaction from a sequence of the same reactions via their X-fields (see Table 4). If NRCTSL = 0 the code uses the standard reactions from the tape. NRCTSL must be less than or equal to 20.
N3(NRCTIN)	26-27	Specifies the number of reaction property designators to be read in from cards. These are read in according to card type 6 and are used to supersede existing data on the library with the user's own data for a particular C, I combination, or to insert reactions or reaction properties. If NRCTIN = 0, then the library data are used for all reaction property designators. NRCTIN must be less than or equal to 50.
N4(NPNTOP)	29-30	Specifies the printout mode which the code is to use. It determines which calculational results will be printed and is defined as follows: 0 - Standard printout; print out only the final results. 1 - Standard printout plus printout of reaction

Card type 1 (continued).

Variable	Columns	Description
		group cross sections and energy deposits as they are calculated.
		2 - Output listed under 0 and 1 plus printout of all transfer cross sections as they are calculated.
		99 - much debug.
N5(NOUTP)	32-33	Specifies how the results are to be output and is defined as follows: <ul style="list-style-type: none"> 0 - Printout only. 1 - Printout plus punched cards of all results that were printed. The format for these punched cards is described in the section on output. 2 - Printout plus BCD output of all printed results. 3 - Printout plus Binary output of all printed results.
N6(NOUT) ^a	35-36	Specifies the type of code for which the output will be used. The options are defined as follows: <ul style="list-style-type: none"> 0 - Process all reactions present for the isotope (C=1,99). In this mode, NPNTOP is automatically set to 2, and only the individual transfer cross sections are output. No total transfer or total fission matrices are created. The output is tailored to no particular type of code. 1 - Process reactions from 10 to 55 for a transport/diffusion code. The total transport corrected transfer matrix does not contain the fission matrix, and each source group is $N_t + N_D + 1$.

^aIgnored by CTART.

Card type 1 (continued).

Variable	Columns	Description
		2 - Process reactions 10 to 55 for a transport/ diffusion code. The total transport-corrected P_0 transfer matrix contains the fission matrix, and all orders are output as full $g \times g$ matrices.
EP1A ^a	38-45	Specifies the relative order of accuracy desired in doing numerical integrations. It has been found that using EP1A = 0.001 provides good results.
LM(LLMAX) ^a	47-48	Specifies the maximum order of transfer matrix, L, to be calculated. The code calculates (LLMAX+1) matrices and uses the <u>LLMAX+1</u> st matrix to form a transport correction. If LLMAX = -1, then the code will only calculate group cross sections and energy deposits, but not the total transfer matrix.
NF(NFLSS)	50-51	Specifies how the fission reaction is to be processed. 0 - Process prompt neutron data only. 1 - Process prompt and delayed neutron data, summing the results into one matrix. 2 - Process prompt and delayed neutron data into two separate matrices. 3 - Process prompt and delayed neutron data into separate matrices, with a separate matrix for each delayed neutron group. 4 - Process prompt and delayed nubar data for Monte Carlo. Results are summed.
NUP ^a	53-56	Specifies the number of up-scatter terms to be included in the total transfer matrices. Note: if NOUT = 2, then NUP should be equal to the number of groups minus one.
NDOWN ^a	58-61	Specifies the number of down-scatter terms to be in- cluded in the total transfer matrices. Note: if NOUT = 2, then NDOWN should be equal to the number of groups minus

^aIgnored by CTART.

Card type 1 (continued).

Variable	Columns	Description
		one.
NEQPB or NEQGP	63-66	Specifies the number of equal probability intervals to be used for Monte Carlo output. If NSPFLG = 1, NEQGP specifies the number of overlapping groups.
I(NSPFLG)	68	Specifies auxiliary or additional processing modes: <ul style="list-style-type: none"> 1 - Specifies that overlapping group processing is done if $v_i = v_o$ (i.e., if the incoming and outgoing particles are the same), and that coupled group processing is done if $v_i \neq v_o$. In this mode, CLYDE assumes that the same isotope will be run twice with different group structures and the results of the two runs merged for the final output. Each isotope must have its own header card, and they must follow one another in the input deck, each with NSPFLG = 1. NEQGP must be set. 2 - Specifies that, before this isotope is processed, two different flux weighting spectra will be merged together. After the group boundaries have been read in from cards or tape, the code expects a card specifying the flux type that is to be used (NFLX) and the fractional part that is to be added to the other weighting spectrum (FRACT). The code expects two of these cards, one for each weighting spectrum; and, if NFLX = 0, (card input for the weighting spectrum), it expects these cards to follow directly behind the card specifying NFLX and FRACT. See card type 7.
J(NTCELG) ^a	69	Specifies transport correction to be used. <ul style="list-style-type: none"> 0 - Code decides. 1 - Approximate correction will be used.

^aIgnored by CTART.

Card type 1 (continued).

Variable	Columns	Description
		2 - Exact correction will be used. 3 - No transport correction.
K(ISFLG)	70	Specifies a single switch (S) to be run if greater than 0.
L(INFLG)	71	Specifies that evaluation is incomplete and passes this information on to specified output (CTART only).
L(VFLG)	71	Multiplies $\sigma_x(E)$ by velocity V(E), so that CLYDE produces $(\sigma_x V)_g$ rather than σ_{xg} .
ML	72	Specifies whether this is the last isotope to be processed: 0 - More isotopes are to be processed. 1 - This is the last isotope to be processed.

If ML and MLN are not equal to zero, and $MLST$, $NRCTSL$, and $NRCTIN$ are equal to zero, as would ordinarily be the case, only one card is required to process an isotope.

Card type 2. Group bounds (optional; used only if $MLN \neq 0$).

Variable	Columns	Description
IEB	1-4	Specifies the number of group boundaries to be found on card 10 the following cards. (IEB-10 groups.)
IEBND	1-41	Is a one-dimensional array from which the group boundaries will be read. The group bounds are expected to be in order of increasing energy, in units of MeV.

This input card type is used to read group boundaries from cards. It is a set of at least two cards; the first gives the number of group bounds to be read, while the second and any following cards list the input group bounds. This set of cards is only used where NGP=0; it must be the first set of cards encountered after the header card.

1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----

2013	2012
MLLKL	
5	

EFLUX(1,L)	EFLUX(2,L)	EFLUX(3,L)	EFLUX(4,L)	EFLUX(5,L)	EFLUX(6,L)
F1 4	F1 4	F1 4	F1 4	F1 4	F1 4

Variable	Columns	Description
LFLUX	1-2(card 1)	Defines the highest Legendre order of flux spectrum to be read. (LFLUX $\geq$ 0)
NFLUX(L)	1-5(card 2)	Defines twice the number of energy-flux pairs on the data cards for this L.
EFLUX(I,L)	1-11(card 3) 12-22 23-33 34-44 45-55 56-66	(LFLUX+1) sets, each set containing NFLUX(L)/2(E, _i) pairs for that order of L in order of increasing energy. The energy lists must span the group bounds, and be in units of MeV.

This type of card input is only used when NFIX=0. This set of cards follows the card input of the group bounds (if any). Otherwise, it is directly behind the header card. Note: if LFLUX is less than LLMAX+1, then the highest order flux spectrum is used for all calculations for which LFLUX+1 ≤ i ≤ LLMAX+1.

Card type 4. Reactions card (optional; used only if NLIST $\neq$ 0).

Variable	Columns	Description
C	1-2	Defines the reaction which is to be processed. The possible reaction numbers, C, are listed in Table 3.
I	4-5	Defines which reaction property designator is to be processed for the given reaction. The possible reaction designators, I, are listed in Table 2.

This type of card allows the user to control which reactions from a set of reactions for an isotope are to be processed. For any C, $I \neq 0$ must be processed if any other reaction property designator is to be done. If these cards appear in a problem, they should follow behind any group bounds and flux spectrum cards. The cards must be arranged in order of monotonically increasing C, and, within each C, of monotonically increasing I. There are NLIST cards.

Card type 5. Selector card (optional; used only if NRCTSL $\neq$ 0).

Variable	Columns	Description
C	1-2	Specifies which reaction is to be selected.
S	4-5	Specifies which reaction modifier should be selected. The possible values for the reaction modifier are defined in Table 4. If $S = 0$, this card requests doppler broadening of the $I = 0$ data for this C at $T = X$.
QIE	7-17	Defines the threshold energy of the reaction.
X(1), I = 1,4	19-29	Defines parameters appropriate to the reaction modifier to be processed. These parameters are defined with the various reaction modifiers in Table 4.
	31-41	
	43-53	
	55-65	

This type of card is used to select one reaction from a set of reactions with the same C number. The reaction selected from the tape will agree with the S, QIE, and X(1) fields specified on the selector card. The number of

Card type 5 (continued).

different reactions to be selected is put in the NRCTSL field on the header card. The reaction selector cards follow any group bounds, flux spectrum, or reaction control input cards. There are NRCTSL cards. If card type 5 is not present, the first of a set of reactions present on the library is processed.

Card type 6. Library override (optional; used only if NRCTIN $\neq$ 0).

1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80															

1	2	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	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	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	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80															

Variable	Columns	Description
1	1-6	1000Z + A
2	8-9	Incident particle
3	11-12	Outgoing particle
4	14-24	Atomic mass for this ZA
DATE	26-31	Current date
12 ¹	33-34	1 = delete, 2 = insert, 3 = retrieve
5	1-2	Defines which reaction will be overridden or inserted. Possible values for reaction numbers are defined in Table 3.
6	4-5	Defines which reaction property designator will be overridden or inserted. The format for the input of the data defined by 1 is given in Table 5.
8	7-8	Defines the value of the reaction modifier for this reaction. See Table 4.
10	10-20	Q (defines the threshold energy of reaction C).
11	22-32	Defines various parameters needed by the code for certain reactions. The following are some instances when this field is pertinent:

¹These fields need not be filled in; they would be used if this data were subsequently put through the UPDATE code.

Card type 6 (continued).

Variable	Columns	Description
		<ol style="list-style-type: none"> 1. If a level excitation results in the residual nucleus, this field contains the value of the level excitation. 2. If C = 15 (fission), and S = 7 (delayed fission), this field contains the half-life $t_{1/2}$ of the delayed group, etc. See Table 4. 3. If S = 5, this field contains the ZA of the product nucleus. See Table 4.
X(2)	34-44	As in the X(1) field, this field defines various parameters for certain reactions. The following is one instance when this field is pertinent: If S = 5, this field contains the level for the product isotope. See Table 4.
X(3)	46-56	See Table 4.
X(4)	58-68	See Table 4.

Card type 6 will be used to either override or insert a reaction property designator, a reaction, or a whole isotope. All cards of this type will be grouped together and will follow in sequence behind any of the other card types. For each reaction property designator input on two of these cards, it is assumed that there will be data corresponding to that property in the format shown in Table 10. After each set of data pertaining to a particular value of I, an end-of-data card (a 1 in column 72) should be inserted. All such sets of data are grouped behind the type-6 cards in an order corresponding to the order in which the C-I pairs appear. These data are the last information present for an isotope. If only one C-I replacement pair appears for this C, then only that I specified is replaced and the rest of the data are taken from the library. If more than one C-I replacement pair appears for this C, then all data for this reaction are assumed to be input from cards. For the replacement of a whole reaction from cards, I = 0 data must be present. Note: if NNZA = 999999, all reaction data are expected to be input from cards of the type just described. There are NRCTIN cards.

Table 5. Field definitions for input data (4E11.4 format with one set of data per card).

Reaction property	1	Data stored in field			
		1	2	3	4
Integrated cross section	0	$\Sigma (1)^a$	---	---	---
Angular distributions	1	$E (1)$	$\mu (2)$	$p(E, \mu)$	---
Legendre coefficients	2	$E (2)$	$g' (1)$	$g^{(1)}$	---
Energy-angle Legendre coefficients	4	$E (2)$	$E' (3)$	$\{ (1)$	$\pi^{-1} (E \cdot E')$
Nu-bar	7	$E (1)$	$\bar{\nu}$	---	---
Histogram energy distribution	8	$E (1)$	$E' (2)$	E'	$\int_{E_1}^{E_2} P(E') dE'$
Multiplicities	9	$E (1)$	M	---	---
Total average energy deposits	10	$E (1)$	$\bar{E}$	---	---
Local average energy deposits	11	$E (1)$	$\bar{E}_{loc}$	---	---
Maxwell-averaged reaction rates	80	$kT (1)$	$\bar{\sigma v}$	---	---

^aNumbers in parenthesis show field hierarchy—i.e., order in which the data are incremented (highest first).

Card type 7. Merged flux weighting spectra (NSPFLG = 2).

1	2	3	4	5	6	7	8	9	10	11	12	13	14
NFLX													
12													

Variable	Columns	Description
NFLX	1-2	Flux spectrum number; if 0, use spectra on cards that follow (see card type 3).
FRACT	4-14	Fractional part to be added to other weighting spectrum.

This card allows a combination of two flux weighting spectra according to any mixing fraction.

SAMPLE PROBLEMS

Input to the code has been made straightforward and versatile in an attempt to satisfy all of the user's needs. Examples are given below of various problems, each showing how a different feature of the code is actually used.

2003	1	1	3	1	0	0	0	0	0	0	+1.0E-03	0	0	9	9	0	0
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Problem 2

70	8	6	5	4	3	2	1	0	+1	0	-1	-2	-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	-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	-61	-62	-63	-64	-65	-66	-67	-68	-69	-70	-71	-72	-73	-74	-75	-76	-77	-78	-79	-80	-81	-82	-83	-84	-85	-86	-87	-88	-89	-90	-91	-92	-93	-94	-95	-96	-97	-98	-99	-100	-101	-102	-103	-104	-105	-106	-107	-108	-109	-110	-111	-112	-113	-114	-115	-116	-117	-118	-119	-120	-121	-122	-123	-124	-125	-126	-127	-128	-129	-130	-131	-132	-133	-134	-135	-136	-137	-138	-139	-140	-141	-142	-143	-144	-145	-146	-147	-148	-149	-150	-151	-152	-153	-154	-155	-156	-157	-158	-159	-160	-161	-162	-163	-164	-165	-166	-167	-168	-169	-170	-171	-172	-173	-174	-175	-176	-177	-178	-179	-180	-181	-182	-183	-184	-185	-186	-187	-188	-189	-190	-191	-192	-193	-194	-195	-196	-197	-198	-199	-200	-201	-202	-203	-204	-205	-206	-207	-208	-209	-210	-211	-212	-213	-214	-215	-216	-217	-218	-219	-220	-221	-222	-223	-224	-225	-226	-227	-228	-229	-230	-231	-232	-233	-234	-235	-236	-237	-238	-239	-240	-241	-242	-243	-244	-245	-246	-247	-248	-249	-250	-251	-252	-253	-254	-255	-256	-257	-258	-259	-260	-261	-262	-263	-264	-265	-266	-267	-268	-269	-270	-271	-272	-273	-274	-275	-276	-277	-278	-279	-280	-281	-282	-283	-284	-285	-286	-287	-288	-289	-290	-291	-292	-293	-294	-295	-296	-297	-298	-299	-300	-301	-302	-303	-304	-305	-306	-307	-308	-309	-310	-311	-312	-313	-314	-315	-316	-317	-318	-319	-320	-321	-322	-323	-324	-325	-326	-327	-328	-329	-330	-331	-332	-333	-334	-335	-336	-337	-338	-339	-340	-341	-342	-343	-344	-345	-346	-347	-348	-349	-350	-351	-352	-353	-354	-355	-356	-357	-358	-359	-360	-361	-362	-363	-364	-365	-366	-367	-368	-369	-370	-371	-372	-373	-374	-375	-376	-377	-378	-379	-380	-381	-382	-383	-384	-385	-386	-387	-388	-389	-390	-391	-392	-393	-394	-395	-396	-397	-398	-399	-400	-401	-402	-403	-404	-405	-406	-407	-408	-409	-410	-411	-412	-413	-414	-415	-416	-417	-418	-419	-420	-421	-422	-423	-424	-425	-426	-427	-428	-429	-430	-431	-432	-433	-434	-435	-436	-437	-438	-439	-440	-441	-442	-443	-444	-445	-446	-447	-448	-449	-450	-451	-452	-453	-454	-455	-456	-457	-458	-459	-460	-461	-462	-463	-464	-465	-466	-467	-468	-469	-470	-471	-472	-473	-474	-475	-476	-477	-478	-479	-480	-481	-482	-483	-484	-485	-486	-487	-488	-489	-490	-491	-492	-493	-494	-495	-496	-497	-498	-499	-500	-501	-502	-503	-504	-505	-506	-507	-508	-509	-510	-511	-512	-513	-514	-515	-516	-517	-518	-519	-520	-521	-522	-523	-524	-525	-526	-527	-528	-529	-530	-531	-532	-533	-534	-535	-536	-537	-538	-539	-540	-541	-542	-543	-544	-545	-546	-547	-548	-549	-550	-551	-552	-553	-554	-555	-556	-557	-558	-559	-560	-561	-562	-563	-564	-565	-566	-567	-568	-569	-570	-571	-572	-573	-574	-575	-576	-577	-578	-579	-580	-581	-582	-583	-584	-585	-586	-587	-588	-589	-590	-591	-592	-593	-594	-595	-596	-597	-598	-599	-600	-601	-602	-603	-604	-605	-606	-607	-608	-609	-610	-611	-612	-613	-614	-615	-616	-617	-618	-619	-620	-621	-622	-623	-624	-625	-626	-627	-628	-629	-630	-631	-632	-633	-634	-635	-636	-637	-638	-639	-640	-641	-642	-643	-644	-645	-646	-647	-648	-649	-650	-651	-652	-653	-654	-655	-656	-657	-658	-659	-660	-661	-662	-663	-664	-665	-666	-667	-668	-669	-670	-671	-672	-673	-674	-675	-676	-677	-678	-679	-680	-681	-682	-683	-684	-685	-686	-687	-688	-689	-690	-691	-692	-693	-694	-695	-696	-697	-698	-699	-700	-701	-702	-703	-704	-705	-706	-707	-708	-709	-710	-711	-712	-713	-714	-715	-716	-717	-718	-719	-720	-721	-722	-723	-724	-725	-726	-727	-728	-729	-730	-731	-732	-733	-734	-735	-736	-737	-738	-739	-740	-741	-742	-743	-744	-745	-746	-747	-748	-749	-750	-751	-752	-753	-754	-755	-756	-757	-758	-759	-760	-761	-762	-763	-764	-765	-766	-767	-768	-769	-770	-771	-772	-773	-774	-775	-776	-777	-778	-779	-780	-781	-782	-783	-784	-785	-786	-787	-788	-789	-790	-791	-792	-793	-794	-795	-796	-797	-798	-799	-800	-801	-802	-803	-804	-805	-806	-807	-808	-809	-810	-811	-812	-813	-814	-815	-816	-817	-818	-819	-820	-821	-822	-823	-824	-825	-826	-827	-828	-829	-830	-831	-832	-833	-834	-835	-836	-837	-838	-839	-840	-841	-842	-843	-844	-845	-846	-847	-848	-849	-850	-851	-852	-853	-854	-855	-856	-857	-858	-859	-860	-861	-862	-863	-864	-865	-866	-867	-868	-869	-870	-871	-872	-873	-874	-875	-876	-877	-878	-879	-880	-881	-882	-883	-884	-885	-886	-887	-888	-889	-890	-891	-892	-893	-894	-895	-896	-897	-898	-899	-900	-901	-902	-903	-904	-905	-906	-907	-908	-909	-910	-911	-912	-913	-914	-915	-916	-917	-918	-919	-920	-921	-922	-923	-924	-925	-926	-927	-928	-929	-930	-931	-932	-933	-934	-935	-936	-937	-938	-939	-940	-941	-942	-943	-944	-945	-946	-947	-948	-949	-950	-951	-952	-953	-954	-955	-956	-957	-958	-959	-960	-961	-962	-963	-964	-965	-966	-967	-968	-969	-970	-971	-972	-973	-974	-975	-976	-977	-978	-979	-980	-981	-982	-983	-984	-985	-986	-987	-988	-989	-990	-991	-992	-993	-994	-995	-996	-997	-998	-999	-1000	-1001	-1002	-1003	-1004	-1005	-1006	-1007	-1008	-1009	-1010	-1011	-1012	-1013	-1014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Problem 3

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46	C	O	C	C	C
		0		3	
		6		38	
		20		55	
		30		52	
		50		48	
		60		45	

Problem 5

[illegible]

-22-

Output

The only sub-routine handles the printout and the PRINTAP sub-routine handles the punched card or tape output of the final results for an isotope. Three types of output are available:

- Group calculated output of any total transfer or fission matrices.
- Intermediate transfer matrices are output according to the flag M001, which is explained below.
- Matrix cards.

The type of quantities output obtained from GROUP is controlled by the control card starting with the input header card. The flags that determine this are the control card flags: MPNDOP, NFISS, M001OP, and M001. These were described in the section on input.

Once the processing of the isotope is complete, and control has been transferred to PRINT, the output of the processed results is governed by the selection of the above flags. The routine begins by first outputting a reaction type telling the meaning of each reaction number. The first calculations created are those which are independent of the order of λ , and begin with the printing of the group data as follows:

Group Properties			Speed-	Total Energy	Local Energy
λ	Standard	Technique	Inverse Averaged	Deposits	Deposits
1	*	*	*	*	*
2	*	*	*	*	*
3	*	*	*	*	*

This is followed by the group cross sections and isotope production cross sections for the reactions processed. The appropriate reaction numbers are used as headings with the group cross sections in columns below each heading. Following this output, the group fluxes for $0 \leq \lambda \leq L+1$ are output in columns with the order of λ corresponding to each as the column heading.

For isotopes with a fission reaction the next quantities output are the prompt and delayed fission neutron group $(\bar{\nu}_{d(p)})_{\lambda}$ cross sections and the associated CHI's. The CHI's are quantities that are calculated in OUTPUT if the fission reaction exists for the isotope. The CHI's are defined as follows for an emission group g and for a particular choice of NFISS:

$$\frac{\sum_g \left(\bar{\psi}_{g_p}^0 f_{g \cdot h} \right) \phi_g^0}{\sum_g \bar{\psi}_g^0 \left(\sum_h \bar{\psi}_{g_p}^0 f_{g \cdot h} \right)} \quad 0$$

$$\frac{\sum_g \bar{\psi}_g^0 \left(\bar{\psi}_{g_p}^0 f_{g \cdot h} + \bar{\psi}_{g_d}^0 f_{g \cdot h} \right)}{\sum_g \bar{\psi}_g^0 \left[\sum_h \left(\bar{\psi}_{g_p}^0 f_{g \cdot h} + \bar{\psi}_{g_d}^0 f_{g \cdot h} \right) \right]} \quad 1$$

$$\frac{\sum_g \bar{\psi}_{g_p}^0 f_{g \cdot h} \phi_g^0}{\sum_g \bar{\psi}_g^0 \left(\sum_h \bar{\psi}_{g_p}^0 f_{g \cdot h} \right)} \quad \text{and} \quad \frac{\sum_{i=1}^{N_d} \sum_g \bar{\psi}_g^0 \bar{\psi}_{g_{d_i}}^0 f_{g \cdot h}}{\sum_g \bar{\psi}_g^0 \sum_h \left(\bar{\psi}_{g_d}^0 f_{g \cdot h} \right)} \quad 2$$

where N_d = number of delayed groups.

$$\frac{\sum_g \bar{\psi}_{g_p}^0 f_{g \cdot h} \phi_g^0}{\sum_g \bar{\psi}_g^0 \left(\sum_h \bar{\psi}_{g_p}^0 f_{g \cdot h} \right)} \quad \text{and} \quad \frac{\sum_g \bar{\psi}_g^0 \bar{\psi}_{g_{d_i}}^0 f_{g \cdot h}}{\sum_g \bar{\psi}_g^0 \left(\sum_h \bar{\psi}_{g_{d_i}}^0 f_{g \cdot h} \right)} \quad 3$$

for each delayed group i .

The format in which these are output will depend upon the choice of NFISS as follows:

NFISS

Type of Output

$$0 \quad \bar{\psi}_{g_p}^0 \bar{\psi}_{g_d}^0, \text{ CHI}_{h_p}$$

-
- 1 $\bar{\sigma}_{g_p}^{\sigma_f g} + \sum_{i=1}^{N_d} \bar{\sigma}_{g_{d_i}}^{\sigma_f g}, CHI_{h_{p+d}}$
- 2 $\bar{\sigma}_{g_p}^{\sigma_f g}, \sum_{i=1}^{N_d} \bar{\sigma}_{g_{d_i}}^{\sigma_f g}, CHI_{h_p}, CHI_{h_d}$
- 3 $\bar{\sigma}_{g_p}^{\sigma_f g}, CHI_{h_p}$
 $\bar{\sigma}_{g_{d_i}}^{\sigma_f g}$ for all $i=1, N_d$
 $CHI_{h_{d_i}}$ for all $i=1, N_d$
-
- 4 $\bar{\sigma}_{g_p}^{\sigma_f g} + \sum_{i=1}^{N_d} \bar{\sigma}_{g_{d_i}}^{\sigma_f g}$ (used only for Monte Carlo output)
-

The next quantities to be output are the total group cross sections, the group transport correction terms, and the transport-corrected total group cross sections. These quantities are defined to be:

$$\sigma_{tot g}^0 = \sum_{C=10}^{49} \sigma_C^0 g \quad (75)$$

$$\sigma_{tr corr g} = \frac{\sum_{g''} \left(\sum_{C=10}^{49} \sigma_C^{L+1} g'' \rightarrow g \right) \phi_g^{L+1}}{\phi_g^{L+1}} \quad (76)$$

$$\sigma_{tr g} = \sigma_{tot g}^0 - \sigma_{tr corr g} \quad (77)$$

The approximate form (see section on transport correction) of tr corr_g is also displayed in the CLYDE output, but the approximate form is only used ^K if tr_g would be negative when the more exact form were used, or if it is explicitly requested. The transport cross section is surrounded by asterisks

$$**\text{tr}_g**$$

for each group in which the approximation has been applied.

The last quantities to be output are the total transfer and fission matrices (if the fission reaction was done). The manner in which these are output depends upon the value of the flag NOCT. If NOCT is 0, control is transferred back to EXEC, and total transfer and fission matrices are not printed. However, if NOCT is 1, the total transfer matrices are output by incident group, each being (NUP + NDDWN + 1) in length; if NOCT is 2, the prompt fission matrix is added into the zeroth-order transfer matrix, and all the transfer matrices are output as full matrices. Following this, the fission matrices are printed separately, each as a full matrix.

A transport correction is applied to the diagonal terms of the total transfer matrices for all orders k :

$$t_{g \rightarrow g}^k \cdot g_{\text{tr corr}} = t_{g \rightarrow g}^k - \text{tr corr}_g - \sum_{C=10}^{49} \left(\begin{matrix} 0 \\ C_g \end{matrix} - \begin{matrix} 0 \\ C_g \end{matrix} \right). \quad (78)$$

The factor $(2l + 1)$ is not applied to the transfer matrices and must be supplied for those codes which require it.

Magnetic tape and punched card output, if specified, is processed as the above results are printed. For tape output the first file on the output tape contains two identification words. The first has the form

IIYYEEV_LV_CV_C

where

II is the installation that originated the version of the evaluated library used for this run

YY is the year this edition of the evaluated library was originated

EE is the edition number of this evaluated library

V_LV_L is the version number of this evaluated library

V_CV_C is the version number of the CLYDE code used for this run

The second word is the date when this version of evaluated library was last changed. For card output, these two words appear on separate cards with appropriate identification.

The output tape is in binary or BCD mode with an end-of-file mark between isotopes, while the punched cards are in a (6E11.4) format unless otherwise specified. For both tape and punched card output, each different type of calculated quantity is preceded by a descriptor number describing what type of output will follow.

