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**ZODIAC (2 + 2) :
A REVISION TO ZODIAC 2**

R. H. HOLEMAN AND D. D. MATSUMOTO

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ZODIAC(2+2): A REVISION TO ZODIAC2

ABSTRACT

The addition of HRG to the 7090 burnup chain ZODIAC2 is described. Reorganization and expansion of cross-section libraries are explained. Revised input instructions are given.

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INTRODUCTION

The ZODIAC2 code has been modified and enlarged to increase the capabilities of this code to handle burnup analysis. The primary change was the inclusion of the superior epithermal cross-section averaging code HRG as an optional alternative to GAM. Further changes were made to COMBO, TEMPEST, SIGMA-3H, and REFIRE.

Libraries for the codes TEMPEST, HRG (GAM), and SIGMA-3H have undergone reorganization and expansion to the extent that Composite Library Tapes (CLT's) previously used are not compatible with current versions of these codes. At present, both current and obsolescent versions of these three codes are included on the chain tape. Hence the name ZODIAC(2+2).

A brief statement describing the nature of the changes will be given as additional user information to the ZODIAC2 USER'S MANUAL.⁽¹⁾ Input is described only where the previous documentation is obsolete. The origin and effect of the CLT changes are discussed.

COMPOSITE LIBRARY TAPES

The CLT of the past was an arrangement of cross-sections used by TEMPEST and GAM, and an array of isotope names and correlated TEMPEST and GAM isotope identification numbers known as the SIGMA-3H library. The TEMPEST and GAM library cross-sections were essentially those libraries obtained by importation from other sites, and then modified by changes or additions to the set. The SIGMA-3H library was correspondingly modified to maintain compatibility.

At the time that the addition of HRG to the ZODIAC2 chain was undertaken, it was decided to begin a reordering of the isotopes on the HRG library. This was prompted by the impending addition of a number of fuel cross-sections from different sources (Sher, Westcott, Leonard, etc.) and the continuing growth of the library. Also, due to the genesis of the HRG library (GAM library plus additional resonance tables, etc.), there was no meaningful order to the library.

The nature of HRG isotope rearrangement was twofold: one requirement was the grouping of isotopes and/or elements into categories such as moderator materials, structure materials and fuel; another equally important qualification was the need to group those isotopes used most at the front of the library to decrease library read time. Consideration was given to both requirements in the manner of grouping the library isotopes. There were seventeen isotopes and/or elements ordered by moderator, structure, and fuel to comprise the first cycle of those cross-sections used most. There were thirty-nine in the second cycle, seventy-two in the third cycle, and one-hundred and nine in the fourth and last cycle. It was felt that any additional isotopes to the existing library would be justifiably placed in cycle four because of the limited amount of use.

The SIGMA-3H library arrangement and content, as documented,⁽²⁾ was completely overhauled. As a replacement for the type 1, 2 and 3 card, there is now a two-card record for every isotope and/or element. The first of these two cards contain identification numbers for SIGMA-3H, HRG, and TEMPEST, and the decay constant which has been left in for possible use in CLERK input. The second card contains all the multipliers for TEMPEST and HRG as described in HW-81691. Also included are the thermal $\chi(5)$ value for forming TEMPEST Σ_g cross-sections were needed, and the thermal ν value. The yields and capture fractions in the older SIGMA-3H libraries were a carryover from the SIGMA-3C for CALX and have been deleted from this new arrangement. The resulting SIGMA-3H library is arranged in the same order as the new HRG library, but includes eighteen isotopes which appeared in the old SIGMA-3H library but were not found on the new HRG. These isotopes were placed at the end of the SIGMA-3H library with sufficient room left between them and the last HRG isotopes to allow additions to the HRG library. Also the identification numbers are now all left-shifted with no preceeding blanks, and their corresponding names are significantly different from their former spelling. It is recommended that the user consult the proper SIGMA-3H library listing when making up his input.

The TEMPEST library has been completely reordered except for two conditions: none of the present code-dependent unit cross-sections have been removed, and the TEMPEST formalism of absorption numbers from 1-99, sigma fission 100-199, etc. has not been changed.

The only other significant thing about the rearranged CLT is that it is essentially based on the Hanford Basic Library for its source of cross-section values.

