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EXPANDA-GENERAL USER'S GUIDE

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EXPANDA-General User's Guide

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Generalized EXPANDA ; EXPANDA-General : A one-dimensional diffusion criticality and perturbation code has been developed based on the code EXPANDA-70DRA. The new code has following characteristics;

- (1) Variable dimensioned coding is adopted. Hence this code is completely free from dimensional restrictions encountered at the fixed dimensioned code. There are no limitations for number of energy groups, regions, mesh points.
- (2) Acceptable all of the libraries ; JAERI-Fast set, JENDL-1 and 2 set, ENDF/B IV set.
- (3) Possibility of exact perturbation calculation as well as first order perturbation .
- (4) Semi-automatic preparation of input data for two or three dimensional criticality calculation codes ; CITATION or EXTERMINATOR-2.
- (5) Semi automatic preparation of input data for two or three dimensional perturbation calculation codes ; CIPER or PERKY.
- (6) More accurate treatment for elastic removal effective cross sections for light and medium weight nuclides in the resonance region using exact weighting fluxes solved by recurrence formulae numerically.
- (7) Proper treatment for gross region heterogeneity due to the large material change at the interface of regions.
- (8) More efficient and easy treatment for the comparison of C/E (calculated to experimental) values of typical integral data obtained by the benchmark test in order to assess the applicability of the group cross section libraries.
- (9) Adoption of self-explanation systems in the group cross section library : General-Library, i.e. all of the informations to define the library are contained in that library itself. Therefore any structured library such as any group number and any independent parameters of self-shielding factor tables is accessed by this new code.

This report is prepared as the reference manual for the users of EXPANDA-General.

Keywords : EXPANDA-General, One-dimensional Diffusion Code, EXPANDA-70DRA, JAERI-Fast Set, JENDL-1, JENDL-2, ENDF/B-IV, First Order Perturbation, Exact Perturbation, CITATION, EXTERMINATOR-2, CIPER, PERKY, Manual

EXPANDA-General コード使用手引書

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従来原研で開発され続けてきた 1 次元拡散臨界および摂動計算コード EXPANDA シリーズを総合して一般化した EXPANDA-General が、EXPANDA-70DRA を元に開発された。本コードは以下のような特長を有している。

- (1) 可変ディメンションによるコーディングの為、従来からの固定ディメンション・サイズによる不便さが解消された。任意エネルギー群、任意領域数、任意メッシュ数がとれる。
- (2) JAERI-Fast, JENDL-1 および 2, ENDF/B-V の各炉定数セットが使用できる。
- (3) 1 次摂動のみでなく、Exact Perturbation 計算が可能である。
- (4) 2 次元、3 次元拡散コード CITATION や EXTERMINATOR-II への入力作成が容易である。
- (5) 2 次元、3 次元摂動計算コード CIPER や PERKY への入力作成が容易である。
- (6) 軽中重核の共鳴領域における実効弹性除去断面積のより正確な取り扱いを、当該領域の詳細スペクトルを純数値的に解き直すことにより求める手法により行う。
- (7) 領域境界に存在する、構成物質の違いに基く非均質性を、適当な補助境界領域を設けて実効断面積を定義しなおすことにより、考慮している。
- (8) 炉定数ファイルの適用性評価作業の為のある特定の選定されたベンチマーク・テストに対する計算値対実験値の比較が容易かつ効率よく出来る。
- (9) 炉定数ライブラリーを規定する各種パラメータ(群数、自己遮蔽因子テーブルのパラメータ(温度 T, background cross section σ_0 , 対 ^{238}U 原子個数比))のライブラリー内収容により、任意構造の炉定数の使用が可能である。

本報告書は EXPANDA-General の使用手引書としてまとめられたものである。

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1. Introduction

The development of EXPANDA series has been continued progressively up to now from the first development of EXPANDA /1/. For the criticality calculation and first order perturbation calculation, EXPANDA-70D /2/ was developed from EXPANDA-4 /3/ and SIMPLE-D /4/. This code gained the position of the standard code coupled with JAERI-Fast 70 group constants /5,6,7/.

Next EXPANDA-70DRA /8/ was developed in order to furnish more accurate treatment of the elastic removal cross section in the resonance energy region of light and medium weight nuclides using exact weighting fluxes solved by recurrence formulas numerically. At the same time an option for exact perturbation calculation was introduced to this code.

These codes are indispensable for the analysis of fast reactor neutronic characteristics due to the fact that those codes are coupled tightly with JAERI-Fast set library. By this reason those codes gain so many users in our country. From users, many requests are sent to authors to extend those code as variable dimensioned, so as to be able to execute those codes completely free from the restrictions due to the fixed dimensioned programs.

Meanwhile it is pointed out that there are some problems in using flat cross section in one region when analyzing the reaction rate distributions near the region boundary whose materials are largely different. In such regions, actual cross sections near boundary region have some effects from adjacent region, therefore the cross section of this region are expressed as some combination of the cross section for those adjacent regions. The method to predict the actual cross section in the sub-region near the interface due to the gross region heterogeneity was developed by ISHIGURO /9/. The adoption of this method to EXPANDA series was decided.

At the same time, in the original library key parameters of group cross section library (for ex. number of energy groups, self-shielding factor table parameters such as σ_0 values or T: temperature or R: number density ratio to U-238 etc.) are implicitly defined for each library. Therefore users always should keep in mind that which option should be specified to run the code with proper library. Several times great confusions occurred. To avoid those difficulties, we decided to develop a new group cross section library whose key parameters are self-explained in the library itself. This new library system, we call it as General-Library.

From those three reasons, we started the work of EXPANDA-General development.

2. DEVELOPMENT OF EXPANDA-GENERAL: Generalisation of EXPANDA-70DRA

It has been recognized among the users that so many restrictions were imposed on the code of EXPANDA series.

These restrictions are as follows;

1. Library restrictions: acceptable libraries tightly depends on the code, for example JAERI-Fast Set, ENDSF/B Set or JENDL Set /10/.
2. Restriction for the specification of the dimensional parameters: number of maximum region, number of nuclides in one library, number of mesh points in one region ,etc. From these restrictions, calculational reactor systems were considerably affected in some cases. To remove these restrictions, variable dimensioned EXPANDA-70DRA was developed. At the same time, we defined a new generalized library file for JAERI-Fast Set and a fine group scattering cross section library to recalculate the effective elastic removal cross section using fine spectra of the weighting flux. In the following texts, we call the JAERI-Fast Set with generalized format as General-Library and also generalized EXPANDA-70DRA as EXPANDA-General. For the old format of JAERI-Fast set, we call it as Original-Library.

2.1 GENERALIZATION OF LIBRARY: explicit introduction of parameter values

1.NUMBER OF NUCLIDES IN THE LIBRARY:

In the Original-Library, the number of nuclides is fixed as 20, therefore in the code of EXPANDA-70DRA, the number of allowable nuclides is the same as that library. We remove this restriction to treat any number of nuclides in the library. In the General-Library, the number of nuclides is given as the general information in the General-Library(variable name:LNMAX) the control for the nuclides related variables is treated through variable 'LNMAX', no restriction is imposed on this number.

2.FISSION SPECTRUM

In the Original-Library, only one fission spectrum was allowed for all nuclides. From this restriction, we had to make several files for each fission spectra. This is very inefficient for the use of DISK space, because except the fission spectra, files are identically same. To enhance the effective use of DISK space ,for the General-Library, several fission spectra are incorporated in one library. In the EXPANDA-General, all fission spectra are read in from the General-Library and one fission spectra will be selected.

At the present time, mixing of fission spectra is not allowed.

For the moment, the dominant fissionable nuclide code number should be specified in the input data to select out the fission-spectra.

3.PARAMETER OF SELF-SHIELDING FACTOR TABLES

In the Original-Library, the number of parameters to the self-shielding factor tables is completely fixed, i.e. 3 values for temperature : 'T', 6 values for back-ground cross section : σ_0 , 2 values for fissionable number density ratio to that of U-238 : 'R'. These parameter values are completely fixed implicitly, for example 'T' : 300., 900., 2100. degree in kelvin.

In the General-Library, the number of parameters and those values are defined explicitly in the library. Therefore any structured self-shielding parameter tables are acceptable not only in the library but also in the code of EXPANDA-General. However the parameter categories are unchanged, i.e. 'T', ' σ_0 ', 'R'. The number of parameters for these categories is referred by the variable 'MTX', 'MXSIG0', 'MXR' respectively in the code.

4.SWITCHING PARAMETERS FOR SELF-SHIELDING FACTOR TABLE SEARCH

In the code of EXPANDA-70DRA, 3 parameters 'NC1', 'NC2', 'NC3' represents the group number for triggering the search of 'f-table' of JAERI-FAST set type, i.e. 'R' search or 'f-er' search, Where 'R' search means search to 'R' parameters and 'f-er' search means f-table search to elastic removal cross section. These three parameters are effective only for the fissionable nuclides: i.e. U-235, U-238, Pu-239, Pu-240, Pu-241.

In the General-Library, these parameter values should be specified for all nuclides. Those parameters are referred in the code as one dimensional array 'NR(N):N=1,LNMAX'. For the nuclides which do not need the search for 'R' parameter, NR number should be specified the last energy group number. In such case, search for 'R' parameter will be skipped for all energy groups. In the Original-Library, for the nuclides unnecessary for 'R' parameter search, the same f-table data are given for 'R1', 'R2' value in order to give the same results as one of the skipped case. For the code of EXPANDA-GENERAL , these restrictions are completely removed.

5.CONSISTENT TREATMENT OF SCATTERING MATRICES.

In the Original-Library, allowable down scattering group number is defined as the common number for both of elastic scattering and inelastic scattering. For the General-Library, allowable down scattering group number is given separately. However, scattering matrices used in the EXPANDA code is defined as the sum of elastic scattering and inelastic scattering matrices.

Therefore allowable down scattering group number is defined as the largest one of the two.

For the Original-Library, inelastic scattering matrices include the $(n,2n)$ matrices at the generation time of this library. For the General-Library, inelastic scattering and $(n,2n)$ matrices are given as independent one. And if necessary, one can treat $(n,3n)$ matrices independently. Also any Legendre components of their individual scattering process are acceptable in this library.

Matrices normalization are as follows:

$$\bar{\sigma}_e^i = \sum_j (\bar{\sigma}_e^{i \rightarrow j})_0 \quad (j = i+0, i+1, \dots, i+MXDNSE)$$

$$\bar{\sigma}_{in}^i = \sum_j (\bar{\sigma}_{in}^{i \rightarrow j})_0 \quad (j = i+0, i+1, \dots, i+MXDSNI)$$

$$\bar{\sigma}_{n,2n}^i = \frac{1}{2} \sum_j (\bar{\sigma}_{n,2n}^{i \rightarrow j})_0 \quad (j = i+0, i+1, \dots, i+MXDNS2)$$

Where i means energy group, 'MXDNSE', 'MXDSNI', 'MXDNS2' mean allowable maximum down scattering energy group number for elastic, inelastic, $(n,2n)$ respectively. And suffix of bracket 0 means P_0 component.

2.2 GENERALIZATION OF SUBROUTINE RECUR

The code EXPANDA-70DRA is designed to use more accurate elastic removal cross sections defined from exact weighting fluxes obtained by solving the slowing down equations numerically and using the fine group scattering cross sections for the nuclides important to the reactivity effects in the sodium cooled fast breeder reactors. This rigorous treatment is applied only for the following 3 nuclides; Na: Cooling materials, a large resonance at 2.85kev Fe: Structural materials, a large resonance at 24kev O: Fuel compounds as UO₂ or PuO₂-UO₂ a deep anisotropic resonance scattering cross section profile from 100 keV to 2 MeV.

In the code EXPANDA-70DRA, this accurate treatment is applied only for the 3 nuclides above described. In accordance with the generalization of the code EXPANDA-70DRA and its library, subroutine RECUR was generalized to apply those treatments to any nuclides in the General-Library. Here after descriptions for the generalization of RECUR subroutine are given.

1. LIBRARY OF FINE SCATTERING CROSS SECTIONS

Fine scattering cross sections necessary for recalculating of elastic removal cross sections are defined by DATA statement in EXPANDA-70DRA. Contrary to this, in EXPANDA-General these fine scattering cross section are given from the file produced by the processing code RECDTA and RECDTB /11/. Only brief discussions are given in next paragraph.

Evaluated nuclear data file with ENDF/B Format are considered as the source library. Adding the smooth cross section part (File:3) and resonance part (File:2), fine group averaged cross sections are generated only for required energy range and required nuclides. The generated fine group cross section are consisted from following 3 reactions i.e. σ_t , σ_{el} and μ . And these data are stored in temporally file in variable records format. Those records become as input data to RECDTB.

RECDTB makes two logical files : P0 & P1 parts-considered nuclides (File1) and P0 part-considered nuclides (File2) using the output from RECDTA.

File1 corresponds to the energy range characterized by the strong anisotropic scattering of Oxygen i.e. from 300 keV to 1.8 MeV. File2 corresponds to the energy range of sodium or iron characteristic large resonance scattering. In both energy range , up to 5 nuclides are allowed. These restrictions are arisen from the codes of RECDTA and RECDTB , these restrictions are free from EXPANDA-General. The code-number of the nuclide in the library should be consistent among the files. Nuclides in the File1 and File2 must be appeared in the General-Library.

Energy range in File1 and File2 should not be overlapped and those energy range are defined by input data in the RECDTA code. For both File1 and File2, energy boundary in each nuclides should be coincide each other.

File1 and File2 are logically separated in one file. Therefore there is no tape-marks between these 2 data files.

2. PROBLEM OF GENERALIZATION OF FINE SCATTERING CROSS SECTION LIBRARY RELATING TO THE JAERI-FAST SET.

In the EXPANDA-70DRA, relations between the energy boundary of the coarse group (General-Library) and energy range of solving the slowing down equations, and also the relations between fine group structure and allowable down scattering groups are given by DATA statements. Therefore many restrictions are given to the code, for examples;

- 1.) acceptable libraries are fixed as JAERI-Fast set.
- 2.) number of nuclides in the library is fixed as 18 and the order of them is fixed .
- 3.) number of heavy nuclides in one library is fixed as 8 and their code number should be the range from 900 to 999, where heavy nuclides are fissile or fertile elements.
- 4.) For the recalculating of elastic removal cross sections,

this code cannot accept lighter elements than carbon because of the scattering matrices treatments.

For these restrictions,

As to 1.) by using the automatical index setting for the recalculation of elastic removal cross sections, comparing between the energy range of the fine scattering cross sections library and group structure of General-File.

As to 2.); code number of the nuclides in the fine scattering cross section library are forced to coincide with the number in the General-Library and the nuclides to be recalculated are chosen automatically in the code.

As to 3.); heavy nuclides are identified by the atomic weight.

As to 4.); there is no restriction for the dimension size, but this problem is not completely solved yet because of the difficulty of programming.

2.3 OTHER GENERALIZATION

In order to remove the restriction to the reactor systems to be solved, control variables such as maximum region number, maximum mesh number, number of nuclides allowed in one region are defined as 'KMAX', 'MSHREG', 'KNMAX' respectively. The array size and control variables in 'DO' loop related to those numbers are completely 'VARIABLED'.

However number of nuclides in one region should not exceed the number of nuclides in the library. And the mesh numbering at the interface of different region should be even number. These restrictions are always existing due to the algorithm used.

2.4 HOW TO CALCULATE THE MEMORY SIZE NECESSARY IN THE CODE EXPANDA-General

In EXPANDA-General, all of the dimensioned array are treated as 'VALIABLE-DIMENSION' array. Then the usable dimension size of one dimensional array in main routine should be assigned. The length of this one dimensional array depends on the systems to be calculated. For examples, it depends on the region number, nuclides number contained in one region, mesh division in one region and parameters of the specification of the RECUR-Library.

Necessary dimensions are calculated from following expressions.

KMAX: number of regions
 KNMAX: maximum number of nuclides in one region
 LNMAX: number of nuclides in GENERAL-Library
 IMAX: number of energy groups
 LAPSE: number of energy group for collapsing
 NFILE: =2
 NMXR1: number of nuclides in FILE1 of fine scattering cross section library i.e. RECUR-Library.
 NMXR2: number of nuclides in FILE2 of fine scattering cross section library i.e. RECUR-Library.
 IDS1: allowable down scattering group number for elastic matrices.
 =IDS+1 ; see input parameter of EXPANDA-General
 NMXR: =MAX0(NMXR1,NMXR2)
 JNMAX1: 1st energy group number of the FILE1 of RECUR-Library correspond to the energy group of GENERAL-LIBRARY.
 JNMAX2: 1st energy group number of the FILE2 of RECUR-Library correspond to the energy group of GENERAL-LIBRARY.
 JNMAX: =JNMAX1+JNMAX2
 MSHKRG: total mesh number of all region + 1
 MSHREG: total mesh number of all region + KMAX
 JLDMAX: =3

```

L1 = KMAX * ( 19 + KNMAX * ( 2 * JNMAX * ( 3 + JLDMAX ) + 5 )
              + 4 * ( NMXR1 * JNMAX1 + NMXR2 * JNMAX2 )
              + NMXR1 + IMAX * ( 14 + IDS1 ) )
              + KNMAX * ( 25 + IDS1 ) + MSHREG * 8 + LNMAX
              + IMAX * ( MSHREG * 2 + 5 ) + LAPSE
              + NFILE * ( 1 + NMXR * KMAX )

L2 = KMAX * ( 7 + KNMAX + ( 18 + IDS1 ) * IMAX + MSHKRG * 3 )
      + IMAX * ( 19 + MSHKRG * 2 + MAX0( IDS1 * KMAX , MSHKRG ) )
      + MAX0( KMAX*MSHKRG , IMAX*IDS1 ) + MSHKRG*8 + LAPSE

L = MAX0( L1,L2 )
  
```

This L means the necessary dimension size.
 Any number larger than L should be given for one dimensional array size in main program to assure the calculation flow consistent.
 Load module for the EXPANDA-GENERAL in FACOM 230/75 occupies about 73k-words for instruction only when we use the standard overlay structure as shown in 4-2-(ii) .

The required core memory is

$$\text{Core-size (k-words)} = 73 + (L / 1024) + LS$$

Where LS is buffer area allocated dynamically at the execution step. (in k-words unit)

3. ADDITIONAL FEATURES IN EXPANDA-General

From the fact that EXPANDA-70DRA is the subset of EXPANDA-General, EXPANDA-General succeeds all features of EXPANDA-70DRA. In addition to that some features are newly incorporated to the EXPANDA-General. Those are followings: space dependent effective cross section treatments between the region boundaries, and new editing functions for collapsed group cross sections. Those features are described here afer.