For tape output, there will be a one-word record containing the descriptor number; for punched card output, there will be a card with the descriptor number and a 10-character description of the type of data in a (I3, 5X, A10) format. The output descriptor numbers are assigned as follows:

Descriptor number	Description
1	Group boundaries
2	Speed - inverse averaged
3	Group flux (for $\rho = 0$)
4	Total energy deposits
5	Local energy deposits
6	Reaction group cross sections
7	Isotope production cross sections
8	Group transport correction terms
9	Total transport-corrected group cross section
10	Transport-corrected total transfer matrix
11	Nubar sigma fission cross section
12	CHI
13	Fission matrix

Data types 1 through 7 will always be present, whereas data types 11 through 13 will be present only if the isotope is fissionable, and data types 8 through 10 will be present only if NOUT = 1 or 2.

The order of output of the calculated quantities for punched cards, disc, or tape is listed below.

- A header card or record contains parameters needed to read the data.

The format of the card and description of the various fields is:

Name	Column	Description
NNZA	1-6	1000*Z+A
LORDER	7-9	Tells the highest order of transfer matrix to be output.
NOFISS	10-12	Defines whether or not fission was done for this NNZA, and if so, how many fission matrices there will be: 0 - no fission + 0 - number of fission matrices.
NOUF	13-15	Input parameter to CLYDE which tells how the total transfer matrix is to be output.
ICG	16-18	Number of groups.
NUF	19-21	Number of up-scatter groups as defined by the input to CLYDE.
NDOFN	22-24	Number of down-scatter groups as defined by the input to CLYDE.
NRS	25-27	Number of reactions for this NNZA.
NISOL	28-30	Number of isotopes produced by this NNZA plus 1 (the destruction cross section).
NGP	31-33	Group structure number defining the group structure used to generate these constants. If NGP = 0, then the group boundaries were read from cards.
NFLX	34-36	Flux spectrum number defining the weighting spectra used to generate these constants. If NFLX = 0, then the weighting spectra were read from cards.

- The second card or record of output lists the reaction numbers which were processed for this isotope. For card output these will be in a (2413) format. (Note: consult section on evaluated library format for a definition of the reaction numbers.)
- Group boundaries—There will be ICG + 1 numbers.
- Descriptor number data types 2 through 5—There will be ICG numbers for each data type.

- Reaction group cross sections—For both cards and tape, the reaction number that the group cross sections represent will precede each set as either a separate card [(13) format] or separate record. For tape output, there will be one set of cross sections per record. There will be IGP numbers per set.
- Isotope production cross sections—For both cards and tape, the isotope number (ZA) that the group cross sections represent will precede each set as either a separate card [(16) format] or separate record. If the ZA is zero, this means that the destruction cross section follows. For tape output, there will be one set of cross sections per record. There will be IGP numbers per set.
- Group transport correction terms—There will be IGP numbers.
- Total transport corrected group cross section—There will be IGP numbers.
- Transport corrected total transfer matrices—There will be one incident group per record for tape output. Each order matrix will be preceded by a card or record containing the descriptor number. If NOUT = 1, then each record is $N_g + N_p + 1$ in length; if NOUT = 2 then each record is IGP in length.
- Nubar sigma fission cross section—The number of sets output will be the same as the number of fission matrices (NOFISS). There will be IGP numbers per set. (Note: only output if NOFISS > 0.)
- CHI—The number of sets output will be the same as the number of fission matrices (NOFISS). There will be IGP number per set. (Note: only output if NOFISS > 0.)
- Fission matrix—There will be one incident group per record. Each record is IGP in length, and each matrix is preceded by a card or record containing the descriptor number. (Note: only output if NOFISS > 0.)

The next four pages show an example of card output for a sample CLYDE run.

EVALUATED LIB IDENTIFICATION WORD

175021300

DATE OF LAST CHANGE TO LIB USED

91575

92233 0 1 1 16 15 15 5 5 5 3

10 11 12 13 15 46

1 GP BDS

1.4100E+01 3.0000E+00 1.4000E+00 9.0000E-01 4.0000E-01 1.0000E-01
 1.7000E-02 3.0000E-03 5.5000E-04 1.0000E-04 3.0000E-05 1.0000E-05
 3.0000E-06 1.0000E-06 4.0000E-07 1.0000E-07 2.5000E-08

2 SPEED

2.8750E+01 1.9555E+01 1.4630E+01 1.0810E+01 6.6267E+00 3.5211E+00
 1.4184E+00 6.0368E-01 2.6181E-01 1.1623E-01 6.2941E-02 3.5723E-02
 1.9778E-02 1.1665E-02 7.0298E-03 3.5149E-03

3 GP FLUX

2.6246E-04 4.5142E-04 2.8239E-04 4.1531E-04 2.6934E-04 4.3665E-05
 1.7864E-06 4.8160E-09 1.1855E-09 1.8213E-11 7.0071E-13 8.2691E-14
 7.2871E-15 7.6515E-16 1.3663E-16 8.5396E-19

4 TOT EN DEP

4.1292E+01 4.8426E+01 5.1594E+01 4.8293E+01 4.2794E+01 3.7100E+01
 4.7232E+01 7.5292E+01 9.8289E+01 1.1606E+02 1.3400E+02 1.3271E+02
 1.3183E+02 1.4891E+02 1.4987E+02 1.5463E+02

5 LOC EN DEP

3.8501E+01 4.6104E+01 4.9230E+01 4.6079E+01 4.0805E+01 3.5365E+01
 4.5006E+01 7.1767E+01 9.3588E+01 1.1043E+02 1.3045E+02 1.2613E+02
 1.2476E+02 1.4299E+02 1.4290E+02 1.4747E+02

6 GP X-SECT

10 ELASTIC N N 0.
 4.0153E+00 3.6944E+00 3.5427E+00 4.5933E+00 6.5651E+00 9.2162E+00
 1.1203E+01 1.0441E+01 1.1015E+01 1.3056E+01 1.3605E+01 1.2620E+01
 1.3081E+01 1.2380E+01 1.3115E+01 1.3958E+01

11 (N,N*) N N 0.

1.6405E+00 1.2621E+00 8.7807E-01 4.3689E-01 9.4972E-02 0.
 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.

12 (N,2N) 0. 0. -5.9000E+00

4.1709E-02 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.

13 (N,3N) 0. 0. -1.3133E+01

3.8851E-05 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.

15 (N,F) 1.8000E+02

1.7419E+00 1.9000E+00 1.8675E+00 1.9554E+00 2.2213E+00 2.5366E+00
 4.2956E+00 6.5009E+00 1.6779E+01 3.5624E+01 8.9820E+01 8.6099E+01
 2.5375E+02 1.2258E+02 1.7472E+02 3.2617E+02

46 (N,GAMMA) 0.8400E+00

1.0125E-02 2.1369E-02 5.7555E-02 1.1848E-01 2.0585E-01 2.6470E-01
 4.9374E-01 9.0566E-01 2.2472E+00 5.3712E+00 1.1947E+01 1.5665E+01
 7.3364E+01 9.5887E+00 1.7030E+01 3.0480E+01

7 ISO PROD

0
 1.7937E+00 1.9276E+00 1.9251E+00 2.0739E+00 2.4271E+00 2.8013E+00
 4.7893E+00 4.4066E+00 1.9026E+01 4.0995E+01 1.0177E+02 1.0176E+02
 3.2772E+02 1.3217E+02 1.9175E+02 3.5665E+02

92231

3.8851E-05 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.
 0. 0. 0. 0. 0. 0.

92232

4.1709E-02 0. 0. 0. 0. 0.

-31-

0.					
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	1.0436E+01	5.3500E-03	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.	0.	1.1010E+01	4.5178E-03	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.	1.3043E+01	1.3686E-02	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	1.3583E+01	2.1876E-02	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.	1.2598E+01	2.2048E-02	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	1.3054E+01	2.6431E-02	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.	1.2337E+01	4.2746E-02	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.	1.3100E+01	1.5959E-02	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	1.3958E+01	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

11 NUBAR S16F
5.3062E+00 5.1393E+00 4.8452E+00 4.9576E+00 5.5325E+00 6.2598E+00
1.0572E+01 2.0911E+01 4.1270E+01 8.7621E+01 2.2092E+02 2.1177E+02
6.2413E+02 3.0149E+02 4.2975E+02 8.0224E+02
12 CHI

2.1242E-01	3.4004E-01	1.6523E-01	1.7889E-01	8.8790E-02	1.3688E-02
9.1172E-04	3.0200E-05	7.4510E-07	0.	0.	0.
0.	0.	0.	0.	0.	0.
13	FISS MAT				
1.2027E+00	1.8069E+00	8.5685E-01	9.1577E-01	4.5015E-01	6.9055E-02
4.5936E-03	1.5215E-04	3.7539E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.0998E+00	1.7482E+00	8.4704E-01	9.1561E-01	4.5393E-01	6.9935E-02
4.6575E-03	1.5427E-04	3.8063E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.0177E+00	1.6472E+00	8.0361E-01	8.7184E-01	4.3339E-01	6.6863E-02
4.4545E-03	1.4755E-04	3.6405E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.0309E+00	1.6849E+00	8.2498E-01	8.9675E-01	4.4640E-01	6.8919E-02
4.5924E-03	1.5212E-04	3.7532E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.1417E+00	1.8798E+00	9.2295E-01	1.0047E+00	5.0066E-01	7.7337E-02
5.1541E-03	1.7073E-04	4.2123E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.2868E+00	2.1266E+00	1.0456E+00	1.1390E+00	5.6789E-01	8.7747E-02
5.8482E-03	1.9372E-04	4.7796E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.
2.1709E+00	3.5914E+00	1.7664E+00	1.9246E+00	9.5972E-01	1.4830E-01
9.8841E-03	3.2741E-04	8.0780E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.
4.2934E+00	7.1039E+00	3.4943E+00	3.8074E+00	1.8986E+00	2.9338E-01
1.9554E-02	6.4772E-04	1.5981E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.
8.4732E+00	1.4020E+01	6.8964E+00	7.5144E+00	3.7471E+00	5.7903E-01
3.8592E-02	1.2784E-03	3.1541E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.7989E+01	2.9766E+01	1.4642E+01	1.5954E+01	7.9556E+00	1.2293E+00
8.1936E-02	2.7141E-03	6.6964E-05	0.	0.	0.
0.	0.	0.	0.	0.	0.
4.5357E+01	7.5051E+01	3.6917E+01	4.0225E+01	2.0059E+01	3.0996E+00
2.0659E-01	6.8432E-03	1.6884E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
4.3478E+01	7.1941E+01	3.5387E+01	3.8558E+01	1.9228E+01	2.9712E+00
1.9803E-01	6.5597E-03	1.6184E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.2814E+02	2.1203E+02	1.0429E+02	1.1364E+02	5.6688E+01	8.7568E+00
5.8354E-01	1.9333E-02	4.7699E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
6.1899E+01	1.0242E+02	5.0391E+01	5.4896E+01	2.7374E+01	4.2301E+00
2.843E-01	9.3730E-03	2.3042E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
8.8230E+01	1.4599E+02	7.1812E+01	7.8247E+01	3.9019E+01	6.0295E+00
4.0186E-01	1.3312E-02	3.2843E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
1.6471E+02	2.7253E+02	1.3406E+02	1.4607E+02	7.2840E+01	1.1256E+01
7.5019E-01	2.4850E-02	6.1311E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.

CLYDE Equations

FLUX AND INVERSE SPEED

The group flux is calculated from

$$\phi_g = \int_{E_{g-1}}^{E_g} dE \phi^0(E), \quad (5)$$

for each order i from 0 to $L+1$.

The flux-weighted average of the inverse speed of the incident particles (v_i) within each group is to be used in α/v terms for converting time-dependent problems to stationary ones. This average is expressed as

$$\text{Speed}_g^{-1} = \int_{E_{g-1}}^{E_g} dE \frac{\phi^0(E)}{V(E)} \bigg/ \int_{E_{g-1}}^{E_g} \phi^0(E) dE. \quad (6)$$

The analytic solution to this equation for linearly interpolable $\phi^0(E)$ in segment i is

$$\begin{aligned} \text{Speed}_g^{-1} = \sum_{i=j_{g-1}}^{i_g} & \left[\frac{2}{3} (\phi_{i+1} - \phi_i) (E_{i+1} + \sqrt{E_{i+1}E_i} + E_i) \right. \\ & \left. + \frac{2(E_{i+1}\phi_i - E_i\phi_{i+1})}{\sqrt{E_{i+1}} + \sqrt{E_i}} \right] \bigg/ 13.832055 \phi_g. \end{aligned} \quad (7)$$

Here the i 's denote elements in the merged table of group bounds and flux energies from the input flux table. The numerical factor converts the speed to the units of cm/shake, where 1 shake = 10^{-8} s.

GROUP CROSS SECTIONS AND ENERGY DEPOSITIONS ($I = 0$ data).

The group averages of the linearly interpolable integrated cross sections are weighted with appropriate fluxes over the group structure. The averages

are expressed by

$$\alpha_{xg}^l = \frac{\int_{E_{g-1}}^{E_g} dE \bar{\Sigma}_x(E) \phi^l(E)}{\int_{E_{g-1}}^{E_g} dE \phi^l(E)}. \quad (8)$$

These quantities are generated for each l , $0 \leq l \leq L+1$. The values obtained for $l=0$ are used in making the Legendre flux expansion correction to the total cross section, as discussed in the section on the transport correction (p. 55).

The quantity in (1=10) carried on the library tape is $\bar{E}_x(E)$, the total energy deposition for reaction x , i.e., the incident neutron energy plus the Q_0 of the reaction less that removed by neutron emission. The group average of this quantity is then

$$\bar{E}_x^g = \frac{\int_{E_{g-1}}^{E_g} dE \phi_x^0(E) \bar{E}_x(E)}{\int_{E_{g-1}}^{E_g} dE \phi_x^0(E)}. \quad (9)$$

This quantity, weighted with σ_{xg}^0/ϕ_g^0 , is added into a $\bar{E}_{\text{tot}}^g$ array since the total energy deposition per collision is a quantity of interest. The division of this term into local and nonlocal energy deposition gives the ultimately desired quantities for some applications.

The above integrals, being comprised only of products of linear functions, are analytic (see UNINT, DIINT, TRIINT subroutine descriptions).

The nonlocal deposition is due to γ radiation, which is generally more penetrating than other forms of energy dispersion (neutrino production in, for example, the fission process is not included in the $\bar{E}_x(E)$ figure, since it is of no further process interest). The nonlocal energy deposition may be obtained by processing the n, x_1 reaction ($c=55$), provided that data are available for that reaction for $y_0=7$:

$$\bar{E}_{\text{nonlocal}}^R = \bar{E}_{55}^R = \frac{\int_{E_g}^{E_g} dE \cdot n_{55}(E) \cdot \phi_0(E) \int_0^{\infty} dE' \cdot n_{55}^0(E \cdot E') E'}{\int_{E_{g-1}}^{E_g} dE \cdot n_{55}(E) \cdot \phi_0(E) \int_0^{\infty} dE' \cdot n_{55}^0(E \cdot E') E'} \quad (10)$$

Alternatively this quantity can be calculated from the difference, if available, of $I = 11$ (local $\bar{E}$) and $I = 10$. As an option, the cross section can be doppler-broadened to any temperature using the doppler routine from the SIGMA 1 code.

TABULAR ENERGY DISTRIBUTIONS

The Tabular energy distribution data ($I = 4$) consists of a series of incident energies E , at each of which is given a set of emission energies E' and their corresponding probabilities. These points are assumed to be linearly interpolable in emission energy. Interpolation in incident energy, however, is not straightforward.

A commonly used method is to do a linear extrapolation in E , but this can result in distributions that have finite probabilities of transfer to energies above E , which might violate conservation of energy. A scheme that avoids this would be to use linear interpolation in E of the end points, and to connect the break points of the line segment distributions based on their relative proportion of the energy span of the distribution, with a resulting distribution constructed by linearly connecting (in E) the interpolated (in E') probabilities. This process, however, does not result in the integral of the distribution at an intermediate energy being linearly interpolable, as would be desirable. If linear interpolation is used to connect two right trapezoids on parallel planes, the intermediate areas so constructed are not linear in the separation variable—unless the two bases are equal.⁶ Therefore, a transformation to equal (unit) basis is used in TABXFR, so that linearly interpolable areas result from linear interpolation of the transfer probabilities in the transformed coordinate system.

The integral to be evaluated is:

$$\overline{\sigma}_{\text{X}}^{\text{O}} = \int_{E^-}^{E^+} dE \overline{\sigma}(E) \cdot \overline{\sigma}'(E) \int_{E^-}^{E^+} dE' \cdot \overline{\sigma}'(E \cdot E') / \int_{E_{G-1}}^{E_G} dE \cdot \overline{\sigma}'(E), \quad (11)$$

where $\overline{\sigma}(E) = 1$ for scattering reactions.

The integration limits will be discussed below. The data are available in the form

$$E_i, E'_{i \min}, \pi^i(E_i \cdot E'_{i \min}), \dots, E'_{ij}, \pi^i(E_i \cdot E'_{ij}), \dots, E'_{i \max}, \pi^i(E_i \cdot E'_{i \max}),$$

where $\pi^i(E_i \cdot E'_{ij})$ is the i th Legendre coefficient of the expansion of the correlated energy-angle distribution data. The transformation is indicated by a tilde and is specified by:

$$\tilde{E}_{ij} = \frac{E'_{ij} - E'_{i \min}}{E'_{i \max} - E'_{i \min}} \quad (12)$$

and

$$\pi^i(E_i \cdot \tilde{E}_{ij}) \equiv \pi^i(E_i \cdot E'_{ij}) \cdot (E'_{i \max} - E'_{i \min}). \quad (13)$$

This equation holds only at the E_i 's, (i.e., at the incident energy entry points). At all other E 's the distributions in E are determined by the following procedure:

1. The two E_i table entries which span the desired incident energy E are determined (E_i, E_{i+1}), and their corresponding E, π^i tables are transformed according to Eqs. (12) and (13).
2. The break points and their corresponding π^i 's on each of the transformed distributions are listed.
3. The two lists of break points are merged into an $\tilde{E}_k$ list.
4. Missing π^i values of the merged list for each distribution are found by linear interpolation in $\tilde{E}$:

$$\pi^i(E_i \cdot \tilde{E}_k) = \pi^i(E_i \cdot \tilde{E}_j) + \left[\pi^i(E_i \cdot \tilde{E}_j) - \pi^i(E_i \cdot \tilde{E}_{j+1}) \right] \frac{\tilde{E}_j - \tilde{E}_k}{\tilde{E}_j - \tilde{E}_{j+1}}. \quad (14)$$

5. The form for the distribution is established at a general E by a linear interpolation in E between the foregoing quantities:

$$\tau^{\pm}(E \cdot \tilde{E}_k) = \tau^{\pm}(E_i \cdot \tilde{E}_k) - \left[\tau^{\pm}(E_i \cdot \tilde{E}_k) - \tau^{\pm}(E_{i+1} \cdot \tilde{E}_k) \right] \frac{E_i - E}{E_i - E_{i+1}}. \quad (15)$$

6. At E 's between the E_k 's, this distribution is linearly interpolable:

$$\tau^{\pm}(E \cdot E) = \tau^{\pm}(E \cdot E_k) - \left[\tau^{\pm}(E \cdot E_k) - \tau^{\pm}(E \cdot E_{k+1}) \right] \frac{E_k - E}{E_k - E_{k+1}}; \quad (16)$$

this is the general form needed for the inner integral of Eq. (11).

7. The integration in the transformed E, E coordinate system is equivalent to integration in the real system; so

$$\tau_{\text{ex}}^{\pm} = \int_{E^-}^{E^+} dE \tau^{\pm}(E) \cdot \tau_{\text{ex}}^{\pm}(E) = \int_{E^-}^{E^+} dE \tau^{\pm}(E \cdot E) \int_{E_{k-1}}^{E_k} dE \tau^{\pm}(E \cdot E) \int_{E_{k-1}}^{E_k} dE \tau^{\pm}(E). \quad (17)$$

8. The inner integral contains only a term of the type shown in step 6, which is in turn composed of two terms of the type in step 5; thus,

$$\begin{aligned} \int_{E^-}^{E^+} dE \tau^{\pm}(E \cdot \tilde{E}) &= \left[\tau^{\pm}(E \cdot \tilde{E}_k) - \left[\tau^{\pm}(E \cdot \tilde{E}_k) - \tau^{\pm}(E \cdot \tilde{E}_{k+1}) \right] \frac{\tilde{E}_k}{\tilde{E}_i - \tilde{E}_{k+1}} \right] \left\{ \left[\tilde{E}^+(E) - \tilde{E}^-(E) \right] \right\} \\ &= \left[\tau^{\pm}(E \cdot \tilde{E}_k) - \tau^{\pm}(E \cdot \tilde{E}_{k+1}) \right] \frac{1}{\tilde{E}_k - \tilde{E}_{k+1}} \left[\frac{\tilde{E}^+(E)^2 - \tilde{E}^-(E)^2}{2} \right] \\ &= \left[\tilde{E}^+(E) - \tilde{E}^-(E) \right] \left(\tau^{\pm}(E \cdot \tilde{E}_k) - \left[\tau^{\pm}(E \cdot \tilde{E}_k) - \tau^{\pm}(E \cdot \tilde{E}_{k+1}) \right] \frac{\tilde{E}_k - \frac{1}{2} [\tilde{E}^+(E) + \tilde{E}^-(E)]}{(\tilde{E}_k - \tilde{E}_{k+1})} \right) = W(E) \tau^{\pm}(E \cdot \tilde{E}), \quad (18) \end{aligned}$$

where we define

$$W(E) = E^+(E) - E^-(E) \quad (19)$$

$$\bar{E} = \frac{E^+(E) + E^-(E)}{2}. \quad (20)$$

9. The outer integral is then

$$\bar{\pi}_{X_g} \pi_{X_g}^{-1} h = \int_{E^-}^{E^+} dE \mathcal{D}(E) \pi_X(E) \phi^i(E) \pi^j(E \cdot \bar{E}) W(E) \left/ \int_{E_{g-1}}^{E_g} dE_1 \epsilon'(E) \right. \quad (21)$$

At this point we must consider the transform of the target group bounds to the new coordinate system. This is derived as follows: for any E ,

$$E_h(E) = E_h \quad (22)$$

$$E'_h(E) = \frac{E_h(E) - E'_{imin}(E)}{E'_{imax}(E) - E'_{imin}(E)}, \quad (23)$$

where

$$E'_{imin/imax}(E) = E'_{imin/imax}(E_{i+1}) - \left[\frac{E'_{imin}(E_{i+1}) - E'_{imin}(E_i)}{E_i - E_{i+1}} \right] \cdot \left[\frac{E - E_{i+1}}{E_i - E_{i+1}} \right]$$

and similarly for $E'_{h-1}(E)$. This yields equations for the transformed boundary of the form

$$E_h(E) = \frac{a_1 + a_2 E}{a_3 + a_4 E},$$

where

$$a_1 = E_h - E'_{imin}(E_{i+1}) - a_2 E_{i+1}$$

$$a_2 = [E'_{imin}(E_{i+1}) - E'_{imin}(E_i)]/[E_i - E_{i+1}]$$

$$a_3 = E'_{imax}(E_{i+1}) - E'_{imin}(E_{i+1}) - a_4 E_{i+1}$$

$$a_4 = [\text{base}_i - \text{base}_{i+1}] / [E_i - E_{i+1}]$$

$$\text{base}_i = E'_{imax}(E_i) - E'_{imin}(E_i)$$

Note that this transformation results in a boundary in the transform plane which is, in general, nonlinear. The boundary crossings must be investigated to ascertain the dependency of the quantities $W(E)$, $\bar{E}$, or $\bar{E}$.

The boundary crossings are defined as:

$$\begin{array}{llll} E_h(E_i) < \bar{E}_{i,j+1} & ; & \bar{E}_{h-1}(E_i) < E_{i,j} & \longrightarrow & O \\ E_h(E_i) < E_{i,j+1} & ; & \bar{E}_{h-1}(E_i) < \bar{E}_{i,j} & \longrightarrow & L \\ \bar{E}_h(E_i) < \bar{E}_{i,j+1} & ; & \bar{E}_{h-1}(E_i) < E_{i,j} & \longrightarrow & R \\ E_h(E_i) < \bar{E}_{i,j+1} & ; & \bar{E}_{h-1}(E_i) < \bar{E}_{i,j} & \longrightarrow & L-R \end{array}$$

Thus in the transformed coordinates the in-scattering group bounds are no longer straight, parallel lines but are continuous, piecewise nonlinear functions—but the source group boundaries are unaffected by the transformation. A schematic representation of the transformation of a representative distribution is shown in Fig. 1, indicating the interpolation mechanism and the

transformation of the emission group boundaries. The integration is carried out between each pair of energies in a merged list of E_{ij} 's and group bounds in the emission coordinate, and between energies in a merged energy list consisting of group bounds and $E_{0\phi\psi}$ in the incident energy coordinate. The contribution thus determined is added to the total for the appropriate g, h element. If the emission group bounds intersect the rectangular areas on the E, E plane (Fig. 2), the manner of intersection determines the various integration limits. Each crossing of an $\bar{E}_{i,j}$ line by an $\bar{E}_h$ boundary generates a further subdivision of the integration rectangle at each crossing.

Fig. 1. A transformation. The heavy outline in both coordinate systems defines the region of integration for the group g transfer to group h. Note that the boundaries of group h are not parallel lines in the $E, \bar{E}$ system. The manner of interpolation in the $E, \bar{E}$ system is indicated at $E = E_{g-1}$.

Fig. 2. A boundary crossing.

Once the boundary crossing type is determined, the forms of $W(E)$ and $\bar{E}(E)$ can be determined from Table 6.

Table 6. Forms of $W(E)$ and $E(E)$.

BC	a_6	a_7	a_8	a_9	a_{10}	a_{11}
O	$a_{12}+a_{13}$	0	$a_{12}-a_{13}$	0	1	0
R	$a_1+a_{13}a_3$	$a_2+a_{13}a_4$	$a_1-a_{13}a_3$	$a_2-a_{13}a_4$	a_3	a_4
L	$a_{12}+a_3+a_5$	$a_{12}a_4+a_2$	$a_{12}a_3-a_5$	$a_{12}a_4-a_2$	a_3	a_4
LR	a_1+a_5	$2a_2$	a_1-a_5	0	a_3	a_4

In Table 6

$$W(E) = \frac{a_8+a_9E}{a_{10}+a_{11}E} \quad (26)$$

$$\bar{E}(E) = \frac{\frac{1}{2} \frac{a_6+a_7E}{a_{10}+a_{11}E}}{a_{10}+a_{11}E} \quad (27)$$

and

$$a_{12} = E_{i,j+1}$$

$$a_{13} = E_{i,j}$$

If we define

$$r_x(E) = t + uE$$

$$r'_x(E) = v + wE$$

$$r(E) = g + hE$$

$$p' (E + E_k) = p + qE$$

$$r' (E + E_{k+1}) = r + sE$$

$$(E_k - E) / (E_k + E_{k+1}) = e + fE,$$

the integral becomes

$$\int \frac{dE (u+hE) (1+uE) (v+wE) (c_4+c_5E+c_6E^2) (a_8+a_9E)}{(a_3+a_4E)^2}, \quad (28)$$

where the constants are defined in Appendix C.

When $a_3 \neq 0$, $a_4 \neq 0$, this integral has the analytic solution

$$\int_{E^-}^{E^+} dE \sum_{m=1}^7 \frac{d_m E^{m-1}}{(a_3+a_4E)^2} \quad (29)$$

$$= \left[\frac{-d_1}{a_4(a_3+a_4E)} + \sum_{m=2}^7 d_m \left\{ \sum_{k=1}^{m-2} \frac{(-1)^{k-1} k a_3^{k-1} E^{m-1-k}}{(m-1-k) a_4^{k+1}} \right. \right. \\ \left. \left. + \frac{(-1)^{m-2} a_3^{m-1}}{a_4^m (a_3+a_4E)} + \frac{(-1)^m (m-1) a_3^{m-2}}{a_4^m} \ln(a_3+a_4E) \right\} \right]_{E^-}^{E^+}$$

where the constants are defined in Appendix C.

