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KINTIC-2 User's Manual

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Abstract

KINTIC-2 is a two dimensional reactor dynamics program, which can be used to analyze operational reactor transients or transients caused by accident situations. In the near future, it will be mainly used for the calculation of the predisassembly phase of sodium cooled fast reactor hypothetical accidents. Reactor kinetics may optionally be calculated with a simple point kinetics model or the adiabatic, normal or improved quasistatic method. The thermodynamics and material motion part, which was adapted from the CAPRI-2 system, uses representative coolant channels in a single channel model. It treats various phenomena which occur in intact fuel subassemblies: One phase steady state and transient heat transfer and coolant pressure distribution, pin deformation and failure, sodium voiding, slumping, and fuel coolant interaction. The report gives a short summary of the underlying physical models and some information on code organization and geometrical and thermohydraulic representation of the reactor. The main part consists of input and output description and sample cases. KINTIC-2 works in the KAPROS system and is operational since mid-1976.

KINTIC-2 Benutzerhandbuch

Zusammenfassung

KINTIC-2 ist ein zweidimensionales Reaktordynamikprogramm, das zur Analyse von Reaktorbetriebstransienten oder von Transienten, die durch Störfallsituationen hervorgerufen werden, eingesetzt werden kann. In nächster Zeit wird es im wesentlichen zur Berechnung der Einleitungsphase hypotetischer Störfälle bei Natrium-gekühlten schnellen Reaktoren benutzt werden. Zur Berechnung der Reaktorkinetik kann wahlweise ein einfaches Punktkinetikmodell oder die adiabatische, die normale oder die verbesserte quasistatische Methode herangezogen werden. Der Programmteil zur Berechnung der Thermodynamik

und Materialbewegung, der von dem CAPRI-2 System übernommen wurde, verwendet ein Einkanalmodell mit charakteristischen Kühlkanälen. Er behandelt verschiedene Phänomene, die in intakten Brennelementen auftreten: Einphasigen stationären und transienten Wärmetransport und Druckverteilung, Brennstabdeformation und -versagen, Natriumsieden, Slumping und Brennstoff-Natrium-Reaktion. Der Bericht enthält eine kurze Zusammenfassung der benutzten physikalischen Modelle und einige Informationen zur Codeorganisation und zur geometrischen und thermohydraulischen Darstellung des Reaktors. Der wesentliche Teil besteht aus Ein- und Ausgabebeschreibung sowie Testfällen. KINTIC-2 läuft im KAPROS-System und ist seit Mitte 1976 verfügbar.

Contents

1. Introduction

With prototype fast breeder reactors being built or in operation and planning proceeding to big fast reactor units of typically 1000-2000 MWe power, accident analysis employing multidimensional neutronics are gaining in importance at least as a means of checking or adjusting simpler calculational tools. The development of multidimensional dynamics codes for fast reactors has started long ago. In GfK, the two-dimensional dynamics code for the predisassembly phase, KINTIC-1, was developed and documented in 1972 /4/. This code, while an important first step and a good basis for further development, was lacking in a number of respects and needed improvement. Apart from a big number of minor alterations, the following important improvements were realized and incorporated into KINTIC-2 in the meantime:

1. For calculating time dependent neutronics, KINTIC-1 provided the point kinetics, adiabatic and normal quasistatic method. The improved quasistatic method was incorporated additionally in the new version.
2. The organization of group constants was basically altered. The need for doing so was already anticipated in /4/ due to the fact that the old concept resulted in too big a number of data to be shuffled and calculated. Instead of correlating the basic data with the single feedback zone as was done in the old code, basic data are now correlated with so called reactor subzones, e.g. core zone, radial blanket or absorber. Apart from a different organization and smaller blocks of data, the concept now allows to take into account composition dependent microscopic group constants, and to define the external perturbations in a much more direct way. The new concept has already been documented /1/.

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3. In order to facilitate a coupling with other codes, KINTIC was broken up into a number of modules with one controlling module and integrated into the nuclear code system KAPROS /2/.

4. The parts concerning thermodynamics, pin deformation, fuel coolant interaction, sodium boiling, and fuel slumping were taken out of the code system CAPRI-2 /5/, converted into KAPROS modules and coupled to KINTIC. Apart from the old thermodynamics modules, which have been kept active as an option, KINTIC is thus equipped with a more modern thermodynamics and material movement code, which will constantly be updated with the newest versions available.

KINTIC thus has become a system of KAPROS modules which will grow in the future and which will be referred to as the KINTIC-2 system.

The main purpose of this document is to aquaint a future user of KINTIC-2 with the basic methods employed and provide him with the material - input description and sample cases - for running his own calculations. It is not intended to compile the methods and formulas used, since this is beyond the scope of this author, many codes having been adapted from other authors; a list of the literature available on e.g. the new thermodynamics and material movement modules is provided /6-9/. As far as the original KINTIC-1 system is concerned, the methods have been documented in /4/; the concept for treating group constants and the modules to be used for creating a file of group constants for KINTIC-2 are published in /1/ and need not be repeated here.

Thus, after a first chapter treating the physical methods employed in the KINTIC-2 system in a more qualitative way, two chapters follow, which are meant to clarify the input:

The first one concerns the code organization only as far as a user has to be acquainted with it; the second one treats the geometrical representation of the reactor. Chapters on job control language, input, output, and sample cases close the publication.

2. Physics of the KINTIC-2 system

This chapter gives a short summary of the physics underlying the code KINTIC-2 and the approximations used. For more detailed information, the reader will be referred to the literature available on the different subjects.

2.1. Nuclear Data

The treatment of nuclear data has been basically altered for KINTIC-2 and a report containing detailed information on the new scheme for handling the group constants and on the creation of a file group constants for KINTIC-2 was published recently /1/. Here, only the details necessary for understanding the input for KINTIC-2 will be repeated.

For the treatment of group constants the reactor is subdivided into so-called subzones, which are different with respect to initial material compositions and/or collapsing spectra. Small differences in initial material composition or collapsing spectrum need not be taken into account; the degree of sophistication is determined by the user. Typically, a few subzones (10-15) are sufficient. For example, subzones would be: The different enrichment zones of the core, upper and lower axial blanket zones taken together, the inner and the outer radial blanket seperately for treating

the change of spectra, etc. As is obvious from this example, subzones need not be geometrically coherent. An illustration of this example is given in fig.'s 4 and 5.

All nuclear data needed for such a subzone, i.e. group constants including their dependence on possible changes of composition and on temperature, and data of delayed neutrons are compiled in the programs for calculation of group constants for KINTIC-2 to be run ahead of KINTIC and described in /1/. They are collected on a file, which is input for KINTIC-2. Apart from this file, the user has to provide the code with the information as to which geometrical zone belongs to which subzone. For the first steady state neutronics calculation, each zone has the original composition of the subzone to which it belongs. Alternately, slight alterations of the original compositions may be defined in order to, e.g., take into account steady state axial sodium density variations. Normally, this option need not be used, since the density distributions are automatically adjusted to the thermodynamics results during the steady state consistency iteration to be described below.

2.2. Calculations for the stationary reactor

Apart from determining the steady state neutronics and thermohydraulics, the calculations for the stationary reactor must achieve the following two objectives:

a. Zero initial reactivity.
b. Consistency of temperature field, densities and volume fractions, and group constants.

In the case of a calculation without feedback, the second objective is omitted.

The first objective may be reached in a number of ways. There are options for criticality search provided by KINTIC-2 as well as the diffusion module DIXY /13/. In the case of calculations with the new thermodynamics modules, some restrictions are placed on the use of these options, which are specified in the input description. Whether or not criticality search is used, the remaining nonzero reactivity is eliminated by dividing all group constants containing ν, the number of neutrons per fission, by k_{eff}. By this operation, fictitious transients arising from nonzero stationary reactivity are avoided.

The second objective is reached by iterating the neutron field and the temperature/material density field until consistency is achieved. This is done automatically by the program. With the old thermodynamics, two iterations are sufficient to reach consistency, whereas for the CAPRI-2 thermodynamics four iterations are used.

Apart from these calculations, the steady state part of KINTIC-2 (see fig.1) comprises the determination of the steady state adjoint and, in preparation for the instationary calculations, an estimate of the initial reactivity ramp as given by the external perturbation (see 2.6).

2.3. Neutron kinetics

The instationary neutronics calculations may be performed with a number of approximate methods. These are

a. the normal or improved quasistatic method;
b. the adiabatic method;
c. a primitive point kinetics method which does not use reactivity coefficients provided by input but only first order perturbation theory with normal and adjoint flux pertaining to steady state conditions.

A detailed derivation of the quasistatic method was given in /4/ and may be found elsewhere in literature /10/. Here only the main formulas will be listed.

The time dependent equations for neutron flux and precursor densities are written as

$$\frac{1}{v}\frac{\partial\phi}{\partial t} = S\phi + \chi^P M^P \phi + \sum_i \chi_i^d \lambda_i C_i \qquad (1)$$

(t=time, v=neutron velocity, ϕ=neutron flux, S=operator for removal, diffusion, and scattering, χ^P=prompt neutron spectrum, M^P=prompt fission yield, χ_i^d=delayed neutron spectrum of precursor i, λ_i=decay constant of precursor i, C_i= concentration of precursor i)

$$\frac{\partial C_i}{\partial t} = M_i^d \phi - \lambda_i C_i \qquad (2)$$

(M_i^d=precursor fission yield of precursor i), and the equation for the steady state adjoint

$$0 = S_o^+ \psi^+ + \left(\chi^P M_o^P + \sum_i \chi_i^d M_{i,o}^d\right)^+ \psi^+ \qquad (3)$$

The time dependent flux is seperated into a strongly time dependent amplitude A and a weakly time dependent shape function ψ

$$\phi = A \cdot \psi \qquad (4)$$

with the additional constraint

$$\frac{d}{dt} < \psi^+, \frac{1}{v} \psi > = 0 \tag{5}$$

(< , > signifying multiplication and integration over all space and energy).

By inserting (4) into (1) and (2), multiplying (1) by ψ^+, (3) by ψ, and (2) by $\psi^+ \chi_i^d$, integrating and suitably subtracting the results, the usual point kinetics equations are derived:

$$\begin{aligned} \dot{A} &= \frac{\rho-\beta}{l} A + \sum_i \lambda_i \bar{C}_i \\ \dot{\bar{C}}_i &= \frac{\beta_i}{l} A - \lambda_i \bar{C}_i \end{aligned} \tag{6}$$

The coefficients are given by

$$\bar{C}_i = \frac{1}{I} < \psi^+, \chi_i^d C_i >$$

$$I = < \psi^+, \frac{1}{v} \psi >$$

$$\frac{\beta_i}{l} = \frac{1}{I} < \psi^+, \chi_i^d M_i^d \psi > \tag{7}$$

$$\frac{\beta}{l} = \sum_i \frac{\beta_i}{l}$$

$$\frac{\rho}{l} = \frac{1}{I} \left[< \psi^+, S\psi > - < \psi, S_o^+ \psi^+ > + < \psi^+, \Delta M \psi > \right]$$

$$\Delta M = \chi^P (M^P - M_o^P) + \sum_i \chi_i^d (M_i^d - M_{i,o}^d)$$

Up to this point, the three different methods provided by KINTIC are equal. The difference arises from the assumptions made concerning the shape function ψ. For point kinetics, ψ is assumed to be the steady state neutron distribution:

Point kinetics: $$\psi = \psi_o \tag{8}$$

In the adiabatic method, all time derivatives in (1) and (2) are neglected, resulting in an equation for ψ which differs from the steady state equation only in that the group constants contained in the operators S and M are time dependent. An eigenvalue has to be introduced to guarantee a nonzero solution.

Adiabatic method: $$0 = S\psi + \frac{1}{k} (\chi^P M^P + \sum_i \chi_i^d M_i^d)\psi \tag{9}$$

For the quasistatic method, (4) is inserted in (1), and by suitably rearranging, the following equation results:

Quasistatic method: $$\frac{1}{v} \frac{\partial \psi}{\partial t} = (S - \frac{1}{v} \frac{\dot{A}}{A})\psi + \chi^P M^P \psi + \frac{1}{A} \sum_i \chi_d^i \lambda_i C_i \tag{10}$$

Time derivatives and precursors are explicitely accounted for by this method. The two variants of the method differ in the way the left hand side of (10) is handled:

Normal quasistatic method: $$\frac{1}{v} \frac{\partial \psi}{\partial t} = 0 \tag{11}$$

Improved quasistatic method: $$\frac{1}{v} \frac{\partial \psi}{\partial t} = \frac{\psi(t) - \psi(t-\Delta t)}{v \cdot \Delta t} \tag{12}$$

Since an external source is not included in (1), initially subcritical assemblies cannot be described in KINTIC. Inclusion of this option would present no principal difficulty but is not planned in the foreseeable future.

2.4. Thermodynamics and material movements initiated by the transient

A calculation with KINTIC may be run without any thermodynamics and feedback mechanisms, in which case the transient is governed solely by the external perturbation. The normal case is, of course, a calculation including thermodynamics and feedback effects.

An older version of a thermodynamics module has been used in KINTIC-1 and was described in /4/. This module has been kept in KINTIC-2 as an additional option, but does not have much significance except for testing purposes. It may treat steady state and transient heat conduction in fuel and cladding and heat transfer to the coolant and structure material. A big number of effects is not included, among them time dependent variation of coolant velocities and phase transitions. Thus no treatment of flow coast-down and of all material movements initiated by a transient (boiling, slumping, FCI) is possible. Simulation of material movements is possible by treating them as external perturbations, but in this case the changes of thermodynamics conditions, e.g. reduced heat transfer to coolant due to boiling, are not accounted for.

In 1975/76 KINTIC-2 was coupled to the thermodynamics modules contained in CAPRI-2 /5/. The resulting code system is now able to treat the following effects occuring in a transient: Steady state and transient heat conduction and heat transfer; steady state and transient pressure distribution along the coolant channel including flow coast-down;

fuel pin deformation and cladding failure; fuel coolant interaction; sodium boiling; cladding and fuel relocation (slumping). This system of modules may be augmented by newer modules, especially by a module for cladding movement and relocation for the time before onset of fuel slumping.

In all modules a single channel model is used with up to 30 channels on different radial positions representing the original three dimensional configuration. It is left to the user to decide, which subassemblies are sufficiently similar with respect to position, burnup, power production and power/coolant flow ratio to be represented by one channel. One coolant channel contains fuel pellet, cladding, and a proportional share of coolant and structure material. Axial distributions are represented by axially subdividing the channel including fission gas plenum and mixing chamber into up to 30 zones.

In the steady state and transient one phase thermohydraulics modules, heat conduction is radial in fuel pellet and cladding, whereas heat conduction in the coolant and axial heat conduction in fuel and cladding are neglected. A central hole in the pellet and a gap between pellet and cladding are accounted for. Heat is removed from the coolant channel by the axial motion of the coolant; this is governed by the pressure drop between coolant inlet and outlet, which may be time dependent. In addition to the temperature fields, time dependent densities, volume fractions, and axial expansions are calculated for further use in the feedback routines. In part these numbers are derived from the results produced by the modules described hereafter.

Pin deformation and failure are calculated using the BREDA model /9/, which includes burnup effects. This model takes into account steady state swelling, production and partial release of fission gas, and radial porosity distrib-

ution with fuel restructuring; transient fission gas release, fuel swelling, and changing material properties of the cladding. For the calculation, the pin is axially subdivided into mechanically uncoupled cylinder segments, and a model based on an axisymmetric quasistatic plane strain approximation is used. The results of BREDA, i.e. dimensions of the central hole, width of gap between fuel and cladding, radial and axial expansion, fuel melt fraction and plastic deformation of cladding are feedback to the other modules for use in the calculation of the temperature fields, feedback and the initiation of fuel-coolant interaction or slumping.

Fuel coolant interaction is initiated, when the fraction of molten fuel and either the mean cladding temperature or the plastic deformation of the cladding exceed user specified limits in a specified number of axial nodes. The interaction is calculated with a model similar to the Cho-Wright model /11/, but with a more refined treatment of heat transfer from fuel to sodium in the two phase region following the model of Caldarola /6/. Only a specified fraction of the molten fuel in the cavity at time of failure participates in the reaction. Fuel ejection, fission-heating, chilling, axial motion, and condensation are neglected.

Sodium voiding is calculated with BLOW 3 /7/, a code using a multiple bubble slug ejection model which has been checked by experiments. Boiling is initiated when the maximum coolant temperature exceeds the sodium boiling temperature plus a user specified, channel dependent superheat. Space dependent vapour pressure inside the bubble and evaporation and condensation of a liquid sodium film including sub-assembly wall effects are taken into account.

Similar to the initiation of fuel coolant interaction, slumping is initiated when the fraction of molten fuel and either the mean cladding temperature or the plastic deformation of the cladding exceed user specified limits in a specified number of axial nodes. At present, a simple three zone model is employed for the description of material movement /8/. The middle fuel segment, for which the slumping criteria are fulfilled, moves into the free space between the lower pins, and at the same time the upper pin segments loose their support and fall down. Movement of the slumping segment is described as viscous flow, whereas the fall of the upper segments is governed by gravitation, friction, and the pressure gradient. Fuel and cladding material are assumed to move coherently. In the future, it is planned to integrate a seperate module describing cladding motion and solidification.

It is possible, with the modules described in this section, to calculate the thermodynamics and material motion in the predisassembly phase of a core disruptive accident in a conservative manner. Other modules might be added. It must be stressed that, in particular, the configuration occuring in the so-called transition phase cannot be modeled, since KINTIC-2 assumes that all fuel subassemblies are intact. In addition, an automatic switch-over to disassembly is not realized at the moment. Possibly, the future development on the KINTIC-2 system will include an integration of the corresponding modules.

2.5. Feedback

Feedback effects are, of course, accounted for in KINTIC-2 only if the thermodynamics modules are used. The following feedback effects are treated:

a. Temperature dependent changes of group constants, i.e. Doppler effect. Only the fuel capture and fission group constants are changed. For more details, see /1/.

b. Temperature dependent changes of density and volume fractions of fuel, cladding, coolant, and structure material. Changes of microscopic group constants due to changes in composition can optionally be accounted for /1/.

c. For the old thermodynamics models, optionally axial and radial core expansion; for the new thermodynamics, optionally axial core expansion.

d. For the new thermodynamic models, gross material movements resulting from voiding, slumping, or fuel coolant interaction. Again, changes of microscopic group constants due to changes in composition may be accounted for. Smeared densities are used for simulating material-movements affecting only part of a zone.

2.6. External perturbation

The description of the external perturbation has been changed basically together with the concept for the group constants. Instead of using rather abstract differences of compositions for the definition of the external perturbation, the user may now describe the perturbation in a more direct way. The external perturbation may originate either in the thermodynamics or in the neutronics part of the program. The following perturbations may be simulated:

a. Origin thermodynamics. The loss of flow situation may be simulated by simply submitting the coefficients of a function describing the time dependent decrease of pressure (see K7 of block THEIN). If this kind of perturbation is not present, the coefficients must be zero. The simulation is not possible with the old thermodynamics modules.

b. Origin neutronics. Material movement may be simulated for a number of different cases. This is possible in conjunction with the old or new thermodynamics modules or without any thermodynamics. Any movement of this kind may start and stop at any time. Transient overpower accidents may be simulated by some sort of material, e.g. control rod movement, or by feeding in an external ramp.

As in the case of feedback, gross material movement in part of a zone is simulated with smeared densities. Since this is only an approximation, zones affected by material movement should be kept sufficiently small to avoid large errors.

It is possible to simulate the following kinds of movement:

b0. A dummy perturbation is provided with no material movement taking place. Since new shape functions are calculated at the beginning and end of each time interval defining an external perturbation, the dummy perturbation may be used to enforce shape function calculation at a certain time.

b1. Replacing one composition by another. This kind of perturbation may be used to simulated control rod movement.

b2. Replacing one macro material(i.e. fuel, coolant, cladding etc.) by another or by vacuum. With this kind of perturbation, voiding or fuel-coolant-interaction without fuel movement may be simulated.

b3. Moving a macro material from one zone into another. This kind of perturbation can be used to simulate slumping or fuel movement.

An important limitation to the simulation of external perturbations is that no thermodynamics data of a zone are changed as a result of an external perturbation affecting that zone. This should be kept in mind when defining external perturbations for zones pertaining to the thermodynamics geometry, if the old thermodynamics modules are used. For the new thermodynamics modules use of perturbation types b1-b3 in thermodynamics zones is forbidden.

2.7. Time step automatization and iterative procedure

The processes described by KINTIC have widely varying time scales with, on the one hand, the extremely fast development of the neutron population, which is characterized by the fast neutron lifetime of a few 10^{-7} seconds. On the other side of the spectrum the changes of the shape function or, for the loss of flow case, the changes of material temperatures at the beginning of the transient have time scales of the order of seconds. Even the thermodynamics processes alone exhibit widely varying time scales, with sudden changes occuring at the onset of boiling or fuel coolant interaction. Since the task of managing the time scales is by far too demanding for the user, regulation of the interaction of the different time scales and the choice of adequate step lengths is largely taken over by KINTIC and the CAPRI-2 modules. A few parameters are left to the user for regulating the accuracy.

The different interacting time scales belong to the following processes:

a. Development of prompt neutron population

b. Thermodynamics: Alterations of temperatures, motion of one and two phase coolant, other material motions initiated by the transient

c. Shape function alterations

d. External perturbation

Apart from the external perturbation, which is predetermined, all processes may require an interative treatment. In the following, the way this is realized is described using the above classification (see also fig.2 and 3):

a. Calculation of the prompt neutron population, i.e. the amplitude A from eq.(4), is effected in so called micro steps, employing the point kinetics coefficients given by eq.(7) and an estimate on their time dependence. The calculation is started with a step length of 10^{-6}sec, and normally the step length is doubled after each step until either a maximum step length ($2 \cdot 10^{-2}$sec) is reached or a stability criterion is fulfilled. If the amplitude starts to rise more rapidly, the step length is automatically reduced by 1/2; the lower limit for the step length is 10^{-7}sec. Upper and lower limits for the stability criterion are user determined, with recommandations as to their values included in the input description.

A number of micro steps is joined together to form one normal step. After each micro step, a number of criteria are checked to determine whether the end of a normal step has been reached. These are:

a1. Reactivity criterion: If ρ_i is the reactivity at the start and ρ_f that at the end of the amplitude calculation, and

$\rho = \text{Max}\ (\rho_i, \rho_f)$; $d\rho = |\rho_i - \rho_f|$,

the amplitude calculation is stopped if:

$d\rho \geq .5$ \$ and $\rho < .8$ \$ or

$d\rho \geq .2$ \$ and $.8 \leq \rho < .95$ \$ or

$d\rho \geq .1$ \$ and $.95 \leq \rho$

a2. Time criterion. A prescribed normal interval may be used, the prescription resulting from thermodynamics or convergence considerations (see below). In addition, if the amplitude has changed by more than 10%, the amplitude calculation is stopped when the interval length exceeds $10^6 * l$, l being the prompt neutron lifetime.

a3. Minimax criterion: The normal interval ends when the amplitude reaches a minimum or maximum. This criterium is not checked as long as the change in amplitude stays below 10%.

a4. Amplitude criterion: The change in amplitude must not exceed a factor of 10.

a5. Slope criterion. The time derivation of the amplitude must not change by more than a factor of 2. This criterion is employed only if the amplitude has changed by more than a factor of 3.

Any of the above criteria, if fulfilled, may define the end of a normal step.

b. KINTIC then proceeds with the thermodynamics calculations for the normal interval just determined. The processes occuring in the thermodynamics part of the program, especially those described by the CAPRI-2 thermodynamics, mostly require their own time scales. These are internally determined and adjusted to the prescribed normal interval.

Since the calculational procedures of the CAPRI-2 thermodynamics could become too much strained by using unreasonably big normal intervals, KINTIC-2 uses an estimate for a reasonable maximum length of the normal interval in case a calculation with the CAPRI-2 thermodynamics modules is done. This maximum length is fed into the amplitude calculation via criterion a2. The following considerations determine the interval length:

b1. The maximum change of radially averaged fuel temperatures at any point in the reactor should be less than $35^{o}K$. For the old thermodynamics modules a similar criterium stating that the maximum change of (not overaged) fuel temperature should not exceed $50^{o}K$ is employed.

b2. The onset of any type of material motion should be determined very accurately. It is especially important that the onset of voiding is determined very well, i.e. that the specified superheat is not much exceeded.

b3. In some cases, small normal steps are required after the onset of material motion. After the onset of voiding, a maximum step length of 10 msec is specified for a superheat of more than $10^{o}K$ and 5 msec for smaller superheat. The first interval after the onset of fuel coolant interaction has a maximum length of 5 msec.

The results of the thermodynamics calculation determine the reactivity at the end of the normal interval. This is compared to the estimate used for the calculation of the time dependent amplitude, and the same is done for the neutron lifetime and the effective fractions of delayed neutrons. If the values disagree, an iteration of the normal interval is warranted. Here, the user may specify how much of an error he is willing to tolerate at the end of a normal interval.

The normal interval may in addition be shortened and a recalculation enforced in case the convergence of the iteration turns out to be weak in spite of the numerical acceleration procedures already built into KINTIC.

c. After each normal step has been fully iterated, the zone dependent contributions to reactivity, neutron lifetime, and effective delayed neutron fraction are checked for large local alterations since the last shape function calculation. Bigger differences are taken as a sign that a shape function recalculation is necessary. The user may influence the frequency of recalculations by defining the limits on the zone dependent alterations. The sum of the normal steps between two shape function recalculations forms one macro interval (see fig.3). Apart from the criterion just described, the start or end of an external perturbation interval or the start of a material movement initiated in the thermodynamics modules always entails a shape function recalculation.

In KINTIC-2, as opposed to KINTIC-1, a linear shape function extrapolation employing the last two shape functions is automatically used whenever reasonable, i.e. as long as no new material movement is initiated. The user defined limits on the alterations of zone dependent contributions to the point kinetics coef-

ficients are employed only if this extrapolation is not used, i.e. for the first macro interval and for all intervals, which start with the onset of some kind of material movement, including movements defined via the external perturbation. Otherwise, the limits are doubled, taking into account the much better shape function resulting from the extrapolation.

With the new shape function determined at the end of the macro interval, point kinetics coefficients as given by eq.(7) may differ from the ones calculated with the old (extrapolated) shape function. As in the case of the normal step, the user may specify, how much of a difference he is willing to tolerate. In case the difference exceeds this value, the whole macro interval is recalculated. This is the "outer" iteration employed by KINTIC as opposed to the "inner" iteration concerning the normal step, which has been described above. The number of inner iterations normally varies between 1 and 12 with, most often, 2-5 inner iterations. The number of outer iterations is 1 (i.e. no iteration) or, at most, 2 (i.e. one recalculation), with 1 occuring for cases with no or weak feedback and no or insignificant material motions.

At the end of this paragraph, a list will be given of the parameters available to the user for checking program speed and accuracy:

a1. Limits for accuracy check in calculation of flux amplitude (EPS1 and EPS2 in block KINPUT). Recommendations as to their values are given in the input list, based on the results of very stringent accuracy tests. Larger values are feasible but will not result in appreciable time savings, since the point kinetics module is the least time consuming module of all.

b1. Maximum error of reacticity, neutron lifetime and effective delayed neutron fraction at end of normal interval (EPS4 in block KINPUT). The number of inner iterations and the accuracy of temperatures and feedback material motions are determined by this limit.

c1. Limits for alterations of zone dependent contributions to point kinetics coefficients (EPS5 in block KINPUT). These limits determine the frequency of shape function recalculations. Recommendations as to their values are included in the input description.

c2. Maximum error of reactivity at end macro interval (EPS3 in block KINPUT). This number decides whether the macro interval is to be recalculated.

c3. Maximum number of shape function recalculations for one macro interval (NIT in block KINPUT). Normally, NIT=0,in which case the macro interval is recalculated if necessary, but the new shape function is calculated only once.

3. Organization of the code system KINTIC-2

It is not the purpose of this description to give a documentation of the internal structure of KINTIC-2 and related programs. Rather, only that part of such information will be presented which is necessary for the user to understand the working of the code and the options provided.