3.1 UTILIZATION OF ORIGINAL-LIBRARY

In chapter 2, generalization of EXPANDA-70DRA and Original-Library are described particulary to the points of the generalization of the code and library. However, EXPANDA-General accept not only GENERAL-LIBRARY but also Original-Library as input data library. While EXPANDA-70DRA accept only for LTFR801 Library, EXPANDA-General accepts all of the Original-Library; i.e. LTFR901, LTFR919 or LTFR915 etc. The selection of the library are performed through the input data in the EXPANDA-General.

Also we supply the format conversion utility 'GFJPRD' /11/ to reformatting from Original-Library to General-Library.

3.2 ADDITIONAL EDITING FEATURES FOR GROUP COLLAPSING

The results from one dimensional calculation of EXPANDA series are often utilized as the input data for the integral data calculation systems to check the nuclear data applicability. Those integral data are as follows; effective multiplication factor, spectral indices, sampleworth, reaction rate traverses, etc. This calculation flow is performed by EXPANDA-General, XPRTC and BENCH for one dimensional problems. We have mentioned them already.

And also the results from this code are used to prepare the input data of few group cross sections to multi-dimensional criticality calculation code. Those collapsing are performed in subroutine 'EDIT', and the collapsed data are printed in line printer or transferred to some files. It was quite combersome work to arrange the input data for multi-dimensional calculation code (for example 'CITATION' or 'EXTERMINATOR') from these data. Hence systematization of these work is requested, more specifically main items are following three items:

1. preparation of few group macroscopic cross sections for multi-dimensional criticality calculation code.
2. preparation of few group macroscopic or microscopic cross

- sections for multi-dimensional perturbation code.
3. preparation of few group micro cross sections for reaction rate mapping in multi-dimensional geometry.

For multi-dimensional diffusion code ; 'CITATION' was selected to be linked among the codes utilized in JAERI. For multi-dimensional perturbation calculation code ; 'CIPER' was selected. And for reaction rate mapping; 'POSTCIT' /11/ was selected to couple with EXPANDA-General. Applying these scheme , many calculation options are incorporated into the code EXPANDA-General. The detailed description for each option are given in the next chapter, here we mention briefly the functions.

1. EDITING OF COLLAPSED CROSS SECTIONS

- a.preparation of region dependent collapsed macro cross sections for 'CITATION' or 'EXTERMINATOR'.
- b.preparation of region dependent collapsed macro cross sections for each reference case and perturbed case to be used in 'CIPER': two dimensional perturbation calculation. At the same time, considering the possibility of using the code 'PERKY' : two dimensional perturbation code, region dependent collapsed micro cross sections of all nuclides are also edited by the option.
For the collapsing, real fluxes of reference case will be chosen for first order perturbation case, and for the exact perturbation case, real fluxes of perturbed case will be used by the option.
- c.the micro cross section collapsed in b) are also used as reaction rate mapping calculation in 'POSTCIT'.

2. OUTPUT OF COLLAPSED CROSS SECTIONS.

There are two possibilities for output type in EXPANDA-GENERAL
(i) the format for 'CITATION'. The output are directly used as input data for 'CITATION'. (ii) temporary data file intending to the input data for 'CITINP' : utility routine to prepare citation input data by the manipulation of those data.

'CITINP' was developed so as to select out any combination of weighting fluxes and the region dependent macro cross sections obtained by several executions of 1-dimensional model calculation . Then it is possible to select and assign more resembling real fluxes for collapsing. When several cases of flux calculation are performed sequentially in one job step in EXPANDA-General , collapsed cross section are output in one file. 'CITINP' accept these cases. It can select out any position's macro cross sections in such file.

This code is very powerful tool for survey calculations of reactor systems.

Performing the calculation of two dimensional perturbation, several cases of perturbation are performed by EXPANDA-General in one step. And any combination of output macro cross

section for each cases (reference and perturbed case) are possible to assign macro cross sections for every perturbed or unperturbed regions. At the moment, such flexibility are only allowed for 'CITATION' input data. For 'EXTERMINATOR-2', only direct use of 'EXTERMINATOR-2' output are allowed.

3. 2-DIMENSIONAL DIFFUSION AND PERTURBATION CALCULATIONAL FLOW INTENDED BY 'EXPANDA-GENERAL'.

For the summary up to here, the system flow diagram of the codes 'EXPANDA-GENERAL', 'CITINP', 'CITATION', 'CIPER', 'POST CIT' are given in Fig. 3-2-1.

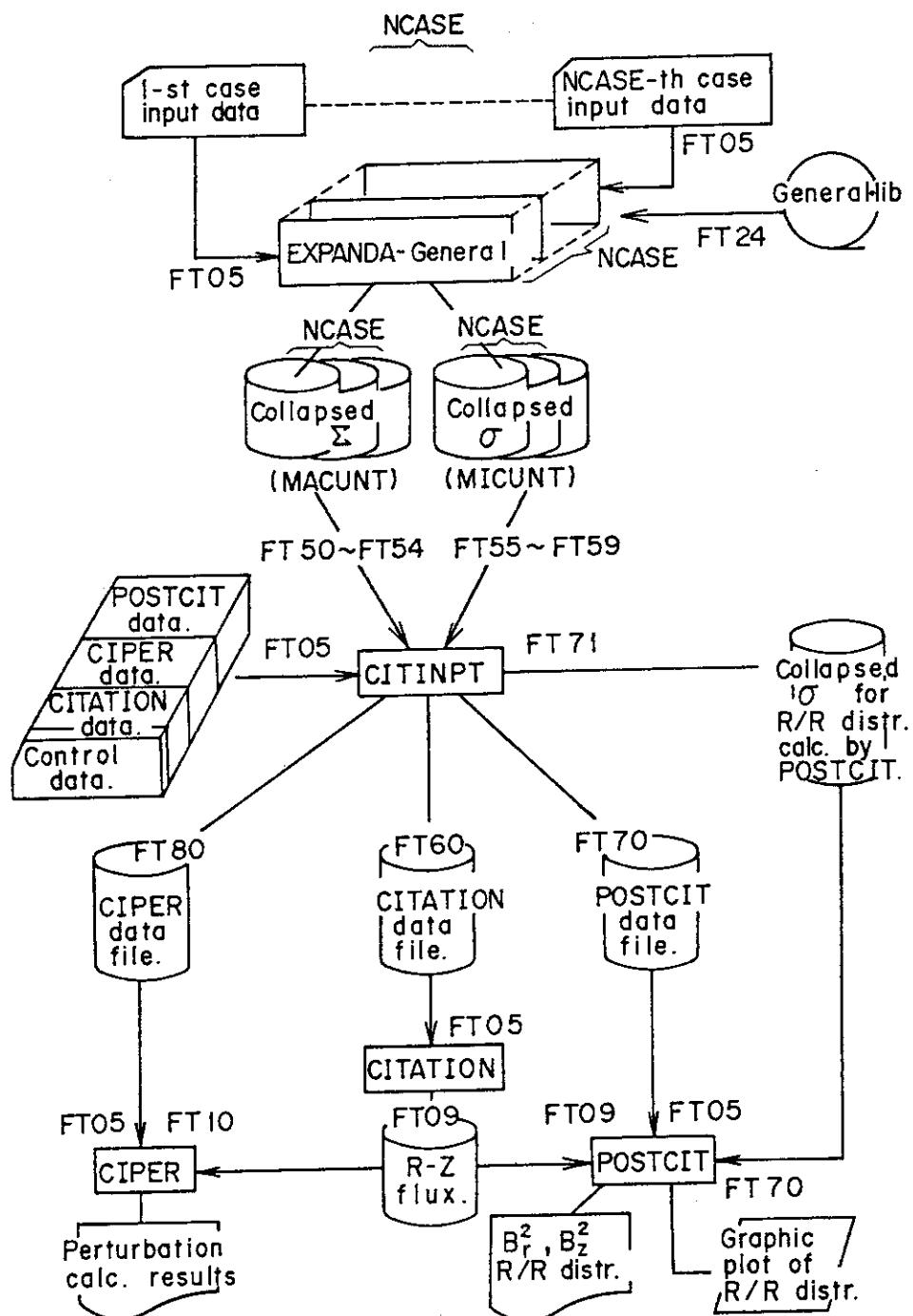


Fig.3-2-1 The system flow chart of two dimensional criticality perturbation, and reaction rate distribution calculation

3.3 RELATION TO THE 'BENCH' CODE: an output editing program for the comparison among huge amounts of integral data

When a new cross section library is generated or some parts of the library are changed, we should perform the benchmark test to ensure the applicability of the library. For the benchmark test two different attitudes are existing; 1: perform the detailed analysis as practical as possible using the rigorous model and exact calculational method, this type of benchmark test aims to test not only data oriented problems but also including the analytical method. The other attitude is; 2: to test the applicability of the library to the simple physical integrated quantity using rather simple analytical method in order to chooseout the data oriented problems. To perform these benchmark test for both cases , the number of benchmark test problems becomes more and more increased , it is very important to calculate them systematically in one through flow and the large output from them should be handled easily to point out the problems in the library. To relax those needs, EXPANDA-General preserves one logical unit for typical integral data-output . The benchmark test of previous attitude are somewhat independent each other, hence nothing special treatments are taken in this code . But even for this case, efficiency of performing benchmark test will be greatly enhanced using the method stated in chapter 3.2.

For the benchmark test of the latter attitude, huge amounts of data should be handled and arranged so as to chooseout easily the problems in the nuclear data. This type of work is rather tedious. In 'EXPANDA-GENERAL' in order to reduce those tedious data manipulations for some special integral data such as keff, spectral indices, sample worths are output to disk file.

And a code 'BENCH' /11/ will be used for the rearragements of the output for these integral data, at the same time statistical analysis for these data are available.

3.4 TREATRMENT FOR GROSS REGION HETEROGENEITY: accurate treatment of neutronic behavior at region interface

In the EXPANDA series developped up to now, effective cross sections used in the code are defined as region dependent cross sections without taking into account the adjacent regions. In one region, effective cross sections inside that region are independent of the position. This type of treatments is common to the usual core neutronic codes. But it does not give the accurate flux shape or accurate reaction rates near the region boundaries where the material compositions are largely changed (for example between core

and blanket interfaces).

In this EXPANDA-General, to overcome those difficulty, one option was introduced for accurate treatment of gross region heterogeneity. A new region was automatically introduced inside that region where the composition are quite different between the regions. This new region, we call it as 'boundary region'. This region size is determined from the mean free path of the adjacent regions. In this boundary region, effective cross sections are newly defined from both composition of the adjacent regions and the cross section values will be nearly average values of the two adjacent regions. Hence we expect this treatment leads the results more realistic ones than the treatment traditional.

Process flow for this space dependent effective cross section treatment is given here after. Now we mention briefly the process.

Nuclides for which this treatment applied are restricted to the following 5 nuclides; U-235, U-238, Pu-239, Pu-240, Pu-241. In the code, the potential scattering cross section are given by 'DATA' statement, then generalisation of calculational flow for this treatments is not accomplished yet.

(i) GENERATION OF 'BOUNDARY REGION'

'BOUNDARY REGION' for recalculating the space dependent effective microscopic cross section will be generated automatically in the region where the material composition of adjacent regions are largely changed. But for the vacuum boundary or the region of special purpose especially specified by input (for example central perturbation region), generation of 'BOUNDARY REGION' will be skipped.

The thickness of 'BOUNDARY REGION' 'd' is calculated from the following equation using the pseudo macroscopic total cross sections summing up the minimum values of group cross section below the resonance energy region for non-resonant nuclides.

$$d = \frac{1.3}{\sum_t^{\min}} \quad (3-4-1)$$

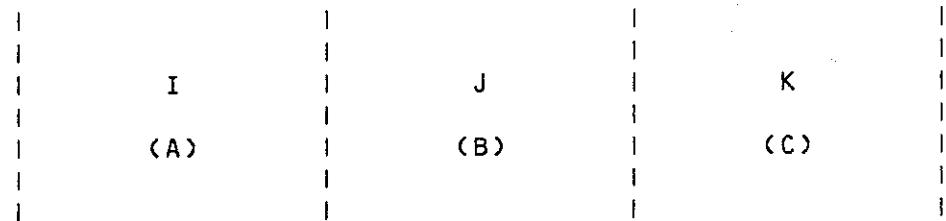
where \sum_t^{\min} is the sum of total cross section of non resonant nuclides (except 5 nuclides stated before) and the potential scattering cross section for the resonant nuclides.

When 'BOUNDARY REGION' will be generated in the region considered, following situations may be encountered frequently. That is, 'd' is smaller than the original region mesh sizes or it exceeds the region size. In such cases, generation of new region and new mesh division taken by the option will be stated below.

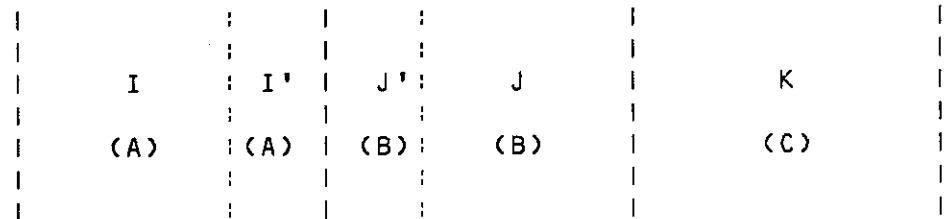
In the explanation, we intend to explain about the following three region systems choosen out from any calculation systems. We represent those three regions as I,J,K and their compositions as A,B,C respectively.

1) AUTOMATIC GENERATION OF 'BOUNDARY-REGION'

case a. A=B=C: no generation of 'BOUNDARY-REGION'

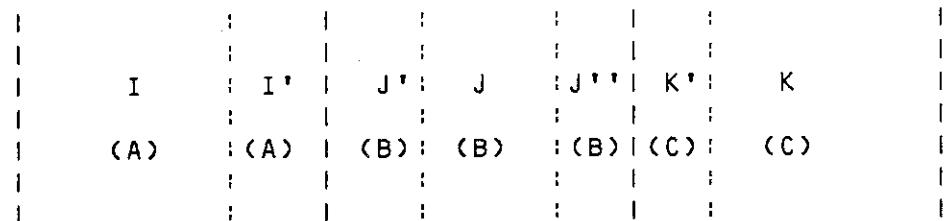


case b. A≠B, B=C : 'BOUNDARY-REGION' of I' and J' will be generated.



case c. A≠B, B≠C : 'BOUNDARY-REGION' of I', J', J'', K' will be generated.

In this case, relation between material (A) and (C) is not considered.



2).RELATION TO MESH DIVISION FOR 'BOUNDARY-REGION' and 'ORIGINAL-REGION'.

Here we explain only for J region of above examples.

a.) 'BOUNDARY-REGION' is generated in one side only. (case b in 1))
Now we use following notation :

L : region width of original region J

$N_{\text{mesh}}^{J'}$: mesh division number in original region J

Δ : mesh width in original region J

and after the generation of 'BOUNDARY-REGION', region width, mesh division number, mesh width are represented as

$d_{J'} \rightarrow N_{\text{mesh}}^{J'}$, $\Delta_{J'} \rightarrow \Delta_{J'}$, for 'BOUNDARY-REGION' J' and

$d_J \rightarrow N_{\text{mesh}}^J$, $\Delta_J \rightarrow \Delta_J$, for the rest 'ORIGINAL-REGION'.

For the case $(d_{J'} / L) < \alpha$ (α is fixed as 1.3 in the code)

$$N_{\text{mesh}}^{J'} = d_{J'} / \Delta$$

$$d_{J'} = \Delta * N_{\text{mesh}}^{J'} \text{ (redefined)}$$

$$\text{if } \text{Mod}(N_{\text{mesh}}^{J'}, 2) \neq 0 \text{ then } N_{\text{mesh}}^{J'} = N_{\text{mesh}}^{J'} + 1$$

$$\text{if } N_{\text{mesh}}^{J'} \leq 2 \text{ then } N_{\text{mesh}}^{J'} = 4$$

$$N_{\text{mesh}}^J = N_{\text{mesh}} - N_{\text{mesh}}^{J'}$$

$$\text{if } N_{\text{mesh}}^{J'} > (N_{\text{mesh}} - 2) \text{ then follow the next example.}$$

For the case $(d_{J'} / L) \geq \alpha$

Generation of 'BOUNDARY-REGION' will be made, but the thickness of this region is independent of Σ_e^{in} , and space dependent cross section calculation will be skipped and effective cross section of original region is applied for this region.

Mesh division is follows:

$$N_{\text{mesh}}^{J'} = N_{\text{mesh}} / 2$$

Mod ($N_{\text{mesh}}^{J'}$, 2) $\neq 0$ $N_{\text{mesh}}^{J'} \leq 2$ then follow above case.