Whenever scattering is elastic, $a_{10} = a_3 = 0$, since

$$\alpha(E)_{\text{elastic}} = \alpha = \left(\frac{\Lambda-1}{\Lambda+1} \right)^2,$$

$$\text{base}_i = E_{i\max_i} - E_{i\min_i} = E_i (1-\alpha)$$

$$a_3 + E_{i+1}(1-\epsilon) - \frac{E_{i+1}}{E_i - E_{i+1}} \left(E_i(1-\epsilon) - E_{i+1}(1-\epsilon) \right) = 0.$$

Then the integral reduces to a simpler form;

$$\begin{aligned} \sum_{m=1}^7 d_m \int_{E^-}^{E^+} \frac{dx x^{m-1}}{(a_3 + a_4 x)^2} &= \sum_{m=1}^7 d_m \int_{E^-}^{E^+} \frac{dx x^{m-1}}{(a_4 x)^2} \\ &= \sum_{m=1}^7 \frac{d_m}{a_4^2} \int_{E^-}^{E^+} dx x^{m-3} = \frac{1}{2} \left[\frac{-d}{x} + d_2 \ln x \right. \\ &\quad \left. + \sum_{m=3}^7 \frac{d_m x^{m-2}}{m-2} \right] \Bigg|_{E^-}^{E^+}. \end{aligned} \quad (30)$$

When $a_4 = 0$, which will occur either when there are no boundary crossings within the sub-zone or when the bases of the distributions spanning the sub-zone in question are equal, the integral reverts to an even simpler form;

$$\frac{1}{a_3} \sum_{m=1}^7 d_m \int_{E^-}^{E^+} dx x^{m-1} = \frac{1}{a_3} \sum_{m=1}^7 \frac{d_m x^m}{m} \Bigg|_{E^-}^{E^+}. \quad (31)$$

Note that these special cases are not contained in the general solution, so they must be checked for and treated explicitly.

As in the other transfer routines, the lower limit of the distribution function (in this case, $E=0$) is always used, even if the lowest group bound exceeds it. This effectively transfers into the lowest group those neutrons which would, according to the model, go to energies below the lowest group. It has been found necessary to use double precision to evaluate Eq. (29) when the tabulated distributions contained approximations to δ -functions. Nevertheless, the analytic nature of the integrals makes this subroutine very efficient.

DIRECT SCATTERING PROCESSES

LEGXFR uses the $l = 1$ entry if available, or otherwise the $l = 2$ entry for the generation of either elastic or single-level inelastic group transfer cross sections. The input center-of-mass (COM) angular distributions are directly related to the COM energy loss and the Q of the level for both kinds of reactions. The equations used in CLYDE for these relations and the translation to lab energies and angles are developed in the ACN-SIGMA report.⁷ The final form of the equation to be solved is

$$g_{x,g+h}' = \frac{\int_{E^-}^{E^+} dE' \phi'(E) \int_{E'^-(E)}^{E'^+(E)} dE'' \frac{g_{x,g}}{x}(E \cdot E'')}{\int_{E_{g-1}}^{E_g} dE \phi'(E)},$$

where

$$\int_{E'^-(E)}^{E'^+(E)} dE'' \frac{g_{x,g}}{x}(E \cdot E'') = \frac{(A+1)^2}{2E} \rho_j(E) g_{x,g}'(E) \\ \times \int_{E'^-(E)}^{E'^+(E)} dE'' P_{\rho_j}[E(E,E'')] P[E, \cdot, (E,E'')], \quad (33)$$

where either

- $l = 1$ data is given: $P[E, n(E, E'')]$ is obtained by linear interpolation of the $l = 1$ data $[E, P(E, n)]$;
- $l = 1$ data is not given, but $l = 2$ data is present, i.e., $g_{x,g}'(E)$. Then:

$$P[E, \cdot, (E, E'')] = \sum_{j=0}^n \frac{2j+1}{2} g_{x,g}'(E) P_j^j[E, (E, E'')].$$

In the above, $P_{\rho_j}^j$ is the j th Legendre component of the expansion of the group transfer cross section in the lab system, and

$$\rho_j(E) = \frac{1}{A} \left[1 + \frac{A+1}{A} \frac{Q_j}{E} \right]^{-1/2}, \quad (34)$$

(35)

$$\text{lab cosine} = g(E, E') \left(\frac{A+1}{2} \right) \left(\frac{E'}{E} \right)^{1/2} - \left(\frac{A-1}{2} \right) \left(\frac{E}{E'} \right)^{1/2} - \frac{\Lambda^2 j}{2(E E')^{1/2}},$$

$$\text{COM cosine} = g(E, E') \frac{j(E)}{2} \left[(A+1)^2 \frac{E'}{E} - \left(1 + \frac{1}{j(E)^2} \right) \right]. \quad (36)$$

The subscript j refers to the specific level being treated—LEGFR processes only one level at a time.

The $g_{x'}^{j'}$, the center-of-mass Legendre expansion coefficients of the angular distribution of the emitted particle, may be entered to the order required to give a desired degree of accuracy in the fit to the $l = 1$ data (the angular distribution tables). The accuracy of $g_{x'}^{j'}$ is limited by both that of the g_x^j expansion and by the numerical integration performed in LEGFR. The non-linear nature of the $l = 2$ form requires that both the inner and outer integrations be done numerically—Simpson integration has been used for both of these integrals.

The integration limits are (see Fig. 3):

$$E^- = \max \left\{ E_{g-1}; E_{th}; E_{\min}; \left[\begin{array}{l} E' E'_{\max} = E'_{h-1} \text{ if } E'_{\max} (E = E_{th}) \leq E'_{h-1} \\ E^- (E'_{\min} = E'_h) \text{ if } E'_h \leq E'_{\min} (E = E_{th}) \end{array} \right] \right\}, \quad (37)$$

$$E^+ = \min \left[E_g; E^+ (E'_{\min} = E'_h) \right], \quad (38)$$

$$E'^-(E) = \max \left[E'_{h-1}, E'_{\min}(E) \right], \quad (39)$$

$$E'^+(E) = \min \left[E'_h; E'_{\max}(E) \right], \quad (40)$$

where

$$E_{th} = -\frac{(\Lambda+1)}{\Lambda} Q_j$$

threshold lab energy
for level m ,

(41)

$$E_{90} = -\frac{\Lambda}{\Lambda-1} Q_j$$

incident lab energy where
90° lab scattering emission
angle is first possible, (42)

$$E'_{max}(E) = \frac{E}{(\Lambda+1)^2} \left[A \left(1 - \frac{E_{th}}{E} \right)^{1/2} + 1 \right]^2,$$
(43)

$$E'_{min}(E) = \frac{E}{(\Lambda-1)^2} \left[A \left(1 - \frac{E_{th}}{E} \right)^{1/2} - 1 \right]^2,$$
(44)

Fig. 3. LECXFR integration limits.

$$E(E'_{max}) = \frac{E'_{max}}{(\Lambda-1)^2} \left(2 \left[1 - \Lambda \left[1 + \left(\frac{\Lambda-1}{\Lambda+1} \right) \frac{E_{th}}{E'_{max}} \right]^{1/2} \right. \right. \\ \left. \left. + (\Lambda+1)(\Lambda-1) \left[1 + \left(\frac{\Lambda-1}{\Lambda+1} \right)^2 \frac{E_{th}}{E'_{max}} \right] \right] \right), \quad (45)$$

$$E(E'_{min}) = \frac{E'_{min}}{(\Lambda-1)^2} \left(2 \left[1 - \Lambda \left[1 - \left(\frac{\Lambda-1}{\Lambda+1} \right) \frac{E_{th}}{E'_{max}} \right]^{1/2} \right. \right. \\ \left. \left. + (\Lambda+1)(\Lambda-1) \left[1 + \left(\frac{\Lambda-1}{\Lambda+1} \right)^2 \frac{E_{th}}{E'_{max}} \right] \right] \right). \quad (46)$$

To ensure that sharp resonances in either the cross section or the angular distributions are not missed by the Simpson integration procedure, the outer integral is "subranged" to include as boundaries not just the group boundaries, but the energies of: all $0 < k < L$ flux tables; the appropriate cross section table; either the $I = 1$ or $I = 2$ data tables; and E_{90} , which marks an abrupt transition from forward-only to full scattering.

The integration is over functions that can be rather strongly peaked; in order to assure an efficient procedure, the intervals are checked not only on the full separation distances, but each half, each quarter, and each eighth of any interval is also checked for convergence, and converged subregions are dropped out of the subdivision process. This procedure is used for both the inner and outer integral of LEGXFR and has been found to result in considerable reduction in computation effort.

It was also observed that, for the heavy isotopes, more work is done in a subgroup cut by an in-scattering group boundary than in one that includes the entire down-scattering range. Therefore, LEGXFR does not calculate the self-scattering term directly, but uses the lower scattering limit to calculate the total transfer; the self-scattering is then this result less all outscatter terms:

$$\sigma_{x, g_1 \rightarrow g_2}^k = \sigma_{x, g_1}^k - \sum_{h \neq g_2} \sigma_{x, g_1 \rightarrow h}^k$$

Note that the inner summation over g_2 , is constant in k ; LEGXFR takes advantage of this fact by carrying out the integrations for all k simultaneously. Convergence of the inner integral is determined by the input quantity

$$\left| \frac{\sigma_{\text{new}}^k}{\sigma_{\text{old}}^k} - 1 \right| < \epsilon \quad (47)$$

For the outer integral, the criterion of convergence is relaxed so that, if after the third iteration

$$\sum_h \frac{\sigma_{\text{sub}, h}^k}{\sigma_{\text{sub}}^k} < \epsilon \quad (48)$$

where $\epsilon = 10$, the subrange is considered completed for all k for that

in-scattering group regardless of the degree of convergence. This is done so that calculation of in-scattering terms which are essentially trivial will not consume an inordinate amount of computer time. It is not possible to determine in advance whether an outer integral will be rejected by the above test, so no comparable rejection mechanism can be developed for the inner integral. The value of the outer integrand at E_{th} is set to zero; this assumes (properly) that $\sigma_x(E_{th}) = 0$. All this care is necessary since LEGXFR is potentially the most time-consuming segment of CLYDE.

In the calculation of elastic and discrete-level inelastic scattering transfer matrices, the inner integral of the double integration is done analytically if probability tables ($I = 1$) are available. This has been done to further improve the running time of this subroutine. The inner integral may be subranged into a sum of integrals, each of which spans a pair of points in the $E, p(E, \omega)$ table, so that the angular distribution is representable as a linear function. In each such region i ,

$$P(E, \omega(E, E')) = a_i + b_i E'. \quad (49)$$

From Eq. (35), μ is a function of E' ,

$$\mu = c(E')^{1/2} + d(E')^{-1/2} \quad (50)$$

where

$$c = (A + 1)/(2E^{1/2}) \quad (51)$$

$$d = \left[\left(\frac{A-1}{2} \right) E^{1/2} + \frac{A}{2} Q_j E^{-1/2} \right]. \quad (52)$$

From the binomial representation of μ ,

$$\mu^n = \sum_{j=0}^n \frac{n!}{j!} \frac{c^{n-j} d^j E^{(n-2j)/2}}{(n-j)! j!} \quad (53)$$

while the Legendre polynomial $p_n(\mu)$ can be represented as the series

$$p_n(\mu) = \frac{1}{2^n} \sum_{m=0}^{n/2} \frac{(-1)^m (2n-2m)!}{m! (n-m)! (n-2m)!} \mu^{n-2m} \quad (54)$$

Substituting Eqs. (49), (53), and (54) into Eq. (33) for the inner integral of that equation and performing the indicated integration over E' yields

$$\begin{aligned} \sum_i \int_{E_i}^{E'_{i+1}} dE' P_n[\mu(E, E')] P[E, n(E, E')] \\ = \sum_i \sum_{m=0}^{n/2} \frac{(2n-2m)! (-1)^m}{2^n m! (n-m)!} \sum_{j=0}^{n-2m} \frac{c^{n-2m-j} d^j}{(n-2m-j)! j!} \\ \times \left\{ \begin{array}{cc} \frac{a_i}{e} (E'_{i+1} - E_i^e) + \frac{b_i}{f} (E'_{i+1} - E_i^f) & \\ \text{except} & \text{except} \end{array} \right\}, \\ \left\{ \begin{array}{cc} a_i \ln(E'_{i+1}/E_i^e) + b_i \ln(E'_{i+1}/E_i^f) & \\ \text{if } e = 0 & \text{if } f = 0 \end{array} \right\}, \end{aligned}$$

where

$$e = \frac{n-2m-2j+2}{2}; \quad f = e + 1$$

$$a_i = P[E, n(E, E'_i)] - b_i E'_i$$

$$b_i = \frac{P[E, n(E, E'_{i+1})] - P[E, n(E, E'_i)]}{E'_{i+1} - E'_i}, \quad E'^- \leq E'_i < E'^+.$$

While this does improve the calculation time, the nature of this expression requires the use of double precision even on the CDC-7600. Even with double precision, the "noise" level is occasionally reached—particularly when the result of the inner integration should be zero.

To prevent excessive and useless iteration on the outer integral when this occurs, a test is made on the magnitude of the inner integral. If its absolute value falls below

$$\text{largest term in sum} \times 10^{-24} / \epsilon,$$

the integrand is set to zero. If the calculation is on elastic scattering and the scattering is isotropic, the $l = 2$ form is used.

Finally, the converged P_0 matrix is normalized to the group cross section by

$$\sigma_{g \rightarrow h}^0 = \frac{\sigma_h}{\sum_h \sigma_{g \rightarrow h}^0} \sigma_{g \rightarrow h}^0 \quad (55)$$

To assure that the input threshold corresponds to that calculated internally, if

$$|E(1) - E_{th}| > 10^{-3},$$

$E(1)$ is set equal to E_{th} as calculated from A and Q . If the criterion is not met, the isotope processing is done, but an appropriate comment is issued. $E(1)$ is set equal to zero in either case. If the modified $E(1) > E(2)$, processing of the current isotope is discontinued and a comment is issued.

In spite of all the care taken with this subroutine, processing can be very time-consuming for higher-order matrices; for this reason direct scattering data is reformulated in the CON 14 subroutine to the $l = 4$ form, which is much more efficiently processed. This action is taken whenever ρ_{max} exceeds unity. We create an $l = 4$ array $E, E', \rho, \sigma(E \cdot E')$ from the given $l = 1$ data $E, \eta, P(E, \eta)$ by the following process:

First, E' is found in terms of η at the given η entries. From Eq. (46) we get

$$E' = \frac{E}{(A+1)^2 \eta_j^2(E)} \left[2 \eta_j(E) \eta(E, E') + \eta_j^2(E) + 1 \right]. \quad (56)$$

This resultant E' array is then expanded, since the final function will not be linear between these points. η and $P(E, \eta)$ are interpolated for this expanded array, and σ' is calculated from

$$\sigma'(E \cdot E') = \frac{(A+1)^2}{2E} \eta_j(E) P_j(\eta(E, E')) P(E, \eta(E, E')) \quad (57)$$

using ρ from Eq. (35).

The resultant data is buffered out to a separate (LEPIEPI) array and subsequently processed as $l = 4$ data.

HISTOGRAM DISTRIBUTIONS

A new data category, histogram energy distributions, has been added to the library, primarily to treat photon emission spectra. This distribution form is given as $E, E'_I, P_X(E, E'_I)$ ($I = 8$ data), where

$$P_X(E, E'_I) = \int_{E_I}^{E'_{I+1}} dE' \cdot r_X^0(E \cdot E').$$

For processing purposes, this is converted into tabular ($I = 4$ type) distributions by creating additional points just below the upper limit of each indicated range, and assuming a flat distribution over that range. Processing then continues as for $I = 4$ data.

LINE EMISSION SPECTRA FOR GAMMA PRODUCTION

If $S = 3$ (gamma production) and $y_0 = 7$ for $I = 2$ data, a test is made to determine isotropy. Isotropic line emission spectra is assumed to be emitted into that energy group containing the line, W . If the distribution is anisotropic, a 3-point δ -function energy spectrum is generated, and the $I = 2, I = 4$ data set is processed in TABXFR as uncorrelated energy-angular distributions. Center-of-mass motion is ignored.

MONTE CARLO INPUT DATA

CTART (stands for CLYDE-TART) now produces Monte Carlo input library data. Its input instructions are the same as for CLYDE, with the exception that the optional card input mode has been deleted. The TTY operating instructions are also the same, and it uses a number of the CLYDE subroutines. Currently, model number cards are also required, but it is intended that these will be generated internally. The Physical Data Group can provide assistance in the use of model numbers and in the use of the TART library generating code, UPTART.

The preparation of TART Monte Carlo² input data is done in the SORES subroutine (a pointwise input Monte Carlo code could operate directly from the cross section library). The required quantities are group cross sections, transfer data in the form of equal probability tables in energy and angle, excitation levels, and group energy depositions.

The group cross sections and energy distributions are calculated in SIGAV with $L = 0$, since Legendre expansions are not used in the TART code.

An input quantity, N , defines the number of equal probability segments for which all energy and angular distribution data is to be defined. Then for $0 < m \leq N$,

$$P_m = \frac{m}{N}$$

defines the cumulative probability of the m th entry. The code then determines the E'_m or ν_m at the corresponding $P_m(E')$ or $P_m(\nu)$.

The various possible combinations of transfer models currently treated are shown in Table 6.

Table 6. Possible collision models for the various neutron emission reactions.

Reaction (C)	Corresponding processed quantities for Monte Carlo output option		
	$i = 1$	$i = 4$ ($i = 0$ only)	$i = 4$ and 1
	Level excitation correlated ^a	$\pi^0(E \rightarrow E')$ (isotropic-lab)	$\pi^0(E \rightarrow E)$, $f(E, \nu)$ uncorrelated ^b
n,n 10	$\nu_m(E)$	—	—
n,n 11	$\nu_m(E), Q_n$	$E'_m(E)$	$E'_m(E), \nu_m(E)$
n,2n ^c 12			
1st	$\nu_m(E), Q_n$ (B)	(D) $E'_m(E)$	(E) $E'_m(E), \nu_m(E)$
2nd ^d	—	(D) $E'_m(E)$	(E)(B) $E'_m(E), \nu_m(E)$
n,3n 13	—	$E'_m(E)$	$E'_m(E), \nu_m(E)$
n,f 15	—	$\{E'_m(E), \bar{\nu}(E)\}$ prompt $\{E'_m(E), \bar{\nu}(E)\}$ delayed	—

^aAngular data in the center-of-mass frame.

^bAngular data in the lab frame.

^cThe circled letter designations indicate the allowable combination of models for the first and second neutron in the n, 2n process; only matching letter pairs are programmed at the present time.

^dIf only one distribution is present, both neutrons are assumed to be emitted according to that distribution.

For emission processes described by energy-angle distributions in the form of normalized Legendre polynomials ($l = 4$ table), cumulative probability tables must be constructed from the library data.

For angular probability $E, u_i, P(u_i)$ ($l = 1$ data), P is linear in u , so the cumulative probability will not be linear; thus, the quantity u_m calculated cannot be evaluated by linear interpolation in u of the $l(u_i)$ tables. Define

$$P(u_m) = a_i + b_i u_m \quad (59)$$

so

$$M(u_m) = \int_{u_i}^{u_m} P(u') du' = a_i(u_m - u_i) + \frac{b_i}{2} (u_m^2 - u_i^2) \quad (60)$$

$$u_{i+1} = u_m + u_{i+1}$$

and

$$I_m - \frac{m}{N} = I_i + M. \quad (61)$$

Solving

$$0 = \left(I_i - \frac{m}{N} \right) - a_i u_i - \frac{b_i u_i^2}{2} + a_i u_m + \frac{b_i}{2} u_m^2, \quad (62)$$

so SORES computes

$$u_m = \frac{-a_i + \sqrt{a_i^2 - 2b_i c}}{b_i}, \quad (63)$$

where

$$c = I_i - \frac{m}{N} - a_i u_i - \frac{b_i u_i^2}{2}.$$

Level energies (if any) are transmitted directly.

An identical process may be followed for the $l = 4$ energy distribution tables $E, E', \mu^0(E \cdot E')$.

TRANSPORT CORRECTION

The transport correction used in CLYDE consists of two parts. The first accounts for the inexactness of weighting the total cross section with an $i = 0$ flux spectrum by supplying all higher orders of weighting up to $L + 1$, where L is the order above which the Legendre expansion of the transfer is to be truncated.

The multigroup form of the Legendre-expanded transport equation⁸ is, in one dimension,

$$\sum_{g'} \left[\frac{(L+1) \phi_{g'}^{L+1}(z) + \phi_{g'}^{L-1}(z)}{2L+1} \right] + \Sigma_g(z) \phi_g^L(z) = \sum_{g'} \Sigma_{g \rightarrow g'}(z) \phi_{g'}^L(z) \quad (65)$$

for each order L of the expansion, where

$$\phi_g^L(z) = \int_R \phi^L(E, z) dE$$

$$\Sigma_g(z) = \int_R \phi^L(E, z) \Sigma(E) dE = \int_R \phi^L(E, z) dE$$

$$\Sigma_{g \rightarrow g'}(z) = \int_{R'} dE' \int_R dE \phi^L(E, z) \Sigma(E \cdot E') = \int_R \phi^L(E, z) dE$$

$$\phi^L(E, z) = \int_{-1}^1 d\mu \phi(E, \mu, z) P_L(\mu)$$

$$\Sigma(E \cdot E') = \int_{-1}^1 d\mu \Sigma(E \cdot E', \mu) P_L(\mu)$$

so that

$$\phi(E, \mu, z) = \sum_{L=0}^L \frac{2L+1}{2} \phi^L(E, z) P_L(\mu), \text{ etc.}$$

Note that the total cross section term, $\Sigma_g(z)$, is different for each order of L , but transport theory codes typically admit only one total cross section to be entered. CLYDE therefore applies (after Sandmeier et al.⁸) the following correction to each order of the transfer matrix:

$$\Sigma_{g \rightarrow g'}^L(z)_{\text{corr}} = \Sigma_{g \rightarrow g'}^L(z) + \left[\Sigma_g(0) - \Sigma_g(z) \right] \delta_{g'g} \quad (66)$$

and uses

$$\phi_g = \phi_g(0).$$

This has the effect of replacing the ϕ^0 -weighted σ_g with the appropriate ϕ^i -weighted term.

The second (and more familiar) transport correction term arises from the truncation of the transport equation to some low order, L . The $L+1$ st term in the transport equation is eliminated by incorporating its "solution" in the transfer terms; i.e.,

$$\frac{\partial}{\partial z} \left[\frac{(L+2) \phi_g^{L+2}(z) + (L+1) \phi_g^L(z)}{2(L+1) + 1} \right] + \sigma_g(L+1) \phi_g^{L+1}(z) = [\sigma'_{tr \text{ corr}_g}(z)] \phi_g^{L+1}(z), \quad (67)$$

where $\sigma'_{tr \text{ corr}_g}(z)$ is the truncated transfer element,

$$\sigma'_{tr \text{ corr}_g}(z) = \frac{\sum_{g'} \sigma_{g' \rightarrow g}^{L+1} (L+1) \phi_{g'}^{L+1}(z)}{\phi_g^{L+1}(z)}.$$

If we define a transport correction term using an assumed flux spectrum,

$$\sigma'_{tr \text{ corr}_g} = \frac{\sum_{g'} \sigma_{g' \rightarrow g}^{L+1} (L+1) \phi_{g'}^{L+1}}{\phi_g^{L+1}},$$

and subtract this term from both sides of the transport equation (i.e., from the total cross section and the diagonal transfer term), formal agreement with the exact equation is retained through order $L+1$. The error arises from the fact that the real $\phi_{g'}^{L+1}(z)$ is spatially dependent, so $\sigma'_{tr \text{ corr}_g}(z) \neq \sigma'_{tr \text{ corr}_g}$, although in practice this turns out to be a very good approximation. The $L+1$ st term of the transport corrected equation tends to be small, and when dropped the truncation error tends toward the order of the $L+2$ nd term of the transport equation.

This transport correction term has been observed to cause numerical difficulties in some LLL codes when it becomes so large as to drive the transport cross section negative ($\sigma_{trg} - \sigma'_{tr \text{ corr}_g}$). Large transport corrections can arise from two conditions: 1) a very rapidly ascending assumed flux weighting

spectrum (which may be inappropriate to the material in question); 2) too low an order of Legendre expansion (in many cases this will be a code limitation) in the case of a highly anisotropic scatterer. A negative diagonal transfer term can arise even in the absence of these conditions, if the group g is sufficiently small that the self-scatter term is less than the in-scatters.

To alleviate this problem, the following modification has been made to CLYDE. Whenever the transport cross section for a given group becomes negative, the approximation

$$\Delta \tau_{\text{tr corr}} = \sum_g \frac{\sigma_g^{L+1}}{\sigma_g \times g'} (L+1) \quad (69)$$

is made for that group only.

This is equivalent to saying that transfers into group g at order $L+1$ are equal to transfers out of g (i.e., absorption and leakage are negligible). This approximate form of the transport correction is the more commonly used version, since it assumes no foreknowledge of the $L+1$ group fluxes. It cannot lead to a negative transport cross section, although it can lead to a negative ingroup scattering term. The approximate or the exact form may be forced, or the transport correction omitted altogether, at the user's option.

ISOTOPE PRODUCTION, CHARGED PARTICLE FORMATION, AND DESTRUCTION CROSS SECTIONS

CLYDE calculates depletion cross sections for neutron-induced reactions as a standard part of its output for each energy group. The procedure is applicable to all isotopes in the evaluated library. Fission is represented by a total fission product production cross section (two isotopes 99120/fission) unless fission product data is explicitly present ($C = 66$). This would be assumed to be complete if present.

The cross section for either isotope production or charged particle formation may be written as

$$\sigma = \sum_c \sigma_c' v_c \quad (70)$$

where c is the pertinent reaction descriptor in the evaluated library and v_c is the multiplicity of the particle emission in reaction c . These are given

in Tables 7 through 9. The destruction cross section for the isotope ZA, $\sigma_{\text{dest}}(\text{ZA})$, is calculated from the relation

$$\sigma_{\text{dest}}(\text{ZA}) = \sum_{\text{Z2}, \text{A2} \neq \text{ZA}} \sigma_{\text{isotope production}}(\text{Z2}, \text{A2}) = \sigma_{15} + (\sigma_{23} + \sigma_{27} + \sigma_{28} + \sigma_{43}). \quad (71)$$

The subscripts are relevant c numbers.

One additional remark pertains to light target nuclei. If, in isotope production, the (Z2, A2) of the residual nucleus is also a charged particle,* the cross section is only output in the charged particle formation table. It is, however, used in the isotope production component of Eq.(71) to calculate the destruction cross section.

Table 7. Reaction designators for isotope production leading to Z2, A2 (neutron-induced reactions, target nucleus being ZA)

Z2	A2	$\sum \sigma_c \sigma_c^a$
Z - 2	A - 4	σ_{26}
	A - 3	$\sigma_{25} + \sigma_{45}$
	A - 2	σ_{44}
Z - 1	A - 3	σ_{24}
	A - 2	$\sigma_{22} + \sigma_{42}$
	A - 1	$\sigma_{20} + \sigma_{21} + \sigma_{41}$
	A	σ_{40}
Z	A - 3	σ_{14}
	A - 2	σ_{13}
	A - 1 ^b	σ_{12}
	A + 1	σ_{46}
99	120 ^c	$2\sigma_{15}$

^aAny pertinent c = 65 data is added in also.

^bFor ${}^6_3\text{Li}$ and ${}^9_4\text{Be}$, there is no such reaction.

^cThe Z2, A2 of fission products is arbitrarily defined as being equal to 99, 120.

*A charged particle is herein defined to mean a particle for which $Z \geq 2$.

Table 8. Reaction designators leading to charged particle formation (neutron-induced reactions). See also Table 9.