3.1. Modules and data organization

Since KINTIC-2 is controlled by the KAPROS system, program and data organization are tailored according to the options provided by KAPROS. Thus, the system KINTIC consists of a number of modules, which communicate via data blocks. The

controlling module is called KINTIC, which mainly organizes the data and controls the flow of calculations. At the moment, the following modules are part of the system:

a. Input testing

KINPRM	test of input for neutronics, new and old thermohydraulics

b. Core of KINTIC-2 system

KINTIC	controlling module, data organization and minor calculational tasks
AIREKI	solution of point kinetics equations
EVA	two dimensional evaluation module for calculating integral parameters, space dependent precursor concentrations, power distribution and source distribution of delayed neutrons.
INØR	processing of neutronics input
KEFFIT	stationary consistency iteration and criticality search
QSUM	calculation of group constants

c. Old thermodynamics

INSTEM	instationary one phase thermodynamics
STATEM	stationary thermodynamics

d. Coupling of neutronics and new thermodynamics

BLØTH	initialization of thermodynamics data before start of instationary calculation
THINIT	processing of thermodynamics input

e. CAPRI-2 thermohydraulics and material motion

BREDA	pin deformation and failure
CLADM	dummy module
FCIKU	fuel coolant interaction
FSLUM	slumping of fuel and cladding
ITCB	sodium voiding
ITC1	one phase instationary thermohydraulics
STATO	stationary thermohydraulics

STAT1 controlling module for instationary thermodynamics and material motion

f. DIXY system /13/ for diffusion calculations
DIXIN processing of input for DIXY
DXDIFF calculation of shape function

g. Auxiliary
INDES output of input description

The number of data blocks is at the moment up to 44, depending on the case to be calculated and excluding the up to 7 input blocks, which are the only ones to be provided by the user. 14 of the 44 data blocks are manifold with 2, 3, or 4 versions depending on the type of block. Another 3 data blocks exist in as many versions as there are thermodynamics channels in the case to be calculated (only for the CAPRI-2 thermodynamics being used), i.e. up to 30.

If, during a calculation in the KAPROS system, control is transfered from one module to another, this entails shuffling the old module out of the fast memory and reloading the new module. In the KINTIC-2 system, transfer of control takes place extremely often, typically 200-400 times per macro interval. Shuffling the modules in and out of the fast memory at every change of control causes a lot of data transfer overhead. Therefore, KINTIC-2 offers the option to keep the modules which are used most often in the fast memory during the whole calculation. This is achieved by putting KAPRST=1 in the block KINPUT; internally, use is made of the KAPROS utilities KSLORD and KSLADY. If KAPRST=1, KINTIC-2 needs a bigger memory than if KAPRST=0, in which case modules are shuffled in and out of the fast memory in the normal way. Thus, KAPRST=1 should be used for production runs, whereas KAPRST=0 for small test runs. Approximate additional

fast memory requirements for KAPRST=1 as compared to KAPRST=0 are 100 K for the old thermodynamics or no feedback, 550 K for the new thermodynamics.

Dynamic dimensioning is used in all of the KINTIC-2 system except the CAPRI-2 thermodynamics modules. Therefore, no upper limits or fairly high ones (group number $\leq$ 26) are given for a number of variables. The dimensions of a case to be calculated are always limited by the fast memory available, which is tested for sufficiency at the start of a calculation.

3.2. MAPLIB messages

In the CAPRI-2 thermodynamics modules extensive use is made of the MAPLIB library /3/ containing material properties in the form of FORTRAN functions. Even for a normal case, these functions produce a number of messages and warnings which tend to inflate the printed output. Therefore, MAPLIB messages may be printed on a seperate dataset by putting KAPRML≠6 in the input block THEIN. If in the DD card of the dataset KAPRML a dummy is defined, the MAPLIB messages are suppressed.

3.3. The restart option

For even a medium case CPU times are too long for terminating a calculation in one run. Therefore, a restart option is provided. No use is made of the KAPROS restart option since this would entail putting the restart blocks into the so-called KAPROS restart lifeline, in which the old blocks are automatically deleted

after seven days. Since the number of restart blocks is big in the case of the KINTIC-2 system, it can be foreseen that KINTIC alone would quickly fill up the restart lifeline, or would not get enough space there.

The KINTIC system therefore uses a restart data set onto which all blocks necessary for the restart of a calculation are copied. The restart routine does the reading or writing even for blocks which may not be defined in a special calculation; in this case warnings are printed which normally may be ignored. They are only helpful in case a restart fails. Internally, the restart data set is updated every time a potential checkpoint is encountered during the flow of calculations, and a message is printed. In the case of an abnormal job end, the job can be restarted from the last of these internal checkpoints. If the remaining CPU-time for writing the restart file may be too small, KINTIC-2 tries to produce a restart file on unit 24 in order to avoid destroying the existing restart file. If a DD-card for unit 24 has been submitted by the user and the CPU-time is sufficient, this file may be used for a restart; otherwise, the normal restart file is to be used, which, of course contains the data of the last but one checkpoint.

3.4. The evaluation files

For a convenient evaluation of the results of a calculation, KINTIC-2 produces up to 5 files containing time dependent results. Production is optimal and may be stopped, continued, or newly started after a checkpoint. If at least one of these files is produced, KINTIC-2 needs an additional intermediate file, the number of which is defined in the initial input; this number is, in case a job produces no evaluation files, automatically put equal to zero, thus requiring no DD-card for the intermediate file in this case. If evaluation files

are to be written by a restart job, the foregoing job of which did not produce evaluation files, the ds-number of the intermediate file is assumed to be 23, and thus a DD-card for this file is to be provided in this special case.

4. Geometrical representation of the reactor

4.1. Introduction

The geometrical description of the reactor especially for cases employing the new thermodynamics has become much more complicated than the one used in KINTIC-1. In the old code, the zones employed for calculation of neutronics, feedback and thermodynamics are basically the same with the only peculiarity that a difference is made between feedback and non-feedback zones, the latter comprising e.g. reflectors or absorbers. Two factors mainly complicated this simple picture:

a. The new scheme for treating group constants described in /1/. This concept had to be adapted since the scheme used in KINTIC-1 - one set of group constants per feedback-zone containing all information on temperature and composition dependence - proved too cumbersome for large cases. In the new scheme, the reactor is divided up into subzones for the calculation of group constants, each subzone encompassing several feedback or non-feedback zones as a rule. Microscopic group constants are constant in each subzone, but may depend on temperature and composition; thus the information on temperature and composition dependence is to be stored once for every subzone. The actual macro-

scopic group constants for each feedback zone are calculated from this information using the actual temperatures and compositions and thus result in one set of group constants per feedback zone, to be used for the actual calculations.

b. The new thermodynamics modules allow a treatment of up to 30 representative coolant channels with up to 20 axial zones in the core and blanket region and additional axial zones above and below. If all zones were used for treating the feedback, this would result in up to 900 zones, and even if only the zones containing fuel were used, up to 600 feedback zones would result. From a neutronics point of view, the zones outside the blanket need not be correlated with the thermodynamics zones. In addition, the axial and radial representation of feedback often need not be as accurate as the thermodynamics; e.g. adjacent radial channels differing only in burnup may be collapsed for the feedback representation. This is necessary since the block of macroscopic group constants for 600 zones is unmanageably big. The number of feedback and non-feedback zones has therefore been restricted to 200; feedback zones may be collapsed axially, radially and azimuthally from the thermodynamics zones.

One therefore has four geometrical representations of the original reactor configuration:

a. The subzone representation concerning the macroscopic group constants;

b. the thermodynamics representation;

c. the feedback representation including non-feedback zones;

d. the neutronics mesh.

Of course, these meshes are correlated. In the following sections, each of the meshes will be discussed together with the rules linking it to the other meshes. A special section is devoted to the representation of control rods.

In any case, the user is strongly advised to make a sketch of the geometry for even a simple problem, containing all information on the different meshes. This greatly helps with the production of the input even in the case, in which the old thermodynamics and therefore the simpler mesh is used.

4.2. Geometry for group constants

The contents of this section is a repetition from /1/ but will be given here for completion of the geometrical picture.

Since a discussion of geometrical representations remains too abstract without pictures, a configuration typical for a small fast reactor is used for demonstration. Fig.4 shows this reactor containing core and blanket zones, absorber, follower, reflector and coolant and fission gas plenum. The figures used in this and the following three sections for describing the different meshes always pertain to the basic geometry shown in fig.4.

Fig.5 shows the subzone configuration of the reactor. 10 subzones are used for describing the different microscopic group constants taking into account differences in steady state material composition and in collapsing spectrum. The latter criterium is applied but once, in the radial blanket, which is subdivided into an inner and an outer zone with a harder and a softer collapsing spectrum.

It should be noted in fig.5 that the core has been shortened axially - the original core height is given by the dashed lines. This anticipates the neutronics representation which needs only a reflector thickness of a few neutron mean free paths for accurately representing the flux at the outer blanket boundaries. Thus, excessive axial height needed for the thermodynamics representation may be trimmed away for the neutronics.

There are no restrictions imposed on the choice of subzones apart from the fact, that they must reflect the material compositions. On the other hand, the choice of the other meshes is influenced by the subzone division through rules to be defined in the following sections. The user should therefore always keep in mind the necessities arising from the thermodynamics and feedback representation even at the stage where only the group constants are to be determined. This is particularly true if an artificial boundary like the one between subzones 4 and 5 is introduced, since such a boundary later influences the possible thermodynamics representations.

4.3. Geometry for thermodynamics

Fig.6 shows the geometric representation of the reactor for thermodynamics. Here, the full axial height of the core is used, but radially, the absorber and reflector regions are not included. 7 radial channels with 14 axial zones are used; 9 axial zones comprise the core and blanket region.

The following rules have to be obeyed for the thermodynamics mesh:

a. In the core and blanket region, axial and radial boundaries from the subzone configuration are to be included as boundaries of thermodynamics zones. The axial mesh outside the core and blanket region need not be correlated.

b. The same axial mesh is to be used for all channels.

c. A radial segment may contain more than one thermodynamics channel, e.g. two with different burnup. It is not possible to define thermodynamics channels pertaining to more than one radial segment.

4.4. Geometry for feedback

This geometry is shown in fig.7. Only the core and blanket zones are correlated with the thermodynamics zones, including a small axial zone above the upper blanket into which the fuel elements expand. Radially, channels 1 and 2, and axially three zones in the middle of the core region are collapsed. This picture illustrates the rules for forming the feedback mesh, which are as follows:

a. Only the core and blanket zones are correlated with the thermodynamics mesh. If axial expansion is to be treated, an additional axial zone is to be added above the uppermost thermodynamics blanket zone for each channel. The height of this zone is arbitrary, but should be of the order of magnitude of the expected maximum expansion. If axial expansion is suppressed, no expansion zone needs to be defined.

b. Radial and axial boundaries of the feedback mesh must coincide with boundaries of the thermodynamics mesh and must include the subzone boundaries. The axial mesh must be the same for all feedback channels.

c. Non-feedback zones are uncorrelated with the thermodynamics mesh.

Fig.7 already contains the zone and composition numbers from the neutronics input. The composition numbers (in parantheses in fig.7) may be arbitrarily chosen; in fig.7, the first 6 compositions are core zone 1 compositions pertaining to subzone 1, the next 6 those of core zone 2 pertaining to subzone 2 etc. The zone numbers, which are given by the order of the cards defining the zones in the input for DIXY, again obey certain rules:

a. First, all feedback zones are to be listed. At the end of the zone input, the non-feedback zones follow in arbitrary oder.

b. All zones pertaining to one feedback channel are to be listed consecutively in the direction of coolant flow. The order of feedback channels is given by the order of zones in the DIXY input.

4.5. Geometry for neutronics

Part of this geometry has already been mentioned at the end of the last section. The feedback and non-feedback zones together form the zone mesh for the neutronics calculations. This mesh is repeated in fig.8 and supplemented by dashed lines, which together with the zone boundaries form the grid for the flux shape calculation. Again, certain rules are to be obeyed for the neutronics mesh:

a. At least one point per zone must not be situated on a zone boundary.

b. Thermodynamics radial channels and axial zone boundaries are to be repeated in the neutronics mesh. In the example, this rule concerns the position of column 2 and lines 13 and 14.

Otherwise, the neutronics mesh is only governed by the rulesprescribed by DIXY, i.e. number of axial and radial points must be a multiple of 4 and 2, resp.

4.6. Representation of control rods

There are two ways of representing control rods, which are treated as non feedback zones in KINTIC. The first one has been implicitely depicted in the example already, with a control rod zone inserted between the thermodynamics zones.

A second pressibility consists in mixing the control rod/follower zones with a feedback channel. In this case, no extra radial segment is defined for the control rod. Instead, the user has to specify, that a certain amount of control rod or follower material is to be mixed with the zones pertaining to one feedback channel. For example if the control rod/fuel element ratio is 1/5, 1/6 has to be specified in the input. Internally, the formalism for a time dependent replacement of one material by another is used for this kind of simulation, and the correlated input therefore turns up among the input defining the external perturbation. It is not possible at the moment, to simulate control rod movement for control rods represented in this second way.

5. Job control language

The following job control language cards are to be provided for a KINTIC-job:

```
//  Jobcard                                                    (a)
/*FØRMAT PR,DDNAME=FT42FOO1
// EXEC KSG
[//K.FT44FOO1 DD SPACE=(3064,msl)]                            (b)
[//K.FTyyFOO1 DD DUMMY]                                       (c)
[//K.FFxxFOO1 DD .....]                                       (d)
.......................
[//K.FT23FOO1 DD .....]                                       (e)
[//K.FT24FOO1 DD .....]                                       (f)
[//K.FT25FOO1 DD .....]                                       (g)
//K.SYSIN DD *
   Kintic input blocks see following chapter
*GØ SM=KINTIC
/*
//
```

Comments:

(a) Region and time parameters are very much a function of the case to be calculated. The minimum region (small test cases with KAPRST=0) is currently about 320 K for the old thermodynamics, 460 K for the new thermodynamics. A user lacking experience may start his case with a 480 K region and then adjust the region using the messages printed at the beginning of the job. Times are 1-5 minutes for small test cases and several hours for production runs; check points should be used in the latter case.

(b) Not to be provided for small test cases only. For cases using the new thermodynamics, msl may be up to 3000.

(c) To be provided for the new thermodynamics only, if yy = KAPRML≠6 (see block THEIN). This is the DD-card for the MAPLIB-dataset (chapter 3.2). If MAPLIB-messages are to be printed seperately, DUMMY is to be replaced by the specifications for a dataset and a corresponding FORMAT-card is to be inserted.

(d) DD-cards to be provided for the up to 5 evaluation datasets (KTPØUT of block INPUT and ICLCMP, NFCIPL, IVØID, NSPLT of block THEIN), the intermediate evaluation file KPLI of block KINPUT, the restart file NBCHI from block KINPUT which contains the data of the foregoing job, and the new restart file NBCH from block KINPUT to be provided by the current job.

(e) DD-card for intermediate evaluation file for restart case with the foregoing job having no evaluation files.

(f) Backup checkpoint file (see chapter 3)

(g) DD-card for dataset containing the group constants. To be provided only for the start of a run.

6. Input

The card input to the code system consists of up to 7 input blocks, which are listed below together with the conditions, under which they are to be provided:

Name of block	to be provided for:
KINPUT	always
INSTIT	start of calculation with use of KINTIC-critically search options
FEEDBC	start of calculation
THEIN	start of calculation with CAPRI-thermodynamics
DX LDIM	start of calculation
DXDIF	start of calculation
DXBUCK	start of calculation with nonzero buckling

A description of the contents of the first four blocks will be given on the following pages. The contents of the last three blocks is detailed in the input description of the KAPRØS-DIXY version and thus is not listed here, but some restrictions on the input for DIXY arising from the use in conjunction with KINTIC-2 are given.

The contents of the four blocks is as follows:

KINPUT : Basic control data for both start of a calculation or restart; definition of perturbation, of variants of subzones if any; assignment of (variants of) subzones to DIXY zones

INSTIT: Control data for stationary critically search option provided by KINTIC-2

FEEDBC : Old or no thermodynamics: Thermodynamics control data and input
CAPRI-2 thermodynamics: Assignment of thermodynamics channels and axial zones to feedback channels and axial zones.

THEIN : Control data and thermodynamics input for CAPRI-thermodynamics.

The geometry for DIXY and the control data for the two dimensional calculation of the shape function are contained in the remaining two blocks, DX LDIM and DXDIF; DXBUCK contains the bucklings, if any.

The notation used on the following pages is: Knn for the start of a sequence of input data; Snn for a logical decision or/involving a skipping of data. All input is unformatted and governed by the rules for KAPROS-input /2/.

A final remark must be made with regard to the input description contained in this report: This is the description as of the beginning of 1977. It may be subject to changes since all modules may be further refined and new modules requiring additional input (e.g. one for cladding motion) may be added. The newest input description may be obtained by starting a KINTIC-job with the input block KINPUT containing the constant 'DESCR' (see the following description of KINPUT).

6.1. BLOCK KINPUT

KAPROS CONTROL CARD:

*KSIOX CBN=KINPUT,TYP=CARD,PM=KINPRM

IF ANY ONE OF THE BLOCKS FEEDBC, INSTIT, OR THEIN IS PRESENT, CONCATENATION OF INPUT BLOCKS, I. E. PM=KETT FOR ALL BLOCKS EXCEPT THE LAST ONE, SHOULD BE USED TO GUARANTEE A FULL INPUT TEST.

CONTENTS OF BLOCK:

S1 FOR START OF CALCULATION K8, FOR RESTART K2, FOR OUTPUT OF INPUT DESCRIPTION K39

K2 'CHCKI' CONSTANT
NCHCI NCHEC FROM FOREGOING RUN, I. E. 1, 2, 3, OR 4
NBCHI DS-NUMBER OF RESTART FILE (.NE. 23, 24)

S3 IF NCHCI.LT.3 CONTINUE WITH S31, OTHERWISE K4

K4 NEVA(1) CONTROL NUMBER FOR CONTINUATION OF EVALUATION FILE KTPOUT (SEE K8)
0: NO EVALUATION OUTPUT
-1: CONTINUE ON SAME FILE
-2: CONTINUE ON NEW FILE
+KTPOUT: START ON NEW FILE

S5 FOR NFEED.GE.0 CONTINUE WITH S31, OTHERWISE K6

K6 (NEVA(I), I=2,5) CONTROL NUMBER FOR CONTINUATION OF EVALUATION FILES ICLCMP, NFCIPL, IVOID, AND NSPLT (IN THIS ORDER, SEE K4 IN BLOCK THEIN). DEFINITION AS IN K4

S7 CONTINUE WITH S31

K8 'START' CONSTANT
NG NUMBER OF ENERGY GROUPS (.LE.26)
NV NUMBER OF PRECURSOR GROUPS (.LE.6)
NZ NUMBER OF FEEDBACK AND NON-FEEDBACK ZONES (.LE.200)
NPKT NUMBER OF NEUTRONICS MESH POINTS
NKKD NUMBER OF RADIAL SEGMENTS FOR FEEDBACK
NMD NUMBER OF AXIAL SEGMENTS PER RADIAL SEGMENT FOR FEEDBACK
NNMAX MAXIMUM NUMBER OF RADIAL ZONES IN PELLET USED FOR THERMODYNAMICS REPRESENTATION
NFEED 1: OLD THERMODYNAMICS MODULES
0: NO THERMODYNAMICS AND FEEDBACK
-1: CAPRI-2 THERMODYNAMICS MODULES
NAUS 1: MAXIMUM OUTPUT FOR TESTING
-2: BIG OUTPUT

```
                -1: MEDIUM OUTPUT INCLUDING SHAPE FUNCTION
                 0: SMALL OUTPUT WITHOUT SHAPE FUNCTION
     KTPOUT     DS-NUMBER OF NEUTRONICS EVALUATION FILE (.NE.
                23, 24, 25)
                 0: NO SUCH FILE
     KPLI       DS-NUMBER OF INTERMEDIATE FILE (.NE. 24, 25)
                0, IF NO EVALUATION FILES ARE PRODUCED
     KAPRST     0: TESTING OPTION; SMALL REGION, BIG OVERHEAD
                1: PRODUCTION RUN OPTION; BIG REGION, LESS OVER-
                HEAD

K9   'PERTUR'   CONSTANT
     NST        NUMBER OF PERTURBATION INTERVALS (.GE.1)
     TMX        MAXIMUM TIME FOR PROBLEM (SEC)

S10  FOR EACH PERTURBATION INTERVAL K11-S21, THEN K22

K11  L          3                FOR PERTURBATION TYPE 0
                5+2*NZP+2*NSTT   FOR PERTURBATION TYPE 1
                5+5*NZP+2*NSTT   FOR PERTURBATION TYPE 2
                5+4*NZP+2*NSTT   FOR PERTURBATION TYPE 3
     NTYP       PERTURBATION TYPE (0.LE.NTYP.LE.3)
     T1         START OF INTERVAL (SEC)
     T2         END OF INTERVAL (SEC)

S12  FOR PERTURBATION TYPE 0 CONTINUE WITH S10, OTHERWISE K13

K13  NZP        NUMBER OF PERTURBATIONS, I. E. FOR NTYP =
                1: NUMBER OF PERTURBED FEEDBACK AND/OR NON-FEED-
                   BACK ZONES;
                2: NUMBER OF MACRO MATERIAL PAIRS, ONE PAIR BE-
                   LONGING TO THE SAME ZONE;
                3: NUMBER OF MACRO MATERIALS IN PAIRS OF ZONES.

S14  FOR PERTURBATION TYPE 1 CONTINUE WITH K15,
     FOR PERTURBATION TYPE 2 CONTINUE WITH K17,
     FOR PERTURBATION TYPE 3 CONTINUE WITH K19

K15  (IDZ1(I),  COMPOSITION NUMBER OF PERTURBED ZONE. DO NOT
                SPECIFY FEEDBACK ZONES EXCEPT FOR NSTT=1 (K20)
     NSZ(I),    SUBZONE NUMBER OF PERTURBING COMPOSITION. FRAC-
     I=1,NZP)   TION OF PERTURBING COMPOSITION: 1.-G(T), SEE K20

S16  CONTINUE WITH K20

K17  (IDZ2(I),  COMPOSITION NUMBER OF PERTURBED ZONE. FOR
                NFEED.LT.0, DO NOT SPECIFY FEEDBACK ZONES
     MANA1(I),  NAME OF FIRST MACRO MATERIAL (5 ALPHANUMERICAL
                CHARACTERS). ITS VOLUME FRACTION IS MULTIPLIED
                BY G(T)
     MANA2(I),  NAME OF SECOND MACROMATERIAL, WHICH FILLS UP/
     I=1,NZP)   PROVIDES THE SPACE OF THE FIRST ONE. 'VACUUM'
                MAY BE SPECIFIED IN CASE THE SPACE IS NOT TO BE
                FILLED UP/PROVIDED. OTHERWISE, 5 ALPHANUMERICAL
                CHARACTERS
```

```
S18 CONTINUE WITH K20

K19 (IDZ3(I),   COMPOSITION NUMBER OF FIRST PERTURBED ZONE. FOR
                NFEED.LT.0, DO NOT SPECIFY FEEDBACK ZONES
    MANA3(I),   NAME OF MACRO MATERIAL. ITS VOLUME FRACTION IN
                THE FIRST PERTURBED ZONE IS MULTIPLIED BY G(T),
                THE DIFFERENCE FROM INITIAL STATE COMING FROM/
                GOING TO THE SECOND PERTURBED ZONE
    IDZ4(I),    COMPOSITION NUMBER OF SECOND PERTURBED ZONE. FOR
    I=1,NZP)    NFEED.LT.0, DO NOT SPECIFY FEEDBACK ZONES.

K20 NSTT        NUMBER OF POINTS DESCRIBING THE WEIGHTING FUNC-
                TION G(T). NORMALLY, NSTT.GE.2, BUT FOR TIME IN-
                DEPENDENT MIXING OF, E. G. CONTROL ROD OR
                FOLLOWER ZONES WITH FEEDBACK ZONES (NTYP=1),
                NSTT=1. THEN, T1=0. AND T2=TMX IN K11
    (TI(I),     TIME (SEC)
    GI(I),      WEIGHTING FUNCTION AT TIME TI(I)
    I=1,NSTT)

S21 CONTINUE WITH S10

K22 'DCN '      CONSTANT
    NDCN        NUMBER OF SUBZONES AND VARIANTS OF SUBZONES IN
                THE REACTOR

S23 FOR EACH (VARIANT OF A) SUBZONE K24 - K26, THEN K27

K24 M           4*NVA+4
    MDC1        NUMBER OF FIRST COMPOSITION PERTAINING TO THE
                (VARIANT OF A) SUBZONE
    MDC2        NUMBER OF LAST COMPOSITION PERTAINING TO THE
                (VARIANT OF A) SUBZONE
    MSU         SUBZONE NUMBER
    NVA         .GT.0: VARIANT OF A SUBZONE. DENSITY AND VOLUME
                FRACTION OF NVA MACRO MATERIALS ARE CHANGED
                0: OTHERWISE

S25 FOR NVA.GT.0 CONTINUE WITH K26, OTHERWISE S23

K26 (MANAV(I), NAME OF MACRO MATERIAL, THE CONTENTS OF WHICH IS
                TO BE CHANGED
    RHO(I),     NEW DENSITY (G/CM**3)
    VF(I),      NEW VOLUME FRACTION
    I=1,NVA)

K27 'CONTROL'   CONSTANT
    NIT         NUMBER OF ITERATIONS OF SHAPE FUNCTION, NORMALLY
                0
    KZERO       0: QUASISTATIC METHOD
                -1: ADIABATIC METHOD
                1: POINT KINETICS
    KQB         0: NORMAL QUASISTATIC METHOD
                1: IMPROVED QUASISTATIC METHOD
```

```
     EPS1          LOWER LIMIT FOR ACCURACY TEST IN POINT KINETICS
                   MODULE (1.E-5)
     EPS2          UPPER LIMIT FOR ACCURACY TEST IN POINT KINETICS
                   MODULE (1.E-4)
     EPS3          MAXIMUM DEVIATION OF REACTIVITY AT ENC OF MACRO
                   INTERVAL ($)
     (EPS4(I),     MAXIMUM DEVIATION OF REACTIVITY RHO, LIFETIME L,
    I=1,2+NV)      AND EFFECTIVE BETA-I AT END OF NORMAL INTERVAL.
                   ORDER: EPS4(RHO) (ABSOLUTE VALUE), EPS4(L)
                   (RELATIVE VALUE), EPS4(BETA-1), EPS4(BETA-2),...
                   (RELATIVE VALUES)
     (EPS5(I),     MAXIMUM ALTERATION OF RHO, L, AND BETA-I IN
     I=1,2+NV)     SINGLE ZONE DURING ONE MACRO INTERVAL; ORDER AND
                   DIMENSIONS AS ABOVE. RECOMMENCED VALUES FOR FAST
                   REACTORS: EPS5(RHO)=.001; EPS5(L)=EPS5(BETA-I)=
                   .1

S28  IF NO EXTERNAL REACTIVITY IS TO BE USED K30, OTHERWISE K29

K29  'RCRAMP'      CONSTANT
     NRO           NUMBER OF POINTS AT WHICH REACTIVITY IS GIVEN
                   (.LE.6)
     (TRO(I),      TIME; TRO(1).GT.0. (SEC)
     I=1,NRO)
     (RO(I),       REACTIVITY AT TIME TRO(I) ($)
     I=1,NRO)

K30  'POWER'       CONSTANT
     XP            STATIONARY REACTOR POWER (MW)

S31  FOR CHECKPOINT CONTINUE WITH K34, OTHERWISE K32

K32  'ENDE '       CONSTANT

S33  CONTINUE WITH K35

K34  'CHECK'       CONSTANT
     NCHEC         0: NO CHECKPOINT
                   1: CHECKPOINT AFTER MAKMAX STATIONARY SHAPE
                      FUNCTION ITERATIONS
                   2: CHECKPOINT AFTER FINAL STATIONARY THERMO-
                      HYDRAULICS
                   3: CHECKPOINT AFTER MAKMAX MACRO INTERVALS
                   4: CHECKPOINT BEFORE RECALCULATION OF NEXT
                      (START OF CALCULATION: FIRST) MACRO INTERVAL
     MAKMAX        NCHEC=1: NUMBER OF STATIONARY ITERATIONS, THOSE
                            OF FOREGOING RUN INCLUDED; MAKMAX=-1
                            FOR CHECKPOINT BEFORE FINAL STATIONARY
                            SHAPE FUNCTION CALCULATION
                   NCHEC=3: NUMBER OF MACRO INTERVALS BEFORE CHECK-
                            POINT, THOSE OF FOREGOING RUNS INCLUDED

K35  NBCH          DS-NUMBER OF RESTART FILE (.NE. 23, 24, 25)

S36  FOR A RESTART CASE END OF BLOCK, OTHERWISE K37
```

```
K37 'CONSIS'    CONSTANT
    KONSI       0:  NO STATIONARY CONSISTENCY ITERATION (FOR
                    NFEED=0 ONLY)
                -1: CONSISTEMCY ITERATION FOR GROUP CONSTANTS
                    (FOR NFEED.NE.0 ONLY)
                1:  CONSISTENCY ITERATION FOR GROUP CONSTANTS
                    AND DENSITIES (FOR NFEED.GT.0 ONLY)
    KONE        0: NO STATIONARY CRITICALITY SEARCH
                1: CRITICALITY SEARCH WITH OPTIONS OF KINTIC-2
    EPS6        MAXIMUM DEVIATION OF STATIONARY K-EFF FROM 1.

S38 END OF BLOCK

K39 'DESCR'     CONSTANT

S40 END OF BLOCK
```

6.2. BLOCK INSTIT

TO BE PROVIDED ONLY FOR START OF A CALCULATION, IF KONE.NE.0 IN BLOCK KINPUT. KAPROS CONTROL CARD:

*KSIOX DBN=INSTIT,TYP=CARD,PM=KINPRM

CONCATENATION SHOULD BE USED (SEE BLOCK KINPUT).