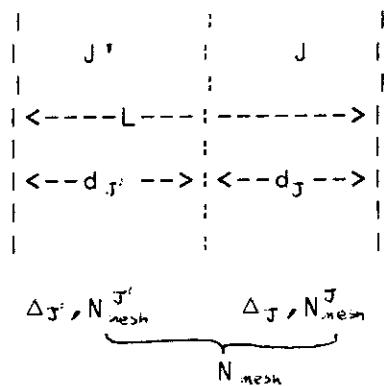
$$\text{next } N_{\text{mesh}}^J = N_{\text{mesh}} - N_{\text{mesh}}^{J'}$$

Using the data of $N_{\text{mesh}}^{J'}$, N_{mesh}^J , $d_{J'}$ defined above,

mesh widths for the region J and J' : $\Delta_{J'}$, Δ_J will be redefined

$$\Delta_{J'} = d_{J'} / N_{\text{mesh}}^{J'}$$

$$\Delta_J = (L - d_{J'}) / N_{\text{mesh}}^J$$



b. 'BOUNDARY-REGIONS' are generated both sides in the 'ORIGINAL-REGION'
(case c in (1))

Following notations will be used for mesh width, number of mesh,
and region width for 'BOUNDARY-REGION' of J' and J'' , for the
rest 'ORIGINAL-REGION' J as

$$J' : d_{J'} , N_{\text{mesh}}^{J'}, \Delta_{J'}$$

J : d_J , N_{mesh}^J , Δ_J after the generation of 'BOUNDARY-REGION'.

$$J'' : d_{J''} , N_{\text{mesh}}^{J''} , \Delta_{J''}$$

respectively, and original input data for them are represented as

J : L , N_{mesh} , Δ before the generation of 'BOUNDARY-REGION'

For the case $(2 * d_{J'}) / L < \alpha$

$$N_{\text{mesh}}^{J'} = d_{J'} / \Delta = N_{\text{mesh}}^{J''}$$

$$\text{if } \text{Mod}(N_{\text{mesh}}^{J'}, 2) \neq 0 \text{ then } N_{\text{mesh}}^{J'} = N_{\text{mesh}}^{J'} + 1 = N_{\text{mesh}}^{J''}$$

$$\text{if } N_{\text{mesh}}^{J'} \leq 2 \text{ then } N_{\text{mesh}}^{J'} = 4 = N_{\text{mesh}}^{J''}$$

$$\text{we redefine } N_{\text{mesh}}^J ; N_{\text{mesh}}^J = N_{\text{mesh}} - N_{\text{mesh}}^{J'} - N_{\text{mesh}}^{J''}$$

$$\text{where if } N_{\text{mesh}}^{J'} + N_{\text{mesh}}^{J''} = 2 * N_{\text{mesh}}^{J'} > (N_{\text{mesh}} - 2) \text{ then}$$

$$\begin{aligned} N_{\text{mesh}}^{J''} &= N_{\text{mesh}} / 2 \\ N_{\text{mesh}}^{J'} &= N_{\text{mesh}}^{J''} / 2 \end{aligned}$$

if $\text{Mod}(N_{\text{mesh}}, 2) \neq 0$ then $N_{\text{mesh}}^{J'} = N_{\text{mesh}}^{J''} + 1$
 (the same for $N_{\text{mesh}}^{J''}$)

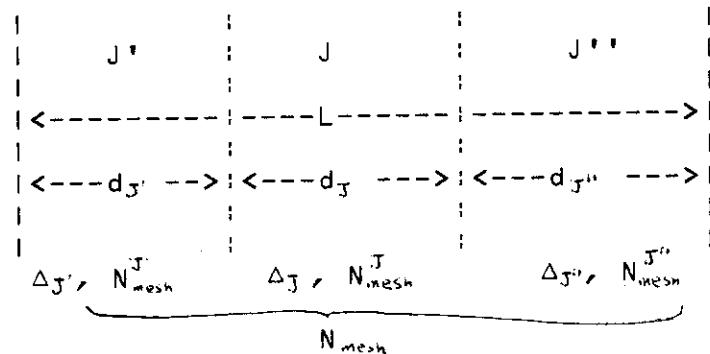
For the case $(2 * d_J / L) \geq \alpha$, 'BOUNDARY-REGION' will be generated, but space dependent cross section calculation will be skipped for this region. Effective cross section in the 'ORIGINAL-REGION' will be taken for this region.

$$N_{\text{mesh}}^{J'} = N_{\text{mesh}}^{J''} = 4$$

$$N_{\text{mesh}}^J = N_{\text{mesh}} - 8$$

if $N_{\text{mesh}} \leq 2$ then $N_{\text{mesh}}^J = 4$

$$\Delta_{J'} = \Delta_{J''} = \Delta_J = L / (N_{\text{mesh}}^{J'} + N_{\text{mesh}}^{J''} + N_{\text{mesh}}^J)$$



(iii) CALCULATION OF SPACE DEPENDENT EFFECTIVE CROSS SECTION FOR GENERATED 'BOUNDARY-REGION'

In the 'BOUNDARY-REGIONS' generated as described in the previous section, space dependent effective cross sections will be calculated through the following two steps.

First step is the self-shielding factor search stage for redefined σ_0 of the 'BOUNDARY-REGION' considered. Modified $\sigma_0 *$ is calculated from the following expression using 'BOUNDARY-REGION' thickness 'd' (where constant Ca is fixed as 1.3 in the program).

$$(\sigma_0 *)_m = (\sigma_0)_m + Ca / (2 \cdot d \cdot N_m) \quad (3-4-2)$$

$$\text{where } (\sigma_0)_m = \sum_{n \neq m} (\sigma_0)_m N_m / N_n \quad (3-4-3)$$

n, m : nuclide

N, N : number density for the nuclide.

The second step is space dependent effective cross section calculation stage from mixing the effective cross sections for 'ORIGINAL-REGION', 'ADJACENT-REGION', 'BOUNDARY-REGION'.

(I) calculation of effective cross section for 'BOUNDARY-REGION'

Here we suppose two 'BOUNDARY-REGION' I' and J' are introduced into the 'ORIGINAL-REGION' I and J. Effective cross section for nuclide M and reaction X will be expressed as $(\overline{\sigma}_{eff}^X)_M^{I,J}$ ($K=I, J, I', J'$). Effective cross sections for 'BOUNDARY-REGION' are searched using $\sigma_0 *$ described above.

Space-dependent effective cross section $(\overline{\sigma}_{eff}^X)_M^{I,J}$ is defined as:

$$(\overline{\sigma}_{eff}^X)_M^{I'} = \frac{C_I^M (\sigma_{eff}^X)_M^I + D_I^M (\sigma_{eff}^X)_M^J + H_I^M (\sigma_{eff}^X)_M^{I'}}{C_I^M + D_I^M + H_I^M} \quad (3-4-4)$$

$$(\overline{\sigma}_{eff}^X)_M^{J'} = \frac{C_J^M (\sigma_{eff}^X)_M^I + D_J^M (\sigma_{eff}^X)_M^J + H_J^M (\sigma_{eff}^X)_M^{J'}}{C_J^M + D_J^M + H_J^M} \quad (3-4-5)$$

I	I'	J'	J
$(\sigma_{eff}^x)_M^{I'}$	$(\sigma_{eff}^x)_M^{J'}$		
$(\sigma_{eff}^x)_M^I$	$(\sigma_{eff}^x)_M^{I'}$	$(\sigma_{eff}^x)_M^{J'}$	$(\sigma_{eff}^x)_M^J$
$\leftarrow d_I \rightarrow$	$\leftarrow d_{J'} \rightarrow$		

Where $C_{I,J}^M$ is fixed as 0.5 (constant).
 But strict speaking, these values reflect the fluxes in each region,

$$C_I = \begin{cases} r_L F_I & (I' = I+1, \text{ i.e. 'BOUNDARY REGION' is right}) \\ = r_R F_I & (I' = I-1, \text{ i.e. 'BOUNDARY REGION' is left}) \end{cases}$$

$\tau_{L,R}$: coefficients depends on the geometry and the distance from the center. $r_L + r_R = 1.0$.
 In the code we set $r_L = r_R = 0.5$.

F_I : region average flux. For taking into account the effects to space dependence from the fluxes.
 In the code we set $F_I = 1.0$.

Other constants are defined as follows;

$$D_I^M = \frac{N_J^M \Sigma_I^* C_J^M}{N_J^M ((\Sigma_c^M)_I + \Sigma_I^*) - N_I^M (\Sigma_c^M)_J} \quad (3-4-6)$$

$$H_I^M = \frac{((1.0 - C_I^M) (\Sigma_c^M)_I - (N_I^M/N_J^M) (\Sigma_c^M)_J D_I^M)}{(\Sigma_c^M)_I + \Sigma_I^*} \quad (3-4-7)$$

where $\Sigma_I^* = C_a / 2 \cdot d_I$ (3-4-8)

$$(\Sigma_c^M)_I = (\Sigma_t)_I - N_I^M (\sigma_{eff}^t)_I^M + N_I^M \sigma_p^M \quad (3-4-9)$$

In the above expression, N_K^M (M : nuclide and K : I, J, I', J')

: region) represents the number density for nuclides M in
region K.

4. How to use EXPANDA-General

4.1 Input instruction for EXPANDA-General

#102 Card : (20A4)

(HEAD(I), I=1,20)

HEAD(1) to HEAD(18) ; Title for this job step.

HEAD(19) to HEAD(20) ; Library identification or benchmark test identification. This identification is valuable when several benchmark test were done using different group cross section library. These data are used at the BENCH code-step for the selective comparison of the calculated integral data to identify the results from each other.

These data are only output to logical unit 15 as becoming the input data to BENCH code.

A Card : (11I6)

(NS , IFX , NP , IMX , ISKIPD , ISIGP , MPMIN ,
MPMAX , I7 , ITAPE, IOUT1)

NS ; Indicator of the macroscopic cross sections for perturbed case.

NS = 0 --- $\Sigma' = N' \sigma$. where σ represents the effective microscopic cross section of reference case, i.e. effective cross sections due to perturbation (material change or temperature change) will not be calculated. Hence for the perturbation calculation such as the temperature effect, this option leads to zero perturbation result.

For the density perturbation case, if this option is specified when performing perturbation for any nuclides which are not presented in the reference case, erroneous results are obtained. To avoid this error, user should prepare the numberdensity input for this nuclide in reference case in such a way that assigning 0.0 number density only to define cross sections for this nuclide. Such perturbation is

thought to be the zero perturbation limit.

$NS \neq 0$ --- $\Sigma' = N' \sigma'$. where σ' represents the effective microscopic cross section of perturbed case, i.e. self-shielding factor search will be performed according to the perturbation condition(temperature or density change). Normal option.

IFX ; Flux calculation option.

IFX= 1 ; Calculate keff , Φ , Φ^* .
Normal option.

IFX= 2 ; keff , Φ , Φ^* are read from logical unit 13. In this case, data are read only for the first case in the file on this logical unit. If the second case data or latter case one are requested, IFX= $\pm 2nn$ option should be used.

IFX= 3 ; The data of keff , Φ , Φ^* are read from card unit(FT05). For this case, # S3 and # S5 cards are necessary.

IFX= 2nn ; From several keff , Φ , Φ^* data sets on the logical unit 13, nn-th set will be selected as input data. Several data sets on the logical unit 13 must have been created in one job step prior to this run.

IFX=-2nn ; After the IFX= 2nn option specified first, successively the next set of data for keff , Φ , Φ^* are read and used for perturbation calculation.

In this case, no rewind applied to logical unit 13. This option was introduced to accomplish the run of the perturbation calculation successively for the restart case in order to save the core duration time resulting from rewinding for this unit.

NB. When IFX= $\pm 2nn$ option is assigned, a file necessary to logical unit 13 is the file created on the logical unit 14 of the run prior to this job. For the restart case, this file should be assigned to logical unit 13 and for the logical unit 14, a work file should be assigned only enough space for one case of keff, Φ , Φ^ data.

NP ; Punch out option for Φ and Φ^* .

NP $\neq 0$ --- Punch out Φ and Φ^* for the restart

case to the perturbation step. (IFX= 3)

NP = 0 --- No punch out.

*NB. NS,IFX,NP are necessary only for the perturbation calculation case , ISKIPD= ±1 .

IMX ; Number of energy groups in the group-constant library. IMX must be equal to IMX in #1 card.

ISKIPD ; Perturbation calculation option.

ISKIPD = 0 --- Execute flux and criticality calculation only for each set of #1 to #9 cards.

ISKIPD = 1 --- Execute first order perturbation calculation. The first set of data from #1 to #9 cards is the reference case,for which flux and criticality calculation is executed. And the succeeding sets are perturbed case,for which first order perturbation calculations are to be executed.

ISKIPD = -1 --- Execute exact perterbation calcu-
lation. The flux and criticality calculation is
executed not only for the reference case but also
for the succeeding case. The exact perturbation
calculations are executed using the perturbed real
flux Φ and the unperturbed adjoint flux Φ^* .
And in such a case, logical units 25 and 26 must be
assigned for work files.

Logical unit 25 --- Real flux Φ ,of each
perturbed case.

Logical unit 26 --- Adjoint flux Φ^*
of the reference case.
(unperturbed.)

ISIGP ; Selecting option for writing the collapsed group constants.

ISIGP = 0 --- Collapsing option I7, LASPSE (#1 card), IX (#4 card) are used. The collapsed macroscopic cross sections are written on the logical unit whose number is specified by the option I7. This collapsing is performed in subroutine EDIT.

ISIGP= 1 --- The same collapsing is made as previous one, but this option has the advantage of the output print control using # C card. (# C card should be

required.)

ISIGP= 10 --- Collapsed microscopic cross sections are output to line printer or disk file through the direction of write-out control in # C card. These outputs are available for all cases in one job step including not only criticality calculation but also perturbation calculation. At the collapsing stage in the perturbation case , for first order perturbation , real flux of reference case is taken as the weighting flux and for exact perturbation , real flux of perturbed case is selected.

If this option specified at the perturbation case, NS ≠ 0 should be assigned in # A card. If NS = 0 is specified, for all cases the same reference case data (unperturbed one) will be output.

ISIGP= 11 --- Collapsed macroscopic cross sections , which are constructed from microscopic collapsed data and number density data, are output to line printer or disk unit using write-out control option specified in # C card. Those output records become input data to 'CIPER' through the code 'CITINP' /11/.

ISIGP= 20 --- This option covers both functions ISIGP=1 and ISIGP=11.

NB. For ISIGP=11, collapsed micro and macro cross sections are available. The output control for each data is possible independently using # C card.

MPMIN ; Nuclide-wise and reaction-wise effective microscopic cross sections are printed out by group with f-values(self-shielding factor). MPMIN indicates the first group number from which they are printed out. If MPMIN=0 , MPMIN is set to the maximum group number, hence the prints of them will be omitted.

MPMAX ; The above prints terminates at MPMAX-th group. If MPMAX=0 , then MPMAX is set to 1, and the prints will be skipped.

I7 ; Write out option for the macroscopic cross sections of fine-group and collapsed one. And also the option for the heterogeneity correction for effective microscopic cross sections.

I7 = 0 --- The fine group and the collapsed macroscopic cross sections will not be output. And the heterogeneity correction will not be performed.

I7 = 1 --- The fine group macroscopic cross sections are output on logical unit 7. The collapsed ones are not output, and the heterogeneity corrections are not performed.

I7= 1 or 8 --- The fine group macroscopic cross sections are written on logical unit 1 or 8. The collapsed ones are not written and the heterogeneity corrections are not performed.

I7= -1nn --- The collapsed macroscopic cross sections are written on the logical unit nn, according to the same format as 'section 008' cards of CITATION. (with fission spectrum.) This option is exercised when ISIGP=0 and LAPSE≠0, in this case the collapsed macroscopic cross sections are calculated in subroutine EDIT. But if ISIGP≠0 and LAPSE≠0, then the group collapsing will be done in subroutine COND and for this option I7 will not be exercised. (Option specified in #C card will be exercised.)
 The collapsed data generated by this option will be directly used for the 'section 008' cards in 'CITATION', i.e. they will be edited by the input generator 'CITINPT' and these data will be assigned to the arbitrary regions in two dimensional model for CITATION. In each collapsed data record, the labeled region number corresponds to the number used in one dimensional model.

I7 = -2nn --- Write-out the collapsed macroscopic cross sections on logical unit nn according to the same format as EXTERMINATOR-II.

I7 = -11nn --- The heterogeneity correction for the effective microscopic cross sections will be made in the region whose number will be specified by #B card , and write out the collapsed macroscopic cross sections on logical unit nn according to the same format as that used when I7=-1nn, for all regions.

I7= -12nn --- Same as the above, except that the collapsed macroscopic cross sections will be written in the same format as that used when

I7=-2nn.

I7= -21nn --- The heterogeneity correction for effective microscopic cross sections will be done in the region specified by #B card, and write the collapsed macroscopic cross sections on logical unit nn only for that region, according to the same format as that used when I7=-1nn.

I7= -22nn --- Same as above, except that the collapsed macroscopic cross sections will be written in the same format as that when I7=-2nn.

ITPE ; Indicator to the group constant library.

ITPE = -11 --- JAERI-Fast Version-II 25-group set in original format.

ITPE = -10 --- JAERI-Fast Version-II 70-group set in original format.

ITPE = -2 --- JAERI-Fast Version-I 25-group set in original format.

ITPE = -1 --- JAERI-Fast Version-I 70-group set in original format.

ITPE = 0 --- JAERI-Fast Version-I 70-group set in general format.

ITPE = 1 --- JAERI-Fast Version-I 25-group set in general format.

ITPE = 10 --- JAERI-Fast Version-II 70-group set in general format.

ITPE = 11 --- JAERI-Fast Version-II 25-group set in general format.

ITPE = N, ≠ 0,1,10,11 --- Other group constant library in general format.

IOUT1 ; Option to calculate more accurate effective elastic removal cross sections in resonance energy region by subroutine RECUR. If IOUT1 is positive-integer this calculation will be performed using the fine group scattering cross section library produced by RECDTB.

And when IOUT1 is a negative-integer, the built-in fine group scattering cross section data will be used.

IOUT1 = 0 or 10 --- This calculation will be skipped completely.

IOUT1 = $\pm 1 \sim \pm 4$ --- This calculation will not be applied for the nuclides in File-1 i.e. oxygen, and also for the regions with a very high concentration of heavy nuclides. (see ref. /8/)

IOUT1 = $\pm 11 \sim \pm 14$ --- This calculation will be forced to perform when the case that the number densities of the nuclides in File-1,2 i.e. oxygen, Na, Fe are not zeros.
If this option is specified, sometimes unphysical fluxes are obtained where the resonance region of oxygen and for the region of heavy nuclides concentration is very high such as blanket region.

NB. Normally IOUT = $\pm 1 \sim \pm 4$.

IOUT1	Print	Plot
± 1 or ± 11	OFF	OFF
± 2 or ± 12	ON	OFF
± 3 or ± 13	OFF	ON
± 4 or ± 14	ON	ON

where Print-ON case, flux,current,macroscopic total cross section and redefined effective cross sections are print out. And Plot-On case, fine group weighting fluxes solved by RECUR and total macroscopic cross section will be plotted.

B Card : (I6, 6X, 2E12.5)

(KHET, ELBAR, HETROA)

KHET ; The region number in which the heterogeneity correction for effective microscopic cross section will be applied. The corrected effective microscopic cross section is given by the f-value which has been searched with the corrected σ_0 parameter σ_0^* defined as follows.

$$\sigma_{o,j}^* = \sigma_{o,j} + HETROA / (N_j * ELBAR)$$

where j indicates nuclide and N_j is the number density of this nuclide j.

ELBAR ; Mean chord length.

HETROA ; The area of the surface common to the next region to KHET-th region.

C Card : (816)

(MACMIN, MACMAX, MAXDWN, MACUNT, MICMIN, MICMAX,
MICDWN, MICUNT)

MACMIN ; The group number from which the collapsed macroscopic cross sections are printed out.
MACMIN = 0 --- No print.