Particle	$\sum v_c \sigma_c^a$
proton	$\sigma_{20} + \sigma_{21} + \sigma_{40}$
deuteron	$\sigma_{22} + \sigma_{23} + \sigma_{41}$
triton	$\sigma_{24} + \sigma_{28} + \sigma_{42} + \sigma_{43}$
^3He	$\sigma_{25} + \sigma_{44}$
^4He	$2\sigma_{23} + \sigma_{26} + 3\sigma_{27}$ $+ 2\sigma_{28} + 2\sigma_{43} + \sigma_{45}$

^aIf data are present for $50 \leq c \leq 54$, it is assumed to be complete and is used instead of the corresponding data from this table.

Table 9. Supplemental reaction designators leading to charged particle formation for light isotopes (neutron-induced reactions, target nucleus being ZA).

Z	A	Particle	$\sum v_c \sigma_c^a$
1	1	deuteron	σ_{46}
1	2	proton	σ_{12}
1	2	triton	σ_{46}
1	3	proton	σ_{13}
1	3	deuteron	σ_{12}
2	3	deuteron	$2\sigma_{41}$
2	3	triton	σ_{40}
2	3	^4He	σ_{46}
3	6	proton	σ_{12}
3	6	^4He	$\sigma_{12} + \sigma_{22} + \sigma_{43}$
3	7	^4He	σ_{24}
4	9	^4He	$2\sigma_{12}$

^aThis informatin replaces that of Table 7 for the equivalent case.

LINEAR INTEGRATION ROUTINES

UNINT integrates a piecewise, continuous linear function. The function list is input at all breakpoints of the function and the integration limits in nondecreasing order, and contains the values of the integrand at those points. The operation performed is⁹

$$\int_{x(K_1)}^{x(K_2)} dx F = \sum_{K=K_1}^{K_2-1} \frac{1}{2} [x(K+1) - x(K)] [F(K+1) + F(K)] ,$$

where K_1, K_2 define the limits of integration over the variable x and function F .

DIINT

DIINT integrates the product of two piecewise, continuous linear functions.⁹ The variable of integration is listed at the integration limits and at the breakpoints of both functions; the two function lists contain the values of the functions at these entries of the variable list:

$$\int_{x(K_1)}^{x(K_2)} dx F \cdot G = \frac{1}{6} \sum_{K=K_1}^{K_2-1} [x(K+1) - x(K)] \{ [F(K+1) + F(K)] \cdot [G(K+1) + G(K)] + F(K) \cdot G(K) + F(K+1) \cdot G(K+1) \} ,$$

where F, G are the functions and K_1, K_2 the integration limits.

TRIINT

TRIINT integrates the product of three piecewise continuous linear functions,⁹ of the same form as in DIINT, above. The equation is

$$\int_{x(K_1)}^{x(K_2)} dx F \cdot G \cdot H = \frac{1}{12} \sum_{K=K_1}^{K_2-1} [x(K+1) - x(K)] \{ [2F(K) \cdot G(K) \cdot H(K) + F(K+1) \cdot G(K+1) \cdot H(K+1)] + [F(K) + F(K+1)] [G(K) + G(K+1)] [H(K) + H(K+1)] \} .$$

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Appendix A: Standard Group Boundary and Flux Spectrum Tables

GROUP LIBRARY

The group structure library on the CLYDE tape is presented in the following tables. Shown are the library (calling) number, the lower bound of the lowest group, and then the upper bounds in ascending energy.

GROUP STRUCTURE NO. -- 1
 GROUP STRUCTURE NAME -- ONE GROUP
 NUMBER OF GROUPS -- 1

2.5000E-08 1.4100E+01

GROUP STRUCTURE NO. -- 2
 GROUP STRUCTURE NAME -- TWO GROUP
 NUMBER OF GROUPS -- 2

2.5000E-08 1.4000E+01 1.4100E+01

GROUP STRUCTURE NO. -- 3
 GROUP STRUCTURE NAME -- SORS-66
 NUMBER OF GROUPS -- 66

2.5000E-08	3.3980E-08	6.5350E-08	1.3590E-07	2.6140E-07	4.2870E-07
1.3070E-06	3.3980E-06	6.5350E-06	1.0720E-05	1.5950E-05	2.2220E-05
2.9540E-05	3.7800E-05	4.7320E-05	5.7770E-05	6.9270E-05	8.1820E-05
1.0300E-04	1.2570E-04	1.4250E-04	1.6020E-04	1.8930E-04	2.4290E-04
3.0170E-04	3.5400E-04	4.2580E-04	4.8650E-04	5.3590E-04	5.8690E-04
6.2240E-04	6.7810E-04	7.7610E-04	8.7940E-04	9.9050E-04	1.1830E-03
1.4440E-03	1.7320E-03	2.0460E-03	2.3850E-03	2.7510E-03	3.1430E-03
3.5620E-03	4.0060E-03	5.0000E-03	6.6460E-03	8.8880E-03	1.2680E-02
1.8010E-02	3.3980E-02	6.5350E-02	1.3590E-01	2.6140E-01	4.2870E-01
6.3780E-01	8.8880E-01	1.1820E+00	1.7150E+00	2.5510E+00	3.5550E+00
4.7250E+00	6.0650E+00	7.5700E+00	9.2440E+00	1.1080E+01	1.3090E+01
1.4600E+01					

GROUP STRUCTURE NO. -- 4
 GROUP STRUCTURE NAME -- TART-176 (OLD)
 NUMBER OF GROUPS -- 175

1.3067E-09	5.2267E-09	2.0907E-08	3.2667E-08	4.7041E-08	8.3628E-08
1.3067E-07	1.8816E-07	2.5611E-07	3.3451E-07	4.2336E-07	5.2267E-07
7.5265E-07	1.1760E-06	1.5105E-06	2.0907E-06	2.7649E-06	3.5333E-06
4.7041E-06	5.6919E-06	6.7738E-06	8.3628E-06	9.6642E-06	1.1060E-05
1.3067E-05	1.4682E-05	1.6391E-05	1.7583E-05	1.8816E-05	2.0745E-05
2.2768E-05	2.4168E-05	2.5611E-05	2.7095E-05	2.8622E-05	3.0190E-05
3.1799E-05	3.3451E-05	3.6007E-05	3.8657E-05	4.0476E-05	4.2336E-05
4.4239E-05	4.6183E-05	4.8169E-05	5.0197E-05	5.2267E-05	5.4379E-05
5.6532E-05	5.8727E-05	6.0965E-05	6.3243E-05	6.5564E-05	6.7927E-05
7.0331E-05	7.2777E-05	7.5265E-05	7.7795E-05	8.0366E-05	8.2980E-05
8.5635E-05	8.8332E-05	9.1070E-05	9.3851E-05	9.6674E-05	9.9538E-05
1.0244E-04	1.0989E-04	1.1760E-04	1.2557E-04	1.3380E-04	1.4230E-04
1.5105E-04	1.6007E-04	1.6935E-04	1.7888E-04	1.8868E-04	1.9875E-04
2.0907E-04	2.7649E-04	3.2667E-04	3.8103E-04	4.7041E-04	5.0229E-04
5.6919E-04	6.0421E-04	6.4027E-04	7.1554E-04	8.3628E-04	9.2199E-04
1.0584E-03	1.3067E-03	1.5811E-03	1.8816E-03	2.2083E-03	2.5611E-03
2.9400E-03	3.3451E-03	3.7763E-03	4.2336E-03	5.7625E-03	7.5265E-03
1.0244E-02	1.5105E-02	2.0907E-02	2.6460E-02	3.2667E-02	3.9527E-02
4.7041E-02	5.7959E-02	7.0015E-02	8.3628E-02	9.8903E-02	1.3067E-01
1.8194E-01	2.0745E-01	2.4168E-01	2.7095E-01	2.9400E-01	3.3451E-01
3.7763E-01	4.2336E-01	5.2267E-01	6.3243E-01	7.5265E-01	8.8332E-01
1.0244E+00	1.1760E+00	1.3380E+00	1.5105E+00	1.6935E+00	1.8868E+00
2.0907E+00	2.3050E+00	2.5297E+00	2.7649E+00	3.0106E+00	3.2667E+00
3.5333E+00	3.8103E+00	4.0978E+00	4.3957E+00	4.7041E+00	5.0229E+00
5.3522E+00	5.6919E+00	6.0421E+00	6.4027E+00	6.7738E+00	7.1554E+00
7.9474E+00	7.9499E+00	8.3628E+00	8.7861E+00	9.2199E+00	9.6642E+00
1.0119E+01	1.0584E+01	1.1060E+01	1.1546E+01	1.2042E+01	1.2549E+01
1.3067E+01	1.3595E+01	1.3863E+01	1.4133E+01	1.4406E+01	1.4682E+01
1.5241E+01	1.5811E+01	1.6391E+01	1.6982E+01	1.7583E+01	1.8194E+01
1.8816E+01	2.0000E+01				

GROUP STRUCTURE NO. -- 5
 GROUP STRUCTURE NAME -- HANSEN-ROACH - 16
 NUMBER OF GROUPS -- 16

2.5000E-08	1.0000E-07	4.0000E-07	1.0000E-06	3.0000E-06	1.0000E-05
3.0000E-05	1.0000E-04	5.5000E-04	3.0000E-03	1.7000E-02	1.0000E-01
4.0000E-01	9.0000E-01	1.4000E+00	3.0000E+00	1.4100E+01	

GROUP STRUCTURE NO. -- G

GROUP STRUCTURE NAME -- TART-176 04/17/73

NUMBER OF GROUPS -- 175

1.3068E-09	5.2271E-09	2.0918E-08	3.2669E-09	4.7044E-08	8.3215E-08
1.3063E-07	1.8817E-07	2.5613E-07	3.3453E-07	4.2339E-07	5.1230E-07
7.5270E-07	1.1761E-06	1.5106E-06	2.0908E-06	2.7411E-06	3.5335E-06
4.7044E-06	5.6578E-06	5.7367E-06	8.3215E-06	9.6199E-06	1.1012E-05
1.3068E-05	1.4683E-05	1.5812E-05	1.7584E-05	1.8817E-05	2.0746E-05
2.2769E-05	2.4170E-05	2.5613E-05	2.7097E-05	2.8623E-05	2.9402E-05
3.0991E-05	3.3453E-05	3.6009E-05	3.8659E-05	4.0478E-05	4.2339E-05
4.3285E-05	4.6186E-05	4.7174E-05	4.9181E-05	5.1230E-05	5.3321E-05
5.6536E-05	5.7628E-05	6.0968E-05	6.3247E-05	6.5568E-05	6.6744E-05
7.0335E-05	7.1553E-05	7.5270E-05	7.7800E-05	7.9080E-05	8.1673E-05
8.4307E-05	8.8337E-05	9.1076E-05	9.3857E-05	9.6680E-05	9.8107E-05
1.0245E-04	1.0990E-04	1.1761E-04	1.2558E-04	1.3381E-04	1.4059E-04
1.5106E-04	1.6008E-04	1.6936E-04	1.7890E-04	1.8870E-04	1.9876E-04
2.0908E-04	2.7411E-04	3.2669E-04	3.8105E-04	4.7044E-04	4.9908E-04
5.6578E-04	6.0425E-04	6.3666E-04	7.1558E-04	8.3215E-04	9.1767E-04
1.0585E-03	1.3068E-03	1.5812E-03	1.8817E-03	2.2084E-03	2.5613E-03
2.9402E-03	3.3453E-03	3.7765E-03	4.2339E-03	5.7628E-03	7.5270E-03
1.0245E-02	1.5106E-02	2.0908E-02	2.6462E-02	3.2669E-02	3.9530E-02
4.7044E-02	5.7615E-02	7.0020E-02	8.3215E-02	9.8909E-02	1.3068E-01
1.8195E-01	2.0746E-01	2.4170E-01	2.7097E-01	2.9402E-01	3.3453E-01
3.7765E-01	4.2339E-01	5.1230E-01	6.3247E-01	7.5270E-01	8.8337E-01
1.0245E+00	1.1761E+00	1.3381E+00	1.5106E+00	1.6936E+00	1.8870E+00
2.0908E+00	2.3051E+00	2.5299E+00	2.7411E+00	3.0108E+00	3.2669E+00
3.5335E+00	3.8105E+00	4.0688E+00	4.3960E+00	4.7044E+00	4.9908E+00
5.3525E+00	5.6578E+00	6.0425E+00	6.3666E+00	6.7367E+00	7.1558E+00
7.5179E+00	7.9096E+00	8.3215E+00	8.7867E+00	9.1767E+00	9.6648E+00
1.0120E+01	1.0585E+01	1.1012E+01	1.1547E+01	1.1993E+01	1.2499E+01
1.3068E+01	1.3542E+01	1.3863E+01	1.4134E+01	1.4407E+01	1.4683E+01
1.5186E+01	1.5754E+01	1.6334E+01	1.6923E+01	1.7523E+01	1.8134E+01
1.8755E+01	2.0000E+01				

GROUP STRUCTURE NO. -- 7

GROUP STRUCTURE NAME -- TART-2021 FOR B DIVISION 04/17/73

NUMBER OF GROUPS -- 2020

1.3068E-09	5.2271E-09	2.0908E-08	3.2669E-08	4.7044E-08	8.3633E-08
1.3068E-07	1.8817E-07	2.5613E-07	3.3453E-07	4.2339E-07	5.2271E-07
7.5270E-07	9.8988E-07	1.0899E-06	1.1887E-06	1.2884E-06	1.3888E-06
1.4894E-06	1.5899E-06	1.6888E-06	1.7890E-06	1.8890E-06	1.9896E-06
2.0887E-06	2.1881E-06	2.2888E-06	2.3893E-06	2.4887E-06	2.5877E-06
2.6887E-06	2.7892E-06	2.8891E-06	2.9882E-06	3.0891E-06	3.1890E-06
3.2879E-06	3.3882E-06	3.4874E-06	3.5291E-06	3.6873E-06	3.7880E-06
3.8900E-06	3.9875E-06	4.0892E-06	4.1893E-06	4.2875E-06	4.3899E-06
4.4874E-06	4.5890E-06	4.6887E-06	4.7894E-06	4.8880E-06	4.9876E-06
5.0882E-06	5.1888E-06	5.2891E-06	5.3894E-06	5.4872E-06	5.5892E-06
5.6888E-06	5.7893E-06	5.8871E-06	5.9893E-06	6.0888E-06	6.1891E-06
6.2866E-06	6.3885E-06	6.4876E-06	6.5874E-06	6.6880E-06	6.7893E-06
6.8876E-06	6.9867E-06	7.0864E-06	7.1868E-06	7.2880E-06	7.3898E-06
7.4884E-06	7.5876E-06	7.6876E-06	7.7881E-06	7.8893E-06	7.9871E-06
8.0896E-06	8.1886E-06	8.2882E-06	8.3884E-06	8.4892E-06	8.5864E-06
8.6884E-06	8.7867E-06	8.8899E-06	8.9893E-06	9.0893E-06	9.1898E-06
9.2885E-06	9.3881E-06	9.4859E-06	9.5886E-06	9.6873E-06	9.7866E-06
9.8864E-06	9.9866E-06	1.0087E-05	1.0189E-05	1.0286E-05	1.0388E-05
1.0486E-05	1.0589E-05	1.0689E-05	1.0788E-05	1.0888E-05	1.0988E-05
1.1089E-05	1.1186E-05	1.1288E-05	1.1390E-05	1.1488E-05	1.1586E-05
1.1689E-05	1.1788E-05	1.1888E-05	1.1988E-05	1.2088E-05	1.2189E-05
1.2285E-05	1.2387E-05	1.2489E-05	1.2586E-05	1.2689E-05	1.2787E-05
1.2885E-05	1.3000E-05	1.3068E-05	1.3172E-05	1.3278E-05	1.3330E-05
1.3436E-05	1.3547E-05	1.3649E-05	1.3756E-05	1.3863E-05	1.3971E-05
1.4080E-05	1.4134E-05	1.4243E-05	1.4352E-05	1.4462E-05	1.4572E-05
1.4627E-05	1.4738E-05	1.4849E-05	1.4961E-05	1.5073E-05	1.5129E-05
1.5242E-05	1.5355E-05	1.5469E-05	1.5526E-05	1.5640E-05	1.5754E-05
1.5869E-05	1.5927E-05	1.6043E-05	1.6159E-05	1.6275E-05	1.6334E-05
1.6451E-05	1.6568E-05	1.6627E-05	1.6743E-05	1.6864E-05	1.6923E-05
1.7042E-05	1.7162E-05	1.7222E-05	1.7342E-05	1.7463E-05	1.7523E-05
1.7645E-05	1.7766E-05	1.7827E-05	1.7950E-05	1.8072E-05	1.8134E-05
1.8257E-05	1.8319E-05	1.8443E-05	1.8567E-05	1.8630E-05	1.8755E-05
1.8817E-05	1.8943E-05	1.9069E-05	1.9132E-05	1.9259E-05	1.9323E-05
1.9450E-05	1.9578E-05	1.9642E-05	1.9770E-05	1.9834E-05	1.9963E-05
2.0028E-05	2.0158E-05	2.0223E-05	2.0353E-05	2.0418E-05	2.0549E-05
2.0615E-05	2.0746E-05	2.0878E-05	2.0944E-05	2.1077E-05	2.1143E-05
2.1276E-05	2.1343E-05	2.1477E-05	2.1544E-05	2.1678E-05	2.1746E-05
2.1813E-05	2.1949E-05	2.2016E-05	2.2152E-05	2.2220E-05	2.2357E-05
2.2425E-05	2.2563E-05	2.2631E-05	2.2769E-05	2.2838E-05	2.2977E-05
2.3046E-05	2.3115E-05	2.3255E-05	2.3324E-05	2.3464E-05	2.3534E-05
2.3675E-05	2.3745E-05	2.3816E-05	2.3957E-05	2.4028E-05	2.4170E-05
2.4241E-05	2.4312E-05	2.4455E-05	2.4527E-05	2.4670E-05	2.4742E-05
2.4814E-05	2.4958E-05	2.5030E-05	2.5175E-05	2.5248E-05	2.5321E-05
2.5466E-05	2.5539E-05	2.5613E-05	2.5759E-05	2.5833E-05	2.5980E-05
2.6054E-05	2.6127E-05	2.6275E-05	2.6350E-05	2.6424E-05	2.6573E-05
2.6447E-05	2.6722E-05	2.6872E-05	2.6947E-05	2.7022E-05	2.7172E-05
2.7248E-05	2.7323E-05	2.7475E-05	2.7551E-05	2.7627E-05	2.7779E-05
2.7855E-05	2.7931E-05	2.8008E-05	2.8161E-05	2.8258E-05	2.8315E-05

2.8469E-05	2.8546E-05	2.8623E-05	2.8778E-05	2.8856E-05	2.8934E-05
2.9011E-05	2.9167E-05	2.9246E-05	2.9324E-05	2.9402E-05	2.9559E-05
2.9638E-05	2.9717E-05	2.9875E-05	2.9954E-05	3.0033E-05	3.0112E-05
3.0271E-05	3.0351E-05	3.0430E-05	3.0510E-05	3.0670E-05	3.0750E-05
3.0830E-05	3.0911E-05	3.1072E-05	3.1152E-05	3.1233E-05	3.1314E-05
3.1476E-05	3.1557E-05	3.1639E-05	3.1720E-05	3.1801E-05	3.1965E-05
3.2047E-05	3.2128E-05	3.2210E-05	3.2375E-05	3.2457E-05	3.2504E-05
3.2622E-05	3.2705E-05	3.2970E-05	3.2953E-05	3.3036E-05	3.3119E-05
3.3203E-05	3.3370E-05	3.3453E-05	3.3537E-05	3.3621E-05	3.3705E-05
3.3873E-05	3.3957E-05	3.4041E-05	3.4126E-05	3.4210E-05	3.4379E-05
3.4464E-05	3.4549E-05	3.4634E-05	3.4719E-05	3.4805E-05	3.4975E-05
3.5081E-05	3.5147E-05	3.5233E-05	3.5318E-05	3.5404E-05	3.5577E-05
3.5663E-05	3.5749E-05	3.5836E-05	3.5922E-05	3.6009E-05	3.6096E-05
3.6270E-05	3.6357E-05	3.6444E-05	3.6532E-05	3.6619E-05	3.6707E-05
3.6794E-05	3.6970E-05	3.7058E-05	3.7146E-05	3.7234E-05	3.7322E-05
3.7411E-05	3.7499E-05	3.7677E-05	3.7765E-05	3.7854E-05	3.7934E-05
3.8033E-05	3.8122E-05	3.8211E-05	3.8301E-05	3.8400E-05	3.8569E-05
3.8659E-05	3.8749E-05	3.8839E-05	3.8930E-05	3.9020E-05	3.9110E-05
3.9201E-05	3.9291E-05	3.9473E-05	3.9564E-05	3.9655E-05	3.9746E-05
3.9837E-05	3.9928E-05	4.0020E-05	4.0111E-05	4.0203E-05	4.0295E-05
4.0478E-05	4.0570E-05	4.0663E-05	4.0755E-05	4.0847E-05	4.0940E-05
4.1032E-05	4.1125E-05	4.1218E-05	4.1311E-05	4.1404E-05	4.1497E-05
4.1590E-05	4.1777E-05	4.1870E-05	4.1964E-05	4.2057E-05	4.2151E-05
4.2245E-05	4.2339E-05	4.2433E-05	4.2528E-05	4.2622E-05	4.2716E-05
4.2811E-05	4.2906E-05	4.3000E-05	4.3095E-05	4.3190E-05	4.3285E-05
4.3476E-05	4.3571E-05	4.3667E-05	4.3762E-05	4.3858E-05	4.3954E-05
4.4050E-05	4.4146E-05	4.4242E-05	4.4338E-05	4.4434E-05	4.4531E-05
4.4627E-05	4.4724E-05	4.4821E-05	4.4918E-05	4.5015E-05	4.5112E-05
4.5209E-05	4.5306E-05	4.5403E-05	4.5501E-05	4.5599E-05	4.5696E-05
4.5794E-05	4.5892E-05	4.5990E-05	4.6088E-05	4.6186E-05	4.6285E-05
4.6383E-05	4.6482E-05	4.6579E-05	4.6677E-05	4.6775E-05	4.6876E-05
4.7075E-05	4.7174E-05	4.7274E-05	4.7373E-05	4.7473E-05	4.7572E-05
4.7672E-05	4.7772E-05	4.7872E-05	4.7972E-05	4.8072E-05	4.8173E-05
4.8273E-05	4.8373E-05	4.8474E-05	4.8575E-05	4.8676E-05	4.8777E-05
4.8878E-05	4.8979E-05	4.9080E-05	4.9181E-05	4.9283E-05	4.9384E-05
4.9486E-05	4.9588E-05	4.9690E-05	4.9792E-05	4.9894E-05	4.9996E-05
5.0098E-05	5.0201E-05	5.0406E-05	5.0508E-05	5.0611E-05	5.0714E-05
5.0817E-05	5.0920E-05	5.1024E-05	5.1127E-05	5.1230E-05	5.1334E-05
5.1438E-05	5.1541E-05	5.1645E-05	5.1749E-05	5.1853E-05	5.1957E-05
5.2166E-05	5.2271E-05	5.2375E-05	5.2480E-05	5.2585E-05	5.2690E-05
5.2795E-05	5.2900E-05	5.3005E-05	5.3110E-05	5.3216E-05	5.3321E-05
5.3427E-05	5.3533E-05	5.3638E-05	5.3744E-05	5.3850E-05	5.3957E-05
5.4063E-05	5.4169E-05	5.4276E-05	5.4382E-05	5.4489E-05	5.4596E-05
5.4810E-05	5.4917E-05	5.5024E-05	5.5131E-05	5.5239E-05	5.5346E-05
5.5454E-05	5.5562E-05	5.5669E-05	5.5777E-05	5.5885E-05	5.5994E-05
5.6102E-05	5.6210E-05	5.6319E-05	5.6427E-05	5.6536E-05	5.6645E-05
5.6754E-05	5.6862E-05	5.6972E-05	5.7081E-05	5.7190E-05	5.7299E-05
5.7409E-05	5.7519E-05	5.7628E-05	5.7738E-05	5.7848E-05	5.7958E-05
5.8068E-05	5.8178E-05	5.8289E-05	5.8399E-05	5.8510E-05	5.8620E-05
5.8731E-05	5.8842E-05	5.8953E-05	5.9064E-05	5.9175E-05	5.9287E-05
5.9398E-05	5.9509E-05	5.9621E-05	5.9732E-05	5.9845E-05	5.9956E-05
6.0069E-05	6.0181E-05	6.0293E-05	6.0405E-05	6.0518E-05	6.0630E-05
6.0743E-05	6.0856E-05	6.0968E-05	6.1081E-05	6.1194E-05	6.1308E-05
6.1421E-05	6.1534E-05	6.1648E-05	6.1762E-05	6.1889E-05	6.2103E-05
6.2217E-05	6.2331E-05	6.2445E-05	6.2559E-05	6.2788E-05	6.2903E-05
6.3010E-05	6.3132E-05	6.3247E-05	6.3362E-05	6.3478E-05	6.3593E-05
6.3824E-05	6.3939E-05	6.4055E-05	6.4171E-05	6.4287E-05	6.4403E-05
6.4519E-05	6.4635E-05	6.4868E-05	6.4984E-05	6.5101E-05	6.5217E-05
6.5334E-05	6.5451E-05	6.5668E-05	6.5685E-05	6.5803E-05	6.6037E-05
6.6155E-05	6.6273E-05	6.6390E-05	6.6508E-05	6.6626E-05	6.6744E-05
6.6862E-05	6.6981E-05	6.7099E-05	6.7336E-05	6.7455E-05	6.7574E-05
6.7693E-05	6.7812E-05	6.7931E-05	6.8050E-05	6.8169E-05	6.8289E-05
6.8408E-05	6.8528E-05	6.9768E-05	6.8888E-05	6.9008E-05	6.9128E-05
6.9248E-05	6.9368E-05	6.9489E-05	6.9610E-05	6.9730E-05	6.9851E-05