CONTENTS OF BLOCK:

K1	ANA	'RADIT', IF K-EFF IS TO BE CHANGED BY ADJUSTING REACTOR DIMENSIONS. NOT TO BE USED TOGETHER WITH CAPRI-2 THERMODYNAMICS
		'MATIT', IF K-EFF IS ADJUSTED BY CHANGING COMPOSITIONS
S2	FOR ANA='RADIT' CONTINUE WITH K3, OTHERWISE K5	
K3	ALPH1	'HSTP', IF HORIZONTAL REACTOR AXIS IS TO BE CHANGED
		'VSTP', IF VERTICAL REACTOR AXIS IS TO BE CHANGED
	FACT1	INITIAL REACTOR DIMENSION L IS VARIED BETWEEN L*FACT1 AND L/FACT1
S4	END OF BLOCK	
K5	NNMI	NUMBER OF COMPOSITIONS TO BE CHANGED
	(NUMI(I), I=1,NNMI)	THEIR NUMBERS IN DIXY ZONE INPUT
	MANA1	NAME OF FIRST MACRO MATERIAL TO BE CHANGED
	MANA2	NAME OF SECOND MACRO MATERIAL. IF NO SECOND MATERIAL IS TO BE USED, MANA2='VACUUM'
	FACT2	VOLUME FRACTION OF FIRST MACRO MATERIAL IS VARIED BETWEEN VF*FACT2 AND VF/FACT2. THE SECOND MACRO MATERIAL FILLS UP/PROVIDES THE SPACE PROVIDED/FILLED UP BY THE FIRST
S6	END OF BLOCK	

6.3. BLOCK FEEDBC

TO BE PROVIDED ONLY FOR START OF A CALCULATION. KAPROS CONTROL CARD:

*KSICX CBN=FEEDBC,TYP=CARD,PM=KINPRM

CONCATENATION SHOULD BE USED (SEE BLOCK KINPUT).

CONTENTS OF BLOCK:

S1 FOR NFEED.GE.0 K2 - S11, OTHERWISE S12 - K13

K2	NKKN	NUMBER OF RADIAL SEGMENTS FOR THE DEFINITION OF COOLANT CHANNELS (0.LE.NKKN.LE.10; =NKKD IN BLOCK KINPUT)
	NM	NUMBER OF AXIAL ZONES PER SEGMENT (0.LE.NM.LE.10; =NMD IN BLOCK KINPUT)
	NNMAX	MAXIMUM NUMBER OF RADIAL ZONES IN FUEL PELLET (0.LE.NNMAX.LE.6; =NNMAX IN BLOCK KINPUT)
	0	CONSTANT
	NVOIN	1: VOLUME CHANGES ARE TAKEN INTO ACCOUNT 0: OTHERWISE
	NPRINT	CONTROLS OUTPUT OF THERMODYNAMICS AND FEEDBACK MODULES, IF NAUS IN BLOCK KINPUT .NE.0 AND .NE.-1 0: NO OUTPUT 1: OUTPUT AT END OF PERTURBATION INTERVAL -2: SHORT OUTPUT FOR EACH ITERATION OF NORMAL INTERVAL -1: LONG OUTPUT FOR EACH ITERATION OF NORMAL INTERVAL
	NSTUE	NUMBER OF AXIAL ZONE CONTAINING THE SPACERS
	NFEED	=NFEED IN BLOCK KINPUT: 0: NO FEEDBACK 1: OLD VERSION OF THERMODYNAMICS
	1	CONSTANT

S3 FOR NFEED=0 END OF BLOCK; FOR NFEED=1 K4 - K7 FOR EACH RADIAL CHANNEL, THEN S8

K4	KKN	NUMBER OF CHANNEL
	VSTRUK	VOLUME OF STRUCTURE MATERIAL PER CM LENGTH OF PIN (CM**2)
	NN	NUMBER OF RADIAL ZONES IN PELLET (2.LE.NN.LE.NNMAX)
	RBR	PELLET RADIUS (CM)
	DCLAD	CLADDING THICKNESS (CM)
	RKUE	EQUIVALENT RADIUS OF COOLANT CHANNEL (CM)
	VDUF	FOLLOWING QUOTIENT: VOLUME OF STRUCTURE MATERIAL /PART OF ITS SURFACE IN CONTACT WITH COOLANT (CM)
	DELTB	ESTIMATE OF RADIAL TEMPERATURE DIFFERENCE IN THE PELLET (DEG. C)

EPSK	ERROR LIMIT FOR ITERATION OF TEMPERATURES (DEG. C). RECOMMENDED VALUE: .01
VKUEL	COOLANT VELOCITY (CM/SEC)
TKIN	TEMPERATURE OF COOLANT AT ENTRY (DEG. C)
ANTB	FRACTION OF HEAT RELEASED IN FUEL
ANTC	FRACTION OF HEAT RELEASED IN CLADDING
ANTK	FRACTION OF HEAT RELEASED IN COOLANT
ANTS	FRACTION OF HEAT RELEASED IN STRUCTURE MATERIAL
TSBR	MELTING TEMPERATURE OF FUEL (DEG. C)
TSCL	MELTING TEMPERATURE OF CLADDING (DEG. C)
TSKUE	BOILING TEMPERATURE OF COOLANT (DEG. C)
TSSTR	MELTING TEMPERATURE OF STRUCTURE MATERIAL (DEG. C)
UMELT	LATENT HEAT OF MELTING FOR FUEL (CAL/CM**3)
UREKR	LATENT HEAT OF RECRISTALLIZATION FOR FUEL (CAL/CM**3)

K5 THIS PART OF THE INPUT CONTAINS THE TEMPERATURE DEPENDENT THERMODYNAMICS PARAMETERS IN THE FORM P(1),...P(4). THE ACTUAL PARAMETER IS CALCULATED FROM THESE VALUES VIA:

P(T)=P(1)+P(2)*T+P(3)*T*T T.LE.TLIMIT,

P(T)=P(4) T.GT.TLIMIT,

WHERE TLIMIT IS ONE OF THE VALUES TSBR, TSCL, TSKUE, OR TSSTR DEPENDING ON WHICH MATERIAL P REFERS TO. THE TRANSFER COEFFICIENTS HBC AND HCK DEPEND ON THE TEMPERATURE OF FUEL AND CLADDING, RESP.

(ROB(I), I=1,4)	FUEL DENSITY (G/CM**3)
(ROC(I), I=1,4	CLADDING DENSITY (G/CM**3)
(ROK(I), I=1,4)	COOLANT DENSITY (G/CM**3)
(ROS(I), I=1,4)	STRUCTURE MATERIAL DENSITY (G/CM**3)
(CPB(I), I=1,4)	SPECIFIC HEAT OF FUEL (CAL/(G*DEG. C))
(CPC(I), I=1,4)	SPECIFIC HEAT OF CLADDING (CAL/(G*DEG. C))
(CPK(I), I=1,4)	SPECIFIC HEAT OF COOLANT (CAL/(G*DEG. C))
(CPS(I), I=1,4)	SPECIFIC HEAT OF STRUCTURE MATERIAL (CAL/(G*DEG. C)
(HBC(I), I=1,4)	HEAT TRANSFER COEFFICIENT FUEL-CLADDING (CAL/(CM**2*SEC*DEG. C))
(HCK(I), I=1,4)	HEAT TRANSFER COEFFICIENT CLADDING-COOLANT (CAL/(CM**2*SEC*DEG. C))
(XLB(I), I=1,4)	HEAT CONDUCTIVITY OF FUEL (CAL/(CM*G*DEG. C))
(XLC(I), I=1,4)	HEAT CONDUCTIVITY OF CLADDING (CAL/(CM*G*DEG. C))

```
K6  KKN          NUMBER OF CHANNEL
    MI           NUMBER OF DIFFERENT SETS OF FOLLOWING DATA
                 (ALPHA, BETAAB,...,E)
    (ALPHA(I),   VOLUME FRACTION OF COOLANT
    BETAAB(I),   VOLUME FRACTION OF SPACER
    BETAKA(I),   VOLUME FRACTION OF SUBASSEMBLY WALLS
    BETATO(I),   VOLUME FRACTION OF OTHER MATERIALS NOT COMPRIS-
                 ING PIN, COOLANT, SPACER, AND SUBASSEMBLY WALLS
    E(I),        CLEARANCE BETWEEN FUEL AND CLADDING (CM)
    I=1,MI)
    (MZ(I),      NUMBER OF FOREGOING DATASET PERTAINING TO AXIAL
    I=1,NM)      NODE I

K7  KKN          NUMBER OF CHANNEL
    AUSBAX       LINEAR AXIAL EXPANSION COEFFICIENT FOR FUEL
                 (1./DEG. C)
    AUSCAX       LINEAR AXIAL EXPANSION COEFFICIENT FOR CLADDING
                 (1./DEG. C)
    AUSSAX       LINEAR AXIAL EXPANSION COEFFICIENT FOR STRUCTURE
                 MATERIAL (1./DEG. C)
    AUSBON       VOLUME EXPANSION COEFFICIENT FOR BONDING
                 (1./DEG. C)
    AUSBRA       LINEAR RADIAL EXPANSION COEFFICIENT FOR FUEL
                 (1./DEG. C)
    AUSCRA       LINEAR RADIAL EXPANSION COEFFICIENT FOR CLADDING
                 (1./DEG. C)
    AUSSRA       LINEAR RADIAL EXPANSION COEFFICIENT FOR
                 STRUCTURE MATERIAL (1./DEG. C)
    AUSKUE       VOLUME EXPANSION COEFFICIENT FOR COOLANT
                 (1./DEG. C)

S8  FOR KONSI (BLOCK KINPUT) .GT.0 CONTINUE WITH S9 - K10,
    OTHERWISE END OF BLOCK

S9  FOR EACH CHANNEL K10

K10 KKN          NUMBER OF CHANNEL
    NTT          NUMBER OF DIFFERENT SETS OF FOLLOWING DATA
                 (TFO,...,TSO)
    (TFO(I),     FUEL TEMPERATURE USED FOR PREPARATION OF NUCLIDE
                 DENSITIES IN CALCULATION OF GROUP CONSTANTS
    TCO(I),      SAME FOR CLADDING
    TKO(I),      SAME FOR COOLANT
    TSO(I),      SAME FOR STRUCTURE MATERIAL
    I=1,NTT)
    (MT(I),      NUMBER OF FOREGOING DATASET PERTAINING TO AXIAL
    I=1,NM)      NODE I

S11 END OF BLOCK

S12 FOR EACH RADIAL FEEDBACK CHANNEL K13, THEN END OF BLOCK

K13 NKAN         NUMBER OF THERMODYNAMICS CHANNELS PERTAINING TO
                 THE FEEDBACK CHANNEL (.LE.10)
    (KKAN(I),    THEIR NUMBER IN THE SEQUENCE OF THERMODYNAMICS
```

	CHANNELS IN BLOCK THEIN
RI(I),	INNER RADIUS OF THERMODYNAMICS CHANNEL (CM)
RA(I),	OUTER RADIUS OF THERMODYNAMICS CHANNEL (CM)
G(I),	WEIGHT OF THERMODYNAMICS CHANNEL IN FEEDBACK
I=1,NKAN)	CHANNEL. NEED NOT BE NORMALIZED AND THUS MAY BE, E. G., THE NUMBER OF FUEL SUBASSEMBLIES PERTAINING TO THE THERMODYNAMICS CHANNEL.
(NMI(I),	FOR EACH AXIAL FEEDBACK ZONE, NUMBER OF AXIAL
I=1,NMD)	THERMODYNAMICS ZONES PERTAINING TO IT. FOR THE EXPANSION ZONE, NMI=0, OTHERWISE NMI.GT.0

6.4. INPUT BLOCK THEIN

THIS BLOCK IS TO BE PROVIDED ONLY FOR THE START OF A CALCULATION WITH CAPRI-2 THERMODYNAMICS. SINCE IT HAS BEEN DEVELOPED FROM THE INPUT FOR THE CAPRI-2 STAND ALONE VERSION, A FEW EXPLANATIONS CONCERNING THE DIFFERENCES ARE IN ORDER. THESE ARE USEFUL ESPECIALLY FOR PERSONS, WHO WISH TO RUN THE TWO CODES IN PARALLEL OR WHO WANT TO CONVERT AN INPUT FOR THE CAPRI-2 SYSTEM INTO THE BLOCK THEIN. TO FACILITATE THIS CONVERSION, THE INPUT HAS NOT BEEN MODIFIED AS FAR AS POSSIBLE. THE DATA IN THE BLOCK THEIN HAVE THE FOLLOWING ORDER:

1. GLOBAL INTEGER DATA, PRECEDED BY THE CONSTANT 'GLOBINT'.
2. GLOBAL REAL DATA, PRECEDED BY THE CONSTANT 'GLOBREAL'.
3. CHANNEL DATA, THE DATA FOR EACH CHANNEL BEING PRECEDED BY THE CONSTANT 'CHAN' AND THE NUMBER OF THE CHANNEL.

THE ORDER OF CHANNELS IS ARBITRARY. THE END OF THE BLOCK THEIN IS SIGNALED BY THE CONSTANT 'END'.
AMONG THE MANY GLOBAL DATA TO BE PROVIDED FOR THE CAPRI-2 SYSTEM, ONLY A FEW NEED BE DEFINED FOR THE CAPRI-2 THERMODYNAMICS MODULES. THEREFORE, THE GLOBAL INPUT WAS NEWLY FORMULATED. THE DATA WERE GROUPED INTO SMALL DATASETS BEING PRECEDED BY CONSTANTS ('NODE', 'GEOM', ETC.). IN THE BLOCK OF GLOBAL INTEGERS, THE DATASET 'NODE' MUST BE THE FIRST ONE, WHEREAS THE ORDER OF THE OTHER TWO SETS IS ARBITRARY, AS IS THE ORDER OF ALL SETS IN THE BLOCK OF GLOBAL DATA. A SET MAY BE OMITTED, IF IT CONTAINS ONLY ZEROS OR DEFAULT VALUES.
THE CHANNEL INPUT WAS NOT REFORMULATED. IT IS UNFORMATTED, BUT SINCE FORMATTED INPUT IS, UNDER CERTAIN CONDITIONS, COMPATIBLE WITH THE KAPROS TYPE OF UNFORMATTED INPUT, THE INPUT CARDS OF A CAPRI-2 STAND ALONE INPUT MAY BE DIRECTLY INSERTED INTO THE BLOCK THEIN. ONLY THE CONTROL CARDS CONTAINING THE CONSTANT 'CHAN' AND THE CHANNEL NUMBER OR THE WORD 'END' MUST BE ADDED. THE FOLLOWING CONDITIONS MUST BE FULFILLED FOR THE FORMATTED INPUT TO BE INSERTED: DIFFERENT NUMBERS MUST BE SEPERATED BY AT LEAST ONE BLANK, NO BLANKS MAY TURN UP IN THE STRING OF CHARACTERS DEFINING ONE NUMBER, SIGNIFICANT ZEROS MAY NOT BE REPLACED BY BLANKS, AND COLUMNS 71 - 80 MAY NOT BE USED. THE CHANNEL INPUT IS GOVERNED BY THE SAME RULES, THAT APPLY FOR THE CHANNEL INPUT OF THE STAND ALONE VERSION: THE DATA OF THE FIRST CHANNEL (NOT NECESSARILY CHANNEL NUMBER 1) NEED BE DEFINED ONLY, IF THEY ARE NONZERO; THOSE OF THE FOLLOWING CHANNELS ONLY INSOFAR AS THEY ARE DIFFERENT FROM THOSE OF THE PRECEDING CHANNEL.

KAPROS CONTROL CARD:

*KSIOX DBN=THEIN,TYP=CARD,PM=KINPUT

CONCATENATION SHOULD BE USED (SEE BLOCK KINPUT).

CONTENTS OF BLOCK:

K1	'GLOBINT'	CONSTANT
K2	'NODE'	CONSTANT
	NKKN	NUMBER OF COOLANT CHANNELS (.LE.30)
	NM2	NUMBER OF AXIAL NODES INCLUDING PLENUM AND MIXING CHAMBER (.LE.30)
	NM	NUMBER OF AXIAL NODES IN CORE AND BLANKET (.LE.20)
	NMOB	NUMBER OF AXIAL NODES IN UPPER AXIAL BLANKET
	NMUB	NUMBER OF AXIAL NODES IN LOWER AXIAL BLANKET
	NMPL	NUMBER OF AXIAL NODES IN FISSION GAS PLENUM
	NN	NUMBER OF RADIAL ZONES IN THE PIN (.LE.10)
K3	'GECM'	CONSTANT
	LART	NUMBER OF DIFFERENT KINDS OF PINS
	(NGRID(I), I=1,NKKN)	PARAMETER FOR SPACER IN CHANNEL I: .GT.0: NUMBER OF RIBS FOR SPIRAL WIRE ON PIN-PERIMETER .LT.0: HONEYCOMB GRID AS SPACER
	(IREGVL(I), I=1,NKKN)	KIND OF PIN IN CHANNEL I
K4	'CNTL'	CONSTANT
	0	CONSTANT
	ICLCMP	DS-NUMBER OF UNIT FOR PLOTTING (.NE. 23, 24, 25) 0: NO PLOT
	IPC	NUMBER OF TIME STEPS PER FULL PRINT BEFORE BOILING
	IPOBOI	NUMBER OF TIME STEPS PER FULL PRINT AFTER BOILING
	IVOID	DS-NUMBER OF UNIT FOR PLOT OF BOILING PATTERN (.NE. 23, 24, 25). 0: NO PLOT
	IEXP	0: NO AXIAL CORE EXPANSION 1: WITH AXIAL CORE EXPANSION
	KPRUG	PARAMETER FOR DETAILED PRINT DURING BOILING 0: NO DETAILED PRINT 1: SHORT OUTPUT AT EVERY TIME STEP 2: =1 + PRINT OF INTERNAL TIME STEPS
	IIREF	0: NO MECHANICAL STRAINS FOR REFERENCE TEMPERATURES 1: NO MECHANICAL STRAINS FOR STEADY STATE TEMPERATURES
	IIAX	1: AXIAL ITERATION (SUBSTITUTE FOR SHEARING FORCE) 0: NO AXIAL ITERATION
	NPAX	1: AXIAL ITERATION OF PRESSURE 0: NO AXIAL ITERATION
	IABB	1: BURNUP EFFECTS ARE ACCOUNTED FOR 0: OTHERWISE
	JERROR	PARAMETER FOR DETAILED PRINT IN BOILING ROUTINE IN CASE OF ERRORS 0: NO ADDITIONAL PRINT 1,2,3: DIFFERENT LEVELS OF ADDITIONAL OUTPUT
	(NSSLB(I), I=1,NKKN)	SLUMPING CRITERION IN CHANNEL I 0: CLADDING TEMPERATURE TCSLB AND FUEL MELT

```
                  FRACTION FMSLB MUST BE REACHED
                1: PLASTIC CLADDING DEFORMATION SPLSLB AND FUEL
                  MELT FRACTION FMSLB MUST BE REACHED
    (MMLSB(I),  MINIMUM NUMBER OF AXIALLY COHERENT NODES, FOR
    I=1,NKKN)   WHICH SLUMPING CRITERION MUST BE FULFILLED
    NSPLT       DS-NUMBER FOR PLOT OF SLUMPING PATTERN (.NE. 23,
                24, 25). 0: NO PLOT
    (NSFCI(I),  FCI CRITERION FOR CHANNEL I
    I=1,NKKN)   0: CLADDING TEMPERATURE TCFCI AND FUEL MELT
                  FRACTION FMFCI MUST BE REACHED
                1: PLASTIC CLADDING DEFORMATION SPLFCI AND FUEL
                  MELT FRACTION FMFCI MUST BE REACHED
    (MMFCI(I),  MINIMUM NUMBER OF AXIALLY COHERENT NODES, FOR
    I=1,NKKN)   WHICH FCI CRITERION MUST BE FULFILLED
    NFCIPL      DS-NUMBER FOR PLOT OF FCI PATTERN (.NE. 23, 24,
                25). 0: NO PLOT
    NNFCI       0: FLIQ IS USED; .NE.0: VBRKU IS USED
                (SEE DATA ON POSITION 539/540 IN CHANNEL INPUT)
    KAPRML      DS-NUMBER OF UNIT FOR MAPLIB MESSAGES (.NE. 23,
                24, 25)
    IFLAG1      0: TIME DERIVATIVE OF COOLANT DENSITY =0 FOR ONE
                  PHASE COOLANT
                1: TIME DERIVATIVE OF COOLANT DENSITY BEING
                  TAKEN INTO ACCOUNT
    IFLAG2      0: ADIABATIC HEATING IN CHANNEL
                1: HEAT TRANSFER TO BYPASS BEING TAKEN INTO
                  ACCOUNT
    IFLAG3      .NE.0: CALCULATION IN BOILING ROUTINE PARTIALLY
                      WITH DOUBLE PRECISION
                0: OTHERWISE

K5  'GLOBREAL'  CONSTANT

K6  'CNT2'      CONSTANT
    TETTA       RELAXATION PARAMETER FOR TRANSIENT CALCULATION
                OF FUEL TEMPERATURES (0.: EXPLICIT; .5: CRANK-
                NICHOLSON; 1.: IMPLICIT)
    (EPS(I),    LIMITS FOR ERRORS IN PIN DEFORMATION MODULE.
    I=1,10)     DEFAULT VALUES PROVIDED IN PROGRAM
    FAXEXP      IEXP=1: AXIAL EXPANSION IS MULTIPLIED BY FAXEXP
                      FOR FEEDBACK
                IEXP=0: IRRELEVANT

K7  'OPER'      CONSTANT
    PKOO        STATIONARY COOLANT PRESSURE AT INLET (N/M**2)
    PKONO       STATIONARY COOLANT PRESSURE AT OUTLET (N/M**2)
    (PDEC(I),   COEFFICIENTS DESCRIBING THE TIME DEPENDENCE OF
    I=1,3)      PRESSURE DURING FLOW COAST-DOWN:
                DP/P(0)=EXP(PDEC(1)*T+PDEC(2)*T**2+PDEC(3)*T**3)
    TKINNO      COOLANT TEMPERATURE AT INLET (DEG. C)
    TPLEN       TEMPERATURE OF UPPER COOLANT PLENUM (DEG. C)
    FTRO        REFERENCE TEMPERATURE FOR COLD GEOMETRY (DEG. C)

K8  'MAPL'      CONSTANT
    COOL        NAME OF COOLANT IN MAPLIB (E. G. 'NAL')
```

	STRUK	NAME OF STRUCTURE MATERIAL IN MAPLIB (E. G. '4988')
	CAN	NAME OF CLADDING MATERIAL IN MAPLIB
	PELLET	NAME OF FUEL IN MAPLIB (E. G. 'UPUO')
K9	'MATD'	CONSTANT
	BNUE	POISSON NUMBER OF FUEL
	FRHOL	DENSITY OF FLUID FUEL AT MELTING TEMPERATURE (KG/M**3)
	FALPHA	LINEAR EXPANSION COEFFICIENT OF FLUID FUEL (1./DEG. C)
	BKL	COMPRESSION MODULE OF FLUID FUEL (N/CM**2) (.27E+12)
	BKS	COMPRESSION MODULE OF SOLID FUEL (N/CM**2) (.13E+12)
	CNUE	POISSON NUMBER OF CLADDING MATERIAL
	TCR	ISOTHERM FOR OUTER BOUNDARY OF COLUMNAR FUEL (DEG. C; 1700.)
	TPL	ISOTHERM FOR OUTER BOUNDARY OF EQUIAXED FUEL (DEG. C; 1300.)
K10	'COOL'	CONSTANT
	CNN1	THE COEFFICIENTS CNN1,...,CN3 ARE FOR CALCULA-
	CNN2	TION OF HEAT TRANSFER FROM CLADDING AND
	CN1	STRUCTURE MATERIAL TO COOLANT:
	CN2	
	CN3	ALPHA=CNN1+CNN2*RE**CN1*PR**CN2*(T(BULK)/ T(WALL))**CN3
		(ALPHA = HEAT TRANSFER COEFFICIENT)
		(RE = REYNOLDS NUMBER; PR = PRANDL NUMBER)
		CNN1, CNN2: (W/(M**2*DEG. C))
	CH21	FRICTION COEFFICIENT OF FLUID SODIUM IN THE
	CH22	COOLANT CHANNEL: F=CH21*RE**CH22
	(DTSH(I), I=1,NKKN)	SUPERHEAT AT ONSET OF BOILING IN CHANNEL I (DEG. C)
	SO	INITIAL THICKNESS OF SODIUM FILM (M)
	SMIN	MINIMUM FILM THICKNESS FOR CALCULATION OF DRYOUT (M)
	RLA	UPPER REDUCED LENGTH (M)
	RLE	LOWER REDUCED LENGTH (M)
	ZSLUG	MINIMUM SLUG LENGTH (M) (ABOUT .5; DEPENDS ON AXIAL NODE LENGTH)

S11 FOR EACH CHANNEL K12 - K14; S13 - K14 MAY BE OMITTED, IF CHANNEL DATA EQUAL THOSE OF PRECEDING CHANNEL

K12	'CHAN'	CONSTANT
	KKN	CHANNEL NUMBER

S13 FOR EACH COHERENT SERIES OF DATA IN THE INTERNAL BLOCK CHINPT, ONE CARD K14. ONLY THOSE DATA NEED BE DEFINED, WHICH ARE NONZERO IN CASE OF THE FIRST CHANNEL RESP. NOT EQUAL TO THE DATA OF THE FOREGOING CHANNEL IN CASE OF ALL OTHER CHANNELS.

```
K14 NPOS        POSITION OF FIRST NUMBER IN BLOCK CHINPT
    NDAT        NUMBER OF FOLLOWING DATA
    (C(I),      NDAT DATA
    I=1,NDAT)

K15 'END'       CONSTANT, END OF BLOCK
```

FOR ACTUALLY WRITING THE CHANNEL INPUT (K14), THE POSITIONS OF THE DATA IN THE BLOCK CHINPT MUST BE KNOWN. FOR THIS, THE FOLLOWING LIST IS TO BE CONSULTED:

A. GEOMETRY

POSITION	CONTENTS	EXPLANATION
1- 30	(RBR(I), I=1,NM2)	INNER RADIUS OF CLADDING IN EACH NODE (M)
31- 60	(DCAN(I), I=1,NM2)	THICKNESS OF CLADDING IN EACH NODE (M)
61- 90	(RKUE(I), I=1,NM2)	EQUIVALENT RADIUS OF COOLANT CHANNEL IN EACH NODE (M)
91-120	(VDUF(I), I=1,NM2)	FOLLOWING QUOTIENT: VOLUME OF STRUCTURE MATERIAL/PART OF ITS SURFACE IN CONTACT WITH COOLANT IN EACH NODE (M)
121-150	(VSTRUK(I), I=1,NM2)	VOLUME OF STRUCTURE MATERIAL PER M PIN IN EACH NODE (M**3/M)
151-180	(DBOND(I), I=1,NM2)	SIZE OF GAP BETWEEN PELLET AND CLADDING IN EACH NODE (M)
181-210	(DELTZ(I), I=1,NM2)	LENGTH OF AXIAL NODES (M)
211	ALPHAS	VOLUME FRACTION OF COOLANT PER CELL
212	BETCAS	VOLUME FRACTION OF CLADDING PER CELL
213	BETSTS	VOLUME FRACTION OF STRUCTURE MATERIAL PER CELL
214	BETABS	VOLUME FRACTION OD SPACERS PER CELL
215	BETKAS	VOLUME FRACTION OF SUBASSEMBLY WALL PER CELL
216	OMEGAS	VOLUME FRACTION OF FUEL PER CELL
217	ALFASP	VOLUME FRACTION OF GAP BETWEEN SUBASSEMBLY WALLS PER CELL NGRID.LT.0: DISTANCE BETWEEN HONEYCOMB GRIDS (M)
219	PSI	NGRID.GT.0: QUOTIENT WIDTH/HEIGHT OF RIB NGRID.LT.0: COEFFICIENT OF FLOW RESISTANCE