MACMAX ; The group number until which the collapsed macroscopic cross sections are printed out.
MACMAX = 0 --- No print.

MACDWN ; The components of the collapsed scattering matrix in the group range MACMIN to MACMAX will be printed out until MACDWN-th sink group. And the sign of MACDWN is an option to print the collapsed data that are calculated by subroutine COND and written on logical unit MACUNT.

MACDWN = +N --- Print $\Sigma^{i,j}$ in the group range $j=i$ to $j=i+N$, and print all of the collapsed macroscopic cross sections that were calculated by subroutine COND (not EDIT) and written on logical unit MACUNT.

MACDWN = 0 --- No print.

MACDWN = -N --- Print $\Sigma^{i,j}$ in the group range $j=i$ to $j=i+N$, but the collapsed data on logical unit MACUNT will not be printed.

MACUNT ; Option to write the collapsed data on a logical unit.

MACUNT = +N --- Write the collapsed macroscopic cross section calculated by subroutine COND on logical unit N, and print them according to the print

option MACMIN and MACMAX. (all of the collapsed data are written on logical unit N.)

MACUNT = 0 --- Print only.

MACUNT = -N --- No print. But the collapsed data for all groups will be written on logical unit N.

MICMIN, MICMAX ; The same options as MACMIN and MACMAX for the collapsed microscopic cross sections.

MICDWN ; The components of the collapsed microscopic scattering matrix in the group range MICMIN to MICMAX will be printed out until MICDWN-th sink group. And the sign of MICDWN has the following meanings.

MICDWN = +N --- Print ($\sigma_e^{i,j} + \sigma_{in}^{i,j}$) in the group range $j=i$ to $j=i+N$.

MICDWN = 0 --- No print.

MICDWN = -N --- Print $\sigma_e^{i,j}$ and $\sigma_{in}^{i,j}$ in the group range $j=i$ to $j=i+N$

MICUNT ; The same option as MACUNT for the collapsed microscopic cross section calculated by subroutine COND (CONDMIC).

0 Card : (I1, I6, 9I1, 3I3, 1X, 13A4, I2)

(LAST, NPROB, (ICARD(I), I=1,9), ICARD8, ICARD9, IBOPT, (TITLE(I), I=1,13), ICARD4)

LAST ; Calculation terminator. LAST = 0 : Not the last case. At the end of the input data stream, LAST = 1 must be specified in #103 card.

NPROB ; Problem number.

NPROB = N --- Input Δr , or use the Δr input or used in the previous problem.

NPROB = -N --- Use the Δr searched in the previous problem, or use the Δr used in the critical calculation case, if the Δr wasn't searched in the previous problem.

ICARD(I); The card identification numbers that will be given for this problem. (Card number ; #1 to #9.) The data should be arranged succeedingly. It is not permitted to use blank character between the two succeeding data. The cards except for #4, #7, #9 cards are always necessary in the 1-st case.
For example 123568 .

ICARD8 ; Number of #8 cards.

ICARD9 ; Number of #9 cards.

ILOPT ; Option for space and composition dependent effective microscopic cross section calculation.

ILOPT = -1 --- Normal effective microscopic cross section calculation.

$$\sigma_{\text{eff}} = f(\sigma_0, R, T) * \sigma_\infty .$$

ILOPT = 0 --- Calculate the space and composition dependent microscopic cross sections.
See section 3-4 of Boundary correction.

ILOPT = N --- Calculate normal effective cross sections for N regions whose region numbers are specified in #16 card, and for the rest regions the space and composition dependent cross sections are calculated.

TITLE(I) ; Comment for this problem. (52 characters.)

ICARD4 ; Number of #4 cards.

1 Card ; (13I3, 5E6.0)

(NO, KMAX, ISYM, IMAX, ICRIT, ISW, IDS, KREG,
IP, NADJ, IBR, IBSQM, LAPSE, EPS1, EPS2,
DRMIN, DRMAX, RAM2)

NO ; Card id. NO = 1 for this card.

KMAX ; Number of regions.

ISYM ; Option for the boundary condition at the origin.

ISYM = +1 --- $\Phi'(0) = 0$. In this case, the numerical

integration is extended to the image part for slab geometry, IP = 0.

ISYM = -1 --- $\Phi(0) = 0$.

IMAX ; Number of energy groups. IMAX must be equal to IMX (#A card).

ICRIT ; Option for criticality search using dimensional search.

ICRIT = 1 --- Δr adjustment will be performed in the region KREG specified in this card.

ICRIT = 0 --- no adjustment.

ISW ; Option for prints of calculated results.

ISW = +2 --- Σ , Φ , Ψ , (B_m^2 , B.R, Collapsed cross sections, Φ^*)

ISW = +1 --- Σ , Φ , (Ditto.)

ISW = 0 --- Φ , (Ditto.)

ISW = -1 --- (B_m^2 , Collapsed data, Φ^*)

IDS ; Number of groups for downscatter. IDS must be less than one from MAX0(MXDNSE,MXDNSI). In original format of JAERI-Fast set, IDS=29 for 70-group set, and IDS=11 for 25-group set.

KREG ; The region number in which the criticality search using dimensional adjustment will be done. If ICRIT=0 in the first case, KREG must be equal to 0

.

IP ; Geometry.

IP = 0 --- Slab.

IP = 1 --- Cylinder.

IP = 2 --- Sphere.

NADJ ; Option to calculate the adjoint fluxes.

NADJ = +1 --- Calculate adjoint flux.

NADJ = -1 --- Not calculated.

IBR ; Option to calculate reaction rate and breeding ratio for each region.

IBR = ±2 --- One group cross sections (Σ, σ collapsed), reaction rates, and breeding ratio will be calculated. If IBR=-2, only one group cross section calculation will be done.

IBR = +1 --- Reaction rate and breeding ratio will be calculated.

IBR = -1 --- Above calculation will not be done.

IBSQM ; Option to calculate material buckling.

IBSQM = +1 --- Calculate material buckling.
(Zero dimensional calculation.)

IBSQM = 0 --- Not calculated.

IBSQM = -1 --- Only material buckling calculation will be done.

LAPSE ; Option for group collapsing calculation.

LAPSE = N --- The cross section will be collapsed to N-group structure. ($1 \leq N \leq IMAX$)

LAPSE = 0 --- Group collapsing calculation is not made, and all of the option for group collapsing, specified in #A and #C card, are ignored.

(*) When LAPSE=N and IBR=+1, the collapsed Σ_c , Σ_a , σ_c , and σ_a are obtained even if ISW=-1.

EPS1 ; Convergence criterion in eigenvalue and B_m^2 (material buckling) calculation.
Normally EPS1= 1.0E-5 ~ 0.5E-5 .

EPS2 ; Convergence criterion in source iteration.
 Normally EPS2= 1.0E-4 . --- 10 times of EPS1.

DRMIN ; The minimum value of Δr in KREG-th region to
 be varied in criticality search.
 If ICRIT=0 , DRMIN must be equal to 0.0 .

DRMAX ; The maximum value of Δr to be varied.
 If ICRIT=0 , DRMAX must be equal to 0.0 .

RAM2 ; The end value of k eff in criticality
 search.

2 Card : (I3, 12I6, 3X, 2A1)

[DO until KA ≠ 0 or blank.
 (NO, (MM(K+K1), K=1, K2), KA, NC)

where K1 = 12*(NC-1), K2 = MINO(12, KMAX-K1)

NO ; Card identification number.
 NO = 2 for this card.

MM(N) ; Number of nuclides in N-th region.

KA ; Card continuation switch. If KA = 0 or blank,
 next #2 card is necessary. KA ≠ 0 indicates
 the end of this data input.

NC ; Card sequence number. NC = 1,2,---,9,A,B,C,---,Z.
 NC must be equal to 1 for the first card.

(*) If KMAX ≤ 12, KA and NC may be equal to 0 or blank.

3 Card : (I3, 12I6, 3X, 2A1)

[DO until KA ≠ 0 or blank.
 (NO, (INTER(K+K1), K=1, K2), KA, NC)

where K1=12*(NC-1), K2=MINO(12,KMAX-K1).

NO ; Card identification number.
 NO = 3 for this card.

INTER(N) ; Mesh point number at the outer boundary of N-th

region. The mesh point must be numbered 0 at the origin, and must be even number at each boundary.

KA, NC ; Same as #2 card.

4 Card : (I3, 12I6, 4X, I1)

DO L = 1, ICARD4

J1 = 12*(L-1)

(NO, (IX(J), J=1,J2), KN)

where J2 = MIN0(12,LAPSE-J1).

NO ; Card identification number.
NO = 4 for this card.

IX(J) ; The last energy group number of the group constant library in use, corresponding to the collapsed coarse group J. The coarse group J corresponds with the group range IX(J-1)+1 to IX(J) in the energy structure of the library in use.

KN ; Card sequence number. If KN is specified, from 1 to ICARD4 , #4 card may be put in arbitrary order.
(J1=12*(KN-1))

(*) This card is not necessary if LAPSE = 0.

5 Card ; (I3, 12E6.0, 3X, 2A1)

DO until KA ≠ 0 or blank.

(NO, (DR(K+K1), K=1,K2), KA, NC)

where K1=12*(NC-1), K2=MIN0(12,KMAX-K1)

NO ; Card identification.
NO = 5 for this card.

DR(N) ; Mesh width for N-th region, in cm unit.

KA, NC ; Same as #2 card.

6 Card : (I3, 12E6.0, 3X, 2A1)

DO until KA ≠ 0 or blank.

(NO, (T(K+K1), K=1,K2), KA, NC)
 where K1=12*(NC-1), K2=MIN0(12,KMAX-K1)

NO ; Card identification.
 NO = 6 for this card.

T(N) ; Temperature for N-th region, in kelvin unit.
 T(N) must be greater than or equal to 300 ° k.

KA, NC ; Same as #2 card.

7 Card : (I3, 6E12.5, 3X, 2A1)

DO until KA ≠ 0 or blank.

(NO, (BSQ(K+K1), K=1,K2), KA, NC)
 where K1=6*(NC-1), K2=MIN0(6,KMAX-K1)

NO ; Card identification.
 NO = 7 for this card.

BSQ(N) ; Transverse buckling for N-th region.

KA, NC ; Same as #2 card.

8 Card ; (I3, 5(I3, E12.5), 2A1)

DO L = 1, ICARD8

(NO, (MCODE(J+J1,KA), AN(J+J1,KA), J=1,J2), KA, NC)
 where J1=5*(NC-1), J2=MIN0(5,MM(KA)-J1).

NO ; Card identification.
 NO = 8 for this card.

MCODE(L,N) ; Nuclide code number for L-th nuclide in N-th region. This code number must agree with the code number used in the group constant library.

AN(L,N) ; Atomic number density of L-th nuclide in N-th region, in 10^{24} atoms/cm³ unit.

KA ; Region number. The character data 1,2,---,9 correspond to integer 1,2,---,9, and A,B,---,Z to 10,11,---,35.

NC ; Card sequence number for each region. In the first card for each region, NC must be set to 1.
The Character-Integer correspondence is the same as above.

(*) The Character-Integer correspondences are the same for all of the foregoing cards.

9 Card ; (I3, 5(I3, E12.5), 2A1)

[DO L = 1, ICARD9

[(NO, (MCODE(J+J1,KA), VR(J+J1,KA), J=1,J2), KA, NC)

where J1=5*(NC-1), J2=MIN0(5,MM(KA)-J1).

NO ; Card identification.
NO = 9 for this card.

MCODE(L,N) ; Nuclide code number of L-th nuclide in N-th region. The order of nuclides must correspond with that one in #8 card.

VR(L,N) ; Volume ratio of L-th nuclide in N-th region.

KA ; Region number. The character data 1,2,---,9 correspond to integer 1,2,---,9, and A,B,---,Z to 10,11,---,35.

NC ; Card sequence number for each region. In the first card for each region, NC must be set to 1.
The Character-Integer correspondence is the same as above.

(*) #9 cards are necessary when the number densities given in #8 cards are pure-densities. If the density are given as effective values in #8 cards, #9 cards data are not necessary.

#103 Card ; (I1)

(LAST)

LAST ; Calculation terminator. LAST = 1 . This indicates

the end of input data stream for diffusion calculation. But two more cardgroups are necessary for the following case:

When IOUT1 (#A card) ≠ 0 or ≠ 10, IBOPT (#0 card) ≠ -1 or ≠ 0, #16 and #17 cards are necessary.

When ISKIPD=0, then this job step terminates after this card, but when ISKIPD ≠ 0, perturbation calculation start after the series of diffusion calculation, reference case and perturbation cases, just before this card. In such a case ,the following set of data cards #S1 - #S5 are necessary for subroutine SPD2.

#16 Card ; (I3, 12I6, 3X, 2A1)

[] DO until KA ≠ 0 or blank.

[] (NO, (IDUM(K+K1), K=1, K2), KA, NC)

where K1=12*(NC-1), K2=MIN0(12,IBOPT-K1).

NO ; Card identification.
NO = 16 for this card.

IDUM(N) ; The region number in which the space and composition dependent effective microscopic cross sections are not calculated when a positive integer number is given to IBOPT in #1 card.

IDUM(N)'s must be read IBOPT in number, and in these regions the normal effective microscopic cross sections, depending on σ_0 , R, temperature T, are calculated.

If IBOPT=0 or -1, this card group is not necessary.

KA,NC ; Same as #2 card.

#17 Card ; (I3, 6E12.5, 3X, 2A1)

[] DO until KA ≠ 0 or blank.

[] (NO, (BSQC(K+K1), K=1, K2), KA, NC)

where K1=6*(NC-1), K2=MIN0(6,KMAX-K1).

NO ; Card identification.
 NO = 17 for this card.

BSQC(N) ; Buckling of N-th region that will be used to estimate the leakage for P1 component by subroutine RECUR.

KA,NC ; Same as #2 card. KA and NC must be punched in 79-th and 80-th column even if less than 6.

(The following card groups are necessary for perturbation calculation by subroutine SPD2, and only one set of them are necessary after #103 card (or #17 card for IOUT1 ≠ 0, 10, or #16 card for IBOPT ≠ -1, IOUT1 = 0, 10), if perturbation calculation option ISKIPD is not equal to zero.)

S1 Card : (6I3)
 (N1, N2, INO, NJ, IDIFF, NX)
 N1, N2, INO, NJ ; always set zeroes.

IDIFF ; Option for $\delta\Sigma$ used in $\Delta k/k$ calculation.
 IDIFF = 0 --- $\delta\Sigma = \Sigma'$. Using Σ' of perturbed system as $\delta\Sigma$.
 IDIFF ≠ 0 --- $\delta\Sigma = \Sigma' - \Sigma$. Using the difference between Σ' of perturbed system and Σ of unperturbed system as $\delta\Sigma$. Normally IDIFF ≠ 0.

NX ; Option for fission spectrum used in perturbation calculation.
 NX = 0 --- Using the fission spectrum in the group constant library.
 NX ≠ 0 --- Read the fission spectrum from #S4 card. Normally NX=0.

S2 Card : (9I3)

(ISG, ISI, ISD, ISR, ISA, IST, ISF, ITN, ISN)

ISG ; Option to print the macroscopic cross sections of the following reactions.

ISG = 0 --- No print.

ISG ≠ 0 --- Print out the macroscopic cross sections according to the following options.

ISI ; Fission spectrum.

ISD ; Diffusion coefficients.

ISR ; Elastic removal cross sections.

ISA ; Absorption cross sections.

IST ; Total cross sections.

ISF ; Fission source. (nu-fission.)

ITN ; Inelastic scattering cross section

ISN ; Inelastic scattering matrix.

ISI~ISN = 0 --- No print.

ISI~ISN ≠ 0 --- Print out the each cross sections.

(*) OUTPUT FORMAT

DO I=1,IMAX
 (Σ_k^I , K=1,KMAX)

DO K=1,KMAX
 DO I=1,IMAX
 ($\Sigma_{m,k}^{I \rightarrow I+J-1}$, J=1,IDS+1)

S3 Card : (E12.5)

(EFFK)

EFFK ; k eff. If IFX ≠ 3 in #A card, this card is not necessary.

S4 Card : (6E12.5)

(XKI(I), I=1,IMAX)

XKI(I) ; The fission spectrum of group I. If NX=0, in #S1
card, this card is not necessary.

S5 Card : (5E15.8)

```

  DO    I=1,IMAX
  DO    K=1,KMAX
    NL = INTER(K-1) + 1
    NU = INTER(K) + 1
  ( PHIX(I,N),N=NL,NU )

```

```

  DO    I=1,IMAX
  DO    K=1,KMAX
    NL = INTER(K-1) + 1
    NU = INTER(K) + 1
  ( AFLX(I,N), N= NL, NU )

```

PHI(I,N) ; Real flux of group I at the spacial mesh
point N.

AFLX(I,N) ; Adjoint flux of group I at point N.

(*) #S5 cards are obtained as the punched out data cards in the
previous calculation using the option NP ≠ 0 (#A card).

(*) If IFX ≠ 3 in #A card, this card is not necessary.

4.2 How to run EXPANDA-General

(i) Creation of load module

For the creation of load module of EXPANDA-General, at first, user should prepare the necessary dimensioned arrays in the main program as described in the section 2-4. And at the collapsing step for the microscopic cross section in subroutine COND, one direct access file is used to save the core memory. Enough space for this file should be assigned by DEFINE FILE statement. In order to perform dinamic allocation of core-memory and file , this DEFINE FILE statement should be defined by the users.

This direct access file is assigned to logical unit 45 and necessary records number and record size are

```
record number: LAPSE * KNMAX ,
record size : KNMAX * ( 10 + IDS1 * 2 ) ,
```

where LAPSE, KNMAX, IDS1 are number of groups for collapsing, maximum nuclides number in one region, allowable slowing down group number (including in-scatter; in-scatter group count as 1) respectively.

record format: U

And record count associated variable should be assighned in common /CND/ as integer variable(INTEGER*4).

If no collapsing requested, i.e. ISIGP<10 in #A card, DEFINE FILE statement and COMMON/CND/ statement are not necessary.

EXPANDA-General was originally designed for FORTRAN-H of FACOM-230/75, then the optimization at the compile stage was effectively functioned, but for subroutine RECUR ,the optimization should not be applied due to the structure of the program. Therefore for the creation of object module (RB) of EXPANDA-General, all of the subroutines except RECUR should be compiled using OPT2 and subroutine RECUR should be compiled by OPT0. And at the link stage, these two object module should be merged to make load module.