ZODIAC(2+2) CHAIN TAPES

The changes made to COMBO, SIGMA-3H, and REFIRE were necessitated by the library rearrangement. The changes in TEMPEST are a result of making the TEMPEST library with large binary records which can be read faster than the single binary card records of older TEMPEST libraries.

The original ZODIAC2 links still exist on the ZODIAC(2+2) chain so that all older CLT's from Physics Chain or ZODIAC2 on the 7090 could be handled with one chain system. However, there have been changes in the link numbers associated with the different segments of the code.

<u>Link</u>	<u>Code</u>	
18	FIREUP	: no change
19	COMBO	: reads new or old CLT's
03	TEMPEST	: uses E. L. Kelley's large record libraries
13	TEMPEST	: uses old BINRD one-card record libraries
04,02	GAM _{1,2}	: no change
14,12	HRG _{1,2}	: added to chain
06	SIGMA-3H	: handles only new rearranged CLT's
16	SIGMA-3H	: handles only old CLT's
05	HFN	: no change
20	CLERK	: no change
23	ALCHEMY	: no change
24	REFIRE	: contains burnable isotopes for both libraries (new and old) in separate tables.
25	DEBUG	: gives SIGMA-3H listing if requested

INPUT INSTRUCTIONS

Listed below are only those input instructions which differ from previous documentation.

18 FIREUP

Columns 10-12, Format 13, Debug switch, IDUM. If IDUM is positive, a listing of the SIGMA-3H library is produced from whatever CLT the user requests. A negative option remains as described by the ZODIAC2 User's Manual, page 20.

19 CMBOZ2

Format 1, location 14, NSET, data type. NSET = 1 means TEMPEST-GAM and NSET = 2 means TEMPEST-HRG.

03, 13 TEMPEST

Input parameters are the same as before, but TEMPEST link 03 reads the library more quickly and runs faster.

04, 14 GAM, HRG

Input is the same for both codes. Note: The identifying code for columns 73-80 of HRG data cards is GAM, exactly as described in ZODIAC2 input instructions for GAM(ZODIAC2 User's Manual, pages 17, 29, and 30).

06 SIGMA-3H

Input is as documented for Locations 1-2673, with three exceptions. The COMMON area beyond Location 5298 is entirely different due to library enlargement. All affected input locations are given.

<u>FORMAT</u>	<u>LOC</u>	<u>NAME</u>	<u>DATA DESCRIPTION</u>
1	17	IMIX	Number of mixtures which must be made ($ IMIX \leq 10$, including gross fission products). IMIX = 0, no mixing. IMIX > 0, make IMIX mixtures for HFN. IMIX < 0, make $ IMIX $ mixtures for EXTERMINATOR.
1	431	MISC(93)	Cross section output option. MISC(93) = 0, make HFN Data Tape. MISC(93) > 0, make data tape for EXTERMINATOR/ ASSAULT MISC(93) < 0, punch cross sections.
None	432	MISC(94)	Used internally. Do not input to this location.
0	21048-21051		Thermal shielding gamma's (was 20418-20421).
0	21052-21055	*	Pu240 resonance shielding gamma's, old formulation (was 20422-20425).
0	21056-21060	*	Pu240 resonance shielding gamma's, new formulation (was 20426-20430).
0	21061-21460	FACT	Fraction of the calculated shielding factor to be used to shield thermal cross sections.

* Two different formulations may be used in computing depression fractor of Pu240 shielding. See R. H. Holeman.

16 SIGMA-3H

Input parameters are the same as before; old CLT's used by this link.

05 HFN

No change.

20 CLERK

The spherical geometry option in location 11 now can handle spherical annuli. The volume equation is now $V = (4\pi/3)(D_2^3 - D_1^3)$.

23 ALCHEMY

No change.

24 REFIRE

No input change necessary.

REFERENCES

- (1) D. D. Matsumoto and G. J. Busselman, ZODIAC2 User's Manual, HW-83577.
Hanford Atomic Products Operations, Richland, Washington, October, 1964.
- (2) J. L. Carter and E. L. Kelley, SIGMA-3 Library, HW-81691. Hanford Atomic
Products Operations, Richland, Washington, December, 1964.

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