B. DATA FOR PIN DEFORMATION MODULE BREDA

POSITION	CONTENTS	EXPLANATION
220-230	(FACR(I), I=1,NN+1)	RADIAL POWER DISTRIBUTION IN PIN (DEFAULT VALUES: 1.)
231	FABBM	MAXIMUM ALLOWABLE BURNUP (MWD/TON)
232	FEPSML	ERROR LIMIT FOR CALCULATION OF LIQUID FUEL VOLUME

233	FFGMOL	MOLECULAR WEIGHT OF FISSION GAS
234-263	(FBPHI(I), I=1,NM)	AXIAL DISTRIBUTION OF NEUTRON FLUX WITH ENERGY GREATER THAN .1 MEV FOR CALCULATION OF SWELLING OF CLADDING (1./(CM**2*SEC))
264	FPCG	POROSITY OF COLUMNAR GRAIN FUEL DIRECTLY AFTER CHANGE OF STRUCTURE
265	FPEQ	POROSITY OF EQUIAXED FUEL DIRECTLY AFTER CHANGE OF STRUCTURE
266	FPUR	POROSITY OF UNRESTRUCTURED FUEL
267	FPSWCG	REDUCTION OF FUEL POROSITY DUE TO FUEL SWELLING FOR COLUMNAR GRAIN FUEL
268	FPSWEQ	SAME AS ABOVE FOR EQUIAXED FUEL
269	FPSWUR	SAME AS ABOVE FOR UNRESTRUCTURED FUEL
270	FRELML	FISSION GAS RELEASE OF MOLTEN FUEL
271	FRELCG	FISSION GAS RELEASE OF COLUMNAR GRAIN FUEL
272	FRELEQ	FISSION GAS RELEASE OF EQUIAXED FUEL
273	FRG	UNIVERSAL GAS CONSTANT (1.E-3*W*SEC/(MOL*DEG. C))
274	FRHOSM	SMEAR DENSITY OF FUEL (KG/M**3)
275	FTAGE	IRRADIATION TIME (D)
276	FVARRH	PARAMETER FOR TRANSIENT FUEL SWELLING
277	FVSWF	STATIONARY FACTOR FOR FUEL SWELLING

C. OPERATING DATA

POSITION	CONTENTS	EXPLANATION
301	TKOUT	STATIONARY COOLANT TEMPERATURE AT OUTLET (DEG. C)
302	FFZO	AXIAL FORCE ACTING ON FUEL COLUMN (N)
303	FSPRIN	ELASTIC CONSTANT OF SPRING (N)
304-333	(ANTB(I), I=1,NM2)	FRACTION OF POWER RELEASED IN FUEL
334-363	(ANTC(I), I=1,NM2)	FRACTION OF POWER RELEASED IN CLADDING
364-393	(ANTK(I), I=1,NM2)	FRACTION OF POWER RELEASED IN COOLANT
394-423	(ANTS(I), I=1,NM2)	FRACTION OF POWER RELEASED IN STRUCTURE MATERIAL

D. MATERIAL DATA

POSITION	CONTENTS	EXPLANATION
424	BOND	MAXIMUM HEAT TRANSFER COEFFICIENT IN GAP BETWEEN FUEL AND CLADDING (W/(M**2*DEG. C))
425	BONDP	GAP PARAMETER FOR CALCULATING A VARIABLE HEAT TRANSFER COEFFICIENT (W/(M*DEG. C)): H(BOND)=MIN(BONDP/DBOND,BOND)
426-455	(DPO(I), I=1,NM2)	PELLET DENSITY RELATIVE TO THEORETICAL DENSITY FOR EACH NODE
456-485	(DPPL(I), I=1,NM2)	PELLET DENSITY RELATIVE TO THEORETICAL DENSITY IN COLUMNAR GRAIN ZONE. FOR A ONE ZONE

		MODEL, LET DPO(I)=DPPL(I)
486-515	(CNPU(I), I=1,NM2)	MOL-CONCENTRATION OF PU IN FUEL
516	FPSGO	STATIC PRESSURE IN FISSION GAS PLENUM (N/M**2)

E. SLUMPING INPUT

POSITION	CONTENTS	EXPLANATION
521	FNY	KINEMATIC VISCOSITY OF FUEL-CLADDING MIXTURE (CM**2/SEC; .01)
522	FXII	FRICTION COEFFICIENT (.3)
523	FFUEL	FOAMING EFFECT (I. E. INCREASE OF VOLUME DURING MELTING) OF FUEL (1.)
524	FCLAD	FOAMING EFFECT OF CLADDING (1.)
525	FQF	DEGREE BY WHICH CROSS SECTION IS FILLED (1.)
526	FG	GRAVITY ACCELERATION (M/SEC**2). MAY BE INCREASED OR DECREASED FOR SIMULATION OF PRESSURE GRADIENT
527	FMSLB	MELT FRACTION OF FUEL LEADING TO ONSET OF SLUMPING
528	TCSLB	LIMIT OF TEMPERATURE IN CLADDING CENTER LEADING TO ONSET OF SLUMPING (DEG. C)
529	SPLSLB	PLASTIC DEFORMATION OF CLADDING LEADING TO ONSET OF SLUMPING

F. FCI INPUT

POSITION	CONTENTS	EXPLANATION
530	SPLFCI	PLASTIC DEFORMATION OF CLADDING LEADING TO ONSET OF FCI
531	RCFCI	LIMIT OF TEMPERATURE IN CLADDING CENTER LEADING TO ONSET OF FCI (DEG. C)
532	FMFCI	MELT FRACTION OF FUEL LEADING TO ONSET OF FCI
533	RFRAG	RADIUS OF PARTICLES AFTER FUEL FRAGMENTATION (CM; .01)
534	TAUM	MIXING TIME CONSTANT (SEC; 5.E-3)
536	XIW	FRICTION COEFFICIENT OF CHANNEL (XIW= .316*RE**(-.25)/HYDR.DIAMETER)
537	EPSFCI	ERROR LIMIT FOR INTEGRATION (.001)
538	HWEGF	2*DISTANCE FROM UPPER CORE BOUNDARY TO FREE SURFACE (CM)
539	FLIQ	FRACTION OF MOLTEN FUEL IN FCI-ZONE PARTAKING IN FCI
540	VBRKU	RATIO OF MASSES FUEL/SODIUM IN FCI-ZONE

G. RADIAL HEAT LOSS

POSITION	CONTENTS	EXPLANATION

601-630	(FWFS(I), I=1,NM2)	QUOTIENT OUTER SURFACE/INNER SURFACE FOR STRUCTURE MATERIAL
631-660	(TBYPO(I), I=1,NM2)	BYPASS TEMPERATURE FOR TIME=TTBYPO (DEG. C)
661-690	(TBYP1(I), I=1,NM2)	BYPASS TEMPERATURE FOR TIME=TTBYP1 (DEG. C)
691	TTBYPO	INITIAL TIME FOR CHANGE OF BYPASS TEMPERATURE
692	TTBYP1	FINAL TIME FOR CHANGE OF BYPASS TEMPERATURE

6.5. RESTRICTIONS CONCERNING INPUT BLOCKS FOR DIXY

INPUT FOR DIXY IS CONTAINED IN THE THREE BLOCKS DX LDIM, DXDIF, AND DXBUCK. OF THESE, DX LDIM AND DXBUCK ARE TO BE PROVIDED ACCORDING TO THE DIXY INPUT DESCRIPTION WITH NO ADDITIONAL RESTRICTIONS ARISING FROM THE USE OF DIXY IN CONNECTION WITH KINTIC-2. FOR DXDIF, THE FOLLOWING RULES CONCERNING THE GEOMETRY HAVE TO BE OBEYED (SEE CHAPTER 4):

1. OVERLAY OF REGION INPUT IS NOT ALLOWED.
2. THE FIRST NKKD*NMD (SEE BLOCK KINPUT) ZONES ARE TO BE THE FEEDBACK ZONES INCLUDING THE ZONES ABOVE THE AXIAL BLANKET ALLOWING FOR AXIAL EXPANSION. AFTER THESE, NON-FEEDBACK ZONES MAY BE DEFINED IN ARBITRARY ORDER.
3. AMONG THE FEEDBACK ZONES, THE FIRST NMD ZONES ARE THOSE PERTAINING TO THE FIRST RADIAL SEGMENT, THE NEXT NMD ZONES THOSE FOR THE SECOND SEGMENT, ETC.
4. THE NMD ZONES PERTAINING TO ONE SEGMENT MUST BE ORDERED ACCORDING TO THE DIRECTION OF THE COOLANT FLOW, I. E. WITH COOLANT ENTERING THE FIRST ZONE AND PROCEEDING THROUGH THE FOLLOWING ZONES ACCORDING TO THEIR ORDER. THE DISTRIBUTION OF AXIAL ZONE HEIGHTS IN ALL RADIAL SEGMENTS MUST BE THE SAME.

FOR A NUMBER OF VARIABLES IN DXDIF, IMPORTANT RESTRICTIONS EXIST. THEY WILL BE LISTED BELOW USING THE NOTATION FROM THE DIXY INPUT DESCRIPTION:

IZO	=NZ FROM BLOCK KINPUT
IGEO	.NE.1 OR 3 FOR NFEED.NE.0 (SEE BLOCK KINPUT)
ICHI	.GT.1
NGP	=NG FROM BLOCK KINPUT
IQUE	=0
NFZ1	=1
JOINT	=0 RECOMMENDED, OTHERWISE UNNECESSARY CALCULATION OF ADJOINT FLUX
INRD	=0
IDIT	.NE.-1
NRRI	FOR NFEED.LT.0, NO FEEDBACK ZONE MUST BE DEFINED AND EXTENSION OR CONTRACTION OF ZONE NRRI MUST NOT AFFECT A FEEDBACK ZONE

7. OUTPUT

OUTPUT OF KINTIC-2 CONSISTS OF A PRINTED OUTPUT AND OPTIONAL EVALUATION FILES.
THE PRINTED OUTPUT MAY BE GREATLY VARIED IN LENGTH USING THE DIFFERENT PRINTING OPTIONS. THE OVERRIDING NUMBER IN THIS CONTEXT IS NAUS FROM BLOCK KINPUT. IF THIS NUMBER IS 0 OR -1, OUTPUT FROM THE THERMODYNAMICS MODULES IS TO A LARGE EXTENT SUPPRESSED AND REPLACED BY A SHORTENED OUTPUT OF THE MAIN THERMODYNAMICS DATA PRODUCED BY KINTIC-2. FOR PRODUCTION RUNS, USE OF THIS OPTION IS RECOMMENDED.
UP TO FIVE EVALUATION FILES MAY BE PRODUCED BY A KINTIC-2 CALCULATION (ONE, IF THE CAPRI-2 THERMODYNAMICS MODULES ARE NOT USED). THE FILES CONTAIN:

1. NEUTRONICS DATA AND, IF THE OLD THERMODYNAMICS MODULES ARE USED, THERMODYNAMICS RESULTS.
2. THERMODYNAMICS DATA FROM THE NEW THERMODYNAMICS MODULES EXCLUDING DATA ON FUEL-COOLANT INTERACTION, SODIUM BOILING, AND SLUMPING.
3. FUEL COOLANT INTERACTION DATA.
4. SODIUM BOILING DATA.
5. SLUMPING DATA.

ALL EVALUATION FILES ARE FILLED IN THE SAME WAY. A FIRST RECORD CONTAINS A 20-WORD IDENTIFICATION AND ONE INTEGER, WHICH IS THE LENGTH OF ALL FOLLOWING RECORDS. THEN, ONE RECORD PER NORMAL TIME STEP FOLLOWS. ONLY THE FINAL RESULTS OF INNER AND OUTER ITERATIONS ARE LISTED. THE FIRST WORD OF EACH RECORD CONTAINS THE TIME. THE CONTENTS OF EACH RECORD OF THE DIFFERENT EVALUATION FILES IS LISTED BELOW.

A. NEUTRONICS AND OLD THERMODYNAMICS FILE KTPOUT

RECORD LENGTH 80 FOR NFEED.LE.0, 140 FOR NFEED.GT.0

1	TIME (SEC)
2	AMPLITUDE
3	REACTIVITY
4- 11	REACTIVITY EFFECT OF: DOPPLER, FUEL, CLADDING, COOLANT, STRUCTURE MATERIAL, AUXILIARY MATERIAL ('BONDI'), EXPANSION, AND EXTERNAL REACTIVITY
12	NEUTRON LIFETIME (SEC)
13	SUM OF EFFECTIVE DELAYED NEUTRON FRACTIONS
14- 19	DELAYED NEUTRON FRACTIONS OF INDIVIDUAL GROUPS
20	INTEGRAL POWER (MW)
21- 50	POWER RELEASED IN ONE PIN FOR EACH CHANNEL (KW)
51- 80	MAXIMUM POWER/CM RELEASED IN PIN FOR EACH CHANNEL (W/CM)
	END OF RECORD FOR NFEED.LE.0
81- 90	MAXIMUM CENTRAL FUEL TEMPERATURE FOR EACH CHANNEL (DEG. C)
91-100	MAXIMUM RADIALLY AVERAGED FUEL TEMPERATURE FOR EACH

```
        CHANNEL (DEG. C)
101-110 MAXIMUM TEMPERATURE IN CENTER OF CLADDING FOR EACH
        CHANNEL (DEG. C)
111-120 MAXIMUM STRUCTURE MATERIAL TEMPERATURE FOR EACH CHANNEL
        (DEG. C)
121-130 COOLANT TEMPERATURE AT OUTLET FOR EACH CHANNEL (DEG. C)
131-140 MAXIMUM COOLANT TEMPERATURE FOR EACH CHANNEL (DEG. C)
```

B. THERMODYNAMICS FILE ICLCMP FOR NFEED.LT.0

RECORD LENGTH 241

```
  1     TIME (SEC)
  2- 31 FUEL CENTRAL TEMPERATURE IN HOTTEST NODE FOR EACH
        CHANNEL (DEG. C)
 32- 61 FUEL AVERAGE TEMPERATURE IN HOTTEST NODE FOR EACH
        CHANNEL (DEG. C)
 62- 91 FUEL SURFACE TEMPERATURE IN HOTTEST NODE FOR EACH
        CHANNEL (DEG. C)
 92-121 CLADDING CENTER TEMPERATURE IN HOTTEST NODE FOR EACH
        CHANNEL (DEG. C)
122-151 COOLANT TEMPERATURE IN HOTTEST NODE FOR EACH CHANNEL
        (DEG. C)
152-181 COOLANT TEMPERATURE AT UPPER CORE BOUNDARY FOR EACH
        CHANNEL (DEG. C)
182-211 FRACTION OF LIQUID FUEL IN HOTTEST NODE FOR EACH
        CHANNEL (DEG. C)
212-241 RELATIVE CHANGE OF MASS FLOW RATE FOR EACH CHANNEL
```

C. FUEL COOLANT INTERACTION FILE NFCIPL

RECORD LENGTH 181

```
  1     TIME (SEC)
  2- 31 COOLANT TEMPERATURE IN REACTION ZONE (DEG. C)
 32- 61 FUEL TEMPERATURE IN REACTION ZONE (DEG. C)
 62- 91 PRESSURE IN REACTION ZONE
 92-121 LOWER LIMIT OF REACTION ZONE
122-151 UPPER LIMIT OF REACTION ZONE
152-181 SODIUM VOID FRACTION IN REACTION ZONE
```

D. SODIUM BOILING FILE IVOID

RECORD LENGTH 1+10*NKKN

```
  1     TIME (SEC)
  2-... FOR EACH CHANNEL, 10 POSITIONS CONTAINING THE UPPER AND
        LOWER BOUNDARIES OF 5 BUBBLES. IF LESS THAN 5 BUBBLES
        ARE PRESENT, DEFAULT VALUES (1.E+6C) ARE INSERTED
```

E. SLUMPING FILE NSPLT

RECCRD LENGTH 61

1	TIME (SEC)
2- 31	LOWER BOUNDARY OF SLUMPING MATERIAL
32- 61	POSITION OF LOWER BOUNDARY OF FALLING UPPER AXIAL BLANKET

THE CONTENTS OF THESE FILES MAY BE USED FOR PRODUCING LISTINGS OR PLOTS. ESPECIALLY, THE PLOT FACILITY PLOTCP /12/ CAN BE APPLIED.

8. Sample cases

In the following, lists are given of the job control cards and input for four jobs. These are

a. A job for creation of a simple group constant file to be used in the following sample cases. The programs described in /1/ are used. The data set created has 1 neutron and 1 precursor group, 5 subzones (core zone 1, core zone 2, blanket, absorber, follower) and may accommodate up to 30 feedback and non-feedback zones.

b. A sample case employing the old thermodynamics routines with 5 feedback and 3 non-feedback zones, with the non-feedback zones containing fissionable material as well, since they serve as a kind of driver. The transient is induced in a rather artificial way by replacing coolant by fuel material in one of the driver zones. In addition, an external reactivity is fed in. One coolant channel is used for thermodynamics. The results of this case were plotted with PLOTCP /12/and are shown in fig's. 9-17.

c. A case employing the new thermodynamics modules with 6 feedback and 6 non-feedback zones. The non-feedback zones comprise an absorber ring and a driver zone. The feedback zones are collapsed axially and radially from the thermodynamics mesh, which comprises two adjacent channels with 21 axial zones, 12 of which are situated in the core/blanket region. These 12 zones are collapsed into 5 feedback zones; the 6th feedback zone is the one used for the description of axial expansion. The transient is initiated by simulation of control rod movement.

d. A restart case to follow up case c. Results of case c and d together were again plotted with PLØTCP and are shown in fig's 18-25.

CASE A

```
//...JOBCARD...,REGION=440K,TIME=(1,30)
/*FORMAT PR,DDNAME=FT42F001
/*SETUP DEVICE=2314,ID=NUSYSO
// EXEC KSG
//K.FT01F001 DD DSN=KNDF,UNIT=2314,VOL=SER=NUSYSO,DISP=SHR
//K.FT04F001 DD DSN=GROUCO,UNIT=3330,VOL=SER=KAPROS,DISP=SHR
//K.FT20F001 DD UNIT=SYSDA,SPACE=(TRK,5)
//K.FT25F001 DD DSN=T1G30Z.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,1)
//K.SYSIN DD *
*KSIOX DBN=KINWQI,TYP=CARD,PM=KETT
1 1 1 5
*$*$
*KSIOX DBN=KINCOI,TYP=CARD,PM=PKINCO
30 1 5
1 4 @BRENN@ 0 8.94 .326 @HUELL@ 0 7.68 .106 @KUEHL@ 0 .862 .472
 @STRUK@ 0 7.76 .096 1
2 4 @BRENN@ 0 8.94 .326 @HUELL@ 0 7.68 .106 @KUEHL@ 0 .862 .472
 @STRUK@ 0 7.76 .096 1
3 4 @BRENN@ 0 9.19 .326 @HUELL@ 0 7.67 .106 @KUEHL@ 0 .862 .472
 @STRUK@ 0 7.76 .096 1
4 1 'STRUK' 0 2.6 1. 0
5 1 'STRUK' 0 2.6 1. 0
*$*$
*KSIOX DBN=NUDABL,IND=4,TYP=CARD,PMN=NUTEST
1 4
'00397'
451 0 0 0
'ENDE '
'00451'
446 0 1 0
0 'SPEKT'
26 12.47
      70.98 186.2 383.9 488.2 927.5 1083. 1159. 970.4 797. 483.6 264.5
 81.12 150.6 70.15 17.73 3.641 .3446 .04184 .002525 .1671-3 .6292-4
 .5774-5 .3387-6 .8213-8 .3569-9
26 92.84
    530.4 1371. 2750. 3439. 6196. 7185. 7475. 6264. 5068. 3057. 1659.
 502.5 844.9 383.3 99.16 22.64 2.731 .4678 .03454 .002606 .001385
 .1714-3 .1268-4 .3669-6 .1441-7
26 10.25
      57.23 160.2 356.7 506. 1207. 1689. 2120. 2026. 1861. 1242. 733.7
 238.1 530.1 353.3 148.3 56.3 15.43 2.988 .3827 .02617 .009342 .002868
 .5619-3 .6429-4 .2306-5
26 73.
    418.5 1121. 2399. 3097. 5766. 6503. 7087. 6216. 5001. 2941. 1521.
 471.5 557.9 218.3 51.42 9.525 1.184 .1226 .008612 .3944-3 .5799-5
 .8717-6 .9643-7 .6774-8 .7313-9
26 20.75
      117.7 312.8 659. 838.3 1647. 1901. 2117. 1774. 1503. 925.8 509.9
 158.2 350.2 174.1 52.59 14.56 2.755 .496 .06093 .004598 .001382
 .3555-3
 .6378-4 .6863-5 .2454-6
0 'ENDE '
```

```
'00446'
352 0 0 3 446
'SIGMA' 'SABBR' 'KOMPO' 446
0 0 0 446
'KOMPO'
@26-GR.KFKINR001@ 0 26 1 0 18 446
@B 100B 110C 120CR520FE560MO960NA230NB930NI590O 160PU390PU400PU410@
 @PU420SPP90U2350U2380V 510@ 446
14  4  0.334470E-02  5  0.110890E-01  6  0.156334E-03  7  0.103501E-01
    8  0.104014E-03  9  0.247123E-02 10  0.124809E-01 11  0.104166E-02
   12  0.305554E-03 13  0.347220E-04 14  0.694441E-05 16  0.121290E-04
   17  0.483946E-02 18  0.658087E-04  446
'WQFIN'
'00352'
0 0 -2 1
'SIGMA' 'SABBR'
'SABBR'
'ST352'
26 1 0 -2 1 1 0
1 5
'CDKNT'
1 26 1
'ENDE '
'NUFIN'
*$*$
*KSIOX DBN=NJDABL,IND=5,TYP=CARD,PMN=NUTEST
1 4
'00397'
446 0 0 0
'ENDE '
'00446'
352 0 0 3 446
'SIGMA' 'SABBR' 'KOMPO' 446
0 0 0 446
'KOMPO'
@26-GR.KFKINR001@ 0 26 1 0 18 446
@B 100B 110C 120CR520FE560MO960NA230NB930NI590O 160PU390PU400PU410@
 @PU420SPP90U2350U2380V 510@ 446
14  4  0.334470E-02  5  0.110890E-01  6  0.156334E-03  7  0.103501E-01
    8  0.104014E-03  9  0.247123E-02 10  0.125310E-01 11  0.151025E-02
   12  0.443006E-03 13 0.503416E-04 14  0.100683E-04 16  0.106296E-04
   17  0.424120E-02 18  0.658087E-04  446
'WQFIN'
'00352'
0 0 -2 1
'SIGMA' 'SABBR'
'SABBR'
'ST352'
26 1 0 -2 1 1 0
2 5
'CDKNT'
1 26 1
'ENDE '
'NUFIN'
*$*$
*KSIOX DBN=NJDABL,IND=6,TYP=CARD,PMN=NUTEST
```

```
1 4
'00397'
446 0 0 0
'ENDE '
'00446'
352 0 0 3 446
'SIGMA' 'SABBR' 'KOMPO' 446
0 0 0 446
'KOMPO'
@26-GR.KFKINR001@ 0 26 1 0 18 446
@B 100B 110C 120CR520FE560MO960NA230NB930NI590O 160PU390PU400PU410@
 @PU420SPP90U2350U2380V 510@ 446
10  4  0.331770E-02  5  0.110016E-01  6  0.154850E-03  7  0.107574E-01
   8  0.103175E-03  9  0.244911E-02 10  0.138484E-01 16  0.173106E-04
  17  0.690691E-02 18  0.658638E-04  446
'WQFIN'
'00352'
0 0 -2 1
'SIGMA' 'SABBR'
'SABBR'
'ST352'
26 1 0 -2 1 1 0
3 5
'CDKNT'
1 26 1
'ENDE '
'NUFIN'
*$*$
*KSIOX DBN=NUDABL,IND=7,TYP=CARD,PMN=NUTEST
1 4
'00397'
446 0 0 0
'ENDE '
'00446'
352 0 0 3 446
'SIGMA' 'SABBR' 'KOMPO' 446
0 0 0 446
'KOMPO'
@26-GR.KFKINR001@ 0 26 1 0 18 446
@B 100B 110C 120CR520FE560MO960NA230NB930NI590O 160PU390PU400PU410@
 @PU420SPP90U2350U2380V 510@ 446
9  1  0.604851E-02  2  0.247954E-01  3  0.771097E-02  4  0.410375E-02
   5  0.133110E-01  6  0.222437E-03  7  0.958653E-02  8  0.127620E-03
   9  0.333236E-02  446
'WQFIN'
'00352'
0 0 -2 1
'SIGMA' 'SABBR'
'SABBR'
'ST352'
26 1 0 -2 1 1 0
4 5
'CDKNT'
1 26 1
'ENDE '
'NUFIN'
```

```
*$*$
*KSIOX  DBN=NJDABL,IND=8,TYP=CARD,PMN=NUTEST
1 4
'0C397'
446 0 0 0
'ENDE '
'00446'
352 0 0 3 446
'SIGMA' 'SABBR' 'KOMPO' 446
0 0 0 446
'KCMPO'
@26-GR.KFKINR001@ 0 26 1 0 18 446
@B 100B 110C 120CR520FE560MO960NA230NB930NI590O 160PU390PU400PU410@
 @PU420SPP90U2350U2380V 510@ 446
6  4  0.260524E-02  5  0.845038E-02  6  0.141213E-03  7  0.189532E-01
   8  0.810186E-04  9  0.211552E-02  446
'WQFIN'
'00352'
0 0 -2 1
'SIGMA' 'SABBR'
'SABBR'
'ST352'
26 1 0 -2 1 1 0
5 5
'CDKNT'
1 26 1
'ENDE '
'NUFIN'
*$*$
*KSIOX  DBN=NJDABL,IND=1,TYP=CARD,PMN=NUTEST
0
'00397'
2291 0 0 0
'ENDE '
'02291'
2250 20 1 26 5
1 'SABBR' 1
'02250'
0 1 5 0
1 6
1.
'PU390' .0032 .08
'PU400' .0032 .08
'PU410' .0032 .08
'PU420' .0032 .08
'U2350' .0032 .08
'U2380' .0032 .08
4
@BRENN@ 7 @O 160@ 1. @PU390@ 1. @PU400@ 1. @PU410@ 1. @PU420@ 1.
 @U2350@ 1. @U2380@ 1.
@HUELL@ 6 @CR520@ .525 @FE560@ .525 @MO960@ .525 @NB930@ .525 @NI590@
 .525 @V 510@ .525
@KUEHL@ 1 @NA230@ 1.
@STRUK@ 6 @CR520@ .475 @FE560@ .475 @MO960@ .475 @NB930@ .475 @NI590@
 .475 @V 510@ .475
4
```

```
@BRENN@ 7 @O 160@ 1. @PU390@ 1. @PU400@ 1. @PU410@ 1. @PU420@ 1.
 @U2350@ 1. @U2380@ 1.
@HUELL@ 6 @CR520@ .525 @FE560@ .525 @MO960@ .525 @NB930@ .525 @NI590@
 .525 @V 510@ .525
@KUEHL@ 1 @NA230@ 1.
@STRUK@ 6 @CR520@ .475 @FE560@ .475 @MO960@ .475 @NB930@ .475 @NI590@
 .475 @V 510@ .475
4
@BRENN@ 3 @O 160@ 1. @U2350@ 1. @U2380@ 1.
@HUELL@ 6 @CR520@ .525 @FE560@ .525 @MO960@ .525 @NB930@ .525 @NI590@
 .525 @V 510@ .525
@KUEHL@ 1 @NA230@ 1.
@STRUK@ 6 @CR520@ .475 @FE560@ .475 @MO960@ .475 @NB930@ .475 @NI590@
 .475 @V 510@ .475
1
@STRUK@ 9 @B 100@ 1. @B 110@ 1. @C 120@ 1. @CR520@ 1. @FE560@ 1.
 @MO960@ 1. @NA230@ 1. @NB930@ 1. @NI590@ 1.
1
@STRUK@ 6 @CR520@ 1. @FE560@ 1. @MO960@ 1. @NA230@ 1. @NB930@ 1.
 @NI590@ 1.
1
4 5
'NUFIN'
*$*$
*KSIOX DBN=NUDABL,IND=3,TYP=CARD,PMN=NUTEST
2 1 4
'00397'
4100 0 0 0
'ENDE '
'04100'
5 300. 600. 900. 1500. 2100.
1 0 0
1 1 1
'COND '
1 26
'NUFIN'
*$*$
*GO SM=KINWQ
/*
//
```