6.9972E-05	7.0093E-05	7.0214E-05	7.0457E-05	7.0578E-05	7.0700E-05
7.0821E-05	7.0943E-05	7.1065E-05	7.1187E-05	7.1309E-05	7.1431E-05
7.1553E-05	7.1676E-05	7.1798E-05	7.1921E-05	7.2043E-05	7.2166E-05
7.2289E-05	7.2535E-05	7.2658E-05	7.2782E-05	7.2905E-05	7.3028E-05
7.3152E-05	7.3276E-05	7.3400E-05	7.3524E-05	7.3648E-05	7.3772E-05
7.3896E-05	7.4020E-05	7.4145E-05	7.4269E-05	7.4394E-05	7.4519E-05
7.4644E-05	7.4769E-05	7.5019E-05	7.5144E-05	7.5270E-05	7.5395E-05
7.5646E-05	7.5772E-05	7.5898E-05	7.6150E-05	7.6277E-05	7.6403E-05
7.6529E-05	7.6783E-05	7.6909E-05	7.7036E-05	7.7163E-05	7.7417E-05
7.7545E-05	7.7672E-05	7.7800E-05	7.8055E-05	7.8183E-05	7.8311E-05
7.8439E-05	7.8695E-05	7.8823E-05	7.8952E-05	7.9080E-05	7.9338E-05
7.9466E-05	7.9595E-05	7.9724E-05	7.9983E-05	8.0112E-05	8.0242E-05
8.0371E-05	8.0631E-05	8.0761E-05	8.0891E-05	8.1021E-05	8.1151E-05
8.1412E-05	8.1542E-05	8.1673E-05	8.1803E-05	8.2065E-05	8.2196E-05
8.2327E-05	8.2459E-05	8.2590E-05	8.2853E-05	8.2985E-05	8.3117E-05
8.3248E-05	8.3512E-05	8.3645E-05	8.3777E-05	8.3909E-05	8.4042E-05
8.4307E-05	8.4440E-05	8.4573E-05	8.4706E-05	8.4839E-05	8.5106E-05
8.5239E-05	8.5373E-05	8.5506E-05	8.5640E-05	8.5908E-05	8.6042E-05
8.6176E-05	8.6310E-05	8.6445E-05	8.6714E-05	8.6849E-05	8.6983E-05
8.7118E-05	8.7253E-05	8.7389E-05	8.7659E-05	8.7794E-05	8.7930E-05
8.8066E-05	8.8201E-05	8.8473E-05	8.8609E-05	8.8745E-05	8.8882E-05
8.9018E-05	8.9155E-05	8.9428E-05	8.9565E-05	9.9702E-05	8.9839E-05
8.9976E-05	9.0113E-05	9.0388E-05	9.0525E-05	9.0663E-05	9.0900E-05
9.0938E-05	9.1076E-05	9.1352E-05	9.1491E-05	9.1629E-05	9.1768E-05
9.1906E-05	9.2045E-05	9.2184E-05	9.2461E-05	9.2501E-05	9.2740E-05
9.2879E-05	9.3018E-05	9.3158E-05	9.3437E-05	9.3577E-05	9.3717E-05
9.3847E-05	9.3997E-05	9.4137E-05	9.4278E-05	9.4559E-05	9.4699E-05
9.4800E-05	9.4981E-05	9.5122E-05	9.5263E-05	9.5404E-05	9.5546E-05
9.5829E-05	9.5970E-05	9.6112E-05	9.6254E-05	9.6396E-05	9.6538E-05
9.6680E-05	9.6822E-05	9.7107E-05	9.7249E-05	9.7392E-05	9.7535E-05
9.7677E-05	9.7820E-05	9.7963E-05	9.8107E-05	9.8393E-05	9.8537E-05
9.8680E-05	9.8824E-05	9.8968E-05	9.9112E-05	9.9256E-05	9.9400E-05
9.9544E-05	9.9833E-05	9.9977E-05	1.0012E-04	1.0041E-04	1.0056E-04
1.0070E-04	1.0099E-04	1.0114E-04	1.0143E-04	1.0157E-04	1.0172E-04
1.0201E-04	1.0216E-04	1.0230E-04	1.0260E-04	1.0274E-04	1.0304E-04
1.0318E-04	1.0333E-04	1.0362E-04	1.0377E-04	1.0392E-04	1.0421E-04
1.0436E-04	1.0451E-04	1.0481E-04	1.0495E-04	1.0510E-04	1.0540E-04
1.0555E-04	1.0570E-04	1.0599E-04	1.0614E-04	1.0629E-04	1.0659E-04
1.0674E-04	1.0704E-04	1.0719E-04	1.0734E-04	1.0764E-04	1.0779E-04
1.0794E-04	1.0824E-04	1.0839E-04	1.0854E-04	1.0869E-04	1.0899E-04
1.0914E-04	1.0929E-04	1.0960E-04	1.0975E-04	1.0990E-04	1.1020E-04
1.1035E-04	1.1051E-04	1.1081E-04	1.1096E-04	1.1111E-04	1.1142E-04
1.1157E-04	1.1173E-04	1.1203E-04	1.1218E-04	1.1234E-04	1.1249E-04
1.1280E-04	1.1295E-04	1.1311E-04	1.1341E-04	1.1357E-04	1.1372E-04
1.1403E-04	1.1418E-04	1.1434E-04	1.1449E-04	1.1480E-04	1.1496E-04
1.1511E-04	1.1542E-04	1.1558E-04	1.1573E-04	1.1589E-04	1.1620E-04
1.1636E-04	1.1651E-04	1.1683E-04	1.1698E-04	1.1714E-04	1.1730E-04
1.1761E-04	1.1777E-04	1.1792E-04	1.1824E-04	1.1839E-04	1.1855E-04
1.1871E-04	1.1902E-04	1.1918E-04	1.1934E-04	1.1950E-04	1.1981E-04
1.1997E-04	1.2013E-04	1.2029E-04	1.2061E-04	1.2077E-04	1.2092E-04
1.2108E-04	1.2140E-04	1.2156E-04	1.2172E-04	1.2188E-04	1.2220E-04
1.2236E-04	1.2252E-04	1.2268E-04	1.2300E-04	1.2316E-04	1.2332E-04
1.2348E-04	1.2380E-04	1.2396E-04	1.2413E-04	1.2429E-04	1.2461E-04
1.2477E-04	1.2493E-04	1.2509E-04	1.2542E-04	1.2558E-04	1.2574E-04
1.2590E-04	1.2623E-04	1.2639E-04	1.2655E-04	1.2672E-04	1.2688E-04
1.2721E-04	1.2737E-04	1.2753E-04	1.2770E-04	1.2802E-04	1.2819E-04
1.2835E-04	1.2851E-04	1.2868E-04	1.2901E-04	1.2917E-04	1.2933E-04
1.2950E-04	1.2983E-04	1.2999E-04	1.3016E-04	1.3032E-04	1.3049E-04
1.3082E-04	1.3098E-04	1.3115E-04	1.3132E-04	1.3148E-04	1.3181E-04
1.3198E-04	1.3215E-04	1.3231E-04	1.3248E-04	1.3281E-04	1.3298E-04
1.3314E-04	1.3331E-04	1.3348E-04	1.3381E-04	1.3398E-04	1.3415E-04
1.3431E-04	1.3448E-04	1.3482E-04	1.3499E-04	1.3515E-04	1.3532E-04
1.3549E-04	1.3583E-04	1.3600E-04	1.3616E-04	1.3633E-04	1.3650E-04
1.3667E-04	1.3701E-04	1.3718E-04	1.3735E-04	1.3752E-04	1.3769E-04

1.3803E-04	1.3820E-04	1.3837E-04	1.3854E-04	1.3871E-04	1.3888E-04
1.3922E-04	1.3939E-04	1.3956E-04	1.3973E-04	1.3990E-04	1.4007E-04
1.4042E-04	1.4059E-04	1.4076E-04	1.4093E-04	1.4110E-04	1.4127E-04
1.4162E-04	1.4179E-04	1.4196E-04	1.4213E-04	1.4231E-04	1.4248E-04
1.4282E-04	1.4300E-04	1.4317E-04	1.4334E-04	1.4352E-04	1.4369E-04
1.4404E-04	1.4421E-04	1.4438E-04	1.4456E-04	1.4473E-04	1.4491E-04
1.4508E-04	1.4525E-04	1.4560E-04	1.4578E-04	1.4595E-04	1.4613E-04
1.4630E-04	1.4648E-04	1.4683E-04	1.4700E-04	1.4718E-04	1.4735E-04
1.4753E-04	1.4770E-04	1.4788E-04	1.4823E-04	1.4841E-04	1.4858E-04
1.4876E-04	1.4894E-04	1.4911E-04	1.4929E-04	1.4947E-04	1.4982E-04
1.5000E-04	1.5017E-04	1.5035E-04	1.5053E-04	1.5071E-04	1.5089E-04
1.5124E-04	1.5142E-04	1.5160E-04	1.5177E-04	1.5195E-04	1.5213E-04
1.5231E-04	1.5249E-04	1.5267E-04	1.5302E-04	1.5320E-04	1.5338E-04
1.5356E-04	1.5374E-04	1.5392E-04	1.5410E-04	1.5428E-04	1.5464E-04
1.5482E-04	1.5500E-04	1.5518E-04	1.5536E-04	1.5554E-04	1.5572E-04
1.5590E-04	1.5608E-04	1.5626E-04	1.5662E-04	1.5680E-04	1.5698E-04
1.5716E-04	1.5735E-04	1.5753E-04	1.5771E-04	1.5789E-04	1.5807E-04
1.5844E-04	1.5862E-04	1.5880E-04	1.5898E-04	1.5917E-04	1.5935E-04
1.5953E-04	1.6008E-04	1.6063E-04	1.6099E-04	1.6155E-04	1.6210E-04
1.6247E-04	1.6302E-04	1.6357E-04	1.6413E-04	1.6450E-04	1.6506E-04
1.6561E-04	1.6599E-04	1.6655E-04	1.6711E-04	1.6748E-04	1.6804E-04
1.6860E-04	1.6898E-04	1.6954E-04	1.7011E-04	1.7049E-04	1.7105E-04
1.7162E-04	1.7200E-04	1.7257E-04	1.7295E-04	1.7352E-04	1.7409E-04
1.7448E-04	1.7505E-04	1.7562E-04	1.7601E-04	1.7658E-04	1.7697E-04
1.7754E-04	1.7812E-04	1.7851E-04	1.7909E-04	1.7948E-04	1.8006E-04
1.8045E-04	1.8103E-04	1.8161E-04	1.8200E-04	1.8259E-04	1.8298E-04
1.8357E-04	1.8396E-04	1.8455E-04	1.8514E-04	1.8553E-04	1.8612E-04
1.8652E-04	1.8711E-04	1.8751E-04	1.8810E-04	1.8850E-04	1.8909E-04
1.8949E-04	1.9009E-04	1.9049E-04	1.9109E-04	1.9149E-04	1.9209E-04
1.9249E-04	1.9309E-04	1.9349E-04	1.9410E-04	1.9450E-04	1.9511E-04
1.9551E-04	1.9612E-04	1.9652E-04	1.9713E-04	1.9754E-04	1.9794E-04
1.9855E-04	1.9896E-04	1.9958E-04	1.9998E-04	2.0060E-04	2.0101E-04
2.0162E-04	2.0203E-04	2.0245E-04	2.0306E-04	2.0348E-04	2.0399E-04
2.0451E-04	2.0513E-04	2.0554E-04	2.0596E-04	2.0658E-04	2.0700E-04
2.0762E-04	2.0804E-04	2.0846E-04	2.0908E-04	2.0950E-04	2.1013E-04
2.1055E-04	2.1097E-04	2.1160E-04	2.1202E-04	2.1244E-04	2.1307E-04
2.1350E-04	2.1413E-04	2.1455E-04	2.1498E-04	2.1561E-04	2.1604E-04
2.1646E-04	2.1710E-04	2.1753E-04	2.1796E-04	2.1860E-04	2.1902E-04
2.1945E-04	2.2010E-04	2.2053E-04	2.2095E-04	2.2160E-04	2.2203E-04
2.2246E-04	2.2311E-04	2.2354E-04	2.2397E-04	2.2462E-04	2.2506E-04
2.2549E-04	2.2593E-04	2.2658E-04	2.2701E-04	2.2745E-04	2.2810E-04
2.2854E-04	2.2898E-04	2.2964E-04	2.3007E-04	2.3051E-04	2.3095E-04
2.3161E-04	2.3205E-04	2.3249E-04	2.3293E-04	2.3360E-04	2.3404E-04
2.3448E-04	2.3492E-04	2.3559E-04	2.3603E-04	2.3648E-04	2.3692E-04
2.3759E-04	2.3804E-04	2.3848E-04	2.3893E-04	2.3960E-04	2.4005E-04
2.4050E-04	2.4095E-04	2.4162E-04	2.4207E-04	2.4252E-04	2.4297E-04
2.4342E-04	2.4410E-04	2.4455E-04	2.4500E-04	2.4546E-04	2.4614E-04
2.4659E-04	2.4705E-04	2.4750E-04	2.4796E-04	2.4864E-04	2.4909E-04
2.4955E-04	2.5001E-04	2.5047E-04	2.5092E-04	2.5161E-04	2.5207E-04
2.5253E-04	2.5299E-04	2.5345E-04	2.5391E-04	2.5460E-04	2.5506E-04
2.5533E-04	2.5599E-04	2.5645E-04	2.5691E-04	2.5761E-04	2.5807E-04
2.5854E-04	2.5900E-04	2.5947E-04	2.5994E-04	2.6064E-04	2.6110E-04
2.6157E-04	2.6204E-04	2.6251E-04	2.6298E-04	2.6344E-04	2.6391E-04
2.6462E-04	2.6509E-04	2.6556E-04	2.6603E-04	2.6650E-04	2.6698E-04
2.6745E-04	2.6792E-04	2.6863E-04	2.6911E-04	2.6958E-04	2.7006E-04
2.7053E-04	2.7101E-04	2.7149E-04	2.7196E-04	2.7244E-04	2.7292E-04
2.7363E-04	2.7411E-04	2.7459E-04	2.7507E-04	2.7555E-04	2.7603E-04
2.7651E-04	2.7699E-04	2.7747E-04	2.7796E-04	2.7844E-04	2.7892E-04
2.7940E-04	2.8013E-04	2.8061E-04	2.8110E-04	2.8158E-04	2.8207E-04
2.8256E-04	2.8304E-04	2.8353E-04	2.8402E-04	2.8450E-04	2.8499E-04
2.8548E-04	2.8597E-04	2.8646E-04	2.8695E-04	2.8744E-04	2.8793E-04
2.8842E-04	2.8891E-04	2.8940E-04	2.8989E-04	2.9038E-04	2.9113E-04
2.9162E-04	2.9211E-04	2.9261E-04	2.9310E-04	2.9360E-04	2.9409E-04
2.9459E-04	2.9509E-04	2.9558E-04	2.9608E-04	2.9658E-04	2.9708E-04

2.9758E-04	2.9808E-04	2.9857E-04	2.9907E-04	3.0008E-04	3.0108E-04
3.0208E-04	3.0309E-04	3.0410E-04	3.0511E-04	3.0612E-04	3.0713E-04
3.0769E-04	3.0891E-04	3.0992E-04	3.1094E-04	3.1196E-04	3.1299E-04
3.1401E-04	3.1504E-04	3.1606E-04	3.1709E-04	3.1812E-04	3.1890E-04
3.1993E-04	3.2097E-04	3.2201E-04	3.2304E-04	3.2408E-04	3.2512E-04
3.2591E-04	3.2695E-04	3.2800E-04	3.2905E-04	3.3010E-04	3.3089E-04
3.3194E-04	3.3299E-04	3.3405E-04	3.3511E-04	3.3590E-04	3.3696E-04
3.3803E-04	3.3909E-04	3.3999E-04	3.4096E-04	3.4203E-04	3.4310E-04
3.4390E-04	3.4497E-04	3.4605E-04	3.4713E-04	3.4793E-04	3.4901E-04
3.5009E-04	3.5091E-04	3.5199E-04	3.5308E-04	3.5389E-04	3.5496E-04
3.5607E-04	3.5689E-04	3.5798E-04	3.5908E-04	3.5990E-04	3.6100E-04
3.6210E-04	3.6293E-04	3.6403E-04	3.6513E-04	3.6596E-04	3.6707E-04
3.6790E-04	3.6901E-04	3.7012E-04	3.7096E-04	3.7207E-04	3.7291E-04
3.7403E-04	3.7487E-04	3.7599E-04	3.7711E-04	3.7795E-04	3.7908E-04
3.7992E-04	3.8105E-04	3.8197E-04	3.8303E-04	3.8388E-04	3.8501E-04
3.8587E-04	3.8700E-04	3.8786E-04	3.8900E-04	3.9014E-04	3.9100E-04
3.9186E-04	3.9300E-04	3.9386E-04	3.9501E-04	3.9587E-04	3.9702E-04
3.9789E-04	3.9904E-04	3.9991E-04	4.0107E-04	4.0194E-04	4.0310E-04
4.0397E-04	4.0513E-04	4.0600E-04	4.0688E-04	4.0805E-04	4.0892E-04
4.1009E-04	4.1097E-04	4.1185E-04	4.1303E-04	4.1391E-04	4.1509E-04
4.1597E-04	4.1686E-04	4.1804E-04	4.1893E-04	4.2011E-04	4.2100E-04
4.2189E-04	4.2308E-04	4.2397E-04	4.2487E-04	4.2606E-04	4.2695E-04
4.2785E-04	4.2905E-04	4.2995E-04	4.3085E-04	4.3205E-04	4.3295E-04
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4.3990E-04	4.4111E-04	4.4202E-04	4.4294E-04	4.4385E-04	4.4507E-04
4.4599E-04	4.4690E-04	4.4813E-04	4.4904E-04	4.4996E-04	4.5088E-04
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4.7012E-04	4.7106E-04	4.7200E-04	4.7295E-04	4.7389E-04	4.7484E-04
4.7610E-04	4.7704E-04	4.7799E-04	4.7894E-04	4.7989E-04	4.8084E-04
4.8211E-04	4.8306E-04	4.8402E-04	4.8497E-04	4.8593E-04	4.8688E-04
4.8784E-04	4.8891E-04	4.9008E-04	4.9104E-04	4.9200E-04	4.9307E-04
4.9393E-04	4.9483E-04	4.9586E-04	4.9683E-04	4.9812E-04	4.9908E-04
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5.0589E-04	5.0687E-04	5.0784E-04	5.0882E-04	5.1013E-04	5.1111E-04
5.1209E-04	5.1307E-04	5.1405E-04	5.1504E-04	5.1602E-04	5.1701E-04
5.1800E-04	5.1898E-04	5.1997E-04	5.2096E-04	5.2195E-04	5.2294E-04
5.2394E-04	5.2493E-04	5.2592E-04	5.2692E-04	5.2792E-04	5.2891E-04
5.2991E-04	5.3091E-04	5.3191E-04	5.3291E-04	5.3391E-04	5.3492E-04
5.3592E-04	5.3692E-04	5.3793E-04	5.3894E-04	5.3994E-04	5.4095E-04
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5.5381E-04	5.5483E-04	5.5585E-04	5.5687E-04	5.5790E-04	5.5892E-04
5.5995E-04	5.6098E-04	5.6200E-04	5.6303E-04	5.6406E-04	5.6509E-04
5.6613E-04	5.6681E-04	5.6785E-04	5.6888E-04	5.6992E-04	5.7095E-04
5.7199E-04	5.7303E-04	5.7407E-04	5.7511E-04	5.7580E-04	5.7684E-04
5.7788E-04	5.7893E-04	5.7997E-04	5.8102E-04	5.8206E-04	5.8311E-04
5.8381E-04	5.8486E-04	5.8591E-04	5.8696E-04	5.8801E-04	5.8906E-04
5.9011E-04	5.9082E-04	5.9187E-04	5.9293E-04	5.9399E-04	5.9504E-04
5.9610E-04	5.9681E-04	5.9787E-04	5.9999E-04	6.0212E-04	6.0389E-04
6.0603E-04	6.0781E-04	6.0995E-04	6.1209E-04	6.1388E-04	6.1603E-04
6.1783E-04	6.1999E-04	6.2179E-04	6.2396E-04	6.2612E-04	6.2793E-04
6.3011E-04	6.3193E-04	6.3411E-04	6.3593E-04	6.3812E-04	6.3995E-04
6.4178E-04	6.4398E-04	6.4581E-04	6.4802E-04	6.4986E-04	6.5208E-04
6.5392E-04	6.5577E-04	6.5800E-04	6.5985E-04	6.6208E-04	6.6395E-04
6.6581E-04	6.6805E-04	6.6992E-04	6.7179E-04	6.7404E-04	6.7592E-04
6.7780E-04	6.8006E-04	6.8195E-04	6.8384E-04	6.8611E-04	6.8801E-04
6.8990E-04	6.9180E-04	6.9409E-04	6.9599E-04	6.9790E-04	6.9981E-04
7.0211E-04	7.0403E-04	7.0595E-04	7.0787E-04	7.0979E-04	7.1211E-04
7.1404E-04	7.1597E-04	7.1791E-04	7.1985E-04	7.2179E-04	7.2412E-04
7.2607E-04	7.2802E-04	7.2997E-04	7.3192E-04	7.3388E-04	7.3584E-04
7.3780E-04	7.3977E-04	7.4213E-04	7.4410E-04	7.4607E-04	7.4805E-04
7.5003E-04	7.5201E-04	7.5399E-04	7.5598E-04	7.5797E-04	7.5996E-04

7.6195E-04	7.6395E-04	7.6595E-04	7.6795E-04	7.6996E-04	7.7197E-04
7.7398E-04	7.7599E-04	7.7800E-04	7.8002E-04	7.8204E-04	7.8407E-04
7.8609E-04	7.8812E-04	7.8974E-04	7.9178E-04	7.9381E-04	7.9585E-04
7.9994E-04	8.0403E-04	8.0814E-04	8.1184E-04	8.1596E-04	8.2010E-04
8.2383E-04	8.2799E-04	8.3174E-04	8.3591E-04	8.4010E-04	8.4387E-04
8.4808E-04	8.5187E-04	8.5610E-04	8.5991E-04	8.6373E-04	8.6799E-04
8.7182E-04	8.7610E-04	8.7995E-04	8.8382E-04	8.8812E-04	8.9201E-04
8.9590E-04	8.9980E-04	9.0414E-04	9.0806E-04	9.1198E-04	9.1592E-04
9.1986E-04	9.2381E-04	9.2777E-04	9.3174E-04	9.3571E-04	9.3970E-04
9.4414E-04	9.4769E-04	9.5171E-04	9.5572E-04	9.5975E-04	9.6379E-04
9.6783E-04	9.7188E-04	9.7595E-04	9.8002E-04	9.8409E-04	9.8773E-04
9.9182E-04	1.0019E-03	1.0120E-03	1.0221E-03	1.0318E-03	1.0421E-03
1.0519E-03	1.0618E-03	1.0717E-03	1.0821E-03	1.0917E-03	1.1017E-03
1.1118E-03	1.1220E-03	1.1317E-03	1.1419E-03	1.1517E-03	1.1620E-03
1.1719E-03	1.1818E-03	1.1918E-03	1.2018E-03	1.2119E-03	1.2219E-03
1.2321E-03	1.2417E-03	1.2519E-03	1.2617E-03	1.2720E-03	1.2818E-03
1.3068E-03	1.3489E-03	1.3971E-03	1.4462E-03	1.4961E-03	1.5812E-03
1.8817E-03	2.2084E-03	2.5613E-03	2.9402E-03	3.3453E-03	3.765E-03
4.2339E-03	5.7628E-03	7.5270E-03	1.0245E-02	1.5106E-02	2.0908E-02
2.1604E-02	2.2289E-02	2.3007E-02	2.3692E-02	2.4410E-02	2.6462E-02
2.7149E-02	2.7844E-02	2.8548E-02	2.9261E-02	2.9957E-02	3.0637E-02
3.2669E-02	3.9530E-02	4.7044E-02	5.7615E-02	7.0020E-02	8.3215E-02
9.8909E-02	1.3068E-01	1.8195E-01	2.0746E-01	2.4170E-01	2.7097E-01
2.9402E-01	3.3453E-01	3.7765E-01	4.2339E-01	5.1230E-01	6.3247E-01
7.5270E-01	8.8337E-01	1.0245E+00	1.1761E+00	1.3381E+00	1.5106E+00
1.6936E+00	1.8870E+00	2.0908E+00	2.3051E+00	2.5299E+00	2.7411E+00
3.0108E+00	3.2669E+00	3.5335E+00	3.8105E+00	4.0688E+00	4.3960E+00
4.7044E+00	4.9908E+00	5.3525E+00	5.6578E+00	6.0425E+00	6.3666E+00
6.7367E+00	7.1558E+00	7.5479E+00	7.9096E+00	8.3215E+00	8.7867E+00
9.1767E+00	9.6648E+00	1.0120E+01	1.0585E+01	1.1012E+01	1.1547E+01
1.1993E+01	1.2499E+01	1.3068E+01	1.3542E+01	1.3863E+01	1.3998E+01
1.4134E+01	1.4407E+01	1.4683E+01	1.5186E+01	1.5754E+01	1.6334E+01
1.6923E+01	1.7523E+01	1.8134E+01	1.8755E+01	2.0000E+01	

GROUP STRUCTURE NO.

8

GROUP STRUCTURE NAME -- TARI-2021 FOR E DIVISION 04/17/73

NUMBER OF GROUPS

-- 2020

1.3068E-09	2.0908E-08	3.2569E-08	4.7044E-08	8.3591E-08	1.3068E-07
1.8917E-07	2.5613E-07	3.3453E-07	4.2339E-07	5.2166E-07	7.5270E-07
9.8968E-07	1.4894E-06	1.9896E-06	2.4887E-06	2.9882E-06	3.4874E-06
3.9875E-06	4.4874E-06	4.9876E-06	5.4872E-06	5.9893E-06	6.4876E-06
6.9867E-06	7.4884E-06	7.9971E-06	8.4892E-06	8.9893E-06	9.4899E-06
9.9866E-06	1.0486E-05	1.0988E-05	1.1488E-05	1.1988E-05	1.2489E-05
1.3068E-05	1.4482E-05	1.6451E-05	1.8443E-05	2.0484E-05	2.2425E-05
2.4455E-05	2.6424E-05	2.8469E-05	3.0430E-05	3.2457E-05	3.4464E-05
3.6444E-05	3.8480E-05	4.0478E-05	4.2433E-05	4.4434E-05	4.6482E-05
4.8474E-05	5.0406E-05	5.2480E-05	5.4489E-05	5.6427E-05	5.8399E-05
6.0405E-05	6.2445E-05	6.4403E-05	6.6390E-05	6.8408E-05	7.0457E-05
7.2412E-05	7.4394E-05	7.6403E-05	7.8439E-05	8.0371E-05	8.2459E-05
8.4440E-05	8.6445E-05	8.8473E-05	9.0388E-05	9.2461E-05	9.4418E-05
9.6396E-05	9.8393E-05	1.0274E-04	1.0704E-04	1.1127E-04	1.1558E-04
1.1997E-04	1.2429E-04	1.2851E-04	1.3281E-04	1.3718E-04	1.4145E-04
1.4578E-04	1.5000E-04	1.5428E-04	1.5862E-04	1.6283E-04	1.6711E-04
1.7143E-04	1.7581E-04	1.8006E-04	1.8435E-04	1.8870E-04	1.9289E-04
1.9733E-04	2.0162E-04	2.0596E-04	2.1013E-04	2.1455E-04	2.1881E-04
2.2311E-04	2.2745E-04	2.3161E-04	2.3603E-04	2.4027E-04	2.4455E-04
2.4887E-04	2.5322E-04	2.5738E-04	2.6180E-04	2.6603E-04	2.7030E-04
2.7459E-04	2.7892E-04	2.8328E-04	2.8768E-04	2.9187E-04	2.9608E-04
3.0058E-04	3.0485E-04	3.0916E-04	3.1324E-04	3.1761E-04	3.2200E-04
3.2617E-04	3.3062E-04	3.3484E-04	3.3909E-04	3.4336E-04	3.4766E-04
3.5199E-04	3.5635E-04	3.6073E-04	3.6486E-04	3.6929E-04	3.7347E-04
3.7795E-04	3.8218E-04	3.8643E-04	3.9071E-04	3.9501E-04	3.9933E-04
4.0368E-04	4.0805E-04	4.1215E-04	4.1656E-04	4.2070E-04	4.2516E-04
4.2935E-04	4.3385E-04	4.3808E-04	4.4233E-04	4.4660E-04	4.5088E-04
4.5519E-04	4.5952E-04	4.6387E-04	4.6824E-04	4.7232E-04	4.7673E-04
4.8116E-04	4.8549E-04	4.8976E-04	4.9393E-04	5.0394E-04	5.1405E-04
5.2394E-04	5.3391E-04	5.4398E-04	5.5381E-04	5.6406E-04	5.7407E-04
5.8381E-04	5.9398E-04	6.0389E-04	6.1388E-04	6.2396E-04	6.3375E-04
6.4398E-04	6.5392E-04	6.6395E-04	6.7404E-04	6.8384E-04	6.9409E-04
7.0403E-04	7.1404E-04	7.2373E-04	7.3388E-04	7.4370E-04	7.5399E-04
7.6395E-04	7.7398E-04	7.8407E-04	7.9381E-04	8.0403E-04	8.1390E-04
8.2383E-04	8.3382E-04	8.4387E-04	8.5398E-04	8.6373E-04	8.7366E-04
8.8382E-04	8.9373E-04	9.0370E-04	9.1373E-04	9.2381E-04	9.3395E-04
9.4369E-04	9.5394E-04	9.6379E-04	9.7369E-04	9.8364E-04	1.0337E-03
1.0840E-03	1.1336E-03	1.1838E-03	1.2336E-03	1.3068E-03	1.3120E-03
1.3917E-03	1.4738E-03	1.5526E-03	1.6334E-03	1.7102E-03	1.7888E-03
1.8692E-03	1.9514E-03	2.0288E-03	2.1077E-03	2.1881E-03	2.2700E-03
2.3534E-03	2.4312E-03	2.5103E-03	2.5906E-03	2.6722E-03	2.7475E-03
2.8315E-03	2.9089E-03	2.9775E-03	3.0670E-03	3.1476E-03	3.2293E-03
3.3119E-03	3.3273E-03	3.4119E-03	3.5490E-03	3.6270E-03	3.7058E-03
3.7854E-03	3.8659E-03	3.9473E-03	4.0295E-03	4.1125E-03	4.1870E-03
4.2716E-03	4.3476E-03	4.4338E-03	4.5112E-03	4.5892E-03	4.6679E-03
4.7473E-03	4.8273E-03	4.9080E-03	4.9894E-03	5.0714E-03	5.1438E-03
5.2271E-03	5.3110E-03	5.3850E-03	5.4703E-03	5.5454E-03	5.6319E-03
5.7081E-03	5.7848E-03	5.8731E-03	5.9509E-03	6.0293E-03	6.1081E-03