(An example of main program.)

```
C      MAIN PROGRAM OF EXPANDA-GENERAL
ELEMENT EXP7DRA
COMMON /CND/ KCNT
DIMENSION A(80000)
DEFINE FILE 45(600,1400,U,KCNT)
CALL EXP7OD(A,80000)
STOP
END
```

In the above case, KNMAX=20, IDS1=30, LAPSE=30.

(ii) Overlay Structure

For the creation of load module of EXPANDA-General, linkage editor input data and their parameters are as follows;

```

$NO    W001,T.5C.3W.3P.0,C35
$GJOB 3112585,AK.HASEGAWA,431.11,RDIST
$HFORT OPT=OPTO,A=NOLIST,NAME=EXP
ELEMENT EX7DRA
COMMON /CND/ KCNT
DIMENSION A(80000)
DEFINENAME 45(2000,1400,U,KCNT)
CALL EXP70D(A,80000)
STOP
END
$HLIED RFNAME=J2585.EX7DRA2R,ENTRY=EX7DRA,OVLY=OVLY,COMLIB=CALL, /
EDIT=YES,GRFD=ON,LWA=80,SPCE2=100,RBSPC=80,B=MAP,A=NOLIST,NAME=EXP
SGMT MAINX
SELECT (EX7DRA,EXP70D,SEPTE,LDNS,RECWR2,RECW1,GRSRCH,SUFFIX,RCLEA, /
        IRZERO,SUFPR)
SGMT SKIPX,CHN=MAINX
SELECT (SKIP,FLXINP,FLXOUT,FLXRD)
SGMT INPUTX,CHN=MAINX
SELECT (INPUT1,INPUT2,INPLST,BSQCIN,CARD2,IDSrch,ICHANG,ICHN2D,AMCHNG,/
        KBSRCH,KREGID,KSWSET,RESNDF,NUCRES)
SGMT MICROX,CHN=MAINX
SELECT (MICRO,SHIELD,ALPHA,BETA,DOP,RECUR,RSRCH,IXTERP,YY,CROSS,FGAM, /
        MACRRS,POT,REGWID,SIGAVE,SVAR)
SGMT RECURX,CHN=MICROX
SELECT (INIT)
SGMT RECURY,CHN=MICROX
SELECT (PRTF,TITLEP)
SGMT ONEDIMX,CHN=MAINX
SELECT (ONEDIM,EXPAND,REGION,SIMPS)
SGMT EDITX,CHN=MAINX
SELECT (EDIT)
SGMT SPD2,CHN=MAINX
SELECT (SPD2,KRGN,JSEARCH,SYMPSN)

```

```
SGMT PRTX,CHN=MAINX
SELECT (PRT,PRTS1,PRTM1)
SGMT JFSIN1X,CHN=MAINX
SELECT (JFSIN1)
SGMT JFSIN2X,CHN=MAINX
SELECT (JFSIN2,LIBRD2,LIBRD1)
SGMT RECLB1X,CHN=MAINX
SELECT (RECLB1,RECRD1,RECRD2,RECRD3,RECRD4)
SGMT RECLB2X,CHN=MAINX
SELECT (RECLB2,RECRD5)
SGMT CONDX,CHN=MAINX
SELECT (COND,CONDMT,CNDMIC,MICPRT,CNDMAC,CNDONE)
FIN
```

(iii) Input and output files.

Logical unit	Comment
1,2,3,4	Scratch work file.
8,9,18	Scratch work file.
25,26,31	Scratch work file.
40,41,42	Scratch work file.
43,44,46	Scratch work file.
45	Direct access work file for collapsed microscopic cross sections.
5	Input data cards.
6	List of calculated results.
7	Punch out unit of macroscopic cross section
13	Allocate the restart data file which consists of k_{eff}, Φ, Φ^* and f-values.
14	Newly calculated k_{eff}, Φ, Φ^* and f-values will be written on this logical unit.
15	Benchmark calculation results.
24	Allocate the group constant library to be used.
30	Allocate the fine group scattering cross section library for subroutine RECUR.
78	COM tape.

5. Run Example for EXPANDA-General

This example shows how to utilize EXPANDA-General to assess the applicability of cross section library through simple one-dimensional benchmark tests. Calculation flow is as follows; one-dimensional criticality calculation is done by this EXPANDA-General and next XPRTC code /2/ is used to calculate reaction rate ratio and other integrated data, finally BENCH code/11/ is used to evaluate the C/E values (Calculated to Experimental values) for each items of integral data. At the same time this BENCH code gives some tables of statistics for those C/E values with graphic plotter output.

The benchmerek test adopted here is the one to check the applicability of cross section library using one dimensional model of 21 benchmark cores for fast reactors from hard to soft spectrum. This set of benchmark test was used to assess the applicability of JAERI-Fast set /5,6,7/ and JENDL library /10/.

As all input data of this benchmark test are stored in a file, it is very easy to perform the same benchmark test by changing the libraries. To accomplish this, TSS becomes very powerfull tool. Because changing part necessary to those data are only liblary identification data part in #102 card.

Results-file from benchmark test necessary for BENCH code has some differences between the code used in the benchmark test; i.e. EXPANDA-General and XPRTC(new) , and EXPANDA-70D and XPRTC(old) ; due to the difference in format of those files. Therefore in this example, FT11- FT14 and FT23 are the files produced from 'EXPANDA-70D' and 'XPRTC(old)' and FT15, FT24-FT25 are the files from 'EXPANDA-General' and 'XPRTC (new)'. User should remind those particular conditions when looking into the sample run JCL listing and input data for BENCH code #5 and #8 card in this example. An input example is given as stating from next page.

5.1 JCL LIST OF EXPANDA-GENERAL RUN EXAMPLE

```

$HRUN EX7GENER,J2585.EX7GENER,SIZE=18,NAME=EXP1
$FD HRUNEXP1-PRINT,DUMMY,DEVD=DA
$DISK F01
$TPDISK F02,DISP=DELETE,RSIZE=3609,BSIZE=10827,BUFNO=1
$TPDISK F03,DISP=DELETE,RSIZE=12000,BSIZE=12000,BUFNO=1
$TPDISK F02,DISP=DELETE,RSIZE=4095,BSIZE=12285,BUFNO=1
$DISK F08
$DISK F09,,800
$TPDISK F14,J2585.FLX,RSIZE=900,BSIZE=6300,BUFNO=1,TRK=1500
$DISKTN F15,J2585.KEF919,TRK=10
$TPDISK F18,DISP=DELETE,RSIZE=459,BSIZE=4131,BUFNO=1
$DISKTO F24,J2585.LTFR919
$DISK F25
$DISK F26
$TPDISK F31,DISP=DELETE,RSIZE=324,BSIZE=4212,BUFNO=1
$DISK F40
$DISK F41
$DISK F42
$DISK F43
$DISK F44
$DISK F46
$DISKTO F30,J2585.DRALIB1
$DISK F78
$FD F05.001,FILE=(CATLG,J2585.BENCHDAT(EXPDAT09)
$HRUN XPRTCV,J2585.XPRTCV,NAME=D,SIZE=10
$FD HRUND-PRINT,DUMMY,DEVD=DA
$TPDISK F04,J2585.FLX
$LIBEDISK F08,J2585.LTXP
$DISKTN F10,J2585.SPX919,TRK=10
$DISK F78
$FD F05.001,FILE=(CATLG,J2585.BENCHDAT(XPRDAT1))
$HRUN XPRTCV,J2585.XPRTCV,NAME=RT,SIZE=10
$FD HRUNRT-PRINT,DUMMY,DEVD=DA
$TPDISK F04,J2585.FLX,DISP=DELETE
$LIBEDISK F08,J2585.LTXP
$DISKTN F10,DUMMY
$GCOM35
$FD F05.001,FILE=(CATLG,J2585.BENCHDAT(XPRDAT2))
$HRUN BENCHV,J2585.BENCHV,NAME=ST1,SIZE=6
$DISK F08
$DISK F09
$DISK F10
$DISKTO F11,J2585.KEF701

```

```
¥DISKTO F12,J2585.KEF801W
¥DISKTO F13,J2585.KEF901W
¥DISKTO F14,J2585.KEFM919
¥DISKTO F15,J2585.KEF919
¥GCOM35
¥FD F05.001,FILE=(CATLG,J2585.BENCHDAT(BENCH))
¥HRUN BENCHV,J2585.BENCHV,NAME=ST2,SIZE=6
¥DISK F08
¥DISK F09
¥DISK F10
¥DISKTO F11,J2585.KEF701
¥DISKTO F12,J2585.KEF801W
¥DISKTO F13,J2585.KEF901W
¥DISKTO F14,J2585.KEFM919
¥DISKTO F15,J2585.KEF919
¥DISKTO F21,J2585.SPC701
¥DISKTO F22,J2585.SPC801
¥DISKTO F23,J2585.SPC901
¥DISKTO F24,J2585.SPCM919
¥DISKTO F25,J2585.SPC919
¥GCOM35
¥FD F05.001,FILE=(CATLG,J2585.BENCHDAT(BENCHR))
¥HRUN BENCHV,J2585.BENCHV,NAME=ST3,SIZE=6
¥DISKTO F01,J2585.BNCDATA
¥DISK F08
¥DISK F09
¥DISK F10
¥DISKTO F11,J2585.KEF701
¥DISKTO F12,J2585.KEF801W
¥DISKTO F13,J2585.KEF901W
¥DISKTO F14,J2585.KEFM919
¥DISKTO F15,J2585.KEF919
¥DISKTO F21,J2585.SPC701
¥DISKTO F22,J2585.SPC801
¥DISKTO F23,J2585.SPC901
¥DISKTO F24,J2585.SPCM919
¥DISKTO F25,J2585.SPC919
¥DISK F78
¥FD F05.001,FILE=(CATLG,J2585.BENCHDAT(BENCHW))
¥JEND
```

5.1.1 INPUT DATA FOR EXPANDA-GENERAL
 CONTENTS OF J2585.BENCHDAT(EXPDAT09)

BENCH	MARK	TEST	FOR	J.F.S	LTFR919		USING	LTFR919	
0	0	1	0	70		-10			
0	1123568		5	0 -1	CORE-1	VERA-11A	2-REG.SPHERE.		
1	3	1	70	0 -1	29	0 2 1 -1	0 01.0E-51.0E-4	0.0 0.0 1.0	
2	8		8		5				
3	10		48		88				
5.069920.34961.075									
6	300.	300.	300.						
8949	7.213		-3940	3.70		-4941 2.80	-5 6 4.6204	-2 24 1.579	-311
8	26	6.533	-3	28	6.65	-4 29 7.402	-3		12
8949	7.213		-3940	3.70		-4941 2.80	-5 6 4.6204	-2 24 1.579	-321
8	26	6.533	-3	28	6.65	-4 29 7.402	-3		22
8925	2.50		-4928	3.44		-2 24 1.70	-3 26 6.50	-3 28 7.10	-431
0	22358		5	0 -1	CORE-2	VERA-1B	2-REG.SPHERE.		
2	7		7		5				
3	10		44		84				
50.28710.47850.9863									
8924	9.20		-5925	7.363		-3928 4.55	-4 6 5.7540	-2 24 6.890	-411
8	26	6.3410	-3	28	1.635	-3			12
8924	9.20		-5925	7.363		-3928 4.55	-4 6 5.7540	-2 24 6.890	-421
8	26	6.3410	-3	28	1.635	-3			22
8925	2.50		-4928	3.44		-2 24 7.08	-4 26 6.464	-3 28 1.682	-331
0	32358		6	0 -1	CORE-3	ZPR-3-6F	2-REG.SPHERE.		
2	8		8		7				
3	10		48		78				
5.114980.57491.0167									
8924	6.90		-5925	6.756		-3928 7.547	-3 13 1.9019	-2 24 1.918	-311
8	26	7.712	-3	28	8.39	-4 25 8.0	-5		12
8924	6.90		-5925	6.756		-3928 7.547	-3 13 1.9019	-2 24 1.918	-321
8	26	7.712	-3	28	8.39	-4 25 8.0	-5		22
8925	8.9		-5928	4.0026		-2 13 1.359	-3 24 1.129	-3 26 4.539	-331
8	28	4.94	-4	25	4.7	-5			32
0	42358		9	0 -1	CORE-4	ZEBRA-3	2-REG.SPHERE.		
2	14		14		11				
3	10		48		78				
5.118360.59181.017									
8925	2.264		-4928	3.1775		-2949 3.466	-3940 1.834	-4941 1.27	-511
8	6	4.2	-5	13	1.9	-5 24 8.64	-4 26 4.599	-3 28 4.83	-412
8	42	8.0	-6	25	6.4	-5 29 4.3702	-3 11 5.4	-5	13
8925	2.264		-4928	3.1775		-2949 3.466	-3940 1.834	-4941 1.27	-521
8	6	4.2	-5	13	1.9	-5 24 8.64	-4 26 4.599	-3 28 4.83	-422
8	42	8.0	-6	25	6.4	-5 29 4.3702	-3 11 5.4	-5	23
8925	2.98		-4928	4.1269		-2 6 4.2	-5 13 1.9	-5 24 8.64	-431
8	26	3.344	-3	28	4.83	-4 42 8.0	-6 25 6.4	-5 29 4.0	-632

										33	
0	8 11 5.4	-5									
	52358		6 0 -1	CORE-5	ZPR-3-12			2-REG.SPHERE.			
	2 9 9	7									
	3 10 48	78									
	50.14380.71901.0167										
	8924 4.6	-5925 4.516	-3928 1.6948	-2 6 2.6762	-2 24 1.419	-311					
	8 26 5.704	-3 28 6.21	-4 25 5.9	-5 11 6.9	-5	12					
	8924 4.6	-5925 4.516	-3928 1.6948	-2 6 2.6762	-2 24 1.419	-321					
	8 26 5.704	-3 28 6.21	-4 25 5.9	-5 11 6.9	-5	22					
	8925 8.9	-5928 4.0026	-2 24 1.237	-3 26 4.971	-3 28 5.41	-431					
	8 25 5.2	-5 11 6.0	-5			32					
0	62358	8 0 -1	CORE-6	SNEAK-7-A	2-REG.SPHERE.						
	2 14 14	9									
	3 10 48	68									
	50.14250.71251.50										
	8925 5.86	-5928 7.9604	-3949 2.6374	-3940 2.380	-4941 2.15	-511					
	8 8 2.18462	-2 6 2.60987	-2 13 8.0	-6 24 2.2423	-3 26 7.9802	-312					
	8 28 1.1664	-3 42 1.65	-5 25 1.109	-4 11 9.33	-5	13					
	8925 5.86	-5928 7.9604	-3949 2.6374	-3940 2.380	-4941 2.15	-521					
	8 8 2.18462	-2 6 2.60987	-2 13 8.0	-6 24 2.2423	-3 26 7.9802	-322					
	8 28 1.1664	-3 42 1.65	-5 25 1.109	-4 11 9.33	-5	23					
	8925 1.624	-4928 3.99401	-2 6 1.35	-5 24 1.1080	-3 26 3.9634	-331					
	8 28 9.845	-4 42 1.00	-5 25 8.75	-5 11 4.53	-5	32					
0	72358	6 0 -1	CORE-7	ZPR-3-11	2-REG.SPHERE.						
	2 7 7	6									
	3 10 38	58									
	5.210741.05371.50										
	8924 4.6	-5925 4.586	-3928 3.4373	-2 24 1.486	-3 26 5.681	-311					
	8 28 7.18	-4 25 2.08	-4			12					
	8924 4.6	-5925 4.586	-3928 3.4373	-2 24 1.486	-3 26 5.681	-321					
	8 28 7.18	-4 25 2.08	-4			22					
	8925 8.9	-5928 4.0025	-2 24 1.196	-3 26 4.925	-3 28 5.36	-431					
	8 25 1.11	-4				32					
0	82358	7 0 -1	CORE-8	ZPR-3-54	2-REG.SPHERE.						
	2 11 11	5									
	3 10 48	78									
	5.179440.89721.2448										
	8925 6.0	-6928 2.615	-3949 1.669	-3940 1.07	-4941 8.0	-611					
	8 6 5.5898	-2 13 1.11	-4 24 2.081	-3 26 7.134	-3 28 9.70	-412					
	8 42 2.08	-4				13					
	8925 6.0	-6928 2.615	-3949 1.669	-3940 1.07	-4941 8.0	-621					
	8 6 5.5898	-2 13 1.11	-4 24 2.081	-3 26 7.134	-3 28 9.70	-422					
	8 42 2.08	-4				23					
	8 6 1.587	-3 24 1.334	-3 26 7.4805	-2 28 6.29	-4 42 5.12	-431					
0	92358	8 0 -1	CORE-9	ZPR-3-53	2-REG.SPHERE.						
	2 11 11	6									
	3 10 48	78									
	5.18773.938651.2443										
	8925 6.0	-6928 2.615	-3949 1.669	-3940 1.07	-4941 8.0	-611					