CASE B

```
//...JOBCARD...,REGION=290K,TIME=(1,30)
/*FORMAT PR,DDNAME=FT42F001
// EXEC KSG
//K.FT22F001 DD DSN=A1.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,2)
//K.FT23F001 DD UNIT=SYSDA,SPACE=(TRK,3)
//K.FT25F001 DD DSN=T1G30Z.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=SHR
//K.FT26F001 DD DUMMY
//K.SYSIN DD *
*KSIOX DBN=KINPUT,TYP=CARD,PM=KETT
'START' 1 1 8 72 1 5 6 1 -1 22 23 0
'PERTUR' 2 10.   3 0 .1 .2
14 2 0 10. 1 4 'BRENN' 'KUEHL' 2 0 1. 10. 1.1
'DCN  ' 2   4 1 4 1 0   4 5 8 3 0
'CONTROL' 0 -1 0 1.-5 1.-4 .0001 .00001 .01 .01 .0004 .1 .1
'RORAMP' 2 .1 .2 .5 .1
'POWER' 400.
'CHECK' 3 3 26
'CONSIS' -1 0 1.
*$*$
*KSIOX DBN=FEEDBC,TYP=CARD,PM=KINPRM
1 5 6 0 0 -1 4 1 1
1 .06 3 .262 .038 .45 .935 20. .005 310. 380. 1. 0 0 0 2700. 1400.
 1000. 1400. 542. 542.
8.9 0 0 8.9 7.7 0 0 7.7 .84 0 0 .84 7.7 0 0 7.7 .067 0 0 .067 .12 0 0
 .12 .3 0 0 .3 .12 0 0 .12 .24 0 0 .24 3. 0 0 3. 9.6-3 0 0 9.6-3 .05 0
 0 .05
1 1 .465 .036 .06 0 .008 1 1 1 1 1
1 12.9-6 21.5-6 21.5-6 0 12.9-6 21.5-6 21.5-6 9.3-5
*$*$
*KSIOX DBN=DX LDIM,TYP=CARD,PMN=KETT
'LDIM' 12 6 8
*$*$
*KSIOX DBN=DXDIF,TYP=CARD,PMN=PRDIXY
'DIXY' 0 0
'KN' 14 2 2 1 30 0 1 0 0 0 20 1 0 0 0
'CN' 6 2*.0005 3*.7104 1.E+10
'REGN' 0   5 1 3 10 12   1 1 3 8 10   2 1 3 5 8
3 1 3 3 5   6 1 3 1 3   7 3 6 10 12   4 3 6 3 10   8 3 6 1 3
'HSTP' 0 5 0 2 25. 3 70.
'VSTP' 0 11 160. 2 125. 2 100. 3 60. 2 35. 2 0
'DXNF' 0
*$*$
*GO SM=KINTIC,ML=3
/*
//
```

CASE C

```
//...JOBCARD...,REGION=440K,TIME=3
/*FORMAT PR,DDNAME=FT42F001
// EXEC KSG
//K.FT44F001 DD SPACE=(3064,210)
//K.FT01F001 DD DUMMY
//K.FT20F001 DD DSN=A2.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,2)
//K.FT21F001 DD DSN=A3.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,2)
//K.FT22F001 DD DSN=A4.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,1)
//K.FT23F001 DD UNIT=SYSDA,SPACE=(TRK,10)
//K.FT25F001 DD DSN=T1G30Z.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=SHR
//K.FT26F001 DD DSN=C0.IIINNN,UNIT=3330,VOL=SER=TSTLIB,
// DISP=(NEW,KEEP),SPACE=(TRK,35)
//K.SYSIN DD *
*KSIOX DBN=KINPUT,TYP=CARD,PM=KETT
'START' 1 1 12 128 1 6 6 -1 -1 20 23 0
'PERTUR' 1 1. 11 1 0 1. 1 9 5 2 0 1. 1. 0
'DCN  ' 5   4 1 3 1 0   4 4 7 3 0   4 8 8 2 0   4 9 9 4 0
          4 10 12 5 0
'CONTROL' 0 -1 0 5.-5 5.-4 .005 .00001 .01 .01 .001 .1 .1
'POWER' 800.
'CHECK' 3 1 26
'CONSIS' -1 0 1.
*$**$
*KSIOX DBN=FEEDBC,TYP=CARD,PM=KETT
2 1 0 12. 1. 2 12. 24. 3. 2 2 4 2 2 0
*$**$
*KSIOX DBN=THEIN,TYP=CARD,PM=KINPRM
'GLOBINT'
'NODE' 2 21 12 2 2 6 6
'GEOM' 1 -1 -1 1 1
'CNT1' 0 21 1 1 0 1 0 1 0 1 1 0 0 0 3 3 0 0 0 2 2 22 0 1 0 0 0
'GLOBREAL'
'CNT2' .5 10. 10. 50. 2. 10. 50. 50. 1.+10 1.+10 0. .5
'OPER' 9.85+5 1.81+5 0 0 0 377. 750. 300.
'MAPL' 'NAL' '4981' '4981' 'UPUO'
'MATD' .276 8740. .34-4 .27+12 .13+12 .3 1700. 1300.
'COOL' 9.7 .286 .498 .498 0 .183 -.2 2*10. .015-2 .005-2 1.1 1.5 .05
'CHAN' 1
1 21 21*2.55-3   31 21 21*.38-3   61 21 18*4.2455-3 3*4.5999-3
91 21 6*.63155-3 12*.28-2 3*.4342-2
121 21 6*1.35-5 12*.67894-5 3*1.2284-5   151 21 21*.7-4
181 21 6*.109166 .25 .151833 7*.12 .122998 2*.2009 .083 .217 .225
211 9 .40221 .097239 .106798 .0086788 .097401 .31256 .081903 .225 1.14
231 3 80000. 1.-10 124.8
234 12 .45+15 1.30+15 2.05+15 2.63+15 3.38+15 3.56+15
       3.49+15 3.31+15 2.74+15 1.94+15 .80+15 .20+15
264 14 .05 .085 .135 .1 .05 .02 1. .9 .6 8314.3 9100. 441. 3. .015
301 3 564. 50. .2   304 21 21*.969   334 21 21*.C35357
364 21 21*.0053246   394 21 21*.041292   424 2 .8+4 1.+7
432 12 12*.865   462 12 12*.95   495 8 8*.247
516 1 3.3+6   521 9 .01 0. 1. 1. 1. 9.80665 .6 1400. 0.
```

```
530 11 0. 600. .5 .0117 10.-3 .307 .091954 .001 321.9 .3 0.
'CHAN' 2
'END'
*$*$
*KSIOX DBN=DX LDIM,TYP=CARD,PMN=KETT
'LDIM' 16 8 12
*$*$
*KSIOX DBN=DXDIF,TYP=CARD,PMN=PRDIXY
'DIXY' 0 0
'KN' 14 2 2 1 30 0 1 0 0 0 20 1 0 0 1
'CN' 6 2*.0005 3*.7104 1.+10
'REGN' 0
4 1 3 13 16   1 1 3 11 13   2 1 3 7 11   3 1 3 5 7
5 1 3 3 5   10 1 3 1 3   9 3 5 1 9   11 3 5 9 16
8 5 8 5 13   6 5 8 13 16   7 5 8 3 5   12 5 8 1 3
'HSTP' 0 7 0 2 24. 2 32. 3 78.
'VSTP' 0 13 182. 2 176.6631 2 136.4831 1 124.1833 7 40.1833 1 25. 2 0
'DXNF' 0
*$*$
*GO SM=KINTIC,ML=3
/*
//
```

CASE D

```
//...JOBCARD...,REGION=440K,TIME=3
/*FORMAT PR,DDNAME=FT42F001
// EXEC KSG
//K.FT44F001 DD SPACE=(3064,210)
//K.FT01F001 DD DUMMY
//K.FT20F001 DD DSN=A2.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=(OLD,KEEP)
//K.FT21F001 DD DSN=A3.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=(OLD,KEEP)
//K.FT22F001 DD DSN=A4.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=(OLD,KEEP)
//K.FT23F001 DD UNIT=SYSDA,SPACE=(TRK,10)
//K.FT26F001 DD DUMMY
//K.FT27F001 DD DSN=C0.IIINNN,UNIT=3330,VOL=SER=TSTLIB,DISP=SHR
//K.SYSIN DD *
*KSIOX DBN=KINPUT,TYP=CARD,PM=KINPRM
'CHCKI' 3 27 -1 -1 -1 0 0
'CHECK' 3 2 26
*$*$
*GO SM=KINTIC,ML=3
/*
//
```

Literature

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/2/ H.Bachmann, S.Kleinheins: Kurzes KAPRØS-Benutzerhandbuch; KFK 2317 (1976)

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/4/ L.Mayer, H.Bachmann: KINTIC-1: A program for the calculation of two-dimensional reactor dynamics of fast reactors with the quasistatic method; KFK 1627 (1972)

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/13/ W.Höbel: Abstract No.ENEA 184 of the ENEA Computer Programme Library.