3.6901E-02	3.6985E-02	3.7066E-02	3.7152E-02	3.7207E-02	3.7291E-02
3.7375E-02	3.7459E-02	3.7543E-02	3.7627E-02	3.7711E-02	3.7795E-02
3.7852E-02	3.7936E-02	3.8021E-02	3.8105E-02	3.8190E-02	3.8274E-02
3.8331E-02	3.8416E-02	3.8501E-02	3.8587E-02	3.8672E-02	3.8759E-02
3.8814E-02	3.8900E-02	3.8985E-02	3.9071E-02	3.9128E-02	3.9214E-02
3.9300E-02	3.9386E-02	3.9472E-02	3.9530E-02	3.9615E-02	3.9702E-02
3.9789E-02	3.9846E-02	3.9933E-02	4.0020E-02	4.0107E-02	4.0194E-02
4.0252E-02	4.0339E-02	4.0426E-02	4.0513E-02	4.0571E-02	4.0659E-02
4.0746E-02	4.0834E-02	4.0892E-02	4.0980E-02	4.1068E-02	4.1127E-02
4.1215E-02	4.1303E-02	4.1391E-02	4.1450E-02	4.1538E-02	4.1627E-02
4.1686E-02	4.1774E-02	4.1863E-02	4.1952E-02	4.2011E-02	4.2100E-02
4.2189E-02	4.2248E-02	4.2338E-02	4.2427E-02	4.2487E-02	4.2576E-02
4.2666E-02	4.2725E-02	4.2815E-02	4.2905E-02	4.2965E-02	4.3055E-02
4.3145E-02	4.3205E-02	4.3295E-02	4.3385E-02	4.3446E-02	4.3536E-02
4.3627E-02	4.3687E-02	4.3778E-02	4.3869E-02	4.3929E-02	4.4020E-02
4.4111E-02	4.4172E-02	4.4263E-02	4.4324E-02	4.4415E-02	4.4507E-02
4.4568E-02	4.4660E-02	4.4751E-02	4.4813E-02	4.4904E-02	4.4966E-02
4.5058E-02	4.5150E-02	4.5211E-02	4.5304E-02	4.5365E-02	4.5458E-02
4.5550E-02	4.5612E-02	4.5705E-02	4.5766E-02	4.5859E-02	4.5952E-02
4.6014E-02	4.6107E-02	4.6199E-02	4.6263E-02	4.6325E-02	4.6418E-02
4.6512E-02	4.6574E-02	4.6668E-02	4.6730E-02	4.6824E-02	4.6887E-02
4.6981E-02	4.7044E-02	4.7138E-02	4.7231E-02	4.7295E-02	4.7389E-02
4.7452E-02	4.7547E-02	4.7610E-02	4.7704E-02	4.7768E-02	4.7862E-02
4.7926E-02	4.8021E-02	4.8084E-02	4.8179E-02	4.8243E-02	4.8338E-02
4.8434E-02	4.8497E-02	4.8593E-02	4.8657E-02	4.8752E-02	4.8816E-02
4.8912E-02	4.8976E-02	4.9072E-02	4.9136E-02	4.9232E-02	4.9297E-02
4.9393E-02	4.9457E-02	4.9545E-02	4.9618E-02	4.9683E-02	4.9779E-02
4.9844E-02	5.0005E-02	5.0167E-02	5.0329E-02	5.0492E-02	5.0654E-02
5.0817E-02	5.0948E-02	5.1111E-02	5.1274E-02	5.1438E-02	5.1601E-02
5.1767E-02	5.1988E-02	5.2073E-02	5.2228E-02	5.2394E-02	5.2559E-02
5.2692E-02	5.2858E-02	5.3024E-02	5.3191E-02	5.3325E-02	5.3492E-02
5.3659E-02	5.3793E-02	5.3961E-02	5.4129E-02	5.4297E-02	5.4432E-02
5.4601E-02	5.4770E-02	5.4905E-02	5.5075E-02	5.5245E-02	5.5381E-02
5.5551E-02	5.5687E-02	5.5858E-02	5.6029E-02	5.6186E-02	5.6338E-02
5.6509E-02	5.6647E-02	5.6819E-02	5.6957E-02	5.7130E-02	5.7268E-02
5.7441E-02	5.7615E-02	5.7754E-02	5.7928E-02	5.8067E-02	5.8241E-02
5.8381E-02	5.8556E-02	5.8696E-02	5.8871E-02	5.9011E-02	5.9187E-02
5.9328E-02	5.9504E-02	5.9645E-02	5.9822E-02	5.9964E-02	6.0141E-02
6.0283E-02	6.0425E-02	6.0603E-02	6.0745E-02	6.0923E-02	6.1066E-02
6.1245E-02	6.1388E-02	6.1532E-02	6.1711E-02	6.1855E-02	6.2035E-02
6.2179E-02	6.2323E-02	6.2504E-02	6.2649E-02	6.2830E-02	6.2975E-02
6.3120E-02	6.3302E-02	6.3447E-02	6.3593E-02	6.3776E-02	6.3922E-02
6.4063E-02	6.4251E-02	6.4398E-02	6.4545E-02	6.4692E-02	6.4876E-02
6.5023E-02	6.5171E-02	6.5355E-02	6.5503E-02	6.5652E-02	6.5800E-02
6.5985E-02	6.6134E-02	6.6283E-02	6.6432E-02	6.6618E-02	6.6768E-02
6.6917E-02	6.7067E-02	6.7217E-02	6.7404E-02	6.7555E-02	6.7705E-02
6.7856E-02	6.8044E-02	6.8195E-02	6.8346E-02	6.8497E-02	6.8649E-02
6.8801E-02	6.8990E-02	6.9142E-02	6.9294E-02	6.9447E-02	6.9599E-02
6.9752E-02	6.9905E-02	7.0066E-02	7.0242E-02	7.0403E-02	7.0556E-02
7.0710E-02	7.0864E-02	7.1018E-02	7.1172E-02	7.1327E-02	7.1502E-02
7.1674E-02	7.1829E-02	7.1985E-02	7.2140E-02	7.2295E-02	7.2451E-02
7.2607E-02	7.273E-02	7.2919E-02	7.3075E-02	7.3231E-02	7.3388E-02
7.3545E-02	7.3702E-02	7.3859E-02	7.4016E-02	7.4173E-02	7.4331E-02
7.4489E-02	7.4647E-02	7.4805E-02	7.4963E-02	7.5122E-02	7.5280E-02
7.5439E-02	7.5598E-02	7.5757E-02	7.5916E-02	7.6076E-02	7.6235E-02
7.6395E-02	7.6555E-02	7.6715E-02	7.6876E-02	7.7036E-02	7.7197E-02
7.7357E-02	7.7518E-02	7.7679E-02	7.7800E-02	7.7962E-02	7.8123E-02
7.8285E-02	7.8447E-02	7.8609E-02	7.8771E-02	7.8934E-02	7.9096E-02
7.9259E-02	7.9381E-02	7.9544E-02	7.9708E-02	7.9871E-02	8.0034E-02
8.0198E-02	8.0362E-02	8.0526E-02	8.0649E-02	8.0814E-02	8.0978E-02
8.1143E-02	8.1308E-02	8.1473E-02	8.1596E-02	8.1762E-02	8.1927E-02
8.2093E-02	8.2259E-02	8.2383E-02	8.2549E-02	8.2715E-02	8.2882E-02
8.3049E-02	8.3174E-02	8.3340E-02	8.3508E-02	8.3675E-02	8.3842E-02
8.3968E-02	8.4135E-02	8.4303E-02	8.4471E-02	8.4597E-02	8.4766E-02

8.4934E-02	8.5103E-02	8.5229E-02	8.5398E-02	8.5568E-02	8.5737E-02
8.5864E-02	8.6033E-02	8.6203E-02	8.6331E-02	8.6501E-02	8.6671E-02
8.6841E-02	8.6969E-02	8.7140E-02	8.7311E-02	8.7439E-02	8.7610E-02
8.7781E-02	8.7910E-02	8.8081E-02	8.8253E-02	8.8425E-02	8.8554E-02
8.8726E-02	8.8899E-02	8.9028E-02	8.9201E-02	8.9373E-02	8.9503E-02
8.9676E-02	8.9806E-02	8.9980E-02	9.0153E-02	9.0283E-02	9.0457E-02
9.0631E-02	9.0762E-02	9.0936E-02	9.1111E-02	9.1242E-02	9.1417E-02
9.1548E-02	9.1723E-02	9.1898E-02	9.2030E-02	9.2205E-02	9.2337E-02
9.2513E-02	9.2689E-02	9.2821E-02	9.2997E-02	9.3130E-02	9.3306E-02
9.3439E-02	9.3616E-02	9.3793E-02	9.3926E-02	9.4103E-02	9.4236E-02
9.4414E-02	9.4547E-02	9.4725E-02	9.4903E-02	9.5037E-02	9.5215E-02
9.5349E-02	9.5528E-02	9.5662E-02	9.5841E-02	9.5975E-02	9.6154E-02
9.6289E-02	9.6469E-02	9.6603E-02	9.6783E-02	9.6918E-02	9.7098E-02
9.7234E-02	9.7414E-02	9.7549E-02	9.7730E-02	9.7866E-02	9.8047E-02
9.8183E-02	9.8364E-02	9.8500E-02	9.8682E-02	9.8818E-02	9.9000E-02
9.9136E-02	9.9319E-02	9.9455E-02	9.9638E-02	9.9775E-02	9.9958E-02
1.0009E-01	1.0023E-01	1.0042E-01	1.0055E-01	1.0074E-01	1.0087E-01
1.0106E-01	1.0120E-01	1.0138E-01	1.0152E-01	1.0166E-01	1.0184E-01
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1.0295E-01	1.0309E-01	1.0328E-01	1.0342E-01	1.0356E-01	1.0374E-01
1.0388E-01	1.0407E-01	1.0421E-01	1.0435E-01	1.0453E-01	1.0468E-01
1.0482E-01	1.0500E-01	1.0514E-01	1.0533E-01	1.0547E-01	1.0561E-01
1.0580E-01	1.0594E-01	1.0608E-01	1.0627E-01	1.0641E-01	1.0655E-01
1.0674E-01	1.0689E-01	1.0703E-01	1.0722E-01	1.0736E-01	1.0750E-01
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1.0864E-01	1.0878E-01	1.0893E-01	1.0912E-01	1.0926E-01	1.0941E-01
1.0960E-01	1.0974E-01	1.0988E-01	1.1003E-01	1.1022E-01	1.1036E-01
1.1051E-01	1.1070E-01	1.1085E-01	1.1099E-01	1.1113E-01	1.1133E-01
1.1147E-01	1.1162E-01	1.1181E-01	1.1196E-01	1.1210E-01	1.1225E-01
1.1244E-01	1.1258E-01	1.1273E-01	1.1288E-01	1.1307E-01	1.1322E-01
1.1336E-01	1.1351E-01	1.1370E-01	1.1385E-01	1.1400E-01	1.1414E-01
1.1429E-01	1.1449E-01	1.1463E-01	1.1478E-01	1.1493E-01	1.1512E-01
1.1527E-01	1.1542E-01	1.1556E-01	1.1571E-01	1.1591E-01	1.1606E-01
1.1620E-01	1.1635E-01	1.1655E-01	1.1670E-01	1.1685E-01	1.1699E-01
1.1714E-01	1.1729E-01	1.1749E-01	1.1764E-01	1.1779E-01	1.1794E-01
1.1808E-01	1.1828E-01	1.1843E-01	1.1858E-01	1.1873E-01	1.1888E-01
1.1903E-01	1.1923E-01	1.1938E-01	1.1953E-01	1.1968E-01	1.1983E-01
1.1998E-01	1.2018E-01	1.2033E-01	1.2048E-01	1.2063E-01	1.2078E-01
1.2093E-01	1.2108E-01	1.2129E-01	1.2144E-01	1.2159E-01	1.2174E-01
1.2189E-01	1.2204E-01	1.2219E-01	1.2235E-01	1.2255E-01	1.2270E-01
1.2295E-01	1.2300E-01	1.2316E-01	1.2331E-01	1.2346E-01	1.2361E-01
1.2382E-01	1.2397E-01	1.2412E-01	1.2428E-01	1.2443E-01	1.2458E-01
1.2473E-01	1.2489E-01	1.2504E-01	1.2519E-01	1.2535E-01	1.2555E-01
1.2571E-01	1.2586E-01	1.2601E-01	1.2617E-01	1.2632E-01	1.2648E-01
1.2663E-01	1.2679E-01	1.2694E-01	1.2709E-01	1.2725E-01	1.2740E-01
1.2756E-01	1.2777E-01	1.2792E-01	1.2808E-01	1.2823E-01	1.2839E-01
1.3068E-01	1.3172E-01	1.3278E-01	1.3436E-01	1.3542E-01	1.3649E-01
1.3756E-01	1.3917E-01	1.4025E-01	1.4134E-01	1.4243E-01	1.4352E-01
1.4517E-01	1.4627E-01	1.4738E-01	1.4849E-01	1.4961E-01	1.5073E-01
1.5186E-01	1.5355E-01	1.5469E-01	1.5583E-01	1.5697E-01	1.5812E-01
1.5927E-01	1.6043E-01	1.6159E-01	1.6275E-01	1.6392E-01	1.6509E-01
1.6627E-01	1.6745E-01	1.6864E-01	1.6983E-01	1.7102E-01	1.7222E-01
1.7342E-01	1.7463E-01	1.7584E-01	1.7705E-01	1.7827E-01	1.7950E-01
1.8072E-01	1.8195E-01	1.8319E-01	1.8443E-01	1.8567E-01	1.8692E-01
1.8817E-01	1.8943E-01	1.9069E-01	1.9196E-01	1.9329E-01	1.9386E-01
1.9514E-01	1.9642E-01	1.9770E-01	1.9899E-01	2.0028E-01	2.0158E-01
2.0223E-01	2.0353E-01	2.0484E-01	2.0615E-01	2.0746E-01	2.0878E-01
2.0944E-01	2.1077E-01	2.1210E-01	2.1343E-01	2.1477E-01	2.1544E-01
2.1678E-01	2.1813E-01	2.1949E-01	2.2016E-01	2.2152E-01	2.2289E-01
2.2425E-01	2.2494E-01	2.2631E-01	2.2769E-01	2.2907E-01	2.2977E-01
2.3115E-01	2.3255E-01	2.3394E-01	2.3464E-01	2.3605E-01	2.3745E-01
2.3816E-01	2.3957E-01	2.4099E-01	2.4170E-01	2.4312E-01	2.4455E-01
2.4598E-01	2.4670E-01	2.4814E-01	2.4958E-01	2.5030E-01	2.5175E-01
2.5248E-01	2.5394E-01	2.5539E-01	2.5613E-01	2.5759E-01	2.5906E-01

2.5980E-01	2.6127E-01	2.6275E-01	2.6350E-01	2.6498E-01	2.6573E-01
2.6722E-01	2.6872E-01	2.6947E-01	2.7097E-01	2.7172E-01	2.7323E-01
2.7475E-01	2.7551E-01	2.7703E-01	2.7779E-01	2.7931E-01	2.8008E-01
2.8161E-01	2.8315E-01	2.8392E-01	2.8546E-01	2.8623E-01	2.8778E-01
2.8856E-01	2.9011E-01	2.9089E-01	2.9246E-01	2.9324E-01	2.9481E-01
2.9638E-01	2.9717E-01	2.9875E-01	2.9954E-01	3.0112E-01	3.0191E-01
3.0351E-01	3.0430E-01	3.0590E-01	3.0670E-01	3.0830E-01	3.0911E-01
3.1072E-01	3.1152E-01	3.1314E-01	3.1395E-01	3.1557E-01	3.1639E-01
3.1720E-01	3.1893E-01	3.1965E-01	3.2128E-01	3.2210E-01	3.2375E-01
3.2457E-01	3.2622E-01	3.2705E-01	3.2870E-01	3.2953E-01	3.3119E-01
3.3203E-01	3.3296E-01	3.3453E-01	3.3537E-01	3.3705E-01	3.3789E-01
3.3957E-01	3.4041E-01	3.4126E-01	3.4295E-01	3.4379E-01	3.4549E-01
3.4634E-01	3.4719E-01	3.4890E-01	3.4975E-01	3.5147E-01	3.5233E-01
3.5318E-01	3.5490E-01	3.5577E-01	3.5749E-01	3.5836E-01	3.5922E-01
3.6096E-01	3.6183E-01	3.6357E-01	3.6444E-01	3.6532E-01	3.6707E-01
3.6794E-01	3.6882E-01	3.7058E-01	3.7146E-01	3.7234E-01	3.7411E-01
3.7499E-01	3.7677E-01	3.7765E-01	3.7854E-01	3.8033E-01	3.8122E-01
3.8211E-01	3.8390E-01	3.8480E-01	3.8569E-01	3.8749E-01	3.8839E-01
3.8930E-01	3.9110E-01	3.9201E-01	3.9291E-01	3.9473E-01	3.9564E-01
3.9655E-01	3.9837E-01	3.9928E-01	4.0020E-01	4.0111E-01	4.0295E-01
4.0386E-01	4.0478E-01	4.0663E-01	4.0755E-01	4.0847E-01	4.1032E-01
4.1125E-01	4.1218E-01	4.1311E-01	4.1497E-01	4.1590E-01	4.1683E-01
4.1870E-01	4.1964E-01	4.2057E-01	4.2151E-01	4.2339E-01	4.2433E-01
4.2528E-01	4.2716E-01	4.2811E-01	4.2906E-01	4.3000E-01	4.3190E-01
4.3285E-01	4.3380E-01	4.3476E-01	4.3667E-01	4.3762E-01	4.3858E-01
4.3954E-01	4.4146E-01	4.4242E-01	4.4338E-01	4.4434E-01	4.4627E-01
4.4724E-01	4.4821E-01	4.4918E-01	4.5112E-01	4.5209E-01	4.5306E-01
4.5403E-01	4.5599E-01	4.5696E-01	4.5794E-01	4.5892E-01	4.5990E-01
4.6186E-01	4.6285E-01	4.6383E-01	4.6482E-01	4.6679E-01	4.6778E-01
4.6877E-01	4.6976E-01	4.7075E-01	4.7274E-01	4.7373E-01	4.7473E-01
4.7572E-01	4.7672E-01	4.7872E-01	4.7972E-01	4.8072E-01	4.8173E-01
4.8273E-01	4.8473E-01	4.8575E-01	4.8676E-01	4.8777E-01	4.8878E-01
4.8979E-01	4.9181E-01	4.9283E-01	4.9384E-01	4.9486E-01	4.9588E-01
4.9792E-01	4.9894E-01	5.0098E-01	5.0201E-01	5.0303E-01	5.0508E-01
5.0611E-01	5.0817E-01	5.0920E-01	5.1127E-01	5.1230E-01	5.1438E-01
5.1541E-01	5.1749E-01	5.1853E-01	5.1957E-01	5.2166E-01	5.2271E-01
5.2480E-01	5.2595E-01	5.2795E-01	5.2900E-01	5.3005E-01	5.3216E-01
5.3321E-01	5.3533E-01	5.3638E-01	5.3744E-01	5.3957E-01	5.4063E-01
5.4276E-01	5.4382E-01	5.4596E-01	5.4703E-01	5.4810E-01	5.5024E-01
5.5131E-01	5.5346E-01	5.5454E-01	5.5562E-01	5.5777E-01	5.5885E-01
5.5994E-01	5.6210E-01	5.6319E-01	5.6536E-01	5.6645E-01	5.6754E-01
5.6972E-01	5.7081E-01	5.7299E-01	5.7409E-01	5.7519E-01	5.7738E-01
5.7848E-01	5.7958E-01	5.8178E-01	5.8289E-01	5.8399E-01	5.8620E-01
5.8731E-01	5.8842E-01	5.9064E-01	5.9175E-01	5.9398E-01	5.9509E-01
5.9621E-01	5.9845E-01	5.9956E-01	6.0069E-01	6.0293E-01	6.0405E-01
6.0518E-01	6.0743E-01	6.0856E-01	6.0969E-01	6.1194E-01	6.1308E-01
6.1421E-01	6.1648E-01	6.1761E-01	6.1875E-01	6.1989E-01	6.2217E-01
6.2331E-01	6.2445E-01	6.2674E-01	6.2788E-01	6.2933E-01	6.3132E-01
6.3247E-01	6.3362E-01	6.3533E-01	6.3708E-01	6.3824E-01	6.3939E-01
6.4171E-01	6.4287E-01	6.4403E-01	6.4635E-01	6.4751E-01	6.4868E-01
6.4984E-01	6.5217E-01	6.5334E-01	6.5451E-01	6.5688E-01	6.5803E-01
6.5920E-01	6.6037E-01	6.6273E-01	6.6390E-01	6.6508E-01	6.6744E-01
6.6862E-01	6.6981E-01	6.7099E-01	6.7336E-01	6.7455E-01	6.7574E-01
6.7693E-01	6.7931E-01	6.8050E-01	6.8169E-01	6.8289E-01	6.8528E-01
6.8648E-01	6.8768E-01	6.8888E-01	6.9128E-01	6.9248E-01	6.9368E-01
6.9482E-01	6.9730E-01	6.9851E-01	6.9972E-01	7.0093E-01	7.0335E-01
7.0457E-01	7.0578E-01	7.0710E-01	7.0943E-01	7.1065E-01	7.1187E-01
7.1309E-01	7.1431E-01	7.1676E-01	7.1798E-01	7.1921E-01	7.2043E-01
7.2289E-01	7.2412E-01	7.2535E-01	7.2658E-01	7.2782E-01	7.3028E-01
7.3152E-01	7.3276E-01	7.3400E-01	7.3648E-01	7.3772E-01	7.3896E-01
7.4020E-01	7.4145E-01	7.4394E-01	7.4519E-01	7.4644E-01	7.4769E-01
7.4894E-01	7.5144E-01	7.5270E-01	7.5395E-01	7.5521E-01	7.5646E-01
7.5898E-01	7.6024E-01	7.6150E-01	7.6277E-01	7.6403E-01	7.6529E-01
7.6783E-01	7.6909E-01	7.7036E-01	7.7163E-01	7.7290E-01	7.7545E-01

7.7672E-01	7.7800E-01	7.7927E-01	7.8055E-01	7.8183E-01	7.8439E-01
7.8567E-01	7.8695E-01	7.8823E-01	7.8952E-01	7.9080E-01	7.9338E-01
7.9466E-01	7.9595E-01	7.9724E-01	7.9854E-01	7.9983E-01	8.0242E-01
8.0371E-01	8.0501E-01	8.0631E-01	8.0761E-01	8.0891E-01	8.1021E-01
8.1281E-01	8.1412E-01	8.1542E-01	8.1673E-01	8.1803E-01	8.1934E-01
8.2196E-01	8.2327E-01	8.2459E-01	8.2590E-01	8.2722E-01	8.2853E-01
8.2985E-01	8.3248E-01	8.3380E-01	8.3512E-01	8.3645E-01	8.3777E-01
8.3909E-01	8.4042E-01	8.4174E-01	8.4440E-01	8.4573E-01	8.4706E-01
8.4839E-01	8.4972E-01	8.5106E-01	8.5239E-01	8.5373E-01	8.5640E-01
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8.6579E-01	8.6849E-01	8.6983E-01	8.7118E-01	8.7253E-01	8.7389E-01
8.7524E-01	8.7659E-01	8.7794E-01	8.7930E-01	8.8066E-01	8.8337E-01
8.8473E-01	8.8609E-01	8.8745E-01	8.8882E-01	8.9018E-01	8.9155E-01
8.9291E-01	8.9428E-01	8.9565E-01	8.9839E-01	6.9976E-01	9.0113E-01
9.0250E-01	9.0388E-01	9.0525E-01	9.0663E-01	9.0800E-01	9.0938E-01
9.1076E-01	9.1214E-01	9.1491E-01	9.1629E-01	9.1768E-01	9.1906E-01
9.2045E-01	9.2184E-01	9.2322E-01	9.2461E-01	9.2601E-01	9.2740E-01
9.2879E-01	9.3018E-01	9.3298E-01	9.3437E-01	9.3577E-01	9.3717E-01
9.3857E-01	9.3997E-01	9.4137E-01	9.4278E-01	9.4418E-01	9.4559E-01
9.4699E-01	9.4840E-01	9.4981E-01	9.5122E-01	9.5263E-01	9.5546E-01
9.5687E-01	9.5828E-01	9.5970E-01	9.6112E-01	9.6254E-01	9.6396E-01
9.6538E-01	9.6680E-01	9.6822E-01	9.6964E-01	9.7107E-01	9.7249E-01
9.7392E-01	9.7535E-01	9.7677E-01	9.7820E-01	9.7963E-01	9.8250E-01
9.8393E-01	9.8537E-01	9.8680E-01	9.8824E-01	9.8968E-01	9.9112E-01
9.9256E-01	9.9400E-01	9.9544E-01	1.0245E+00	1.1761E+00	1.3381E+00
1.5106E+00	1.6936E+00	1.8870E+00	2.0908E+00	2.3051E+00	2.5299E+00
2.7627E+00	3.0108E+00	3.2663E+00	3.5335E+00	3.8105E+00	4.0951E+00
4.3960E+00	4.7044E+00	5.0200E+00	5.3525E+00	5.6888E+00	6.0425E+00
6.3995E+00	6.7705E+00	7.1558E+00	7.5479E+00	7.9463E+00	8.3591E+00
8.7867E+00	9.2161E+00	9.6648E+00	1.0120E+01	1.0589E+01	1.1056E+01
1.1547E+01	1.2038E+01	1.2545E+01	1.3068E+01	1.3590E+01	1.3869E+01
1.4134E+01	1.4407E+01	1.4688E+01	1.5236E+01	1.5806E+01	1.6386E+01
1.6977E+01	1.7578E+01	1.8189E+01	1.8811E+01	2.0000E+01	

FLUX SPECTRUM LIBRARY

All spectra for which calculations were required were obtained from ANISN results. The S_{16} approximation was used with 66 groups (group structure number 3). Cross sections and transfer matrices were obtained from the LLL evaluated neutron cross section library by the use of CLYDE. P_1 transfer matrices were used for all results except Jezebel, which used P_3 .

The CLYDE spectrum library stores the Legendre moments of the angular flux. These are used in spectrum averaging the appropriate transfer matrices. If, for a specific region, the $\lambda = 0$ flux moment, f_0 , is taken equal to the volume integrated flux, then the f_1 component is proportional to the leakage out of the region.

As an example, the method for obtaining the $\lambda = 0$ flux moment will be described. The volume-integrated group flux from ANISN is designated as ϕ_g (neutrons-cm/s). Note that it has been integrated over the group. To obtain the corresponding average differential flux, $\phi(E_g)$ (neutrons-cm/sec-MeV), one divides ϕ_g by the group energy width, ΔE_g . This average quantity is assigned to an average (arithmetic) group energy, E_g , and a curve drawn through these points yields the spectrum.