8 6 5.5898	-2 13 1.11	-4 24 2.081	-3 26 7.134	-3 28 9.70	-412
8 42 2.08	-4				13
8925 6.0	-6928 2.615	-3949 1.669	-3940 1.07	-4941 8.0	-621
8 6 5.5898	-2 13 1.11	-4 24 2.081	-3 26 7.134	-3 28 9.70	-422
8 42 2.08	-4				23
8925 8.3	-5928 3.9770	-2 6 2.4	-5 24 1.311	-3 26 4.496	-331
8 28 6.11	-4				32
0 102358	8 0 -1	CORE-10	SNEAK-7B	2-REG.SPHERE.	
2 14	14	9			
3 10	58	78			
5.162560.81281.50					
8925 2.663	-4928 1.45794	-2949 1.8312	-3940 1.652	-4941 1.49	-511
8 8 3.31936	-2 6 6.31	-5 13 1.2112	-3 24 2.7560	-3 26 9.8271	-312
8 28 1.4594	-3 42 1.84	-5 25 6.46	-5 11 1.174	-4	13
8925 2.663	-4928 1.45794	-2949 1.8312	-3940 1.652	-4941 1.49	-521
8 8 3.31936	-2 6 6.31	-5 13 1.2112	-3 24 2.7560	-3 26 9.8271	-322
8 28 1.4594	-3 42 1.84	-5 25 6.46	-5 11 1.174	-4	23
8925 1.624	-4928 3.99401	-2 6 1.35	-5 24 1.1080	-3 26 3.9634	-3 31
8 28 9.845	-4 42 1.00	-5 25 8.75	-5 11 4.53	-5	32
0 112358	8 0 -1	CORE-11	ZPR-3-50	2-REG.SPHERE.	
2 12	12	6			
3 10	58	88			
5.173720.86861.3447					
8925 1.6	-5928 7.404	-3949 1.645	-3940 1.064	-4941 1.1	-511
8 6 4.594	-2 13 1.1	-4 24 1.816	-3 26 7.3	-3 28 7.96	-412
8 42 2.05	-4 25 7.6	-5			13
8925 1.6	-5928 7.404	-3949 1.645	-3940 1.064	-4941 1.1	-521
8 6 4.594	-2 13 1.1	-4 24 1.816	-3 26 7.3	-3 28 7.96	-422
8 42 2.05	-4 25 7.6	-5			23
8925 8.3	-5928 3.9613	-2 24 1.161	-3 26 4.671	-3 28 5.08	-431
8 25 4.8	-5				32
0 122358	8 0 -1	CORE-12	ZPR-3-48	2-REG.SPHERE.	
2 13	13	7			
3 10	58	78			
5.180980.90491.50					
8925 1.6	-5928 7.405	-3949 1.645	-3940 1.064	-4941 1.1	-511
8 6 2.0770	-2 11 6.355	-3 13 1.09	-4 24 2.531	-3 26 1.0180	-212
8 28 1.119	-3 42 2.06	-4 25 1.06	-4		13
8925 1.6	-5928 7.405	-3949 1.645	-3940 1.064	-4941 1.1	-521
8 6 2.0770	-2 11 6.355	-3 13 1.09	-4 24 2.531	-3 26 1.0180	-222
8 28 1.119	-3 42 2.06	-4 25 1.06	-4		23
8925 8.3	-5928 3.9690	-2 24 1.225	-3 26 4.925	-3 28 5.36	-431
8 25 5.1	-5 11 6.0	-5			32
0 132358	9 0 -1	CORE-13	ZEBRA-2	2-REG.SPHERE.	
2 12	12	11			
3 10	58	88			
50.18180.90901.0567					
8925 2.526	-3928 1.5667	-2 8 1.544	-4 6 3.7992	-2 13 1.9	-511
8 24 8.64	-4 26 3.9783	-3 28 4.83	-4 42 8.0	-6 25 6.4	-512

8 29 4.0	-6 11 5.4	-5				13
8925 2.526	-3928 1.5667	-2 8 1.544	-4 6 3.7992	-2 13 1.9	-521	
8 24 8.64	-4 26 3.9783	-3 28 4.83	-4 42 8.0	-6 25 6.4	-522	
8 29 4.0	-6 11 5.4	-5				23
8925 2.98	-4928 4.1269	-2 6 4.2	-5 13 1.9	-5 24 8.64	-431	
8 26 3.344	-3 28 4.83	-4 42 8.0	-6 25 6.4	-5 29 4.0	-632	
8 11 5.4	-5					33
0 142358	7 0 -1	CORE-14	ZPR-3-49	2-REG.SPHERE.		
2 12 12	5					
3 10 58	88					
5.190120.95061.2143						
8925 1.6	-5928 7.406	-3949 1.644	-3940 1.064	-4941 1.1	-511	
8 6 2.0766	-2 13 1.09	-4 24 2.508	-3 26 1.0083	-2 28 1.121	-312	
8 42 2.06	-4 25 1.05	-4				13
8925 1.6	-5928 7.406	-3949 1.644	-3940 1.064	-4941 1.1	-521	
8 6 2.0766	-2 13 1.09	-4 24 2.508	-3 26 1.0083	-2 28 1.121	-322	
8 42 2.06	-4 25 1.05	-4				23
8925 8.3	-5928 3.9556	-2 24 1.242	-3 26 4.626	-3 28 6.11	-431	
0 152358	7 0 -1	CORE-15	ZPR-3-56B	2-REG.SPHERE.		
2 12 12	5					
3 10 58	88					
5.210881.05441.1447						
8925 1.4	-5928 6.195	-3949 1.358	-3940 1.81	-4 8 1.5	-211	
8 6 1.03	-3 11 8.669	-3 24 2.5	-3 26 1.37	-2 28 1.09	-312	
8 42 3.43	-4 25 2.2	-4				13
8925 1.4	-5928 6.195	-3949 1.358	-3940 1.81	-4 8 1.5	-221	
8 6 1.03	-3 11 8.669	-3 24 2.5	-3 26 1.37	-2 28 1.09	-322	
8 42 3.43	-4 25 2.2	-4				23
8 11 7.879	-3 24 1.941	-3 26 7.824	-3 28 4.2261	-2 25 3.0	-431	
0 162358	8 0 -1	CORE-16	ZPR-6-7	2-REG.SPHERE.		
2 12 12	8					
3 10 88	100					
50.22041.10202.8175						
8925 1.26	-5928 5.78036	-3949 8.8672	-4940 1.1944	-4941 1.33	-511	
8 8 1.390	-2 11 9.2904	-3 24 2.842	-3 26 1.3431	-2 28 1.291	-312	
8 42 2.357	-4 25 2.21	-4				13
8925 1.26	-5928 5.78036	-3949 8.8672	-4940 1.1944	-4941 1.33	-521	
8 8 1.390	-2 11 9.2904	-3 24 2.842	-3 26 1.3431	-2 28 1.291	-322	
8 42 2.357	-4 25 2.21	-4				23
8925 8.56	-5928 3.96179	-2 8 2.4	-5 24 1.295	-3 26 4.637	-331	
8 28 5.635	-4 42 3.8	-6 25 9.98	-5			32
0 172358	6 0 -1	CORE-17	ZPR-6-6A	2-REG.SPHERE.		
2 8 8	7					
3 10 88	100					
5.239181.19592.8175						
8925 1.153	-3928 5.8176	-3 8 1.390	-2 11 9.2904	-3 24 2.842	-311	
8 26 1.3431	-2 28 1.291	-3 25 2.21	-4			12
8925 1.153	-3928 5.8176	-3 8 1.390	-2 11 9.2904	-3 24 2.842	-321	
8 26 1.3431	-2 28 1.291	-3 25 2.21	-4			22

8925	8.56	-5928	3.95508	-2	8	2.30	-5	24	1.247	-3	26	4.4669	-331		
8	28	5.407	-4	25	9.60	-5							32		
0	181235678	17	0	-1	CORE-18	ZPPR-2	5-REG.CYLINDER.								
1	6	1	70	0	-1	29	0	1	1	-1	0	01.0E-51.0E-4	0.0	0.0	1.0
2	15	15	15	12	12	8									
3	10	64	78	86	94	98									
50.23001.15001.90502.34252.38252.9275															
6	300.	300.	300.	300.	300.	300.									
7	5.92	-4	5.92	-4	5.92	-4	5.92	-4	5.92	-4	5.92	-4	5.92	-4	11
8925	1.23	-5928	5.5549	-3949	8.433	-4940	1.141	-4941	1.53	-4941	1.53	-4941	1.53	-511	
8	8	1.3116	-2	6	3.0	-5	11	8.933	-3	13	3.0	-6	24	2.702	-312
8	26	1.2576	-2	28	1.221	-3	42	2.31	-4	25	2.09	-4	29	1.9	-513
8925	1.23	-5928	5.5549	-3949	8.433	-4940	1.141	-4941	1.53	-4941	1.53	-4941	1.53	-521	
8	8	1.3116	-2	6	3.0	-5	11	8.933	-3	13	3.0	-6	24	2.702	-322
8	26	1.2576	-2	28	1.221	-3	42	2.31	-4	25	2.09	-4	29	1.9	-523
8925	1.15	-5928	5.1980	-3949	1.2741	-3940	1.724	-4941	2.31	-4941	2.31	-4941	2.31	-531	
8	8	1.1761	-2	6	2.3	-5	11	8.682	-3	13	4.0	-6	24	2.523	-332
8	26	1.3852	-2	28	1.160	-3	42	3.41	-4	25	2.02	-4	29	2.0	-533
8925	2.4	-5928	1.1085	-2	8	2.0132	-2	6	1.013	-3	11	6.492	-341		
8	13	2.0	-6	24	1.991	-3	26	6.931	-3	28	8.98	-4	42	1.4	-542
8	25	1.57	-4	29	1.7	-5									43
8925	2.4	-5928	1.1085	-2	8	2.0133	-2	6	1.013	-3	11	6.065	-351		
8	13	3.0	-6	24	2.172	-3	26	7.549	-3	28	9.87	-4	42	1.5	-552
8	25	1.74	-4	29	1.8	-5									53
8	6	5.58	-4	24	1.205	-3	26	7.5161	-2	28	5.13	-4	42	1.2	-561
8	25	5.98	-4	29	1.3	-5	11	9.1	-5						62
0	191235678	22	0	-1	CORE-19	MZA	6-RE7=SP85R5=								
1	7	1	70	0	-1	29	0	2	1	-1	0	01.0E-51.0E-40.0	0.0	1.0	
2	17	17	15	15	15	14	9								
3	14	34	42	50	58	82	92								
50.15581.41830.97461.04690.57091.56872.3294															
6	300.	300.	300.	300.	300.	300.									
70.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	01
70.0															12
8925	3.886181E-5949	1.361012E-3928	5.357208E-3940	3.232607E-4	6	3.123281E-311									
8	8	1.079941E-2	11	8.579973E-3	26	1.251963E-2115	4.009848E-8	24	3.463726E-312						
8	29	4.963544E-4941	4.644822E-5	42	1.145005E-5	25	2.502263E-4	28	1.738612E-313						
8105	1.143000E-8	13	2.600244E-5												14
8925	3.886181E-5949	1.361012E-3928	5.357208E-3940	3.232607E-4	6	3.123281E-321									
8	8	1.079941E-2	11	8.579973E-3	26	1.251963E-2115	4.009848E-8	24	3.463726E-322						
8	29	4.963544E-4941	4.644822E-5	42	1.145005E-5	25	2.502263E-4	28	1.738612E-323						
8105	1.143000E-8	13	2.600244E-5												24
8925	3.883492E-5949	1.343325E-3928	5.353500E-3940	3.500438E-4	6	3.126006E-331									
8	8	1.079278E-2	11	8.514944E-3	26	1.261317E-2	24	3.448112E-3	29	9.960136E-432					
8941	5.477312E-5	42	1.144756E-5	25	2.714402E-4	28	1.714983E-3	13	2.579546E-533						
8925	3.885767E-5949	1.347098E-3928	5.356683E-3940	3.320482E-4	6	3.126891E-341									
8	8	1.080012E-2	11	8.519853E-3	26	1.260898E-2	24	3.448391E-3	29	4.963019E-442					
8941	5.312421E-5	42	1.144967E-5	25	2.714488E-4	28	1.715343E-3	13	2.579969E-543						
8925	3.885767E-5949	1.347873E-3928	5.356637E-3940	3.304518E-4	6	3.116583E-351									

8 8 1.079740E-2 11 8.519840E-3 26 1.259615E-2 24 3.448059E-3 29 4.963019E-452
 8941 5.344748E-5 42 1.144967E-5 25 2.714184E-4 28 1.714732E-3 13 2.499184E-553
 8925 7.013167E-5928 9.717569E-3 6 1.443702E-2 8 3.317917E-3 11 5.066874E-361
 8 26 1.395105E-2115 1.340673E-8 24 2.030370E-3 29 6.855061E-6 42 1.081886E-562
 8 25 1.420715E-4 28 1.026837E-3105 1.135431E-6 13 4.245644E-3 63
 8 6 4.848179E-4 26 5.310974E-2 24 3.451174E-4 29 1.582560E-6 42 3.135814E-671
 8 25 4.008082E-4 28 1.928590E-4 13 1.150333E-2 11 1.854708E-4 72
 0 201235678 23 0 -1 CORE-20 MZB 7-REG.SPHERE.
 1 8 1 70 0 -1 29 0 2 1 -1 0 01.0E-51.0E-40.0 0.0 1.0
 2 15 15 15 15 15 15 14 9
 3 10 40 46 48 52 58 78 90
 50.25001.40151.45241.46511.88611.90231.91192.1941
 6 300. 300. 300. 300. 300. 300. 300.
 7 0.0 0.0 0.0 0.0 0.0 0.0 0.0 01
 7 0.0 0.0 01
 89498.916317E-049401.832231E-049412.711883E-059254.293537E-059285.925857E-0311
 8 61.110577E-04 81.255138E-02 261.253244E-02 281.810516E-03 119.242322E-0312
 8 132.730518E-05 243.447433E-03 252.592416E-04 292.324749E-04 421.124641E-0513
 89498.916317E-049401.832231E-049412.711883E-059254.293537E-059285.925857E-0321
 8 61.110577E-04 81.255138E-02 261.253244E-02 281.810516E-03 119.242322E-0322
 8 132.730518E-05 243.447433E-03 252.592416E-04 292.324749E-04 421.124641E-0523
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 8 61.114478E-04 81.255052E-02 261.251216E-02 281.819472E-03 119.243704E-0332
 8 132.727679E-05 243.455182E-03 252.591512E-04 292.357492E-04 421.124624E-0533
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 8 132.727679E-05 243.552276E-03 252.534788E-04 292.357492E-04 421.124624E-0543
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 8 132.721186E-05 243.549894E-03 252.532701E-04 292.357578E-04 421.124636E-0553
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 89255.537491E-059287.644106E-031051.753696E-071154.630810E-09 61.125709E-0271
 8 85.121978E-04 261.289106E-02 281.678413E-03 119.099398E-03 136.831933E-0472
 8 243.355167E-03 252.358001E-04 291.043136E-05 421.635068E-05 00.0 73
 8 64.616631E-04 264.957446E-02 282.300861E-04 111.685362E-04 131.372378E-0281
 8 244.117345E-04 253.575375E-04 291.888036E-06 423.741112E-06 00.0 82
 0 211235678 9 0 -1 CORE-21 FCA-5-2 2-REG.SPHERE.
 1 3 +1 70 0 -1 29 0 2 +1 -1 0 01.0E-51.0E-4 0. 0. 0.
 2 18 18 5
 3 10 48 78
 5.181160.90581.0
 6 300. 300. 300.
 7 0.0 0.0 0.0 11
 8949 0.0010458 940 0.00009325 941 0.00001069 925 0.0014700 928 0.0058359 11
 8 8 0.013101 11 0.0081341 13 0.0088295 24 0.0032734 26 0.011950 12
 8 28 0.0015345 105 0. 115 0. 6 0. 25 0. 13
 8 29 0. 42 0. 924 0. 14

8949	0.0010458	940	0.00009325	941	0.00001069	925	0.0014700	928	0.0058359	21
8 8	0.013101	11	0.0081341	13	0.0088295	24	0.0032734	26	0.011950	22
8 28	0.0015345	105	0.	115	0.	6	0.	25	0.	23
8 29	0.	42	0.	924	0.					24
8925	0.0002891	928	0.039890	24	0.001827	26	0.006625	28	0.0007964	31

1

**5.1.2 INPUT DATA FOR LTXP STEP.
CONTENTS OF J2585.BENCHDAT(LTXPDAT)**

2 8 70 20 0 0										
10.5E+6	8.3E+6	6.5E+6	5.1E+6	4.0E+6	3.1E+6					
2.5E+6	1.9E+6	1.4E+6	1.1E+6	8.0E+5	6.3E+5					
5.0E+5	4.0E+5	3.1E+5	2.5E+5	2.0E+5	1.5E+5					
1.2E+5	1.0E+5	7.73E+4	5.98E+4	4.65E+4	3.6E+4					
2.78E+4	2.15E+4	1.66E+4	1.29E+4	1.00E+4	7.73E+3					
5.98E+3	4.65E+3	3.60E+3	2.78E+3	2.15E+3	1.66E+3					
1.29E+3	1.0E+3	7.73E+2	598.	465.	360.					
278.	215.	166.	129.	100.	77.3					
59.8	46.5	36.	27.8	21.5	16.6					
12.9	10.	7.73	5.98	4.65	3.6					
2.78	2.15	1.66	1.29	1.0	0.773					
0.598	0.465	0.360	0.278	0.215						

**5.1.3 INPUT DATA FOR XPRTC STEP FOR SPECTRAL INDEX CALCULATION.
CONTENTS OF J2585.BENCHDAT(XPRDAT1)**

1	CORE-1 VERA-1A	00000010
1	1	0
0		00000020
		00000030
0		00000040
		00000050
12		
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00000060		
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00000070		
0		00000080
		00000090
21	CORE-2 VERA-1B	00000100
1	1	0
0		00000110
		00000120
0		00000130
12		
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00000140		
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00000150		
0		00000160
		00000170
3	CORE-3 ZPR-3-6F	00000180
1	1	0
0		00000190
		00000200
0		00000210
12		
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00000220		
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00000230		
0		00000240
		00000250
4	CORE-4 ZEBRA-3	00000260
1	1	0
0		00000270
		00000280
0		00000290
12		
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00000300		
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00000310		
0		00000320
		00000330
5	CORE-5 ZPR-3-12	00000340
1	1	0
0		00000350
		00000360
0		00000370
12		
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00000380		
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00000390		
0		00000400
		00000410
6	CORE-6 SNEAK-7A	00000420
1	1	0
0		00000430

0	1	1					
12			00000440				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000450
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000460
0	1	1					
7	CORE-7	ZPR-3-11					
1	1	0	00000470				
0			00000480				
0	1	1					
12			00000490				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000500
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000510
0	1	1					
8	CORE-8	ZPR-3-54					
1	1	0	00000520				
0			00000530				
0	1	1					
12			00000540				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000550
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000560
0	1	1					
9	CORE-9	ZPR-3-53					
1	1	0	00000570				
0			00000580				
0	1	1					
12			00000590				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000600
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000610
0	1	1					
9	CORE-9	ZPR-3-53					
1	1	0	00000620				
0			00000630				
0	1	1					
12			00000640				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000650
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000660
0	1	1					
10	CORE-10	SNEAK7B					
1	1	0	00000670				
0			00000680				
0	1	1					
12			00000690				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000700
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000710
0	1	1					
11	CORE-11	ZPR-3-50					
1	1	0	00000720				
0			00000730				
0	1	1					
12			00000740				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000750
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000760
0	1	1					
11	CORE-11	ZPR-3-50					
1	1	0	00000770				
0			00000780				
0	1	1					
12			00000790				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000800
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000810
0	1	1					
11	CORE-11	ZPR-3-50					
1	1	0	00000820				
0			00000830				
0	1	1					
12			00000840				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000850
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000860
0	1	1					
12	CORE-12	ZPR3-48					
1	1	0	00000870				
0			00000880				
0	1	1					
12			00000890				
949F/	925F,	928F/ 925F,	928G/ 925F,	940F/ 925F,	924F/ 925F,	11G/ 925F,	00000900
105G/	925F,	25G/ 925F	925F/ 949F,	940F/ 949F,	941F/ 949F,	928G/ 949F	00000910
0	1	1					
0			00000920				