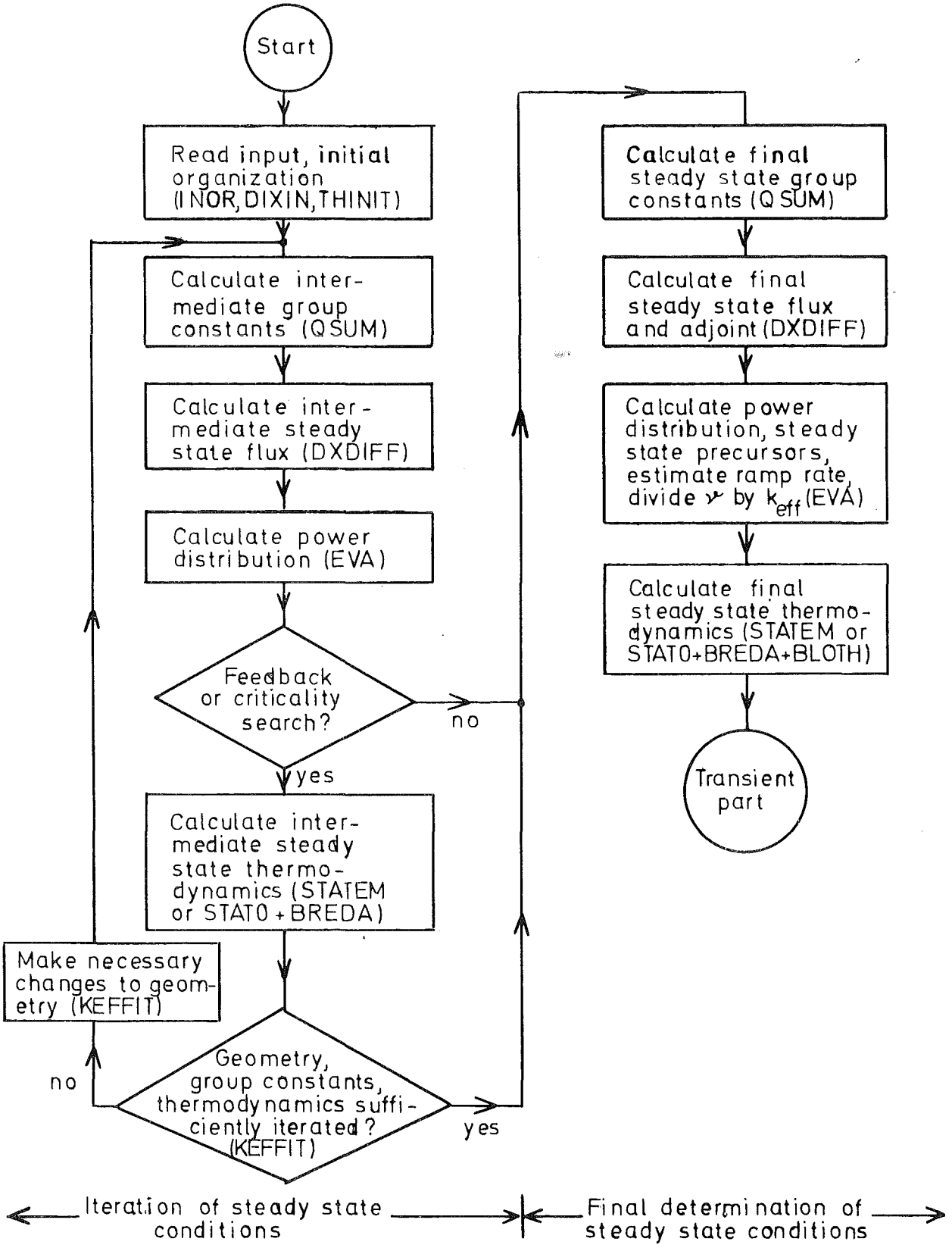

Fig. 1: Flow chart of steady state part of KINTIC-2

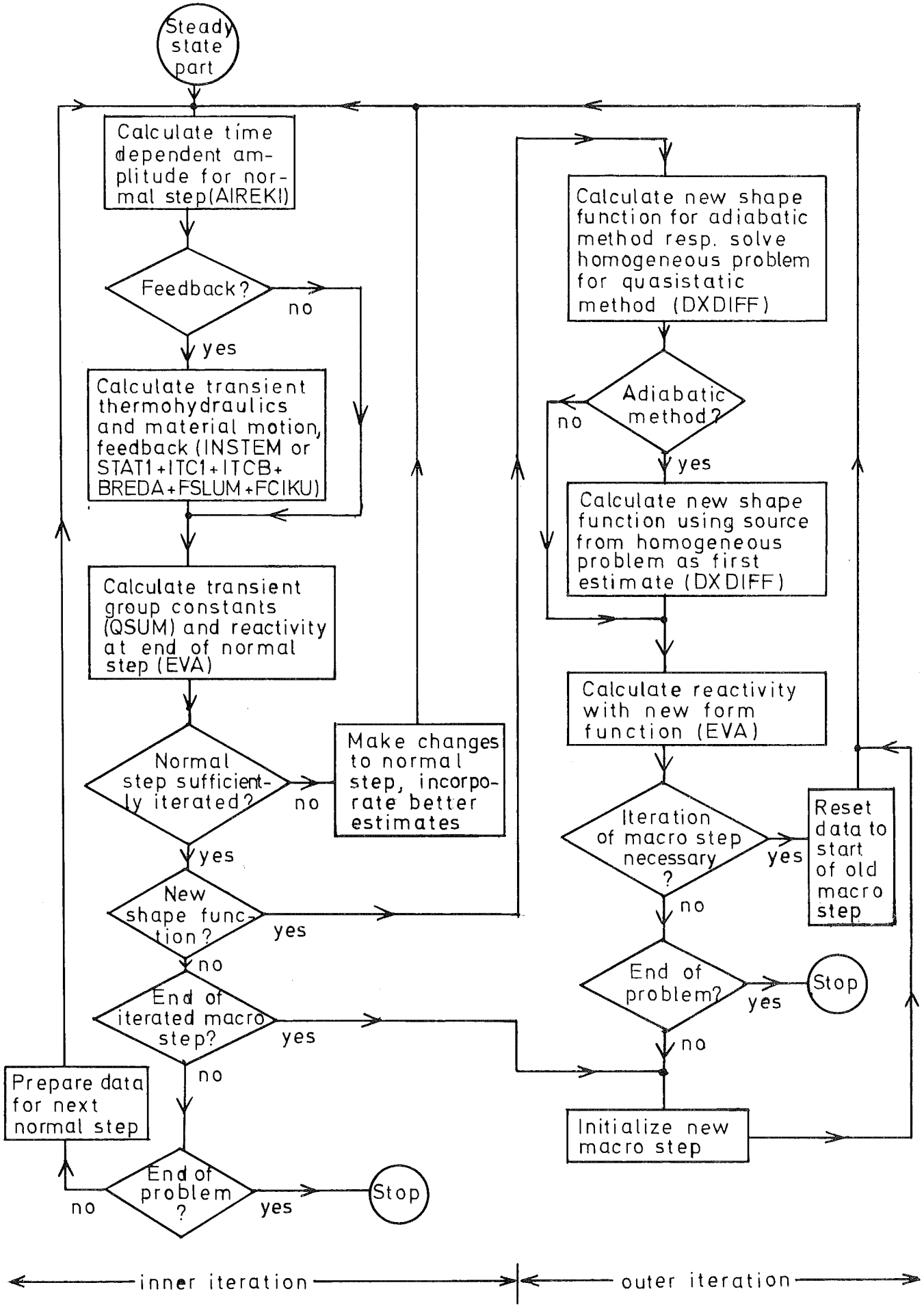

Fig. 2: Flow chart of transient part of KINTIC-2

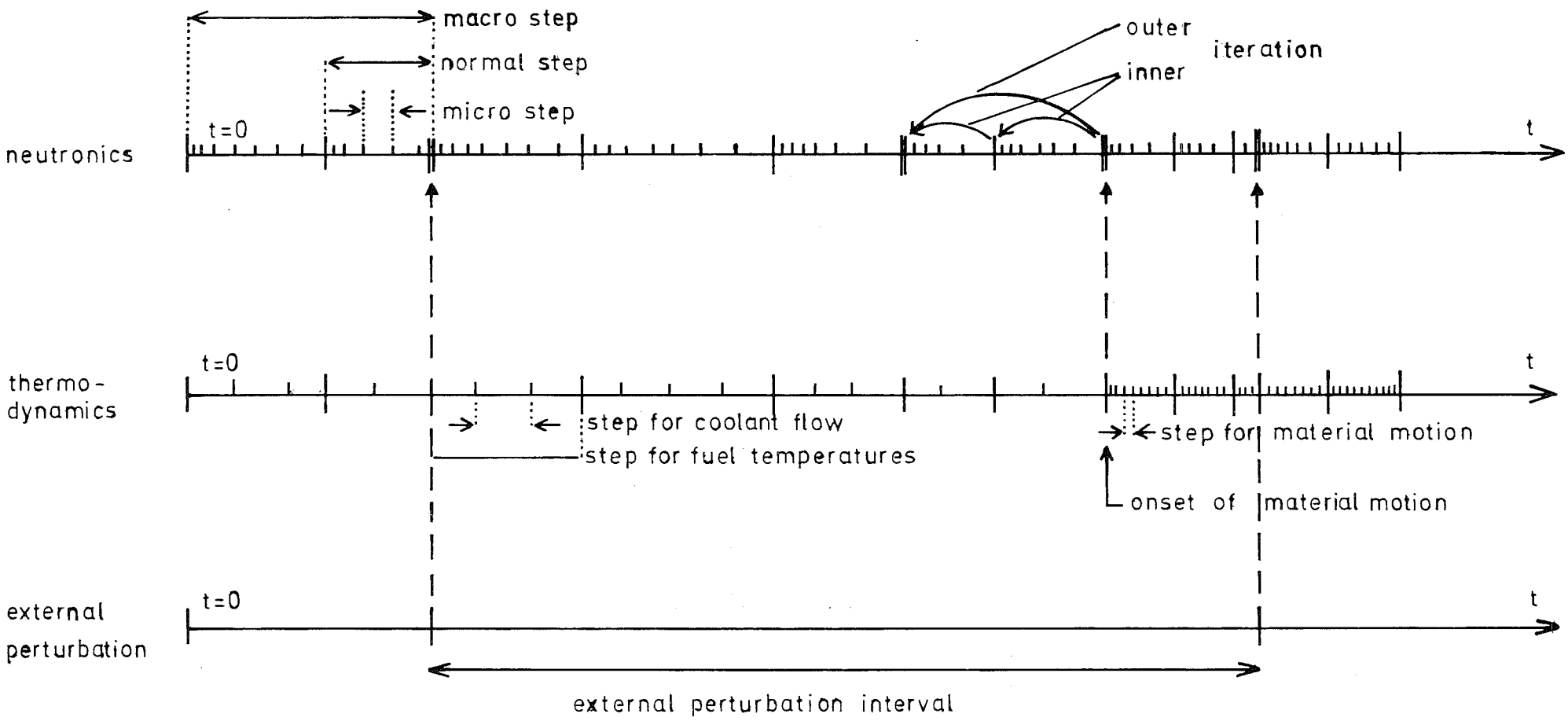

Fig. 3: Interaction of time scales in KINTIC-2

end of normal interval

end of macro interval

end of micro interval or end of internal thermodynamics interval

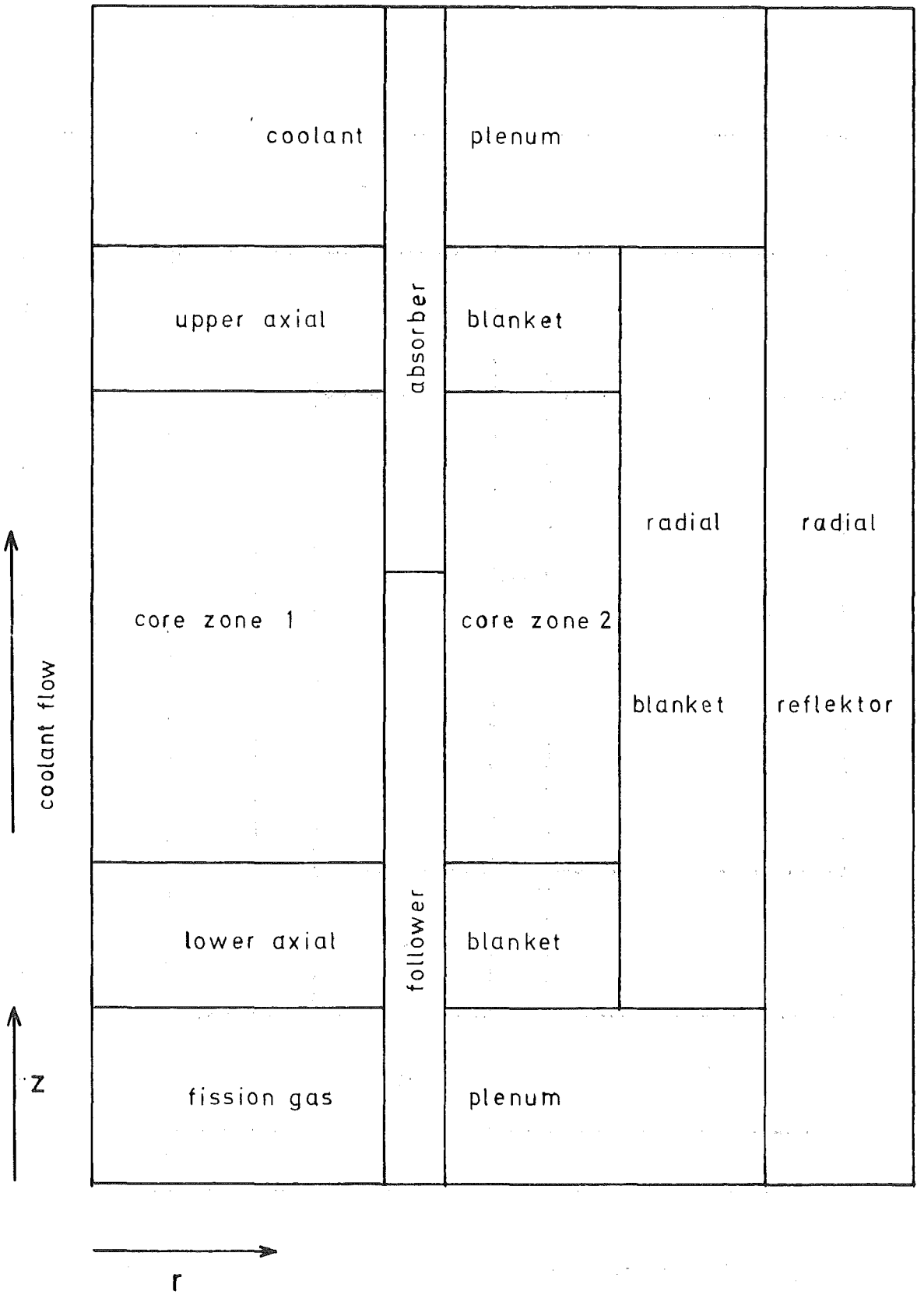

Fig. 4: Scheme of original reactor configuration

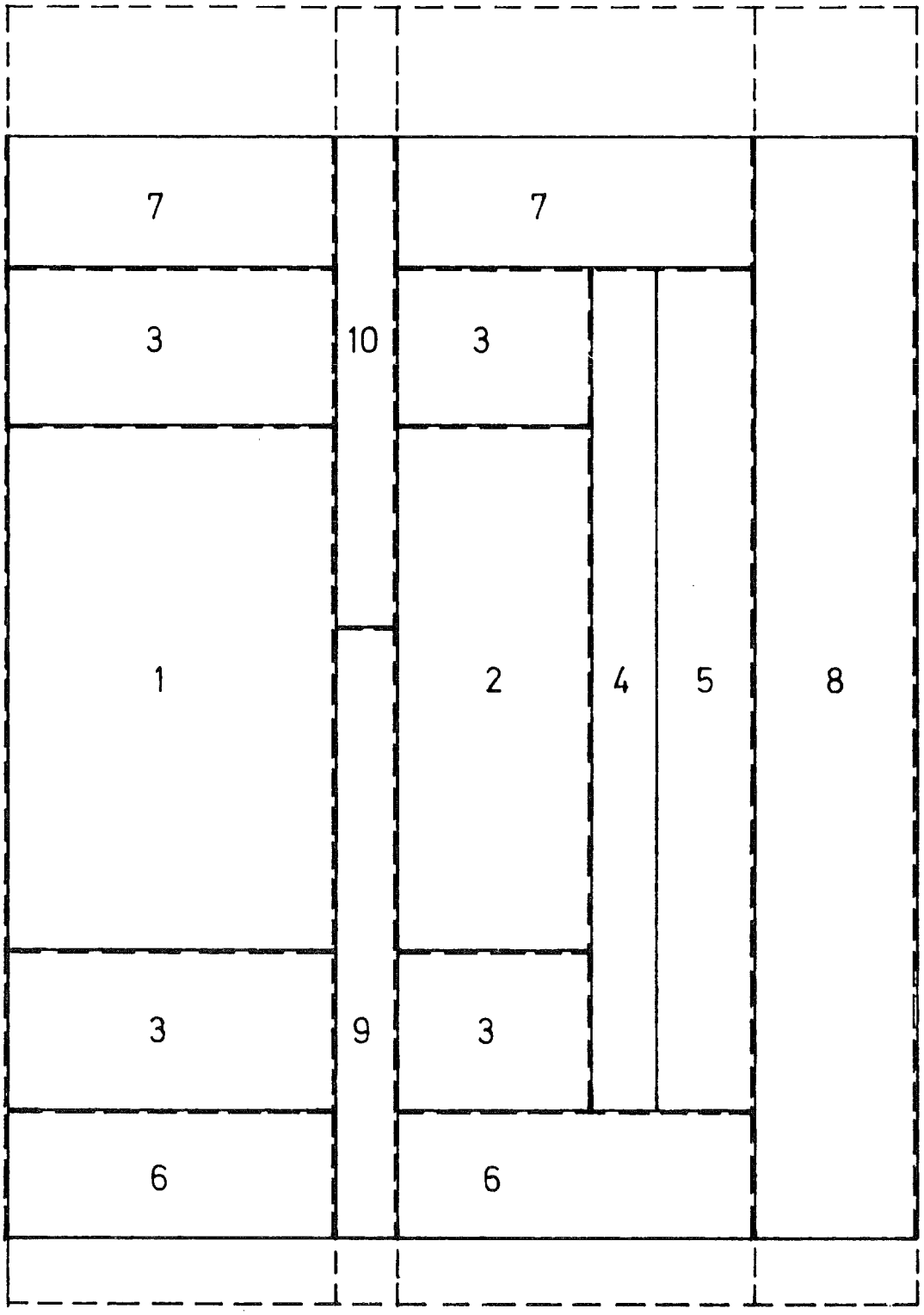

Fig. 5: Subzone configuration for calculation of group constants

--- original reactor configuration

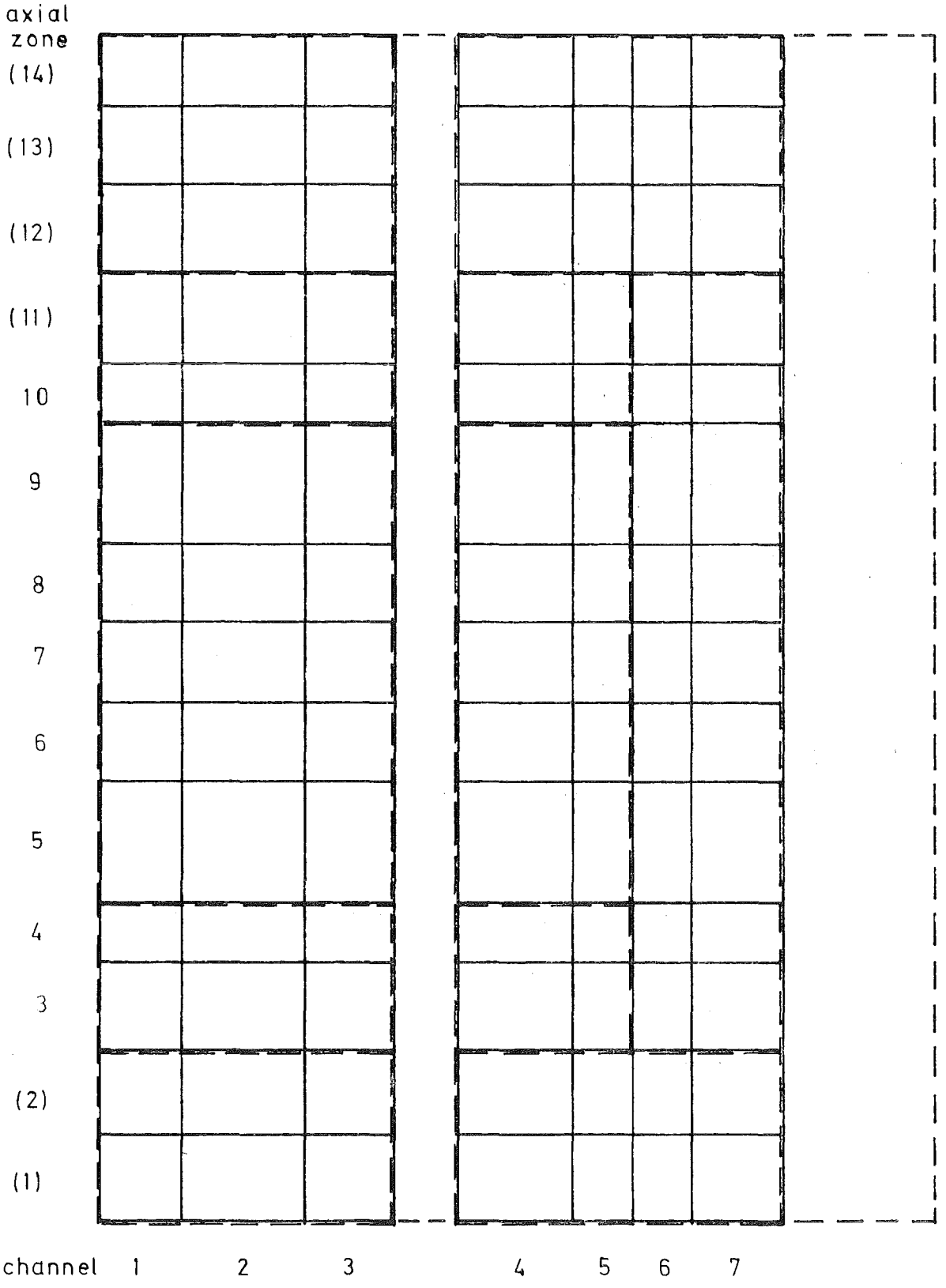

Fig. 6: Thermodynamics representation

--- original reactor configuration

(i) axial zone, which is not correlated with neutronics representation

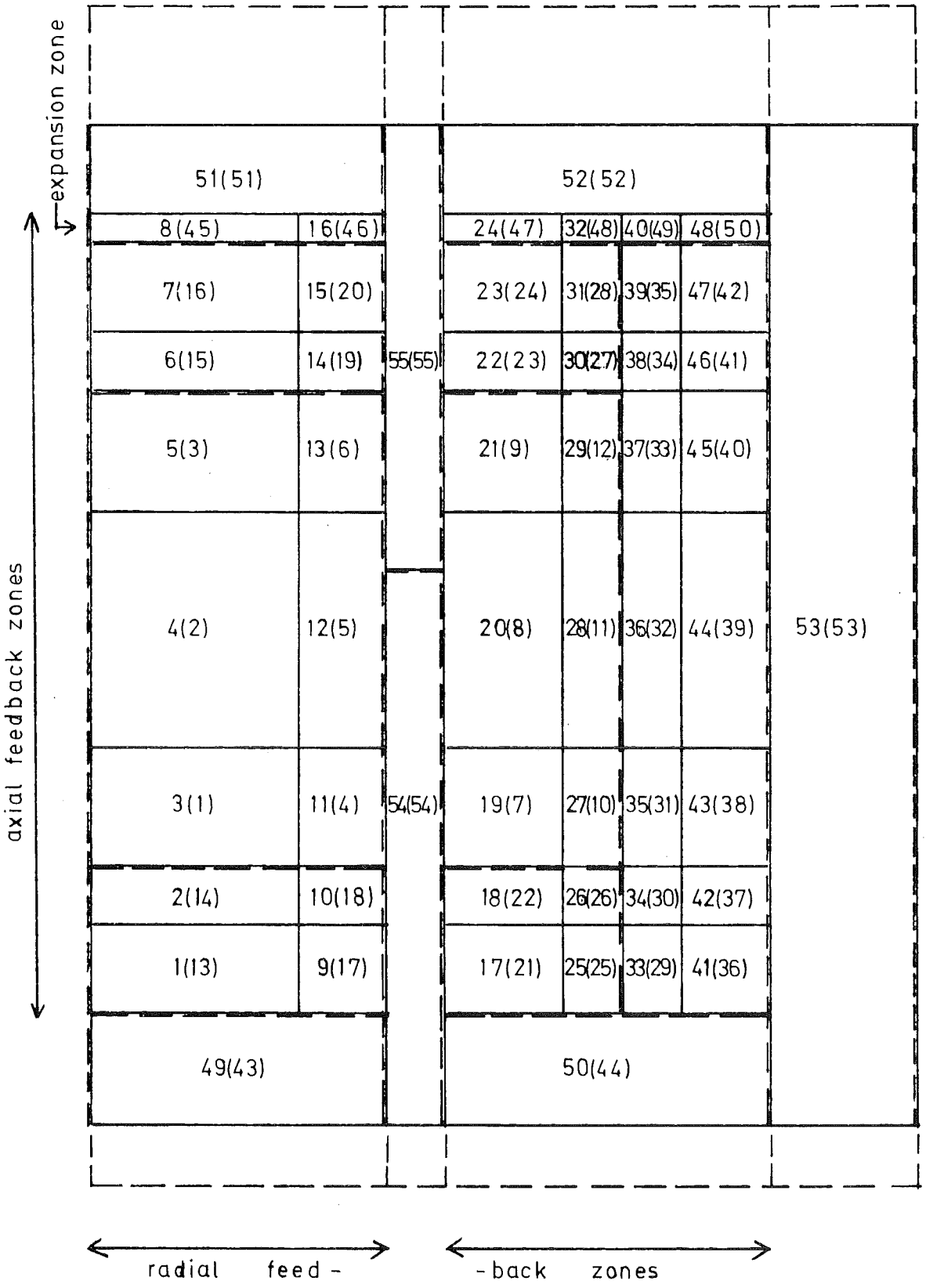

Fig. 7: Feedback and non-feedback zones
Numbers: Zone number (composition number)
– – – – : Original reactor configuration

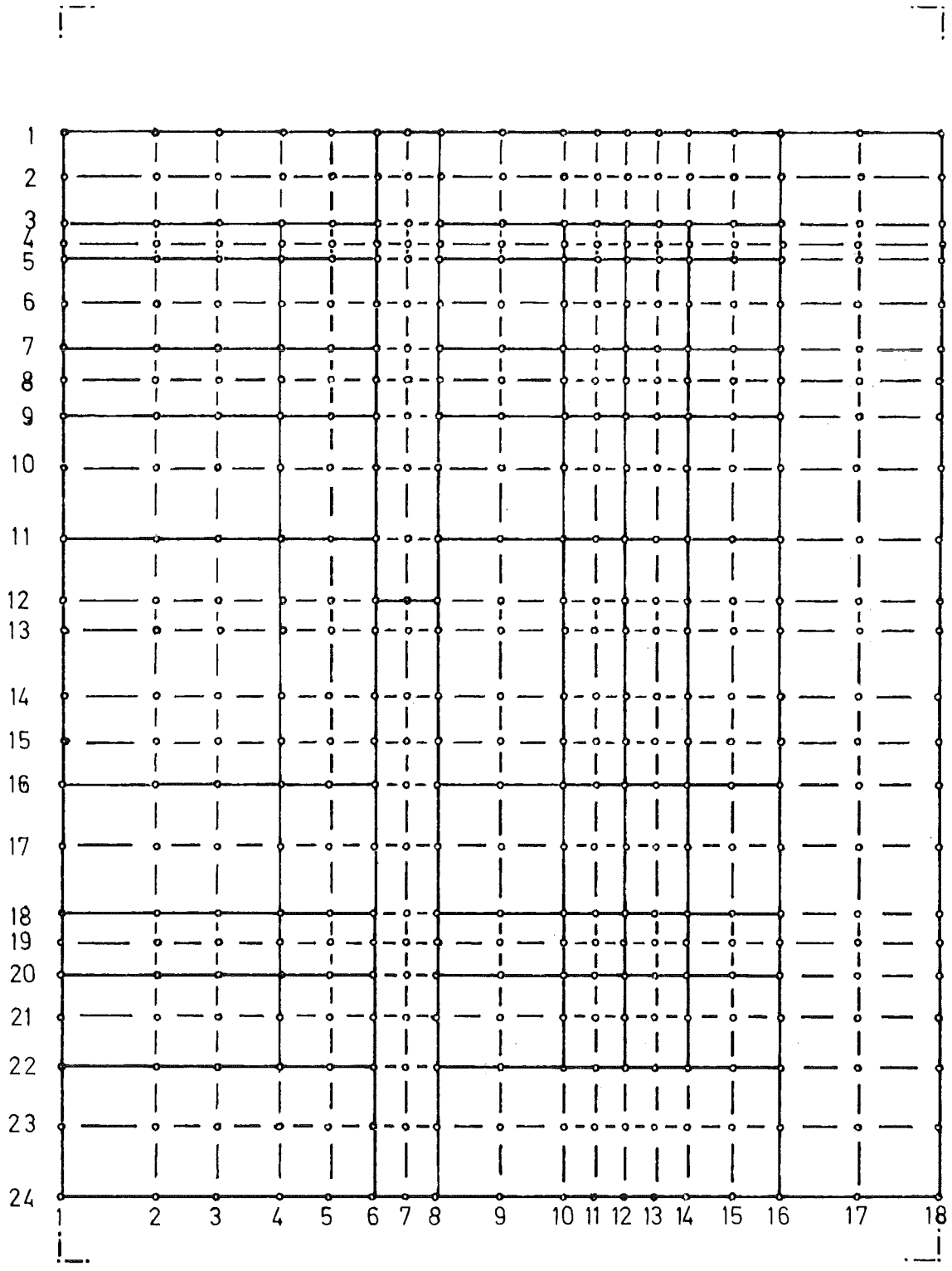

Fig. 8: Neutronics mesh

—— zone configuration comprising feedback and non-feedback zones

outer edge of original configuration

o mesh point

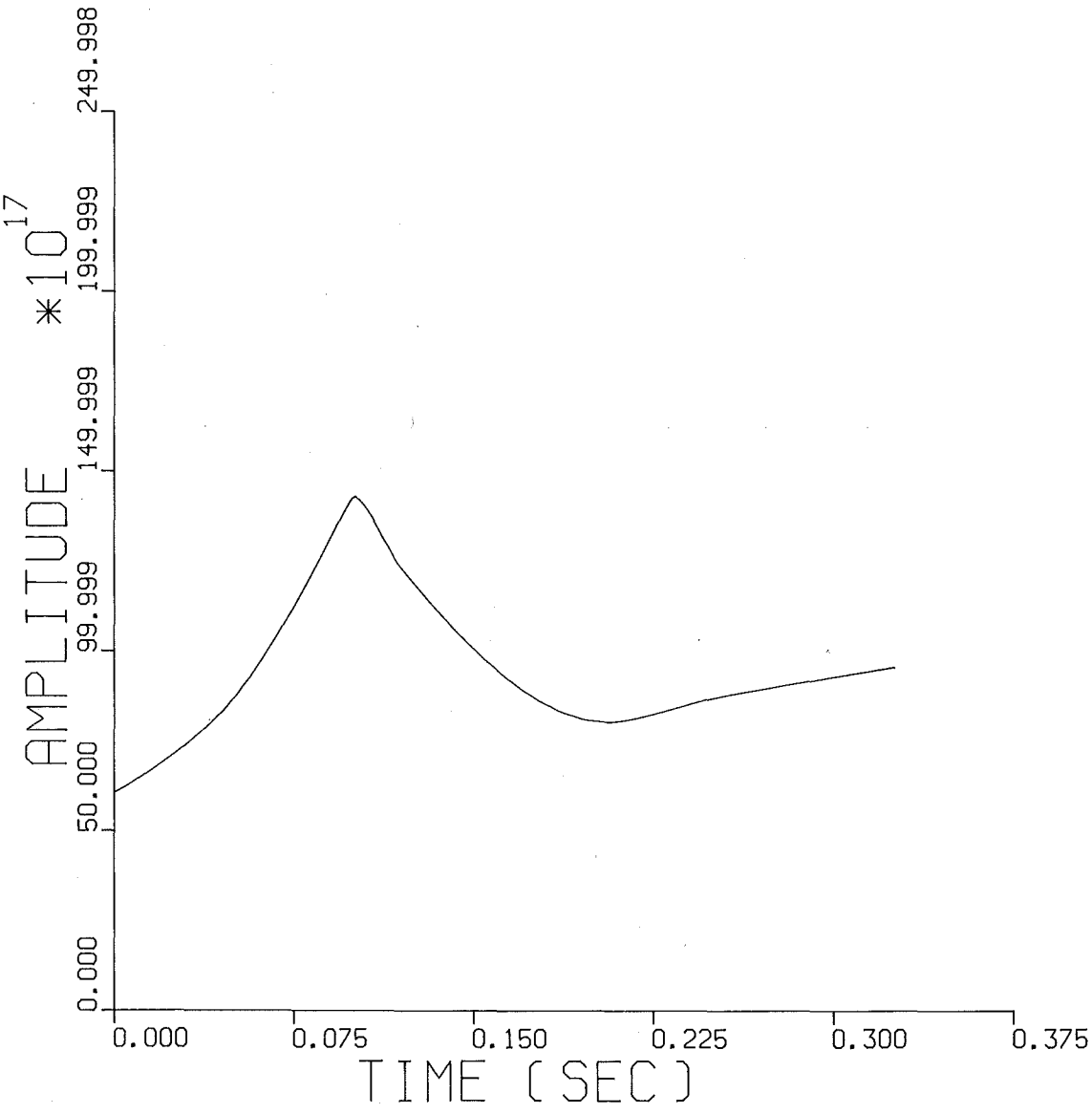

FIG. 9 CASE B AMPLITUDE(T)

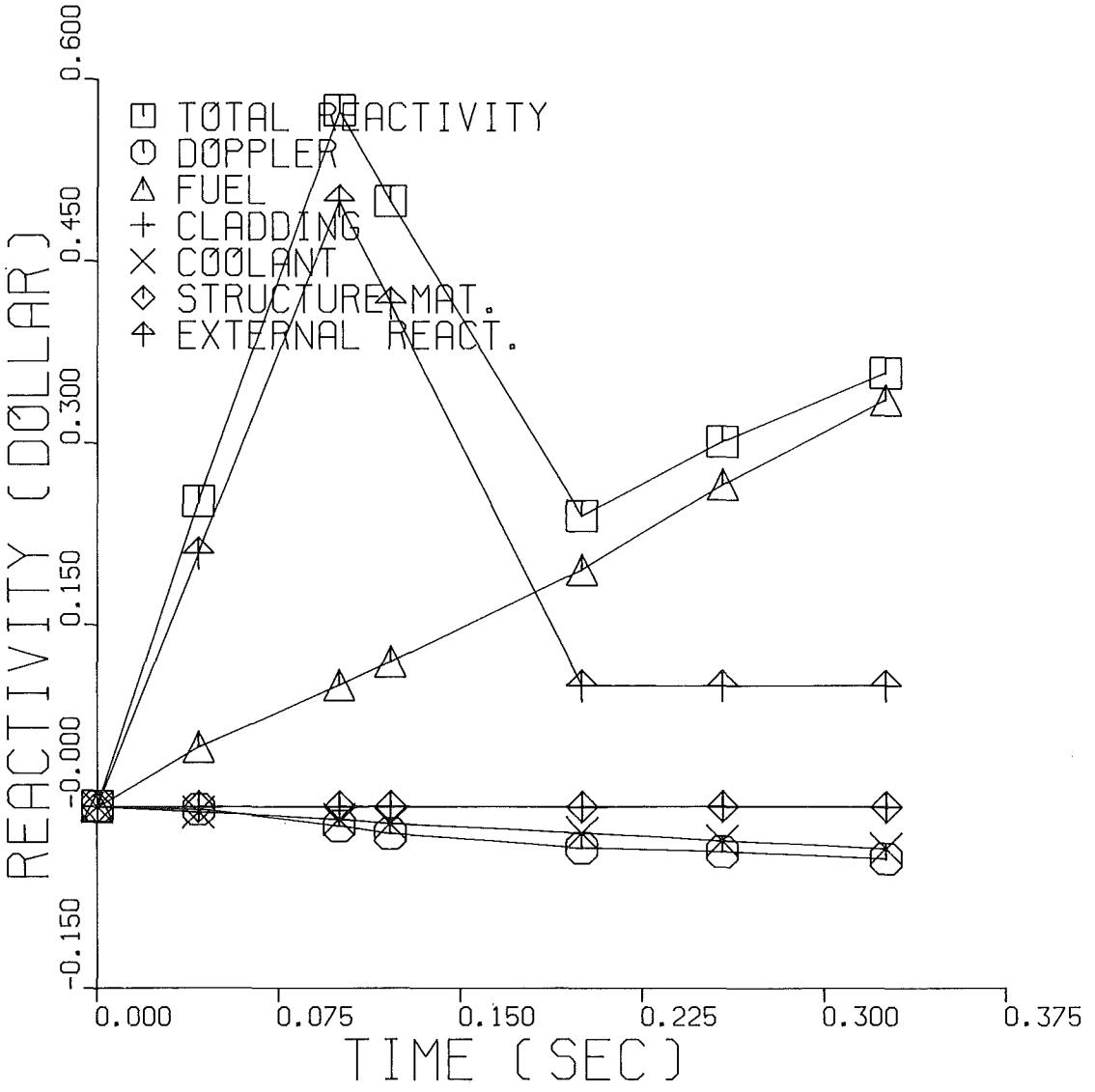

FIG. 10 CASE B REACTIVITY(T)

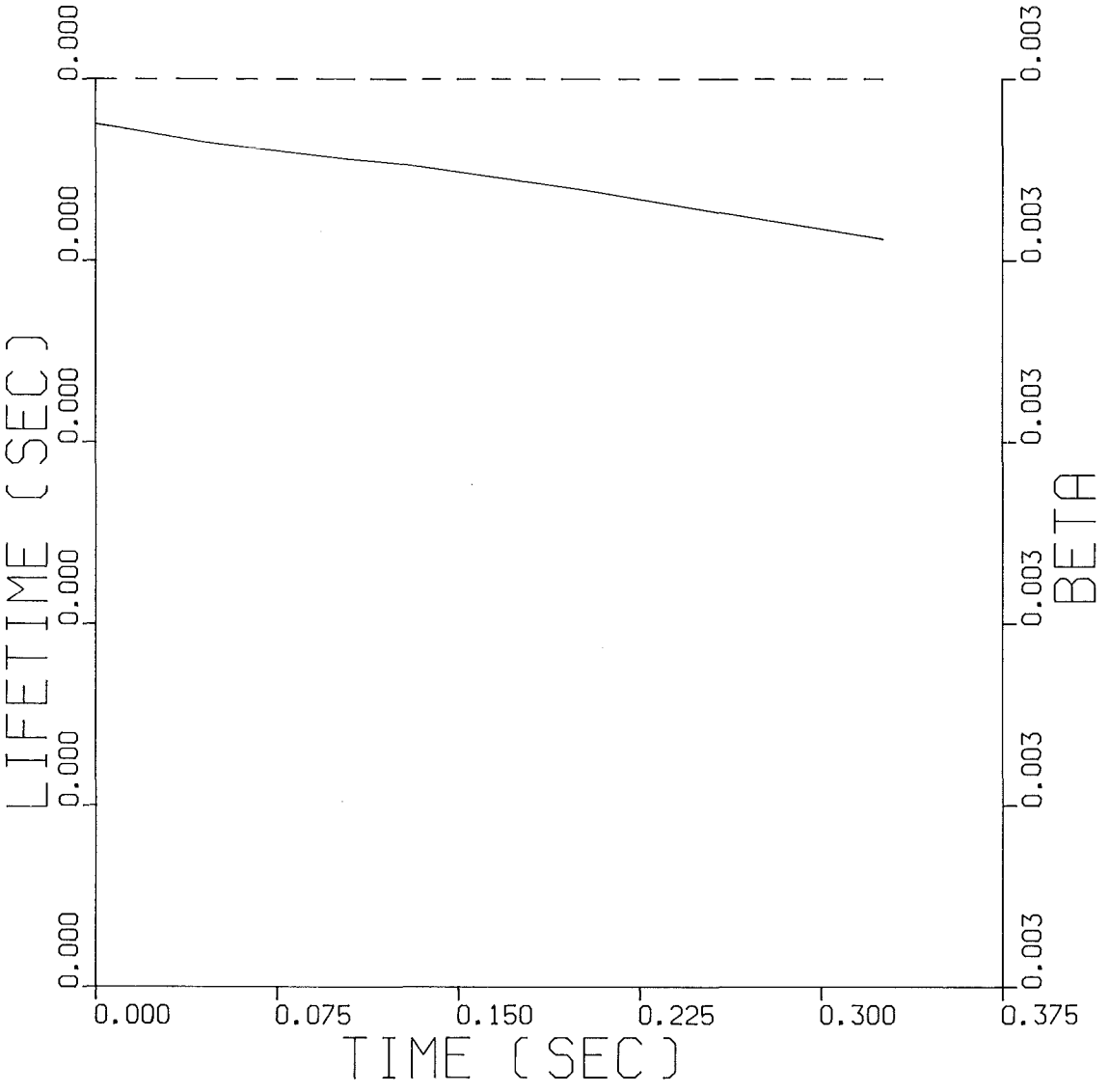

FIG. 11 CASE B LIFETIME(T) AND BETA(T)

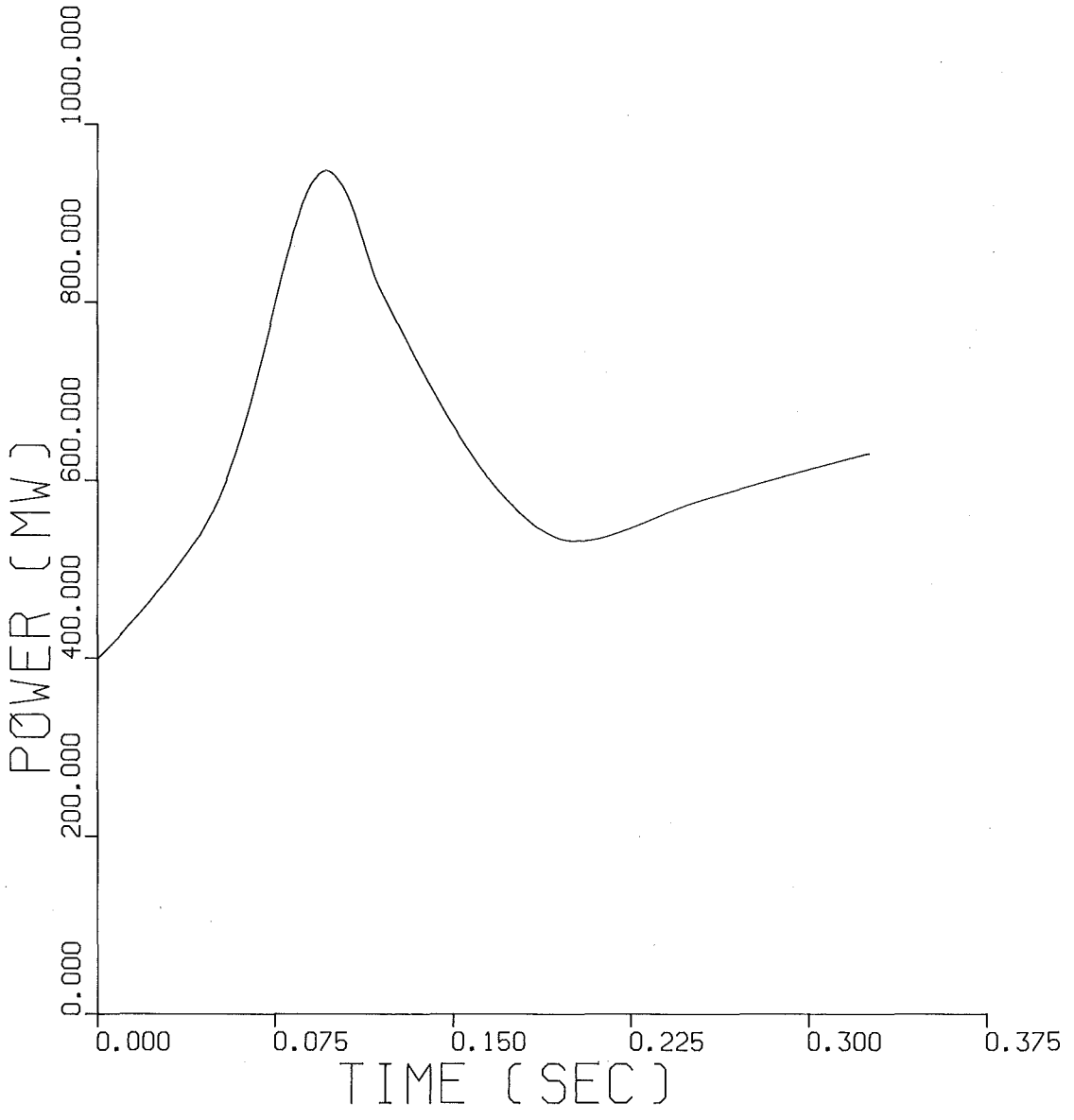

FIG. 12 CASE B PØWER(T)