For purposes of comparison, several normalizations are made for many of these spectra before the data are put into the CLYDE library. First, the spectrum is normalized to one source neutron (from fission, fusion, leakage into the region, or an extraneous source, etc.). Then, the spectrum is put on a unit volume basis. Units of the flux are then neutrons/cm² . s. MeV. Similarly the $\lambda = 1$ component, starting from the leakage, L_g (neutrons/s.), would now have units of neutrons/cm³ . s. MeV. Higher flux moments could, in principle, be developed along similar lines.

Table A1 summarizes the systems used in obtaining the current CLYDE spectra. Numbers 2, 3, and 7 through 10 were criticality calculations.

Table A1. Summary of spectra in CLYDE spectrum library.

Spectrum library No.	Evaluation No.	Remarks	Normalized
1	—	Flat flux— $\phi(E) \propto k$	No
2	26	Gediva—bare Oy core	Yes
3	6	Jezebel—bare Pu core	Yes
4	—	Fission spectrum— ^{235}U thermal fission	
5	—	$1/E$ flux— $\phi(E) \propto k/E$	No
6	—	Thermal flux—"typical" with $KT_n = 0.025 \text{ eV}$	No
7-10		Be reflected, Oy core	
7	—	$\Delta t_{\text{Be}} = 0.25 \text{ cm}$	Yes
8	—	$\Delta t_{\text{Be}} = 1.00 \text{ cm}$	Yes
9	45	$\Delta t_{\text{Be}} = 2.22 \text{ cm}$	Yes
10	15	$\Delta t_{\text{Be}} = 4.699 \text{ cm}$	Yes

The spectra are listed in the following tables. CRT plots of these are also shown. The interpolated values on the CRT displays are found on a linear-linear basis, in the same manner that CLYDE would use the given point library.

LIBRARY NUMBER = 1

ENERGY (MEV)
FLAT FLUX DISTRIBUTION

FLUX SPECTRUM NO. -- 1

FLUX SPECTRUM NAME -- FLAT

MAXIMUM ORDER OF FLUXES - 0

ORDER -- 0 NUMBER OF FLUX POINTS 2

0. 8.5000E+01 2.1000E+01 8.5000E+01

FLUX SPECTRUM NO. -- 2
 FLUX SPECTRUM NAME -- GODIVA
 MAXIMUM ORDER OF FLUXES -- 1

ORDER --	0	NUMBER OF FLUX POINTS --	102
1.0000E-20	0.	3.736E-06	4.8072E-11
5.5739E-06	2.0332E-10	6.8080E-06	4.1814E-10
1.0156E-05	1.7685E-09	1.2405E-05	3.6370E-09
1.8506E-05	1.5382E-08	3.0511E-05	6.5015E-08
5.0305E-05	2.1599E-07	7.8108E-05	5.2282E-07
5.7715E-04	8.2818E-06	1.2341E-03	2.0279E-05
2.7465E-03	4.4259E-05	4.0973E-03	6.5443E-05
9.1188E-03	1.4507E-04	1.3504E-02	2.1551E-04
4.5166E-02	7.1243E-04	6.7379E-02	1.0082E-03
1.8316E-01	1.7178E-03	2.2371E-01	1.7580E-03
6.3292E-01	1.2505E-03	9.0718E-01	9.2220E-04
1.1533E+00	7.2242E-04	1.3534E+00	5.9519E-04
1.7204E+00	4.4173E-04	1.8637E+00	3.9490E-04
2.2764E+00	2.9841E-04	2.7304E+00	2.0916E-04
3.2620E+00	1.5122E-04	3.3960E+00	1.3944E-04
4.1478E+00	8.4993E-05	4.4933E+00	6.8077E-05
5.0662E+00	4.8820E-05	5.4881E+00	3.9087E-05
6.0653E+00	2.5422E-05	6.3128E+00	2.1403E-05
6.9768E+00	1.3739E-05	7.2615E+00	1.1417E-05
7.8663E+00	7.8829E-06	8.5214E+00	5.1492E-06
9.2312E+00	3.1820E-06	9.6079E+00	2.5014E-06
1.0202E+01	1.7139E-06	1.0408E+01	1.4939E-06
1.0833E+01	1.1349E-06	1.1052E+01	9.8920E-07
1.1503E+01	7.5150E-07	1.1735E+01	6.5502E-07
1.2461E+01	4.1764E-07	1.2712E+01	3.5051E-07
1.3231E+01	2.4689E-07	1.3499E+01	2.0720E-07
1.4049E+01	1.4595E-07	1.4333E+01	1.2249E-07
1.4918E+01	8.6276E-08	1.5220E+01	6.4769E-08
1.5841E+01	3.6503E-08	1.6161E+01	2.7403E-08
1.6820E+01	1.5444E-08	1.7160E+01	1.1594E-08
1.7860E+01	6.5342E-09	1.8221E+01	4.9054E-09
1.8965E+01	2.6481E-09	1.9346E+01	1.9457E-09
2.0138E+01	1.0504E-09	2.0544E+01	7.7174E-10
2.1383E+01	4.1661E-10	2.1815E+01	3.0610E-10
			4.5635E-06
			8.3153E-06
			1.5151E-05
			3.7267E-05
			2.2545E-04
			1.8411E-03
			6.1125E-03
			3.0276E-02
			1.2277E-01
			3.3373E-01
			1.0228E+00
			1.5259E+00
			2.1014E+00
			3.0119E+00
			3.8289E+00
			4.8675E+00
			5.7121E+00
			6.5705E+00
			8.8692E+00
			9.8020E+00
			1.0618E+01
			1.1275E+01
			1.1972E+01
			1.2969E+01
			1.3771E+01
			1.4623E+01
			1.5527E+01
			1.6487E+01
			1.7507E+01
			1.8589E+01
			1.9739E+01
			2.0959E+01
			2.2255E+01
			8.8864E-11
			8.5992E-10
			7.4797E-09
			1.0509E-07
			2.5373E-06
			2.9129E-05
			9.3585E-05
			4.7236E-04
			1.5143E-03
			1.7141E-03
			8.2002E-04
			5.1470E-04
			3.3379E-04
			1.7785E-04
			1.0611E-04
			5.4527E-05
			3.2908E-05
			1.8020E-05
			9.4866E-06
			4.0478E-06
			2.2178E-06
			1.3021E-06
			8.6220E-07
			5.7092E-07
			2.9417E-07
			1.7390E-07
			1.0280E-07
			4.8624E-08
			2.0572E-08
			8.7039E-09
			3.6042E-09
			1.4296E-09
			5.6702E-10
			2.2491E-10

LIBRARY NUMBER = 2

ENERGY (MEV)
GODIVA LEAKAGE SPECTRUM P1

ORDER -- 1 NUMBER OF FLUX POINTS -- 78

1.0000E-20	0.	1.0010E-20	0.	1.0020E-20	0.
1.8554E-06	3.0935E-12	4.1292E-06	2.6586E-11	6.1601E-06	5.9068E-11
8.3153E-06	1.0749E-10	1.2405E-05	2.3882E-10	1.6745E-05	4.3460E-10
2.4981E-05	9.6556E-10	3.3720E-05	1.7571E-09	6.1442E-05	5.8189E-09
8.2938E-05	1.6324E-08	7.4852E-04	4.9944E-07	1.0622E-03	7.5264E-07
1.5073E-03	1.1342E-06	2.1390E-03	1.7092E-06	3.0354E-03	2.5756E-06
4.3074E-03	3.8814E-06	6.1125E-03	5.8491E-06	2.2882E-02	2.2935E-05
5.5166E-02	5.7032E-05	1.0052E-01	9.2477E-05	1.4996E-01	1.0737E-04
2.2371E-01	1.2466E-04	3.3373E-01	1.7775E-04	4.9787E-01	1.2567E-04
5.8426E-01	1.1251E-04	6.5875E-01	1.7775E-04	8.3743E-01	8.4873E-05
9.7296E-01	7.3419E-05	1.0970E+00	5.7775E-05	1.2003E+00	5.9034E-05
1.5259E+00	4.4161E-05	1.7204E+00	3.7475E-05	1.8637E+00	3.3587E-05
2.0190E+00	3.0104E-05	2.2313E+00	2.6998E-05	2.4660E+00	2.4212E-05
2.7804E+00	1.9483E-05	3.1982E+00	1.4769E-05	3.3960E+00	1.2941E-05
3.6059E+00	1.1339E-05	3.9455E+00	9.3004E-06	4.3605E+00	7.1143E-06
4.5841E+00	6.1451E-06	4.7711E+00	5.4508E-06	5.1685E+00	4.2888E-06
5.7121E+00	3.0697E-06	6.0653E+00	2.4340E-06	6.3128E+00	2.0852E-06
6.5705E+00	1.7864E-06	6.8386E+00	1.5189E-06	7.1177E+00	1.2817E-06
7.5578E+00	9.9349E-07	7.8663E+00	8.3834E-07	8.1873E+00	7.0743E-07
8.5214E+00	5.4250E-07	8.8692E+00	4.1603E-07	9.2312E+00	3.1904E-07
9.6079E+00	2.4466E-07	1.0000E+01	1.8762E-07	1.0408E+01	1.4388E-07
1.0833E+01	1.1034E-07	1.1275E+01	8.4616E-08	1.1735E+01	6.4890E-08
1.2214E+01	4.9762E-08	1.2511E+01	1.1573E-08	1.2815E+01	2.6913E-09
1.3126E+01	6.2588E-10	1.3445E+01	1.4555E-10	1.3771E+01	3.3850E-11
1.4106E+01	7.8721E-12	1.4448E+01	1.8307E-12	1.4799E+01	4.2575E-13
1.5159E+01	9.9012E-14	1.5527E+01	2.3026E-14	2.0000E+01	0.

FLUX SPECTRUM NO. -- 3
 FLUX SPECTRUM NAME -- JEZEBEL
 MAXIMUM ORDER OF FLUXES -- 1

ORDER --	0	NUMBER OF FLUX POINTS --	66
1.0000E-20	0.	2.4981E-05	4.5510E-08
7.5046E-05	3.1324E-07	1.2373E-04	5.5815E-07
7.4852E-04	7.2438E-06	1.2341E-03	1.3326E-05
3.7074E-03	4.3057E-05	6.1125E-03	7.6635E-05
2.4788E-02	3.0290E-04	3.6979E-02	4.0084E-04
6.7379E-02	6.1021E-04	7.1546E-02	6.2815E-04
2.2371E-01	9.2695E-04	4.9787E-01	9.3354E-04
8.3743E-01	7.2407E-04	1.2003E+00	5.3257E-04
1.7204E+00	3.5983E-04	1.8637E+00	3.2913E-04
2.6185E+00	2.0989E-04	2.7804E+00	1.8990E-04
3.4994E+00	1.1844E-04	3.8289E+00	9.6666E-05
4.5841E+00	5.9481E-05	4.8675E+00	4.9928E-05
5.4881E+00	3.5179E-05	5.7121E+00	2.9532E-05
6.3128E+00	1.9069E-05	6.7032E+00	1.4668E-05
7.7105E+00	8.1868E-06	8.2696E+00	6.1164E-06
9.5123E+00	3.4139E-06	1.0202E+01	2.5505E-06
1.1735E+01	1.4236E-06	1.2586E+01	1.0636E-06
1.3771E+01	6.2552E-07	1.3910E+01	5.5459E-07
1.4477E+01	3.4336E-07	1.4770E+01	2.7017E-07
1.5841E+01	8.9853E-08	1.6323E+01	5.5018E-08
1.7333E+01	2.0627E-08	1.7860E+01	1.2630E-08
1.8965E+01	4.7354E-09	1.9542E+01	2.8995E-09

ORDER -- 1 NUMBER OF FLUX POINTS -- 80

1.0000E-20	0.	1.0010E-20	0.	1.0020E-20	0.
2.7698E-05	3.0217E-09	6.1442E-05	1.4918E-08	1.0757E-04	4.6522E-08
1.7363E-04	1.1480E-07	2.8093E-04	2.6369E-07	8.2724E-04	1.3515E-06
1.1167E-03	2.0189E-06	1.5073E-03	3.0157E-06	2.0347E-03	4.5048E-06
3.9131E-03	9.3250E-05	6.0517E-03	1.5146E-05	9.2381E-03	2.4372E-05
1.6238E-02	4.5959E-05	2.4788E-02	7.3956E-05	4.5166E-02	1.2011E-04
6.7579E-02	1.6596E-04	1.1796E-01	2.3311E-04	1.6245E-01	2.6224E-04
2.2371E-01	2.9500E-04	4.0762E-01	3.1481E-04	4.9787E-01	3.1297E-04
7.4274E-01	2.8384E-04	8.6294E-01	2.5824E-04	1.2369E+00	1.9045E-04
1.4661E+00	1.5966E-04	1.7201E+00	1.3435E-04	2.1871E+00	1.0066E-04
2.3693E+00	8.9640E-05	2.5666E+00	7.9824E-05	2.7804E+00	7.1083E-05
3.0119E+00	6.3298E-05	3.2956E+00	5.1700E-05	3.4994E+00	4.5174E-05
3.8269E+00	3.6896E-05	4.2316E+00	2.8542E-05	4.4933E+00	2.3776E-05
4.7711E+00	1.9806E-05	5.2729E+00	1.3890E-05	5.5990E+00	1.1003E-05
5.9452E+00	8.7163E-06	6.3128E+00	6.9047E-06	6.5051E+00	6.1454E-06
6.9768E+00	4.5517E-06	7.2615E+00	3.7879E-06	7.4082E+00	3.4555E-06
7.7105E+00	2.8756E-06	8.0252E+00	2.3931E-06	8.3946E+00	1.8987E-06
8.6071E+00	1.5513E-06	8.8250E+00	1.4362E-06	9.0484E+00	1.2491E-06
9.2774E+00	1.0863E-06	9.5123E+00	9.4480E-07	9.7531E+00	8.2171E-07
1.0000E+01	7.1465E-07	1.0253E+01	6.2155E-07	1.0513E+01	5.4057E-07
1.0693E+01	4.5798E-07	1.0876E+01	3.8800E-07	1.1063E+01	3.2872E-07
1.1252E+01	2.7849E-07	1.1445E+01	2.3594E-07	1.1642E+01	1.9989E-07
1.1841E+01	1.6935E-07	1.2044E+01	1.4348E-07	1.2251E+01	1.2155E-07
1.2738E+01	7.7373E-08	1.3021E+01	5.8133E-08	1.3311E+01	4.3677E-08
1.3607E+01	3.2816E-08	1.3910E+01	2.4556E-08	1.4219E+01	1.8525E-08
1.4535E+01	1.3918E-08	1.4859E+01	1.0457E-08	1.5189E+01	7.8569E-09
1.5527E+01	5.9032E-09	2.0000E+01	0.

FLUX SPECTRUM NO.

4

FLUX SPECTRUM NAME

FISSION

MAXIMUM ORDER OF FLUXES

0

ORDER 0 NUMBER OF FLUX POINTS 167

1.0000E-20	0.	1.0000E-10	0.	1.0200E-10	7.7781E-06
1.1487E-10	8.2541E-06	1.5769E-10	9.6710E-06	2.0807E-10	1.1109E-05
2.6388E-10	1.2511E-05	3.2810E-10	1.3950E-05	4.6061E-10	1.6672E-05
6.4330E-10	1.9533E-05	8.3218E-10	2.2217E-05	1.0347E-09	2.4773E-05
1.5375E-09	3.0199E-05	2.1107E-09	3.5382E-05	2.7850E-09	4.0643E-05
3.5321E-09	4.5771E-05	4.3917E-09	5.1037E-05	6.3979E-09	6.1601E-05
8.7829E-09	7.2176E-05	1.1352E-08	8.2090E-05	1.4409E-08	9.2447E-05
1.7916E-08	1.0308E-04	2.5589E-08	1.2320E-04	3.5128E-08	1.4434E-04
4.5442E-08	1.6417E-04	5.7631E-08	1.8488E-04	7.1657E-08	2.0616E-04
1.0234E-07	2.4638E-04	1.4050E-07	2.8867E-04	1.8175E-07	3.2832E-04
2.3050E-07	3.6975E-04	2.8660E-07	4.1229E-04	4.0933E-07	4.9273E-04
5.6192E-07	5.7731E-04	7.2690E-07	6.5661E-04	9.2189E-07	7.3945E-04
1.1463E-06	9.2454E-04	1.6371E-06	9.8540E-04	2.2474E-06	1.1546E-03
2.9073E-06	1.3131E-03	3.6872E-06	1.4768E-03	4.5845E-06	1.5490E-03
6.5478E-06	1.9707E-03	8.9887E-06	2.3090E-03	1.1628E-05	2.5261E-03
1.4747E-05	2.9574E-03	1.8336E-05	3.2977E-03	2.6188E-05	3.3411E-03
3.5951E-05	4.6176E-03	4.6505E-05	5.2518E-03	5.8981E-05	5.9144E-03
7.3356E-05	6.5948E-03	1.0474E-04	7.8813E-03	1.4379E-04	9.2339E-03
1.8601E-04	1.0502E-02	2.3590E-04	1.1826E-02	2.9331E-04	1.3187E-02
4.1892E-04	1.5758E-02	5.7509E-04	1.8461E-02	7.4394E-04	2.0994E-02
9.4349E-04	2.3679E-02	1.1731E-03	2.6354E-02	1.6755E-03	3.1483E-02
2.3001E-03	3.6870E-02	2.9754E-03	4.1913E-02	3.7736E-03	4.7171E-02
4.6919E-03	5.2551E-02	6.7013E-03	6.2718E-02	9.1994E-03	7.3342E-02
1.1906E-02	8.3242E-02	1.5093E-02	9.3513E-02	1.8398E-02	1.0298E-01
2.6277E-02	1.2232E-01	3.6072E-02	1.4224E-01	4.6663E-02	1.6045E-01
5.9180E-02	1.7895E-01	7.2140E-02	1.9560E-01	1.0101E-01	2.2634E-01
1.3595E-01	2.5556E-01	1.7587E-01	2.8181E-01	2.1867E-01	3.0393E-01
2.6656E-01	3.2339E-01	3.1856E-01	3.3956E-01	3.7324E-01	3.5233E-01
4.3731E-01	3.6286E-01	5.0234E-01	3.6979E-01	6.4982E-01	3.7515E-01
9.2413E-01	3.6308E-01	1.0452E+00	3.5018E-01	1.2996E+00	3.2059E-01
1.9697E+00	2.3477E-01	2.2626E+00	2.0051E-01	2.4981E+00	1.7553E-01
2.7040E+00	1.5568E-01	2.9269E+00	1.3627E-01	3.1061E+00	1.2218E-01
3.3621E+00	1.0423E-01	3.5679E+00	9.1538E-02	3.8620E+00	7.5821E-02
4.0984E+00	6.5074E-02	4.2640E+00	5.8340E-02	4.4362E+00	5.2068E-02
4.7077E+00	4.3457E-02	4.9959E+00	3.5805E-02	5.3017E+00	2.9106E-02
5.4077E+00	2.7071E-02	5.6262E+00	2.3310E-02	5.7387E+00	2.1576E-02
5.9746E+00	1.9387E-02	6.0900E+00	1.6928E-02	6.3360E+00	1.4265E-02
6.4627E+00	1.3062E-02	6.7238E+00	1.0882E-02	6.8583E+00	9.9026E-03
7.1354E+00	8.1483E-03	7.2781E+00	7.3675E-03	7.4236E+00	6.8469E-03
7.5721E+00	5.9832E-03	7.7236E+00	5.3734E-03	7.8780E+00	4.8144E-03
8.0356E+00	4.3033E-03	8.1963E+00	3.8370E-03	8.3602E+00	3.4128E-03
8.5274E+00	3.0277E-03	8.6960E+00	2.6791E-03	8.8719E+00	2.3645E-03
9.0494E+00	2.0811E-03	9.2304E+00	1.8267E-03	9.4150E+00	1.5989E-03

9.6033E+00	1.3955E-03	9.7953E+00	1.2144E-03	9.9912E+00	1.0537E-03
1.0191E+01	9.1144E-04	1.0395E+01	7.8598E-04	1.0603E+01	6.7565E-04
1.0815E+01	5.7893E-04	1.1031E+01	4.9444E-04	1.1252E+01	4.2086E-04
1.1477E+01	3.5700E-04	1.1706E+01	3.0178E-04	1.1940E+01	2.5420E-04
1.2173E+01	2.1334E-04	1.2423E+01	1.7839E-04	1.2671E+01	1.4860E-04
1.2925E+01	1.2331E-04	1.3183E+01	1.0193E-04	1.3447E+01	8.3919E-05
1.3716E+01	6.8798E-05	1.3990E+01	5.6172E-05	1.4270E+01	4.5669E-05
1.4555E+01	3.6969E-05	1.4846E+01	2.9794E-05	1.5133E+01	2.3904E-05
1.5446E+01	1.9090E-05	1.5755E+01	1.5174E-05	1.6070E+01	1.2004E-05
1.6392E+01	9.4496E-06	1.6720E+01	7.4019E-06	1.7054E+01	5.7686E-06
1.7395E+01	4.4724E-06	1.7743E+01	3.4492E-06	1.8098E+01	2.6451E-06
1.8460E+01	2.0183E-06	1.8629E+01	1.5311E-06	1.9205E+01	1.1548E-06
1.9590E+01	8.6597E-07	2.0001E+01	6.4551E-07

FLUX SPECTRUM NO

5

FLUX SPECTRUM NAME

ONE OVER 1

MAXIMUM ORDER OF FLUXES

0

ORDER	0	NUMBER OF FLUX POINTS	225
1.0000E-20	1.6810E+07	1.0000E+10	0.9197E+06
1.2579E-10	7.0910E+06	1.4108E+10	6.3225E+06
1.7835E-10	5.0013E+06	2.0102E+10	4.4371E+06
2.5413E-10	3.5099E+06	2.8502E+10	3.1295E+06
3.6211E-10	2.4633E+06	4.0613E+10	2.1963E+06
5.1086E-10	1.7460E+06	5.7582E+10	1.5491E+06
7.2431E-10	1.2314E+06	8.1236E+10	1.0980E+06
1.0270E-09	8.6855E+05	1.1518E+09	7.7442E+05
1.4560E-09	6.1259E+05	1.6412E+09	5.4348E+05
2.0747E-09	4.2992E+05	2.3269E+09	3.8332E+05
2.9564E-09	3.0171E+05	3.3157E+09	2.6302E+05
4.1916E-09	2.1280E+05	4.7011E+09	1.8974E+05
5.9430E-09	1.5009E+05	6.6987E+09	1.3315E+05
8.4683E-09	1.0533E+05	9.4976E+09	9.3915E+04
1.2007E-08	7.4290E+04	1.3466E+08	6.6238E+04
1.7023E-08	5.2397E+04	1.9093E+08	4.6719E+04
2.4136E-08	3.6956E+04	2.7205E+08	3.2787E+04
3.4221E-08	2.6055E+04	3.8381E+08	2.3240E+04
4.8520E-08	1.8383E+04	5.4689E+08	1.6310E+04
6.9136E-08	1.2931E+04	7.7928E+08	1.1446E+04
9.8024E-08	9.0918E+03	1.1049E+07	8.0729E+03
1.3968E-07	6.3859E+03	1.5665E+07	5.6939E+03
1.9804E-07	4.5041E+03	2.2111E+07	4.0159E+03
2.8078E-07	3.1767E+03	3.1491E+07	2.8324E+03
3.9810E-07	2.2405E+03	4.4872E+07	1.9877E+03
5.6726E-07	1.5724E+03	6.3622E+07	1.4020E+03
8.0428E-07	1.1090E+03	9.0656E+07	9.8393E+02
1.1460E-06	7.7830E+02	1.2853E+06	6.9395E+02
1.6168E-06	5.5168E+02	1.8224E+06	4.8945E+02
2.3038E-06	3.8717E+02	2.5839E+06	3.4521E+02
3.2654E-06	2.7308E+02	3.6818E+06	2.4227E+02
4.6544E-06	1.9164E+02	5.2201E+06	1.7087E+02
6.5991E-06	1.3516E+02	7.4383E+06	1.1992E+02
9.3565E-06	9.5333E+01	1.0494E+05	8.5000E+01
1.3266E-05	6.7237E+01	1.4953E+05	5.9652E+01
1.8903E-05	4.7187E+01	2.1200E+05	4.2073E+01
2.6935E-05	3.3115E+01	3.0209E+05	2.9527E+01
3.8189E-05	2.3356E+01	4.2831E+05	2.0825E+01
5.4146E-05	1.6474E+01	6.1031E+05	1.4615E+01
7.7154E-05	1.1561E+01	8.6964E+05	1.0257E+01
1.0939E-04	8.1539E+00	1.2330E+04	7.2341E+00
1.5510E-04	5.7510E+00	1.7395E+04	5.1277E+00
2.2100E-04	4.0361E+00	2.4786E+04	3.5986E+00
3.1216E-04	2.8321E+00	3.5002E+04	2.5466E+00
4.3126E-04	1.9542E+00	5.0000E+04	3.5126E+00
5.9491E-04	1.3601E+00	7.1963E+04	4.5811E+00
8.2921E-04	9.7028E+00	9.1110E+04	6.7902E+00
1.1680E-03	6.8706E+00	1.2982E+05	9.6706E+00
1.6407E-03	4.8449E+00	1.8407E+05	1.3949E+01
2.3028E-03	3.4008E+00	2.6228E+05	2.0008E+01
3.2306E-03	2.3905E+00	3.7187E+05	2.9905E+01
4.5299E-03	1.6833E+00	5.2989E+05	4.0833E+01
6.3512E-03	1.1874E+00	7.5129E+05	5.8741E+01
8.7932E-03	8.3342E+00	1.0705E+06	8.3342E+01
1.2157E-02	5.8741E+00	1.5176E+06	1.1874E+02
1.7152E-02	4.1448E+00	2.1520E+06	1.6719E+02
2.3933E-02	2.9233E+00	3.0512E+06	2.3240E+02
3.3618E-02	2.0618E+00	4.3261E+06	3.3261E+02
4.7337E-02	1.4547E+00	6.1337E+06	4.7337E+02
6.5606E-02	1.0266E+00	8.7400E+06	6.5606E+02
9.0729E-02	7.1488E+00	1.2392E+07	9.0729E+02
1.2657E-01	5.0416E+00	1.7657E+07	1.2657E+03
1.7491E-01	3.4166E+00	2.4911E+07	1.7491E+03
2.4108E-01	2.4108E+00	3.5496E+07	2.4108E+03
3.3459E-01	1.6459E+00	5.0578E+07	3.3459E+03
4.6712E-01	1.1242E+00	7.1122E+07	4.6712E+03
6.4933E-01	8.0433E+00	1.0218E+08	6.4933E+03
8.9395E-01	5.6874E+00	1.4416E+08	8.9395E+03
1.2439E-01	3.9643E+00	2.0439E+08	1.2439E+04
1.7294E-01	2.7308E+00	2.9427E+08	1.7294E+04
2.4227E-01	2.0164E+00	3.4227E+08	2.4227E+04
3.3261E-01	1.3516E+00	5.0000E+08	3.3261E+04
4.5833E-01	9.5333E+00	7.0000E+08	4.5833E+04
6.3424E-01	6.6924E+00	1.0000E+09	6.3424E+04
8.7400E-01	4.7400E+00	1.4000E+09	8.7400E+04
1.1874E-01	3.1874E+00	2.0000E+09	1.1874E+05
1.6459E-01	2.1645E+00	2.8000E+09	1.6459E+05
2.2341E-01	1.5341E+00	3.9000E+09	2.2341E+05
3.0825E-01	1.0825E+00	5.4000E+09	3.0825E+05
4.2073E-01	8.4207E+00	7.6000E+09	4.2073E+05
5.6927E-01	4.0569E+00	1.0700E+10	5.6927E+05
7.7535E-01	2.9535E+00	1.4600E+10	7.7535E+05
1.0753E-01	2.0753E+00	2.0000E+10	1.0753E+06
1.4592E-01	1.4592E+00	2.8000E+10	1.4592E+06
2.0008E-01	1.0008E+00	3.9000E+10	2.0008E+06

3.1334E-04	2.8466E+00	3.5143E-04	2.5481E+00	3.9414E-04	2.1643E+00
4.4206E-04	2.0170E+00	4.9827E-04	1.7902E+00	5.5884E-04	1.7461E+00
6.2980E-04	1.4161E+00	7.0999E-04	1.2563E+00	7.9629E-04	1.1171E+00
8.9308E-04	9.9874E-01	1.0066E-03	8.6608E-01	1.1798E-03	7.9604E-01
1.2726E-03	7.0092E-01	1.4273E-03	6.2495E-01	1.6087E-03	5.6449E-01
1.8133E-03	4.9180E-01	2.0347E-03	4.3659E-01	2.1879E-03	4.0101E-01
2.5582E-03	3.4867E-01	2.8691E-03	3.1009E-01	3.0430E-03	2.8461E-01
3.6452E-03	2.4469E-01	4.0683E-03	2.1818E-01	4.3492E-03	1.9453E-01
5.1623E-03	1.7259E-01	5.6255E-03	1.5412E-01	6.0434E-03	1.3901E-01
7.3277E-03	1.2178E-01	8.2595E-03	1.0799E-01	8.4736E-03	1.0004E-01
1.0441E-02	8.5425E-02	1.1769E-02	7.1891E-02	1.6204E-02	6.0704E-02
1.4804E-02	6.0251E-02	1.6604E-02	5.2771E-02	1.9624E-02	4.3899E-02
2.0990E-02	4.2485E-02	2.3541E-02	3.7890E-02	2.6743E-02	3.2616E-02
2.9760E-02	2.9972E-02	3.3644E-02	2.6590E-02	3.7623E-02	2.2704E-02
4.2405E-02	2.1034E-02	4.7560E-02	1.8754E-02	5.3608E-02	1.6134E-02
6.0425E-02	1.4762E-02	6.7769E-02	1.3162E-02	7.6001E-02	1.1152E-02
8.5672E-02	1.0411E-02	9.6086E-02	9.2627E-03	1.0832E-02	8.0318E-03
1.2147E-01	7.3421E-03	1.3623E-01	6.5474E-03	1.5779E-02	5.6571E-03
1.7222E-01	5.1792E-03	1.9316E-01	4.5179E-03	2.2172E-02	4.0099E-03
2.4418E-01	3.6529E-03	2.7523E-01	3.2438E-03	3.1863E-02	2.8899E-03
3.4794E-01	2.5636E-03	3.9023E-01	2.2866E-03	4.5894E-02	2.0704E-03
4.9332E-01	1.8061E-03	5.5605E-01	1.6041E-03	6.5004E-02	1.4718E-03
7.0294E-01	1.2689E-03	7.8838E-01	1.1314E-03	9.2656E-02	1.0724E-03
9.9665E-01	8.9508E-04	1.1170E+00	7.9797E-04	1.3047E-02	7.0744E-04
1.4131E+00	6.3123E-04	1.5848E+00	5.6281E-04	1.7864E-02	5.0464E-04
2.0035E+00	4.4521E-04	2.2583E+00	3.9438E-04	2.5328E-02	3.6218E-04
2.8548E+00	3.1244E-04	3.2018E+00	2.7856E-04	3.6044E-02	2.6104E-04
4.0679E+00	2.1927E-04	4.5624E+00	1.9550E-04	5.1169E-02	1.8311E-04
5.7765E+00	1.5465E-04	6.4687E+00	1.3789E-04	7.2429E-02	1.2854E-04
8.1775E+00	1.0908E-04	9.2172E+00	9.6770E-05	1.0338E-01	9.0784E-05
1.1594E+01	7.6931E-05	1.3004E+01	6.8594E-05	1.4657E-01	6.6654E-05
1.6521E+01	5.3990E-05	1.8952E+01	4.8739E-05	2.0696E-01	4.7704E-05

LIBRARY NUMBER = 6

ENERGY (MEV)
THERMAL FLUX SPECTRUM .025 E.V.