12			00000930									
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00000940
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00000950
0	1	1										00000960
13	CORE-13	ZEBRA-2										00000970
1	1	0										00000980
0												00000990
0	0	1	1									00001000
12												00001010
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00001020
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00001030
0	1	1										00001040
14	CORE-14	ZPR3-49										00001050
1	1	0										00001060
0												00001070
0	0	1	1									00001080
12												00001090
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00001100
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00001110
0	1	1										00001120
15	CORE-15	ZPR3-56B										00001130
1	1	0										00001140
0												00001150
0	0	1	1									00001160
12												00001170
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00001180
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00001190
0	1	1										00001200
16	CORE-16	ZPR-6-7										00001210
1	1	0										00001220
0												00001230
0	0	1	1									00001240
12												00001250
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00001260
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00001270
0	1	1										00001280
17	CORE-17	ZPR6-6A										00001290
1	1	0										00001300
0												00001310
0	0	1	1									00001320
12												00001330
949F/	925F,	928F/	925F,	928G/	925F,	940F/	925F,	924F/	925F,	11G/	925F,	00001340
105G/	925F,	25G/	925F	925F/	949F,	940F/	949F,	941F/	949F,	928G/	949F	00001350
0	1	1										00001360
18	CORE-18	ZPPR-2										00001370
1	1	0										00001380
0												00001390
0	0	1	1									00001400
12												00001410

949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00001420
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00001430
0 1 1 00001440
19 CORE-19 MZA 00001450
1 1 0 00001460
0 00001470
0 00001480
12 00001490
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00001500
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00001510
0 1 1 00001520
20 CORE-20 MZB 00001530
1 1 0 00001540
0 00001550
0 00001560
12 00001570
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00001580
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00001590
0 1 1 00001600
21 CORE-21 FCA-5-2 00001610
1 1 0 00001620
0 00001630
0 00001640
12 00001650
949F/ 925F, 928F/ 925F, 928G/ 925F, 940F/ 925F, 924F/ 925F, 11G/ 925F, 00001660
105G/ 925F, 25G/ 925F 925F/ 949F, 940F/ 949F, 941F/ 949F, 928G/ 949F 00001670
0 1 1 00001680
999 00001690

5.1.4 INPUT DATA FOR XPRTC-STEP FOR PERTURBATION CROSS SECTION.
 CONTENTS OF J2585.BENCHDAT(XPRDAT2)

1	CORE-1	VERA-11A	00000010	
0 0 1			00000020	
0 1 1 1	LTFR919	CORE-1	VERA-11A	00000030
21	CORE-2	VERA-1B	00000040	
0 0 1			00000050	
0 1 1 1	LTFR919	CORE-2	VERA-1B	00000060
3	CORE-3	ZPR-3-6F	00000070	
0 0 1			00000080	
0 1 1 1	LTFR919	CORE-3	ZPR-3-6F	00000090
4	CORE-4	ZEBRA-3	00000100	
0 0 1			00000110	
0 1 1 1	LTFR919	CORE-4	ZEBRA-3	00000120
5	CORE-5	ZPR-3-12	00000130	
0 0 1			00000140	
0 1 1 1	LTFR919	CORE-5	ZPR-3-12	00000150
6	CORE-6	SNEAK-7A	00000160	
0 0 1			00000170	
0 1 1 1	LTFR919	CORE-6	SNEAK-7A	00000180
7	CORE-7	ZPR-3-11	00000190	
0 0 1			00000200	
0 1 1 1	LTFR919	CORE-7	ZPR-3-11	00000210
8	CORE-8	ZPR-3-54	00000220	
0 0 1			00000230	
0 1 1 1	LTFR919	CORE-8	ZPR-3-54	00000240
9	CORE-9	ZPR-3-53	00000250	
0 0 1			00000260	
0 1 1 1	LTFR919	CORE-9	ZPR-3-53	00000270
10	CORE-10	SNEAK7B	00000280	
0 0 1			00000290	
0 1 1 1	LTFR919	CORE-10	SNEAK-7B	00000300
11	CORE-11	ZPR-3-50	00000310	
0 0 1			00000320	
0 1 1 1	LTFR919	CORE-11	ZPR-3-50	00000330
12	CORE-12	ZPR3-48	00000340	
0 0 1			00000350	
0 1 1 1	LTFR919	CORE-12	ZPR-3-48	00000360
13	CORE-13	ZEBRA-2	00000370	
0 0 1			00000380	
0 1 1 1	LTFR919	CORE-13	ZEBRA-2	00000390
14	CORE-14	ZPR3-49	00000400	
0 0 1			00000410	
0 1 1 1	LTFR919	CORE-14	ZPR-3-49	00000420
15	CORE-15	ZPR3-56B	00000430	

0 0 1				00000440
0 1 1 1				00000450
16 CORE-16 ZPR-6-7	LTFR919	CORE-15	ZPR-3-56B	00000460
0 0 1				00000470
0 1 1 1				00000480
17 CORE-17 ZPR6-6A	LTFR919	CORE-16	ZPR-6-7	00000490
0 0 1				00000500
0 1 1 1				00000510
18 CORE-18 ZPPR-2	LTFR919	CORE-17	ZPR-6-6A	00000520
0 0 1				00000530
0 1 1 1				00000540
19 CORE-19 MZA	LTFR919	CORE-18	ZPPR-2	00000550
0 0 1				00000560
0 1 1 1				00000570
20 CORE-20 MZB	LTFR919	CORE-19	MZA	00000580
0 0 1				00000590
0 1 1 1				00000600
21 CORE-21 FCA-5-2	LTFR919	CORE-20	MZB	00000610
0 0 1				00000620
0 1 1 1				00000630
999	LTFR919	CORE-21	FCA-5-2	00000640

5.1.5 INPUT DATA FOR BENCH K-EFF CASE.
CONTENTS OF J2585.BENCHDAT(BENCH)

K	2 21	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	00001900 00002000 00002100 00002200 00002300 00002400 00002500 00002600 00002700 00002800 00002900 00003000 00003100 00003200 00003300 00003400 00003500 00003600 00003700 00003800 00003900 00004000 00004100 00004200 00004300 00004400 00004500 00004600 00004700 00004800 00004900 00005000
1 1 1 1 1			
1 2			
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 5 6 2			
1 1 1 1 1			
1 0.0035 .0472	VERA-11A	P	
2 .0038 .0237	VERA-1B	U	
3 -.0028 .0192	ZPR-3-6F	U	
4 -.0006 .0126	ZEBRA-3	P	
5 -.0009 .0099	ZPR-3-12	U	
6 .0061 .0120 -.0045	SNEAK-7A	P	
7 .0001 .0060	ZPR-3-11	U	
8 -.0164 .0144 .0230	ZPR-3-54	P	
9 -.0150 .0087 .0230	ZPR-3-53	P	
10 .0042 .0047 -.0021	SNEAK-7B	P	
11 -.0133 .0056 .0220	ZPR-3-50	P	
12 -.0009 .0064 .0183	ZPR-3-48	P	
13 -.0007 .0033	ZEBRA-2	U	
14 -.0139 .0068 .0158	ZPR-3-49	P	
15 -.0166 .0065 .0102	ZPR3-56B	P	
16 -.0020 .0016 .0166	ZPR-6-7	P	
17 -.0013 .0013 .0073	ZPR-6-6A	U	
18 .0003 .0024 .0175	ZPPR-2	P	
19-0.0196 0.0075 0.0140 0. 1.0108 MZA		P	
20-0.0186 0.0036 0.0123 0.0 1.0040 MZB(1)		P	
21-0.0150 0.0044 0.0151 0. 1.0000 FCA-5-2		P	
K-EFFECTIVE			
1			
10.0	4000.		

5.1.6 INPUT DATA FOR BENCH SPECTRAL INDEX CASE.
CONTENTS OF J2585.BENCHDAT(BENCHR)

R	2	21	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
																										00006600
																										00006700
																										00006800
																										00006900
																										00007000
																										00007100
																										00007200
																										00007300
																										00007400
																										00007500
																										00007600
																										00007700
																										00007800
																										00007900
																										00008000
																										00008100
																										00008200
																										00008300
																										00008400
																										00008500
																										00008600
																										00008700
																										00008800
																										00008900
																										00009000
																										00009100
																										00009200
																										00009300
																										00009400
																										00009500
																										00009600
																										00009700
																										00009800
																										00009900
																										00010000
																										00010100
																										00010200
																										00010300
																										00010400
																										00010500
																										00010600
																										00010700
																										00010800
																										00010900
																										00011000
																										00011100
																										00011200
																										00011300
																										00011400

**5.1.7 INPUT DATA FOR BENCH SAMPLE-WORTH CASE.
CONTENTS OF J2585.BENCHDAT(BENCHW)**

W	2 21949	00013100
1	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	00013200
1	1 1 1 1 1	00013300
1	2	00013400
2	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 5 6 2	00013500
1	1 1 1 1	00013600
1	0.077 1.07 0.475	00013700
2	0.066 1.070 0.399 0.131 0.122	VERA-11A P 00013800
3	0.078 1.220 0.530 0.104 0.085	VERA-1B U 00013900
4	0.0461 1.190 0.373	ZPR-3-6F U 00014000
5	0.047 1.120 0.000 0.123 0.110	ZEBRA-3 P 00014100
6	0.0448 1.016 0.000 0.1376 0.135	ZPR-3-12 U 00014200
7	0.038 1.190 0.340 0.112 0.094	SNEAK-7A P 00014300
8	0.0254 0.928 0.174 0.000	ZPR-3-11 U 00014400
9	0.0254 0.928 0.174	ZPR-3-54 P 00014500
10	0.0330 1.012 0.000 0.131 0.129	ZPR-3-53 U 00014600
11	0.0251 0.903 0.159	SNEAK-7B P 00014700
12	0.0326 0.976 0.243 0.138 0.141	ZPR-3-50 P 00014800
13	0.0320 0.987 0.237 0.136 0.138	ZPR-3-48 U 00014900
14	0.0345 0.986	ZEBRA-2 P 00015000
15	0.0308 1.028 0.282	ZPR-3-49 U 00015100
16	0.023 0.953 0.000 0.136 0.143	ZPR-3-56B P 00015200
17	0.0245 0.000 0.000 0.139	ZPR-6-7 U 00015300
18	0.0201 0.937 0.170	ZPR-6-6A U 00015400
19	.03366 1.01338 .25993 .131435 .1297	ZPPR-2 P 00015500
20	0.02256 0.94877 .191935 .135104 .1424	MZA P 00015600
21	0.03960 1.10400	MZB P 00015700
		0.14000 0.12680 FCA-5-2 P 00015800
		00015900
CENTRAL REACTIVITY WORTH		
1		00016000
10.0	4000.	00016100
		00016200

5.1.8 OUTPUT EXAMPLE FROM BENCH.

FIG. 5.1.1 KEFF VS FERTILE TO FISSION RATIO FOR 21 BENCHMARK CORES.

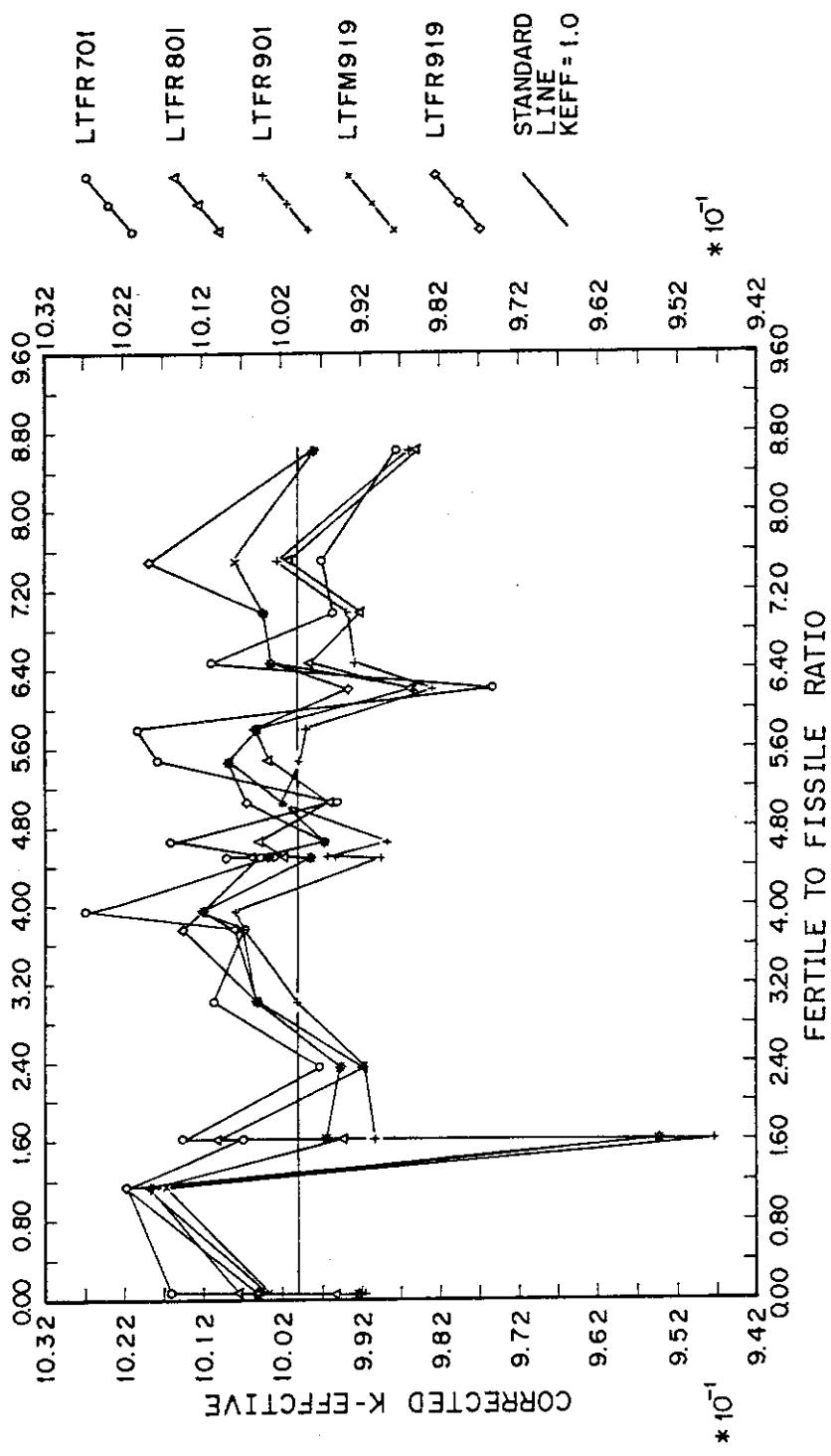


FIG. 5.1.2 C/E OF SPECTRAL INDICES FOR 928F/925F VS FERTILE TO FISSION RATIO FOR 21 BENCHMARK CORES.

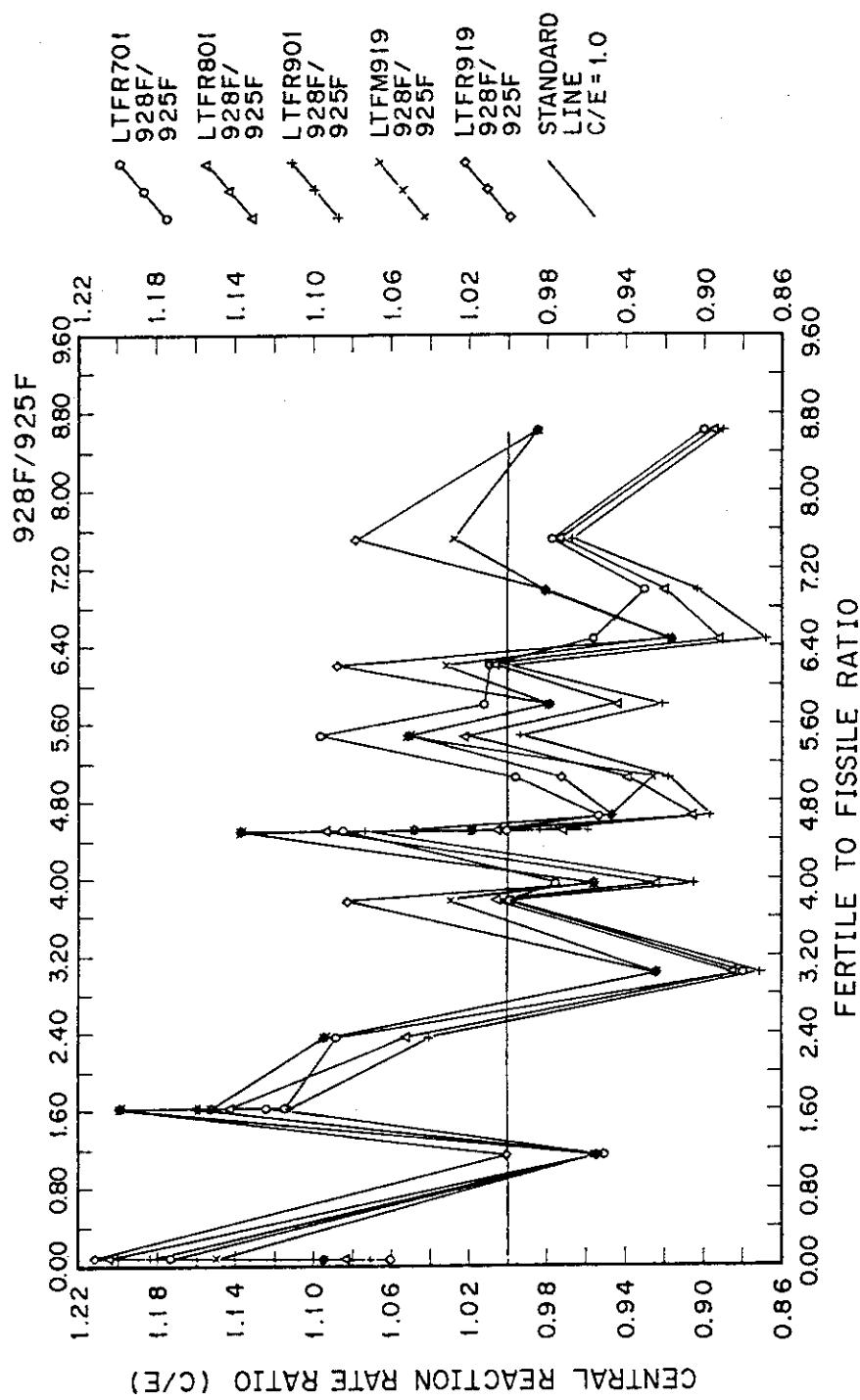


FIG. 5.1.3 C/E OF SPECTRAL INDICES FOR 949F/925F VS FERTILE TO FISSILE RATIO FOR 21 BENCHMARK CORES.