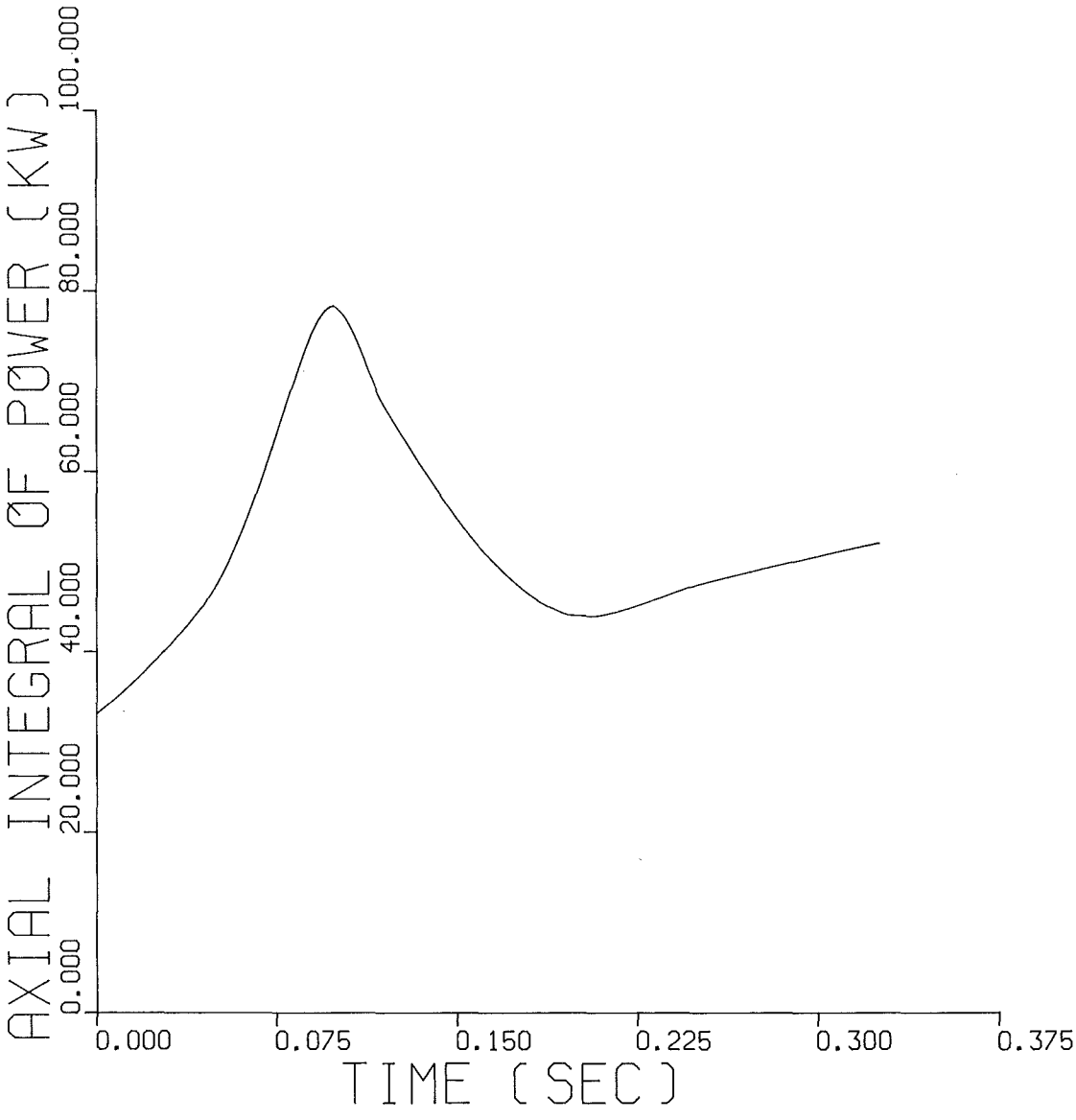

FIG. 13 CASE B AXIAL INTEGRAL ØF PØWER

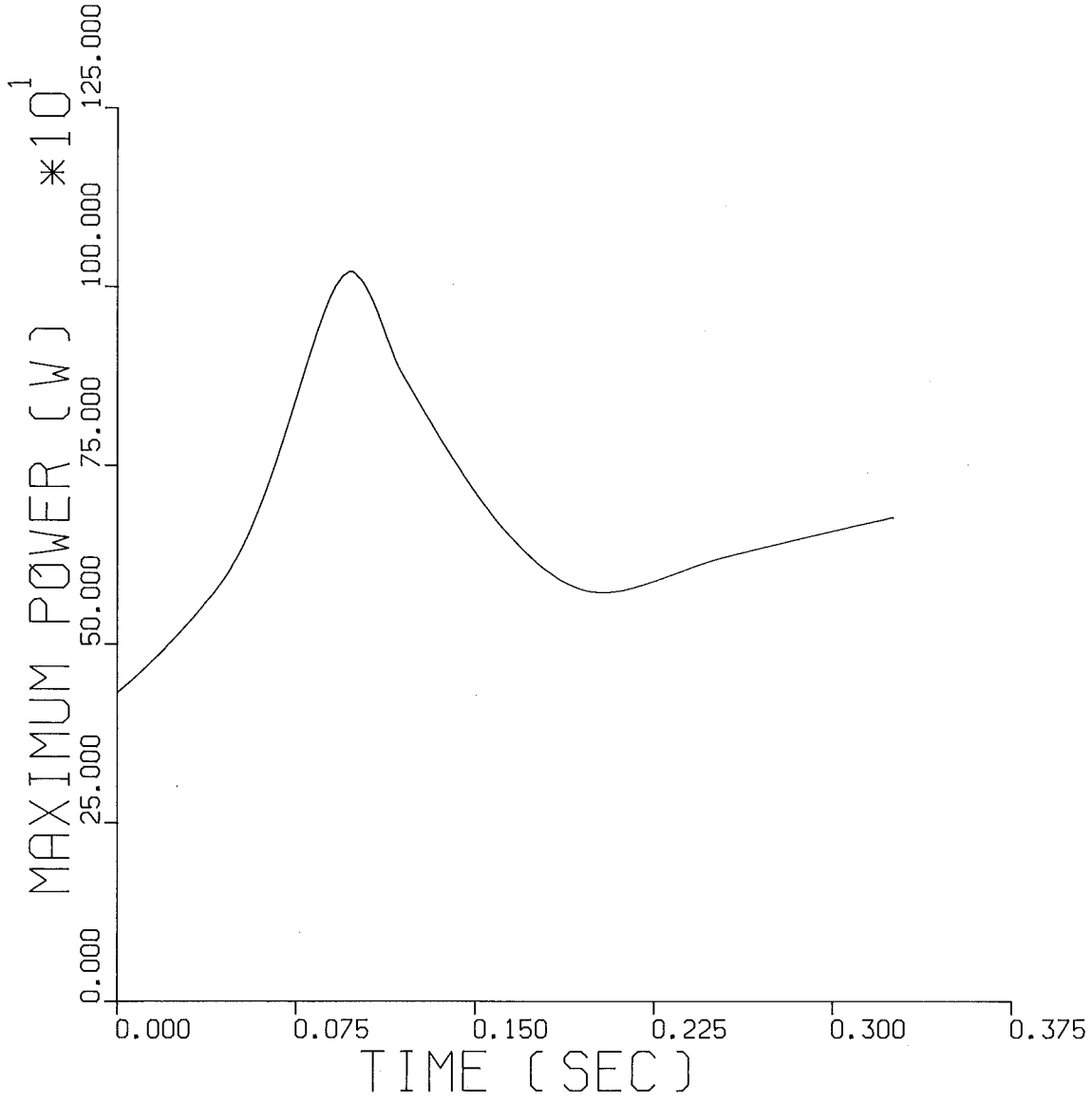

FIG. 14 CASE B MAXIMUM POWER IN PIN

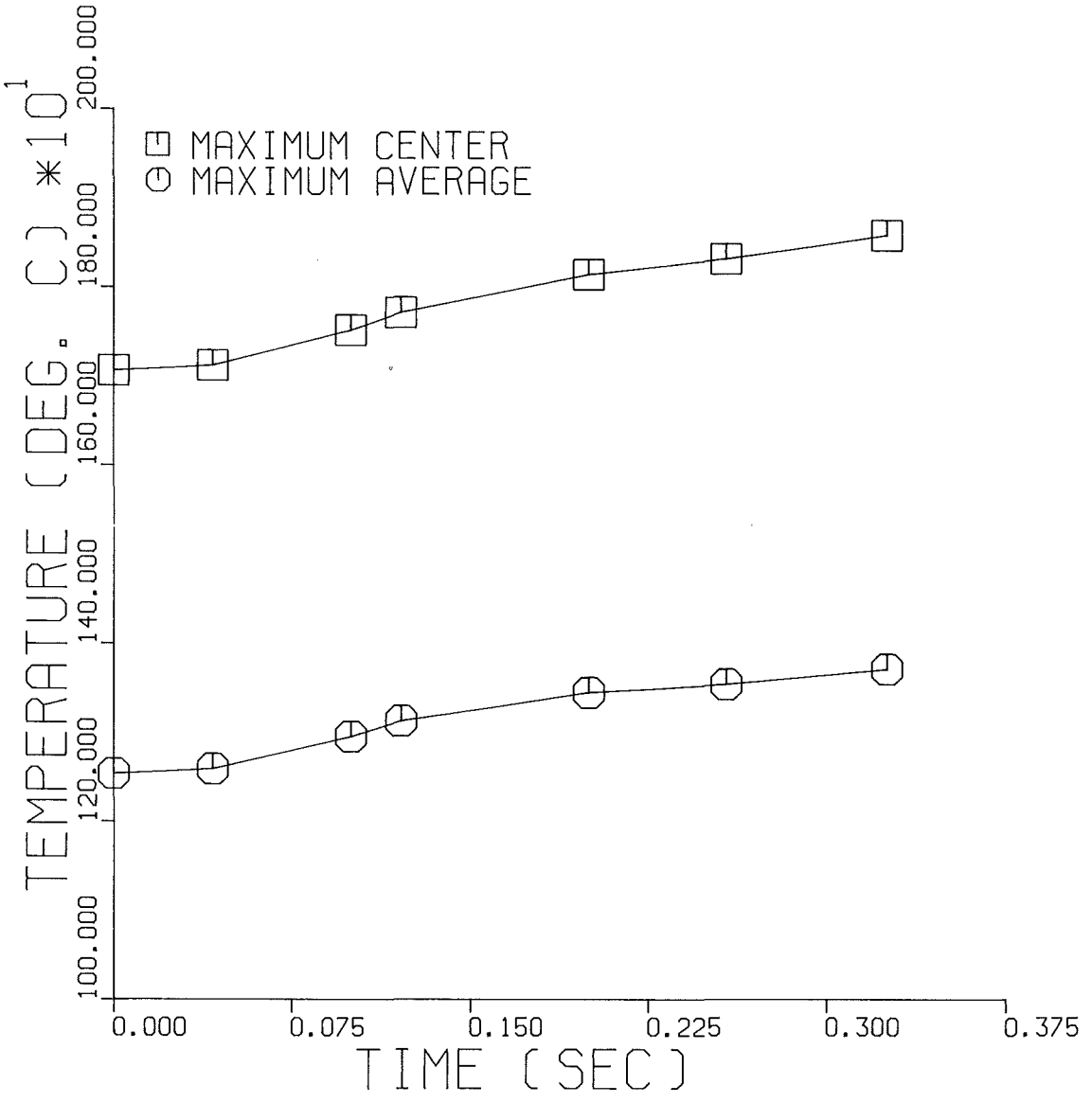

FIG. 15 CASE B FUEL TEMPERATURES

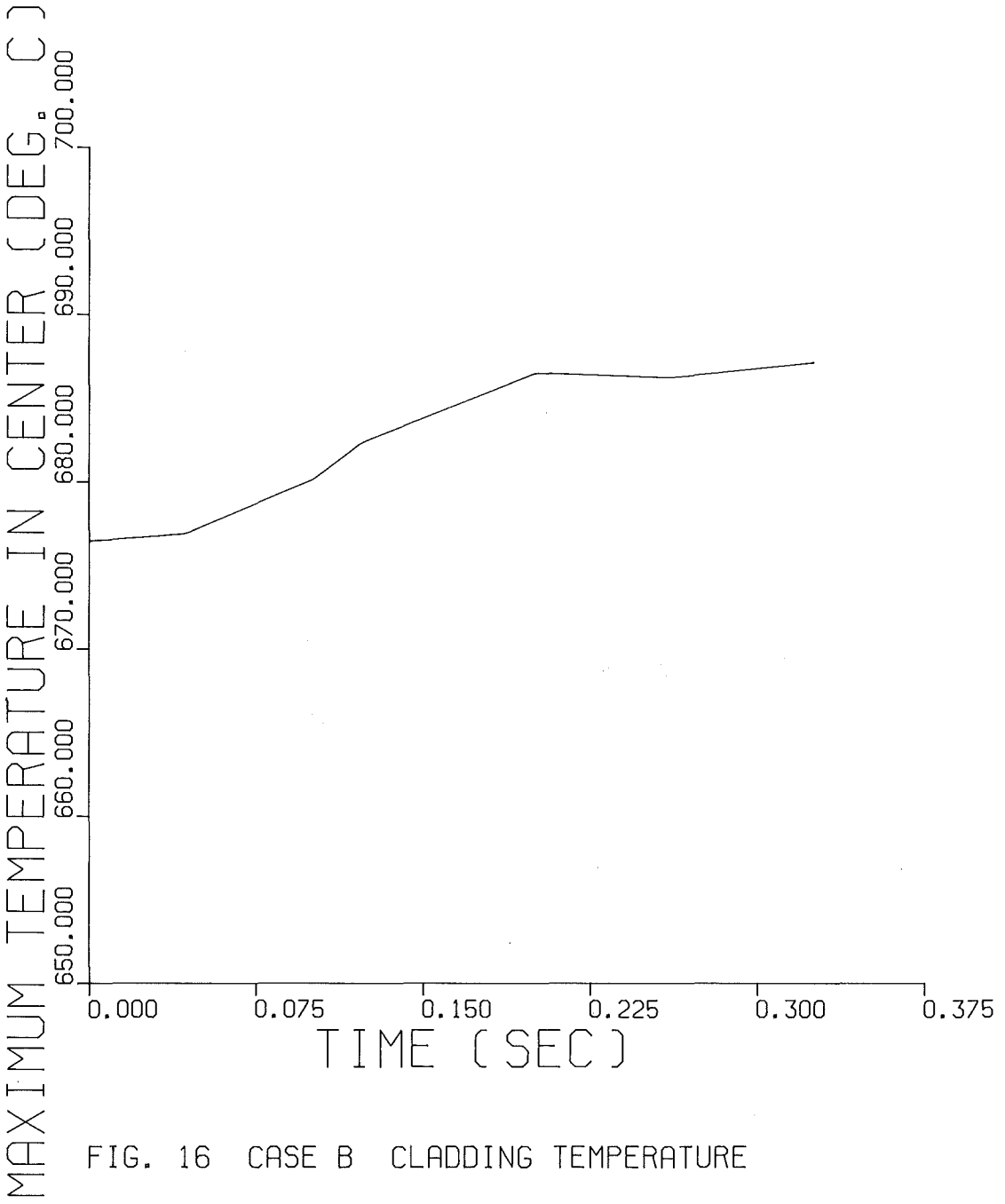

FIG. 16 CASE B CLADDING TEMPERATURE

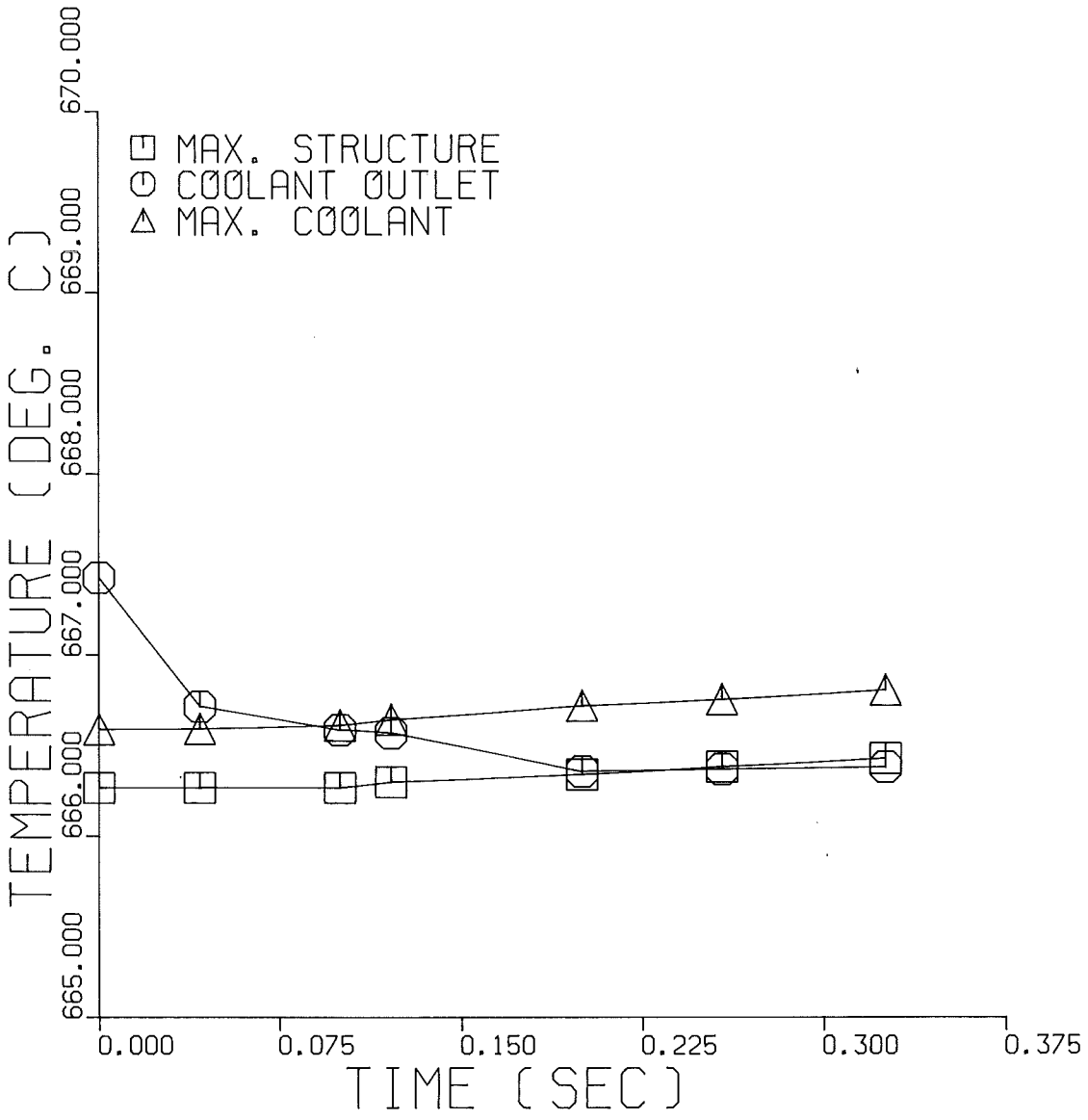

FIG. 17 CASE B COOLANT + STRUCT. TEMP.

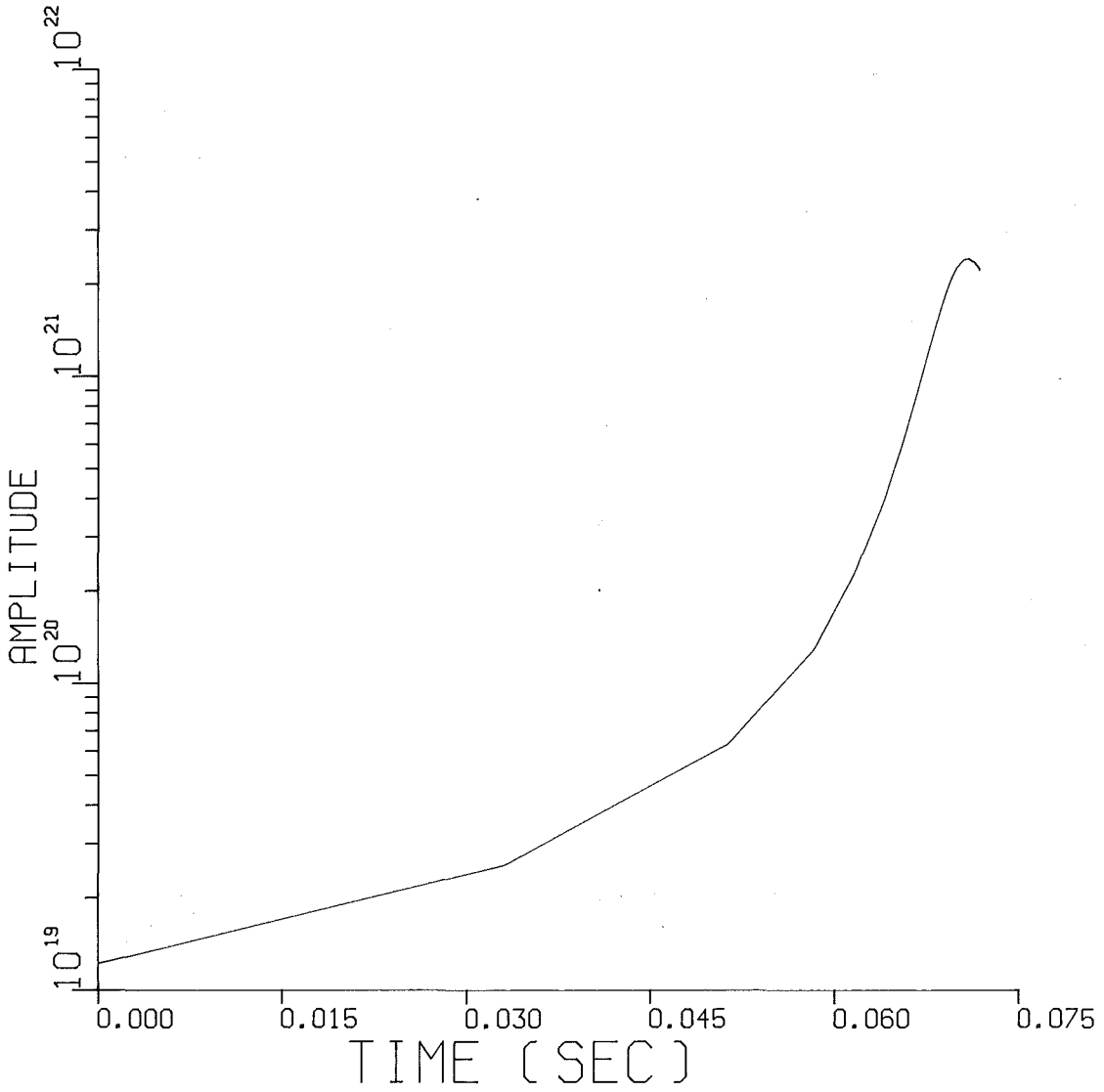

FIG. 18 CASE CD AMPLITUDE(T)

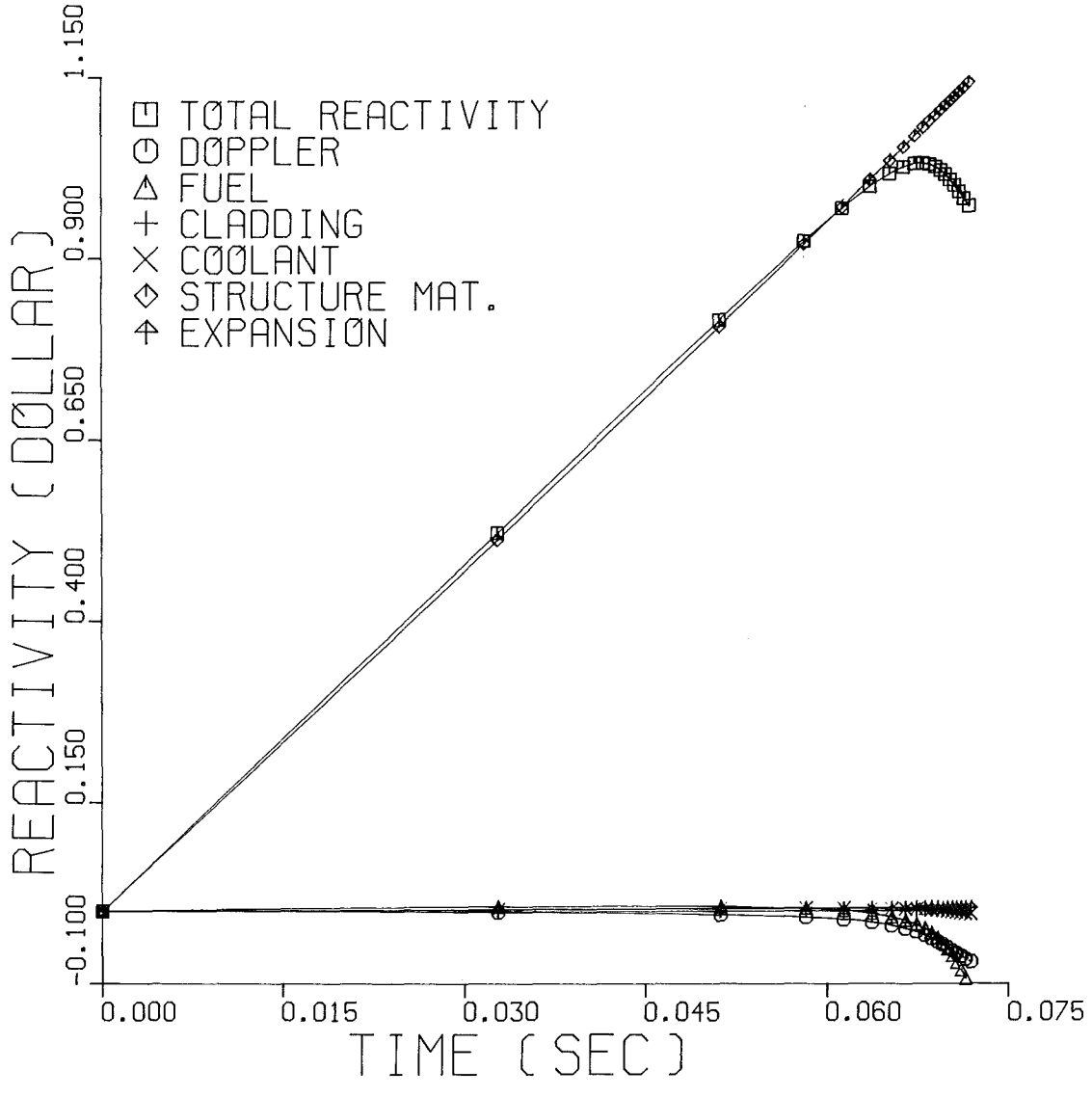

FIG. 19 CASE CD REACTIVITY(T)

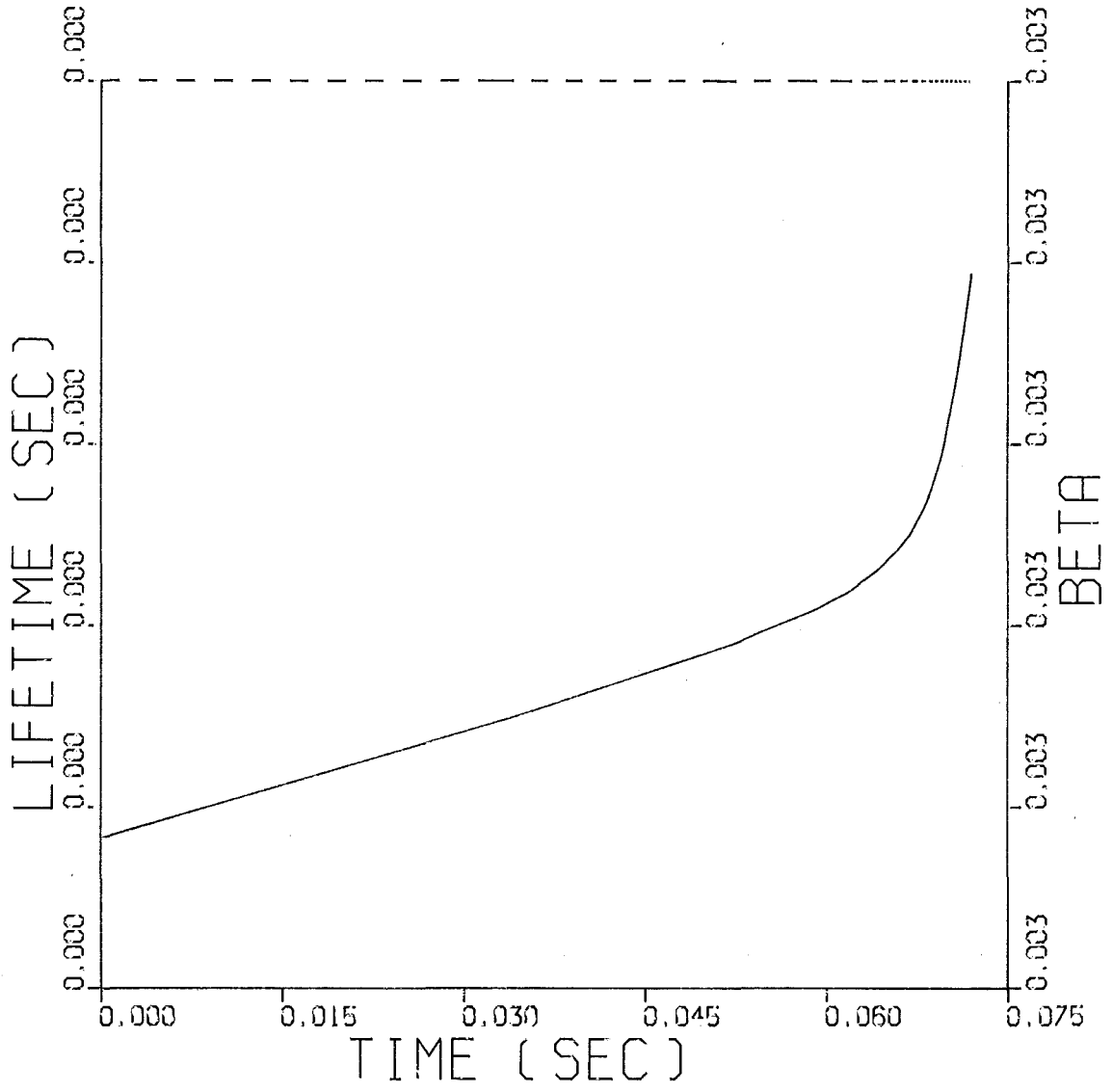

FIG. 20 CASE CD LIFETIME(T), BETA(T)