FLUX SPECTRUM NO.

6

FLUX SPECTRUM NAME

THERMAL - ROOM TEMP.

MAXIMUM ORDER OF FLUXES -

0

ORDER -- 0 NUMBER OF FLUX POINTS -- 56

0.	1.2197E+04	1.9000E-08	3.7763E+04	2.7000E-08	4.7237E+04
4.0000E-08	5.3815E+04	6.0000E-08	4.8380E+04	1.0000E-07	2.6830E+04
1.7000E-07	1.0273E+04	2.5000E-07	4.9768E+03	3.6000E-07	3.1690E+03
5.5000E-07	1.9417E+03	9.0000E-07	1.1652E+03	1.5000E-06	7.0577E+02
2.3000E-06	4.4743E+02	3.1622E-06	3.2553E+02	5.0000E-06	2.0864E+02
8.0000E-06	1.3663E+02	1.3000E-05	8.5000E+01	2.1000E-05	5.2143E+01
2.9000E-05	3.8086E+01	4.5000E-05	2.5592E+01	7.0000E-05	1.7079E+01
1.1000E-04	1.0742E+01	1.9000E-04	6.3874E+00	2.7000E-04	4.4756E+00
4.0000E-04	3.1048E+00	6.0000E-04	2.0787E+00	1.0000E-03	1.2788E+00
1.7000E-03	7.7151E-01	2.5000E-03	5.1994E-01	3.6000E-03	3.7254E-01
5.5000E-03	2.4276E-01	9.0000E-03	1.5202E-01	2.1000E-02	7.0144E-02
3.6000E-02	4.0361E-02	8.0000E-02	2.0729E-02	1.5000E-01	1.2044E-02
2.3000E-01	7.8565E-03	3.1622E-01	6.2434E-03	4.0000E-01	4.9355E-03
5.0000E-01	3.9477E-03	6.0000E-01	3.2903E-03	6.4430E-01	3.0640E-03
7.0000E-01	2.9666E-03	8.0000E-01	2.7882E-03	9.0000E-01	2.5933E-03
1.0000E+00	2.4037E-03	1.5000E+00	1.5328E-03	2.0000E+00	9.4481E-04
3.0000E+00	3.0260E-04	4.0000E+00	1.0122E-04	5.0000E+00	3.0855E-05
6.0000E+00	9.6133E-06	7.0000E+00	2.8410E-06	1.0000E+01	7.0299E-08
1.5000E+01	1.3673E-10	2.3000E+01	0.

FLUX SPECTRUM NO.

FLUX SPECTRUM NAME

BE-REFLECTOR 0 25 CM

MAXIMUM ORDER OF FLUXES

0

ORDER -- 0 NUMBER OF FLUX POINTS -- 105

1.0000E-20	0.	3.3983E-08	6.7363E-14	6.1900E-08	2.2040E-13
9.2374E-08	4.8573E-13	1.3781E-07	1.0705E-12	2.0558E-07	2.3597E-12
2.5952E-07	3.8541E-12	4.1358E-07	1.0285E-11	5.2410E-07	1.6807E-11
8.3202E-07	4.4839E-11	1.0503E-06	7.3250E-11	1.6738E-06	1.9548E-10
2.1130E-06	3.1934E-10	3.0468E-06	6.9884E-10	4.3834E-06	1.5293E-09
6.3350E-06	3.3468E-09	9.1348E-06	7.3242E-09	1.3172E-05	1.6028E-08
1.9184E-05	3.3846E-08	2.7941E-05	7.1472E-06	4.3387E-05	1.5868E-07
9.5688E-05	6.0203E-07	9.4209E-04	9.3882E-06	1.0837E-03	1.1255E-05
1.3104E-03	1.3172E-05	1.5846E-03	1.5979E-05	1.8971E-03	1.8235E-05
2.2263E-03	2.2363E-05	2.9457E-03	3.0267E-05	3.3546E-03	3.3169E-05
3.7823E-03	3.9036E-05	4.4832E-03	4.7003E-05	7.6932E-03	7.8436E-05
1.0701E-02	9.6648E-05	1.5185E-02	1.5641E-04	2.4788E-02	2.4401E-04
4.7482E-02	4.9122E-04	9.4665E-02	8.9663E-04	1.3367E-01	9.9891E-04
1.8873E-01	1.1496E-03	3.3709E-01	1.1892E-03	5.2340E-01	1.2412E-03
6.5350E-01	8.6937E-04	8.8478E-01	6.5822E-04	1.1036E-00	5.2104E-04
1.2185E-00	4.6525E-04	1.3453E-00	4.1539E-04	1.5505E-00	3.4399E-04
1.7377E-00	3.0316E-04	1.9476E-00	2.6260E-04	2.3582E-00	3.1217E-04
2.4268E-00	1.8865E-04	2.7035E-00	1.5817E-04	3.2640E-00	1.1544E-04
3.4082E-00	1.0046E-04	3.7393E-00	8.1578E-05	4.1025E-00	6.6247E-05
4.3275E-00	5.5258E-05	4.5642E-00	4.6096E-05	4.6884E-00	4.2101E-05
4.9455E-00	3.5110E-05	5.2168E-00	2.9297E-05	5.4854E-00	2.4516E-05
5.7493E-00	2.0581E-05	5.8860E-00	1.8857E-05	6.1693E-00	1.5830E-05
6.3160E-00	1.4594E-05	7.0695E-00	8.8658E-06	7.3742E-00	1.0460E-05
7.6920E-00	5.5997E-06	8.0236E-00	4.4502E-06	8.3694E-00	3.5368E-06
8.6934E-00	2.9825E-06	9.2031E-00	2.3097E-06	9.5593E-00	1.9477E-06
1.0120E-01	1.5083E-06	1.0296E-01	1.2684E-06	1.0476E-01	1.0667E-06
1.0659E-01	8.9698E-07	1.0845E-01	7.5430E-07	1.1035E-01	6.3432E-07
1.1227E-01	5.3342E-07	1.1423E-01	4.4857E-07	1.1623E-01	3.7722E-07
1.1826E-01	3.1722E-07	1.2199E-01	2.2636E-07	1.2309E-01	1.5208E-07
1.2541E-01	1.6300E-07	1.2715E-01	1.3831E-07	1.2892E-01	1.1131E-07
1.3071E-01	9.9594E-08	1.3252E-01	8.4512E-08	1.3437E-01	1.1714E-08
1.3623E-01	6.0854E-08	1.4201E-01	3.1692E-08	1.4549E-01	1.4450E-08
1.5010E-01	1.1937E-08	1.5431E-01	7.3258E-09	1.5865E-01	4.4460E-09
1.6310E-01	2.7593E-09	1.6768E-01	1.6934E-09	1.7239E-01	1.0493E-09
1.7723E-01	6.3783E-10	1.8221E-01	3.9145E-10	2.0000E-01	0.

FLUX SPECTRUM NO.

8

FLUX SPECTRUM NAME

BF REFLECTOR 1 00 2M

MAXIMUM ORDER OF FLUXES

0

ORDER --	0	NUMBER OF FLUX POINTS --	9
1.0000E-20	4.6952E-08	3.3983E-08	4.0663E-08
2.0558E-07	2.3337E-06	5.2210E-07	4.7608E-08
1.3172E-05	2.2501E-07	2.1075E-05	4.5081E-07
1.1422E-04	5.9927E-06	9.4209E-04	4.7799E-05
1.3104E-03	5.9900E-05	1.5846E-03	7.1198E-05
4.4832E-03	1.5194E-04	5.8144E-03	1.9178E-04
1.1986E-02	4.0281E-04	1.5185E-02	4.9494E-04
3.4307E-02	8.5087E-04	4.7482E-02	1.0242E-03
9.4665E-02	1.4322E-03	1.8873E-01	1.4923E-03
4.0196E-01	1.2689E-03	5.2340E-01	1.1075E-03
7.3022E-01	8.0189E-04	8.3159E-01	7.0017E-04
1.0016E+00	5.7350E-04	1.1406E+00	4.9722E-04
1.4927E+00	3.6663E-04	1.6729E+00	3.1626E-04
2.2582E+00	2.0610E-04	2.5158E+00	1.6891E-04
3.1065E+00	1.1283E-04	3.3045E+00	9.7714E-05
3.8560E+00	6.8208E-05	4.1025E+00	5.9073E-05
4.5648E+00	4.1612E-05	4.8152E+00	3.4925E-05
5.2168E+00	2.6154E-05	5.4854E+00	2.2474E-05
5.8860E+00	1.7131E-05	6.1693E+00	1.4295E-05
7.6995E+00	7.9469E-06	7.2202E+00	7.1006E-06
7.6920E+00	5.0650E-06	8.0236E+00	4.0436E-06
8.6934E+00	2.7102E-06	9.2031E+00	2.0847E-06
1.0120E+01	1.3463E-06	1.0296E+01	1.1321E-06
1.0559E+01	8.0066E-07	1.0845E+01	6.7332E-07
1.1227E+01	4.7618E-07	1.1423E+01	4.0045E-07
1.1826E+01	2.8320E-07	1.2193E+01	2.0163E-07
1.2541E+01	1.4451E-07	1.2715E+01	1.2235E-07
1.3071E+01	8.7691E-08	1.3252E+01	7.4239E-08
1.3623E+01	5.3210E-08	1.3813E+01	4.5048E-08
1.4599E+01	3.2633E-08	1.5010E+01	2.7775E-09
1.5865E+01	2.0120E-08	1.6310E+01	1.7125E-09
1.7239E+01	1.2405E-08	1.7723E+01	1.0559E-09
2.0000E+01	3.3695E-09

FLUX SPECTRUM NO. -- 9
 FLUX SPECTRUM NAME -- BE-REFLECTOR 2.22 CM
 MAXIMUM ORDER OF FLUXES -- 3

ORDER --	0	NUMBER OF FLUX POINTS --	94
1.0000E-20	1.2823E-05	3.3983E-08	1.4505E-05
2.1130E-06	1.0365E-04	9.1348E-06	1.7974E-04
1.7383E-04	5.3943E-04	7.2640E-04	8.6207E-04
1.5846E-03	1.0741E-03	2.9457E-03	1.2254E-03
7.6932E-03	1.5611E-03	1.0701E-02	1.6625E-03
2.4788E-02	1.9822E-03	2.6229E-02	2.0071E-03
9.4665E-02	2.2321E-03	1.4321E-01	2.0105E-03
2.8325E-01	1.6035E-03	3.3709E-01	1.4995E-03
4.3893E-01	1.2322E-03	5.8484E-01	9.5749E-04
7.3022E-01	7.5109E-04	8.3159E-01	6.5305E-04
1.1036E+00	4.8337E-04	1.2593E+00	4.2115E-04
1.6729E+00	2.9923E-04	1.8750E+00	2.5679E-04
2.3410E+00	1.7595E-04	2.5158E+00	1.5143E-04
3.1065E+00	9.6725E-05	3.4082E+00	7.7678E-05
4.3275E+00	4.2140E-05	4.5548E+00	3.5447E-05
4.9455E+00	2.7347E-05	5.2168E+00	2.3003E-05
5.8860E+00	1.4587E-05	6.1693E+00	1.2130E-05
6.9219E+00	7.574E-06	7.2202E+00	6.0155E-06
7.6920E+00	4.3147E-06	8.0236E+00	3.4573E-06
8.6934E+00	2.3127E-06	8.8601E+00	2.1131E-06
9.3795E+00	1.6118E-06	9.7426E+00	1.3456E-06
1.0296E+01	9.4638E-07	1.0476E+01	7.9729E-07
1.0845E+01	5.6586E-07	1.1035E+01	4.7672E-07
1.1423E+01	3.3834E-07	1.1623E+01	2.8504E-07
1.2032E+01	2.0230E-07	1.2199E+01	1.5923E-07
1.2541E+01	9.8644E-08	1.2715E+01	7.7641E-08
1.3071E+01	4.8059E-08	1.3252E+01	3.7858E-08
1.3623E+01	2.3453E-08	1.3813E+01	1.8460E-08
1.4599E+01	1.3256E-08	1.5010E+01	1.1233E-08
1.5865E+01	8.0664E-09	1.6310E+01	6.8355E-09
1.7239E+01	4.9085E-09	1.7723E+01	4.1595E-09
2.0000E+01	1.2567E-09

FLUX SPECTRUM NO. -- 10
 FLUX SPECTRUM NAME -- BE-REFLECTOR 4.69 CM
 MAXIMUM ORDER OF FLUXES -- 0

ORDER -- 0 NUMBER OF FLUX POINTS -- 107

1.0009E-20	9.9266E-01	3.3983E-08	6.9137E-01	6.1920E-08	4.4367E-01
9.2374E-08	3.3009E-01	1.3781E-07	2.4558E-01	2.0558E-07	1.8271E-01
2.1130E-06	1.8671E-01	6.3350E-06	1.1704E-01	1.7463E-05	1.6497E-02
4.0735E-05	5.4350E-02	8.5038E-05	4.0708E-02	1.9757E-04	2.9564E-02
3.0923E-04	2.4703E-02	8.6014E-04	1.6359E-02	1.2615E-03	1.4169E-02
1.7653E-03	1.2249E-02	2.4728E-03	1.0465E-02	2.9457E-03	9.7040E-03
3.7823E-03	8.7442E-03	5.8144E-03	7.5572E-03	1.0019E-02	6.2411E-03
1.2748E-02	5.5912E-03	1.5185E-02	5.1493E-03	2.4788E-02	4.8034E-03
3.2148E-02	4.3673E-03	3.9068E-02	4.0684E-03	5.4508E-02	3.6188E-03
7.1833E-02	3.3056E-03	9.4665E-02	3.7196E-03	1.1644E-01	2.6646E-03
1.4321E-01	2.3514E-03	1.7615E-01	2.0749E-03	2.1195E-01	1.8384E-03
2.3802E-01	1.6982E-03	2.8325E-01	1.5077E-03	3.8465E-01	1.1767E-03
4.5867E-01	9.9094E-04	5.4313E-01	8.3411E-04	6.0689E-01	7.3224E-04
7.0369E-01	6.1549E-04	7.8160E-01	5.4647E-04	9.1264E-01	4.6541E-04
1.0331E+00	4.0931E-04	1.1789E+00	3.6029E-04	1.5595E+00	2.6701E-04
1.7377E+00	2.2697E-04	1.8750E+00	2.0367E-04	2.1014E+00	1.7313E-04
2.1784E+00	1.5888E-04	2.3410E+00	1.3380E-04	2.5158E+00	1.1268E-04
2.6080E+00	1.0340E-04	2.8027E+00	8.7082E-05	3.1065E+00	6.8132E-05
3.4082E+00	5.4632E-05	3.6255E+00	4.7153E-05	3.8566E+00	4.0698E-05
4.4446E+00	2.7209E-05	4.6884E+00	2.2947E-05	4.9455E+00	1.9344E-05
5.2168E+00	1.6323E-05	5.6158E+00	1.2422E-05	5.8960E+00	1.0293E-05
6.1693E+00	8.5289E-06	6.4662E+00	7.0672E-06	7.0695E+00	4.7082E-06
7.3742E+00	3.7854E-06	7.6920E+00	3.0435E-06	8.6211E+00	2.4470E-06
8.3694E+00	1.9674E-06	8.5299E+00	1.7951E-06	8.8611E+00	1.4944E-06
9.2031E+00	1.2441E-06	9.5593E+00	1.0357E-06	9.9211E+00	8.6273E-07
1.0120E+01	7.8671E-07	1.0296E+01	6.6372E-07	1.0478E+01	5.5996E-07
1.0659E+01	4.7242E-07	1.0845E+01	3.9856E-07	1.1035E+01	3.3625E-07
1.1227E+01	2.8369E-07	1.1423E+01	2.3934E-07	1.1623E+01	2.0192E-07
1.1826E+01	1.7035E-07	1.2032E+01	1.4372E-07	1.2199E+01	1.1270E-07
1.2369E+01	8.8381E-08	1.2541E+01	6.9307E-08	1.2715E+01	5.4350E-08
1.2932E+01	4.2621E-08	1.3071E+01	3.3422E-08	1.3250E+01	2.6210E-08
1.3437E+01	2.0553E-08	1.3523E+01	1.6118E-08	1.3813E+01	1.2639E-08
1.4201E+01	1.0965E-08	1.4599E+01	8.0155E-09	1.5010E+01	6.3832E-09
1.5431E+01	5.0932E-09	1.5865E+01	4.0481E-09	1.6310E+01	3.2237E-09
1.6768E+01	2.5672E-09	1.7239E+01	2.0444E-09	1.7723E+01	1.6281E-09
1.8221E+01	1.2965E-09	2.0000E+01	1.1177E-10		

Appendix B: Table of Isotopes

Table B1 gives a list of the isotopes and elements currently contained in the LLL evaluated library. Associated with each isotope is its relative atomic mass, and whether all significant reactions have been evaluated. All evaluations span the range 1×10^{-10} to 20 MeV. The isotope number is $1000Z + AM$. If AM is zero, the naturally occurring element, rather than a specific nuclide, is represented. For isomers, the A number of the longest-lived level is taken to be the mass number, e.g., for ^{242}Am , AM = 242. For the shorter-lived level, the AM number is defined to be equal to the mass number plus 600.

Table B1. LLL evaluated library as of April 26, 1971.

Isotope	Chemical symbol	Atomic weight	Reaction evaluation
1001	H	1.007825	Complete
1002	H	2.01410	Complete
1003	H	3.01704	Complete
2003	He	3.01603	Complete
2004	He	4.00260	Complete
3006	Li	6.01513	Complete
3007	Li	7.01601	Complete
4007	Be	7.01000	Complete
4009	Be	9.01219	Complete
5010	B	10.01294	Complete
5011	B	11.0093	Complete
6012	C	12.0000	Complete
7014	N	14.00307	Complete
8016	O	15.99491	Complete
9019	F	18.99840	Complete
11023	Na	22.98977	Complete
12000	Mg	24.312	Complete
12024	Mg	23.985	Incomplete
13027	Al	26.98153	Complete
14000	Si	28.086	Complete
15031	P	30.97376	Complete
16032	S	31.97207	Complete

Table B1. (continued)

Isotope	Chemical symbol	Atomic weight	Reaction evaluation
17000	Cl	35.453	Complete
18000	Ar	39.948	Complete
19000	K	39.102	Complete
20000	Ca	40.08	Complete
21045	Sc	44.95592	Incomplete
22000	Ti	47.40	Complete
23051	V	50.94396	Complete
24000	Cr	51.996	Complete
25055	Mn	54.9381	Complete
26000	Fe	55.847	Complete
26054	Fe	53.9396	Incomplete
26058	Fe	57.9330	Incomplete
27059	Co	58.935	Complete
28058	Ni	57.9353	Complete
29000	Cu	63.54	Complete
29063	Cu	62.930	Incomplete
30064	Zn	63.929	Incomplete
31000	Ga	69.72	Complete
40000	Zr	91.224	Complete
40090	Zr	89.900	Incomplete
41093	Nb	92.9064	Complete
42000	Mo	95.94	Complete
47107	Ag	106.90509	Complete
47109	Ag	108.90476	Complete
48114	Cd	113.90336	Incomplete
48000	Cd	112.40	Complete
49115	In	114.90	Incomplete
50000	Sn	118.69	Complete
56138	Ba	137.9050	Complete
63000	Eu	151.96	Complete
64000	Gd	157.25	Complete
67005	Ho	164.9303	Complete
73181	Ta	180.9480	Complete

Table B1. (continued)

Isotope	Chemical symbol	Atomic weight	Reaction evaluation
74000	W	183.85	Complete
74186	W	183.85	Incomplete
75185	Re	184.9531	Complete
75187	Re	186.9558	Complete
77191	Ir	190.9606	Incomplete
77193	Ir	192.963	Incomplete
78000	Pt	195.09	Complete
79197	Au	196.967	Complete
82000	Pb	207.19	Complete
90232	Th	232.0382	Complete
92233	U	233.0395	Complete
92234	U	234.0409	Complete
92235	U	235.0439	Complete
92236	U	236.0457	Complete
92237	U	237.12275	Complete
92238	U	238.0508	Complete
92239	U	239.12936	Complete
92240	U	240.13181	Complete
93237	Np	237.0400	Complete
93238	Pu	238.0493	Complete
93239	Pu	239.0522	Complete
93240	Pu	240.0540	Complete
93241	Pu	241.13215	Complete
94242	Pu	242.07	Complete
94243	Pu	243.01	Complete
95241	Am	241.03	Complete
95242	Am	242.100	Complete
95243	Am	243.070	Complete
96244	Cm	244.080	Complete
96245	Cm	245.01	Complete
96246	Cm	246.07	Complete
96247	Cm	247.01	Complete

Table B1. (continued)

Isotope	Chemical symbol	Atomic weight	Reaction evaluation
96248	Cm	248.01	Complete
97249	Bk	249.01	Complete
98249	Cf	249.08	Complete
98250	Cf	250.01	Complete
98251	Cf	251.01	Complete
98252	Cf	252.01	Complete
98253	Cf	253.01	Complete
98254	Cf	254.01	Complete
99120	Fiss.Prod.	120.00	Complete

Appendix C: Constants for TABAFR

We define:

$$c_4 = b_1 + c_1$$

$$c_5 = b_2 + c_2$$

$$c_6 = b_3 + c_3$$

$$c_1 = b_4(b_6 + b_8)$$

$$c_2 = b_5(b_6 + b_8) + b_4(b_7 + b_9)$$

$$c_3 = b_5(b_7 + b_9)$$

$$b_1 = pa_3$$

$$b_2 = pa_4 + qa_3$$

$$b_3 = qa_4$$

$$b_4 = r - p$$

$$b_5 = s - q$$

$$b_6 = e \cdot a_3$$

$$b_7 = e \cdot a_4$$

$$b_8 = \frac{f}{2} a_6$$

$$b_9 = \frac{f}{2} a_7$$

Constants for TABXFR (continued).

where

$$t = -1/(\tilde{E}_k - \tilde{E}_{k+1})$$

$$c = -f\tilde{E}_k$$

$$p = \pi^q(E_i \rightarrow \tilde{E}_k) - \frac{E_i}{E_i - E_{i+1}} [\pi^q(E_i \rightarrow \tilde{E}_k) - \pi^q(E_{i+1} \rightarrow \tilde{E}_k)]$$

$$q = \frac{1}{E_i - E_{i+1}} [\pi^q(E_i \rightarrow \tilde{E}_k) - \pi^q(E_{i+1} \rightarrow \tilde{E}_k)]$$

$$r = \pi^q(E_i \rightarrow \tilde{E}_{k+1}) - \frac{E_i}{E_i - E_{i+1}} [\pi^q(E_i \rightarrow \tilde{E}_{k+1}) - \pi^q(E_{i+1} \rightarrow \tilde{E}_{k+1})]$$

$$s = \frac{1}{E_i - E_{k+1}} [\pi^q(E_i \rightarrow \tilde{E}_{k+1}) - \pi^q(E_{i+1} \rightarrow \tilde{E}_{k+1})]$$

Further definitions are:

$$d_1 = c_{10}c_{13}$$

$$d_2 = c_{10}c_{14} + c_{11}c_{13}$$

$$d_3 = c_{10}c_{15} + c_{11}c_{14} + c_{12}c_{13}$$

$$d_4 = c_{10}c_{16} + c_{11}c_{15} + c_{12}c_{14}$$

$$d_5 = c_{10}c_{17} + c_{11}c_{16} + c_{12}c_{15}$$

$$d_6 = c_{11}c_{17} + c_{12}c_{16}$$

$$d_7 = c_{12}c_{17}$$

Constants for TABXFR. (continued)

Further definitions (continued)

$$c_{13} = c_7 c_4$$

$$c_{14} = c_7 c_5 + c_4 c_8$$

$$c_{15} = c_7 c_6 + c_5 c_8 + c_9 c_4$$

$$c_{16} = c_6 c_8 + c_9 c_5$$

$$c_{17} = c_6 c_9$$

$$c_7 = gt$$

$$c_8 = gu + th$$

$$c_9 = hu$$

$$c_{10} = a_8 v$$

$$c_{11} = a_8 w + a_9 v$$

$$c_{12} = a_9 w$$

MSG/gw