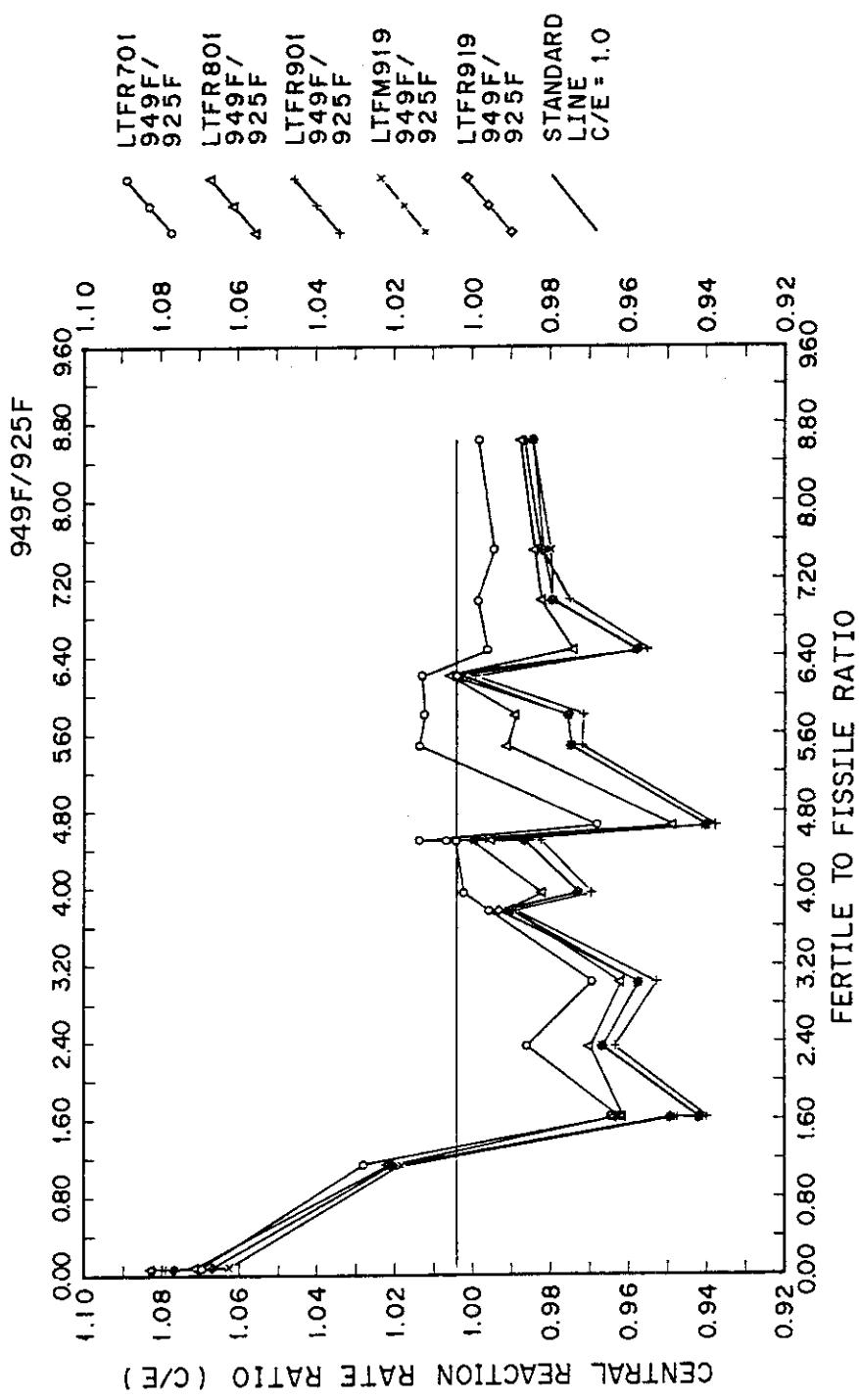


FIG. 5.1.4 C/E OF SPECTRAL INDICES FOR 940F/925F VS FERTILE TO FISSION RATIO FOR 21 BENCHMARK CORES.

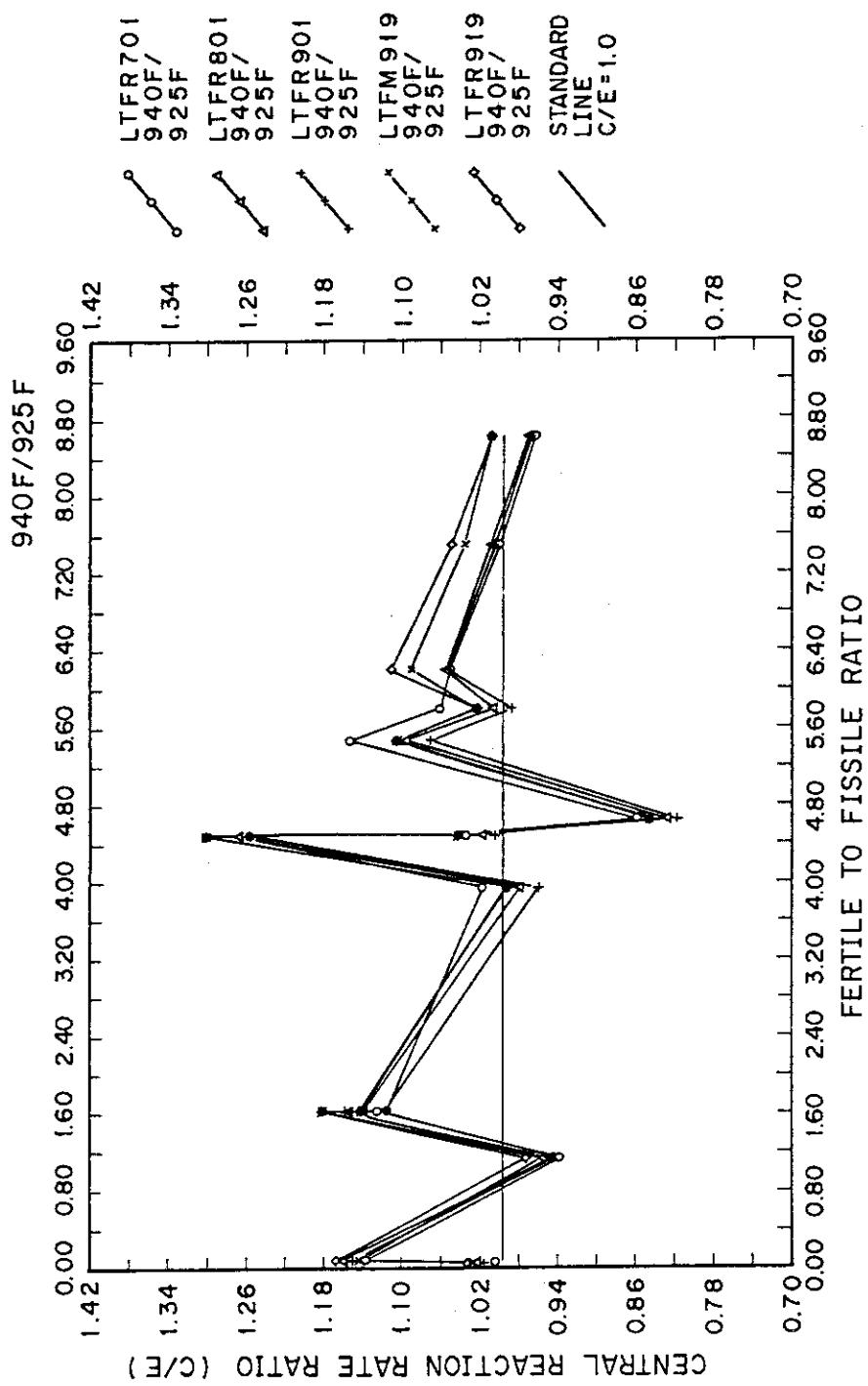


FIG. 5.1.5 C/E OF SPECTRAL INDICES FOR 928G/925F VS FERTILE TO FISSION RATIO FOR 21 BENCHMARK CORES.

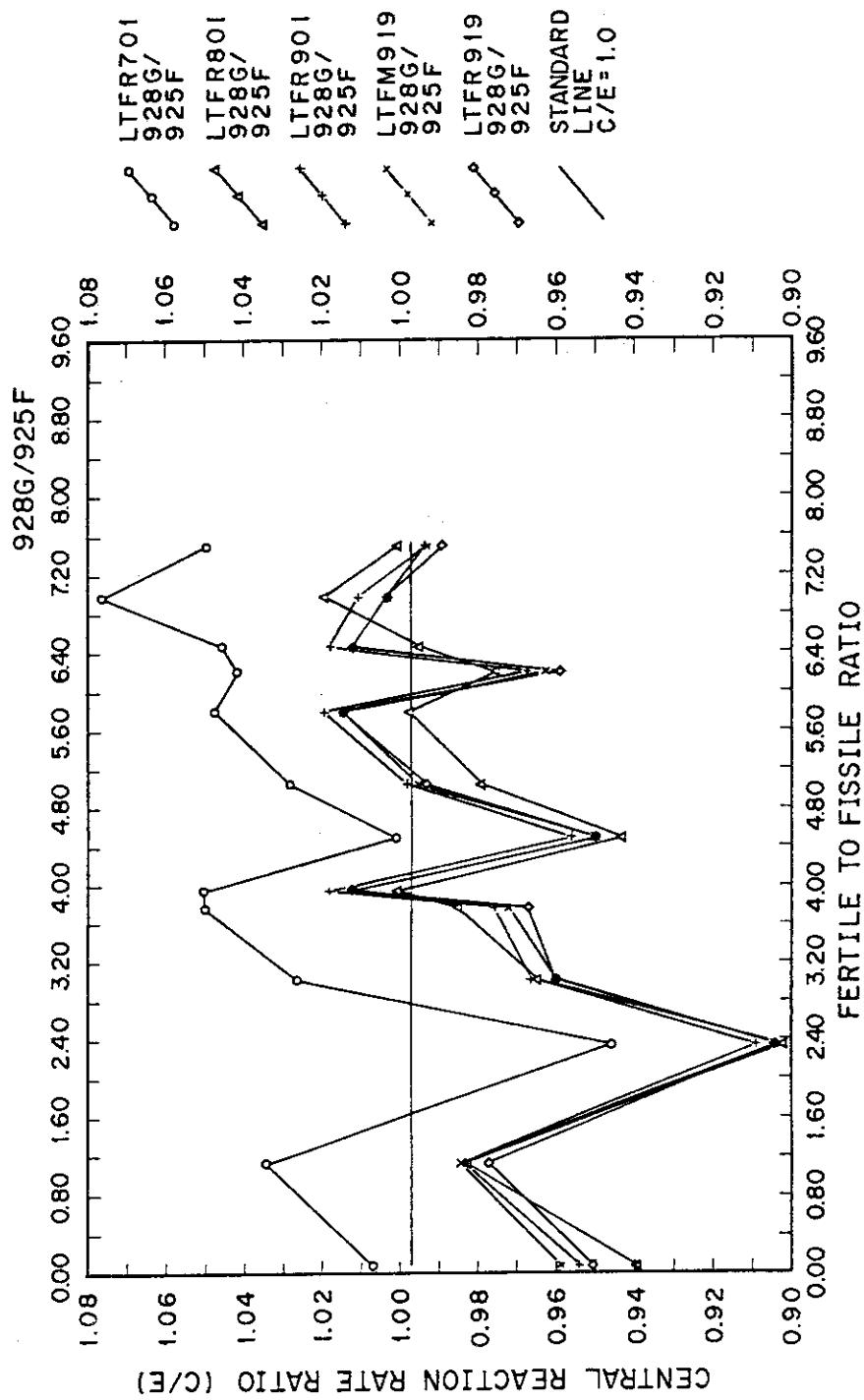
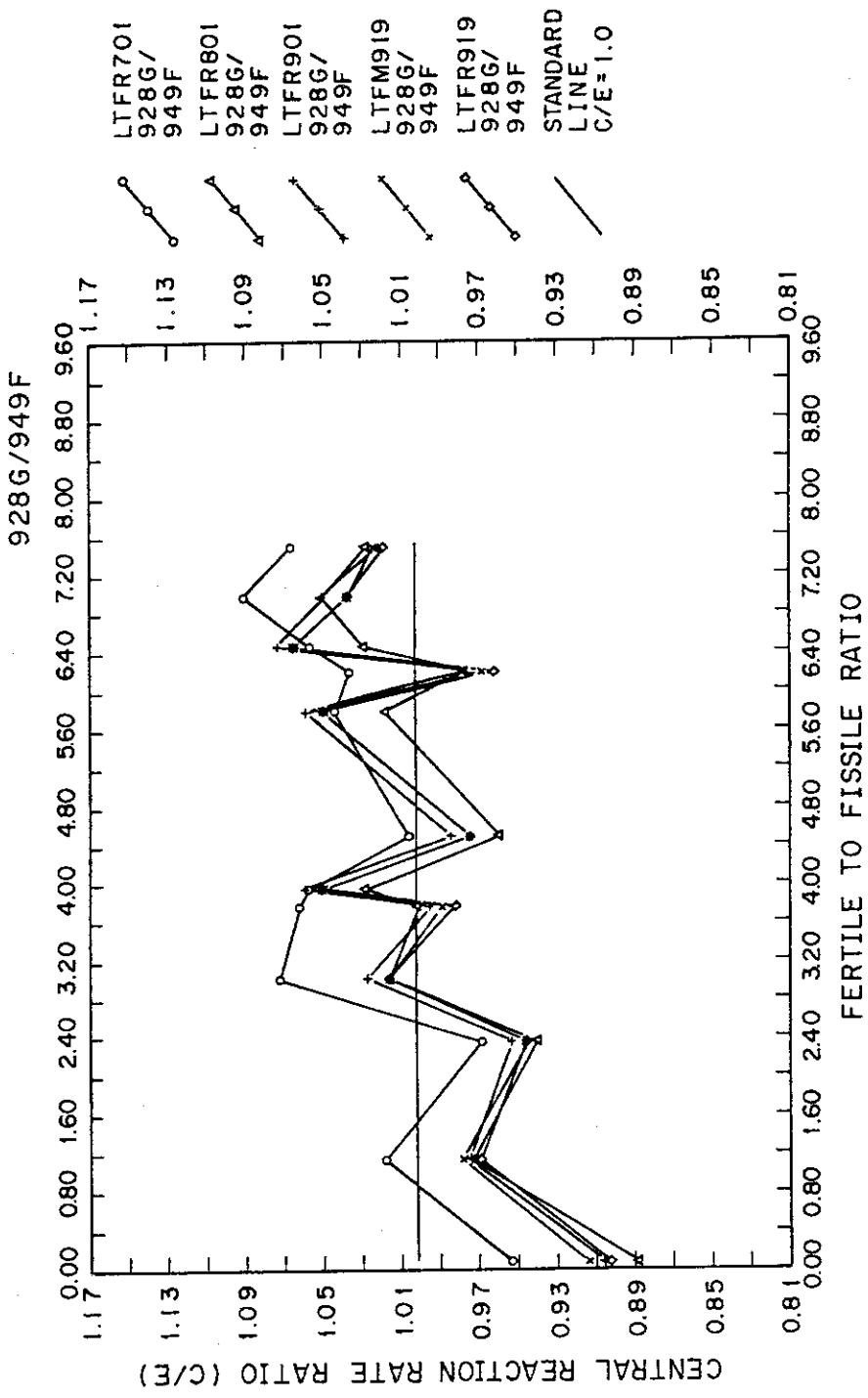


FIG. 5.1.6 C/E OF SPECTRAL INDICES FOR 928G/949F VS FERTILE TO FISSILE RATIO FOR 21 BENCHMARK CORES.



6. Conclusion

As described previously, generalized EXPANDA : EXPANDA-General has been developed. This new code has the following advantages compared with standard EXPANDA-70D or EXPANDA-70DRA.

- (1). Variable dimensioned coding is adopted. Hence this code is completely free from dimensional restrictions encountered at the fixed dimensioned code. There are no limitations for number of energy groups, regions, mesh points, etc.
- (2). Acceptable all of the libraries whose searching method of self-shielding factor tables are different.(i.e. JAERI-Fast set: f_f, f_c, f_e, f_t, f_r (σ_0, T, R) ; for JENDL-set or ENDF/B IV set: f_f, f_c, f_e, f_t (σ_0, T) .)
- (3). Possibility of exact perturbation calculation as well as first order perturbation calculation.
- (4). Semi-automatic preparation of input data for two or three dimensional criticality calculation codes ; CITATION or EXTERMINATOR-II.
- (5). Semi automatic preparation of input data for two or three dimensional perturbation calculation codes ; CIPER or PERKY.
- (6). More accurate treatment for elastic removal effective cross sections for light and medium weight nuclides in the resonance region using exact weighting fluxes solved by recurrence formulas numerically.
- (7). Proper treatment for gross region heterogeneity due to the large material change at the interface of regions.
- (8). More efficient and easy treatment for the comparison of C/E (calculated to experimental) values of typical integral data obtained by the benchmark test in order to assess the applicability of the group cross section libraries.
- (9). Adoption of self-explanation systems in the group cross section library : General-Library, i.e. all of the informations to define the library are contained in that library itself. Therefore any structured library such as any group number and any independent parameters of self-shielding factor tables is accessed.

This report covers only for the materials for the utilization of EXPANDA-General in detail. But the theory behind the code is not mentioned. Full description of the code with back ground theory will be published another reports including the peripheral codes together with library file definition.

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