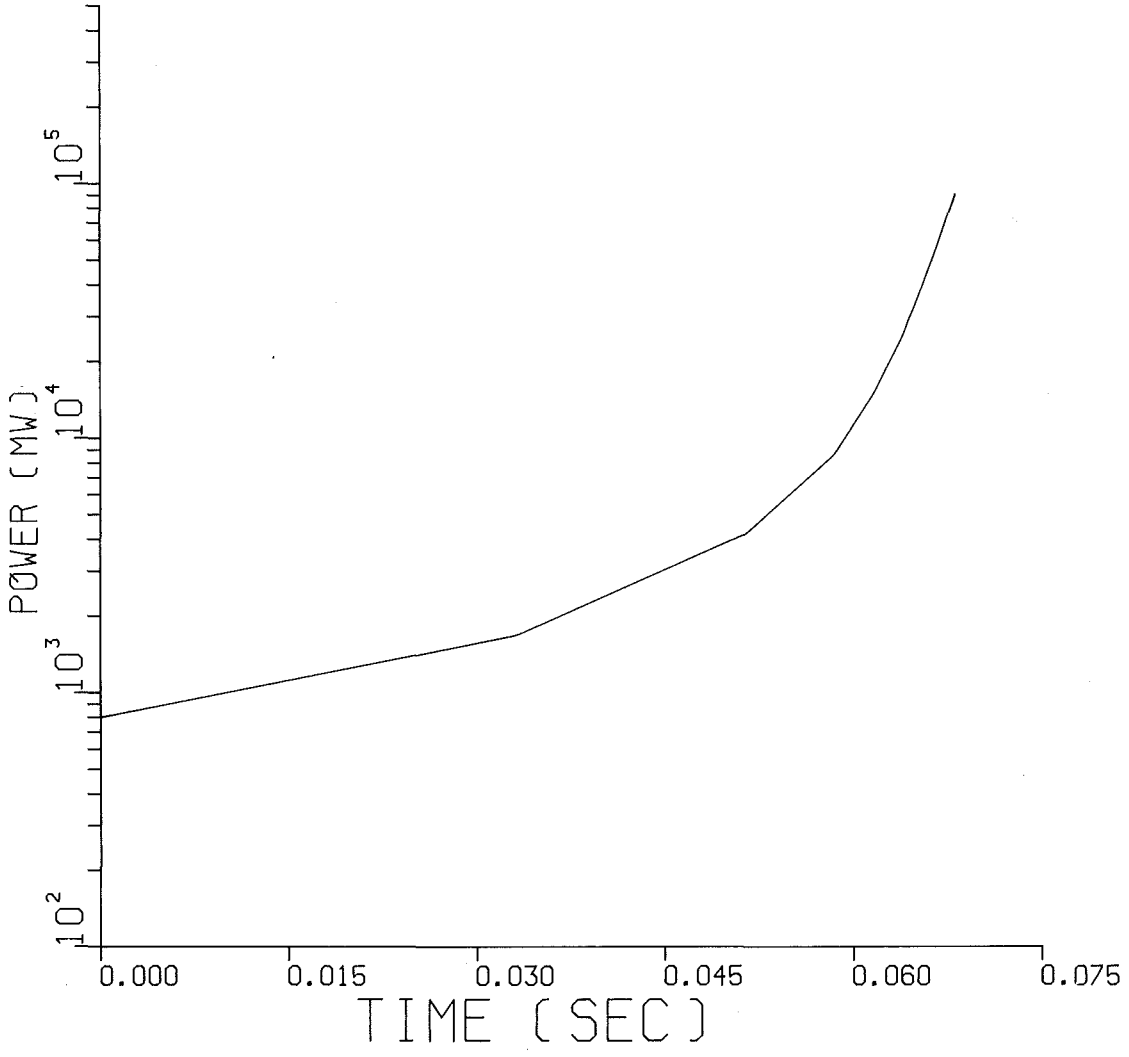

FIG. 21 CASE CD PØWER(T)

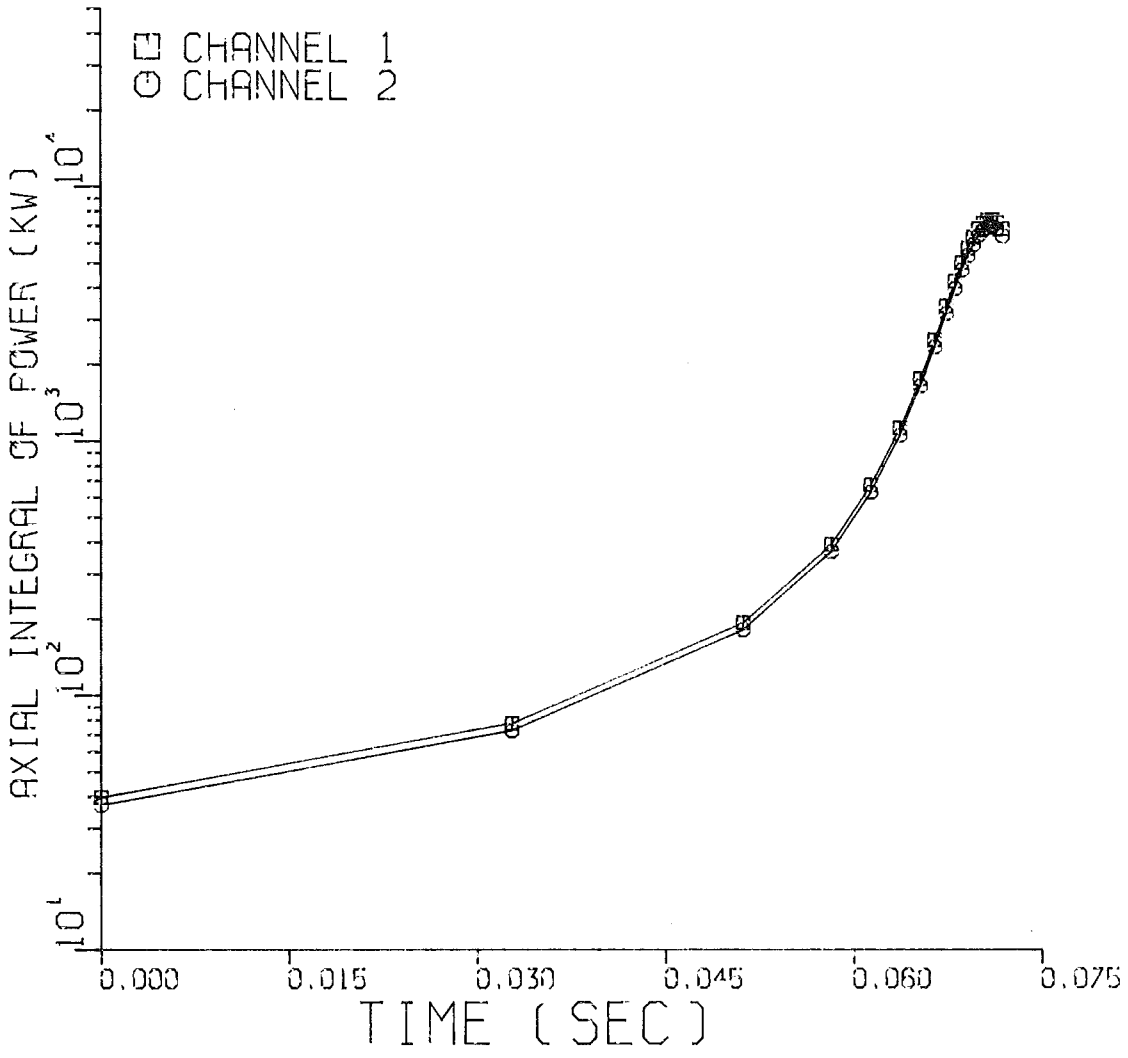

FIG. 22 CASE CD AX. INTEGRAL OF POWER

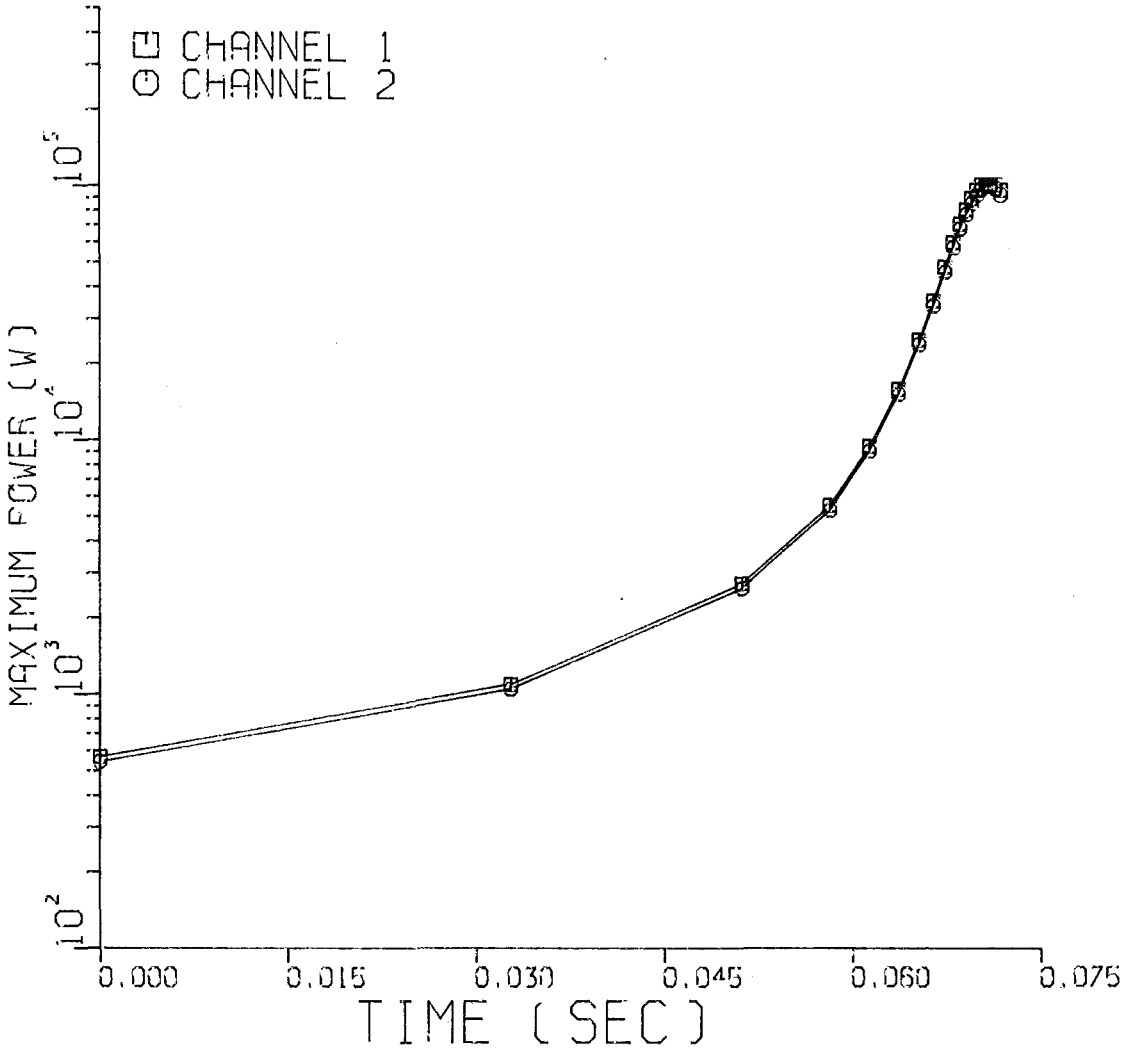

FIG.23 CASE CD MAXIMUM POWER IN PIN

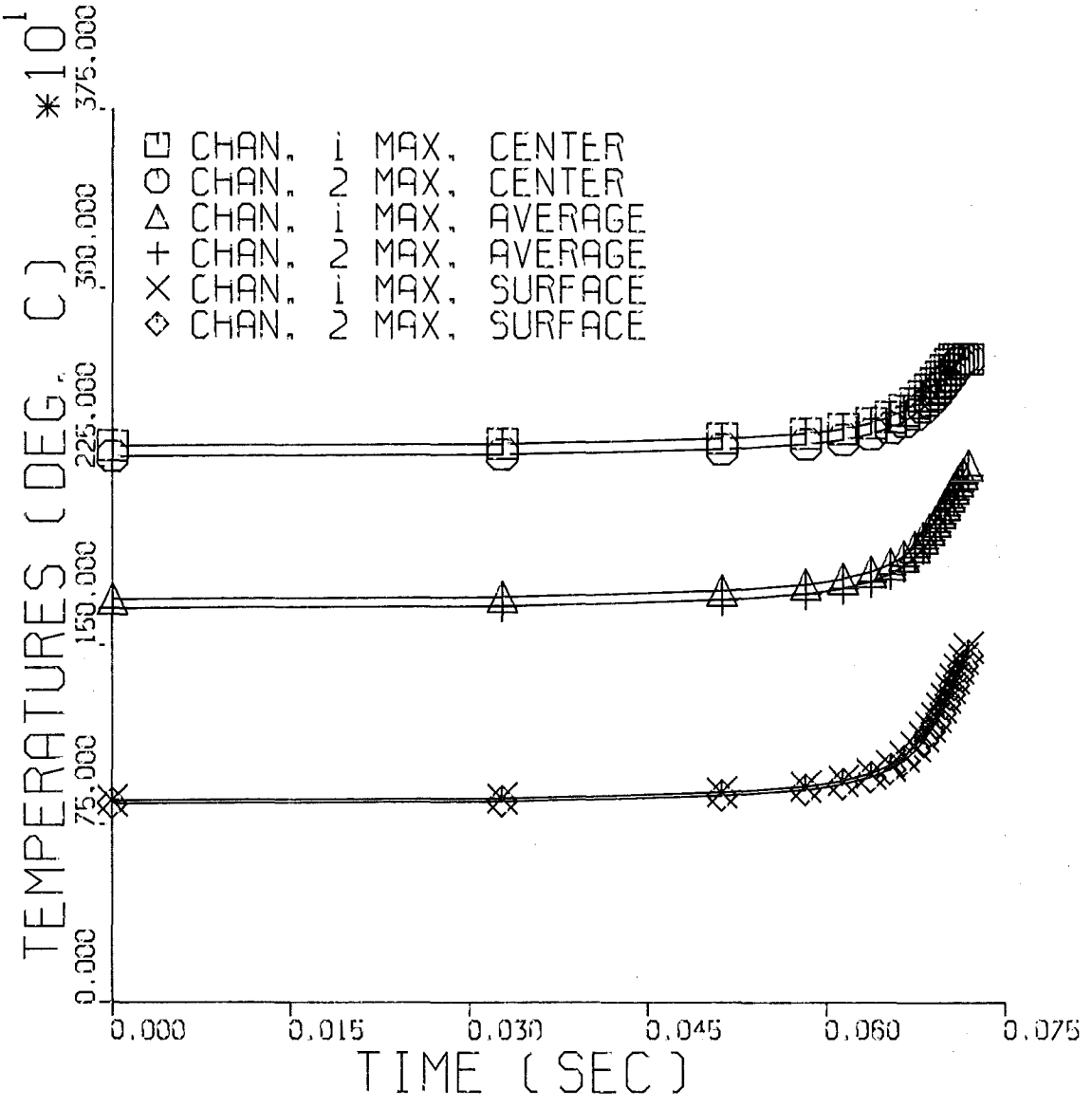

FIG. 24 CASE CD FUEL TEMPERATURES

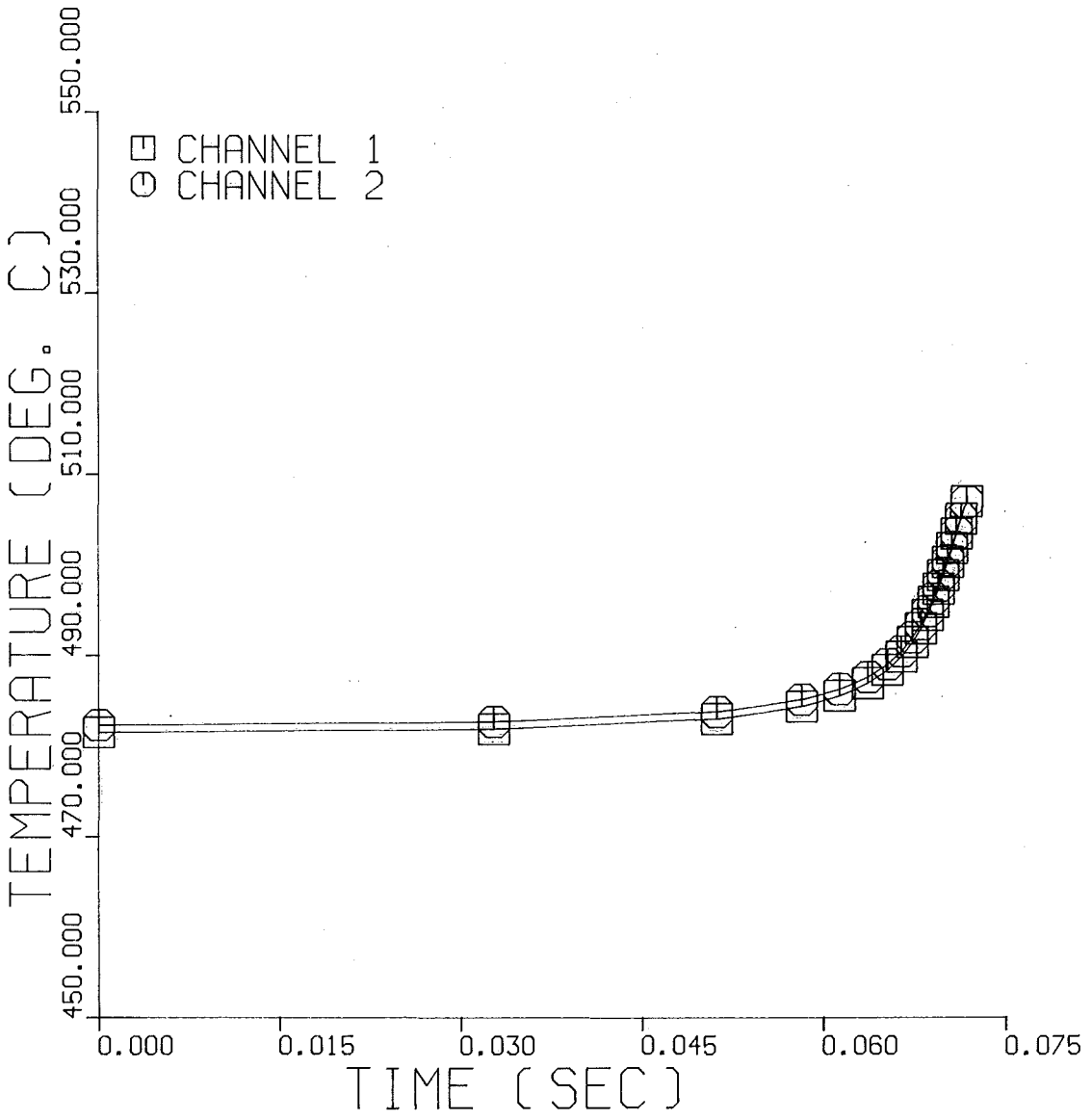

FIG. 25 CASE CD CLAD TEMP. HØTTEST NØDE

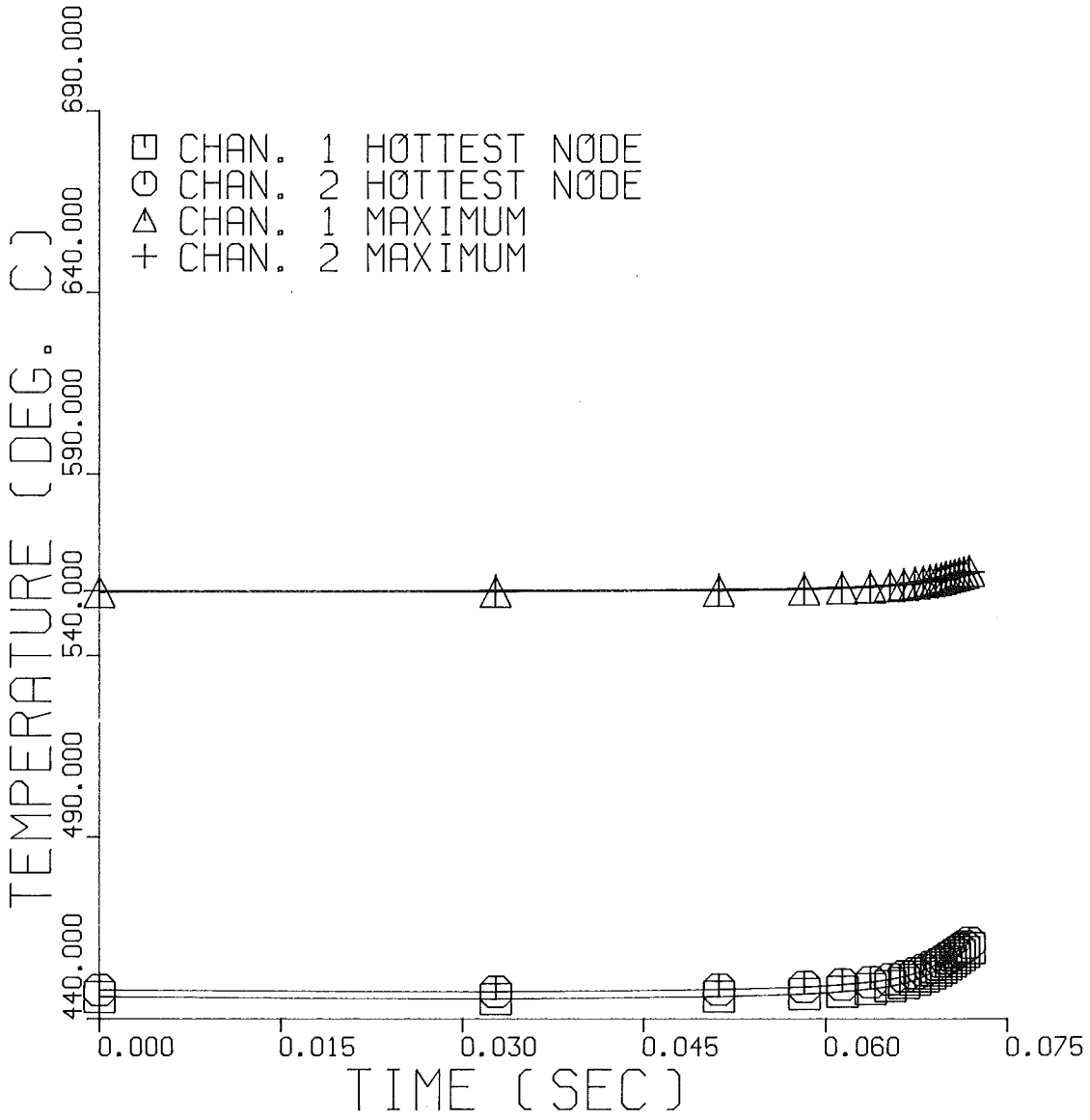

FIG.26 CASE CD CØØLANT TEMPERATURE

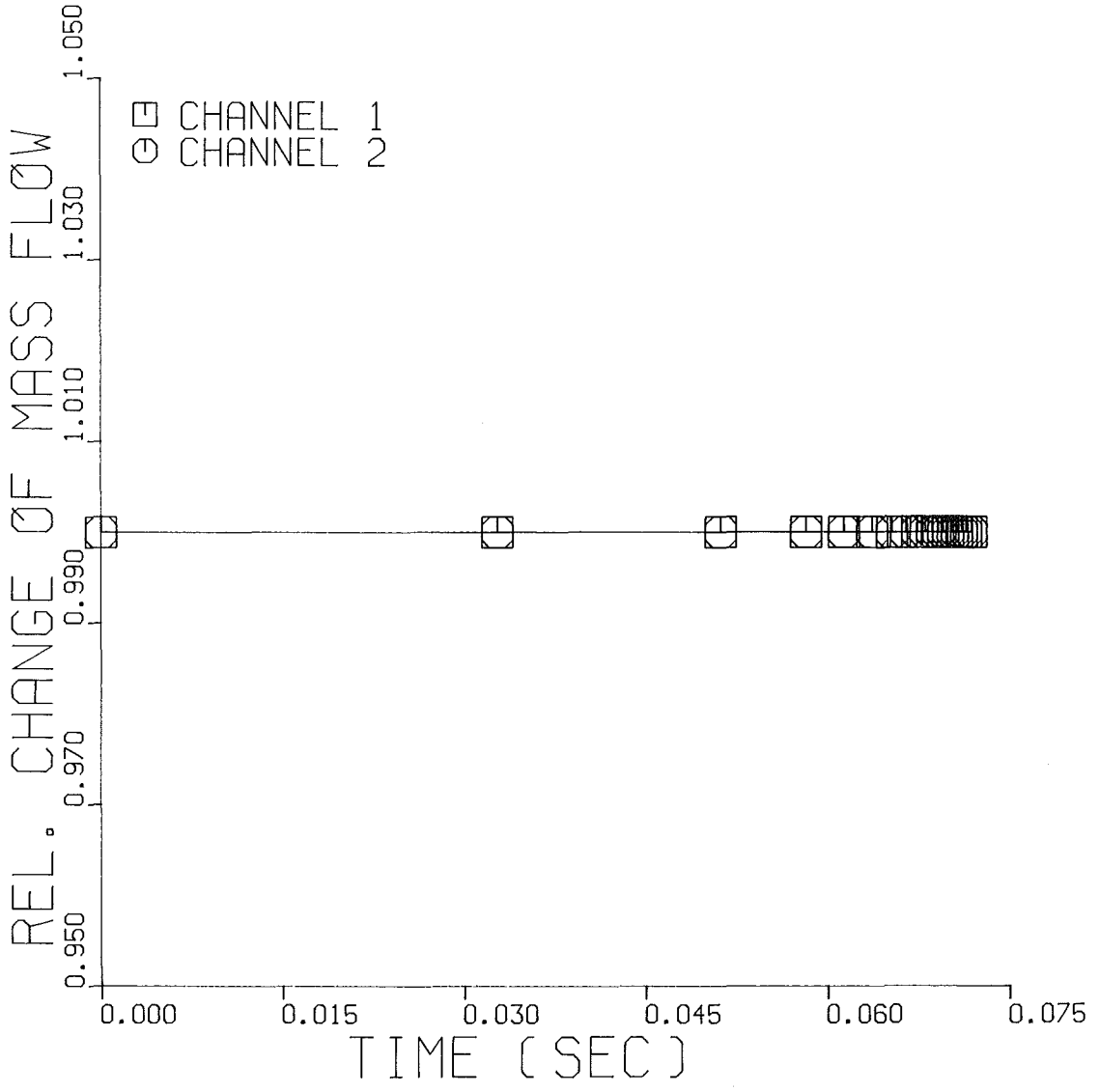

FIG. 27 CASE CD REL. CHANGE OF MASS FLOW

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