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HADA-2 (Modified Version of HADA)

A FORTRAN-IV Program for the Thermohydraulic Design of an Advanced Pressurized Light Water Reactor with a Tight Fuel Rod Lattice

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H A D A - 2 (MODIFIED VERSION OF HADA)

A FORTRAN-IV PROGRAM FOR THE THERMOHYDRAULIC DESIGN OF AN ADVANCED PRESSURIZED LIGHT WATER REACTOR WITH A TIGHT FUEL ROD LATTICE

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ABSTRACT

MORI, Takamasa, CIGARINI, Marco and DALLE DONNE, Mario :
HADA-2 (Modified Version of HADA): A FORTRAN-IV Program for the Thermohydraulic Design of an Advanced Pressurized Light Water Reactor with a Tight Fuel Rod Lattice

The FORTAN-IV program HADA, which computes the thermohydraulic parameters for Advanced Pressurized Light Water Reactors with a tight fuel rod lattice, has been modified to extend its applicability. The new version can be applied to homogeneous reactors using grid spacers with an arbitrary linear heat rating or an arbitrary core height. This version is also applicable to an axially heterogeneous reactor (multiple stacked core) which has been designed in JAERI and is not based on the modern PWR plant of German design. For users of the program, the present report describes the modifications and the input data in detail. Three sample runs demonstrate the usage of the program and the output. The provided and used solution algorithms are explained, in addition to the description of the physical background given in KfK 3453 and KfK 4148. The utility programs are described and an installation guide for the program system is listed.

ZUSAMMENFASSUNG

MORI, Takamasa, CIGARINI, Marco and DALLE DONNE, Mario :
HADA-2 (eine geänderte Version von HADA): Ein FORTRAN-IV Programm zur thermohydraulischen Auslegung von fortgeschrittenen Druckwasserreaktoren mit enger Stabteilung

Das FORTRAN-IV Programm HADA zur Berechnung der thermohydraulischen Parameter von fortgeschrittenen Druckwasserreaktoren mit enger Stabteilung wurde modifiziert, um seine Anwendbarkeit zu erweitern. Die neue Version kann für homogene Reaktoren mit Gitterabstandshalter mit beliebiger Stableistung und mit beliebiger Kernhöhe angewendet werden. Diese Version ist anwendbar auf axial heterogene Reaktoren (geschichtete Kerne), die von JAERI entworfen worden sind und nicht den deutschen DWR-Entwürfen entsprechen. Der vorliegende Bericht beschreibt ausführlich die Änderungen und die Eingabe-Daten für die Programmbenutzer. Drei Beispielrechnungen zeigen die Verwendung des

Programms und die Ausgabe. Die angegebenen und verwendeten Lösungsalgorithmen werden erklärt. Die Beschreibungen der physikalischen Hintergründe sind in den Berichten KfK 3453 und KfK 4148 angegeben. Die Dienstprogramme sind be- schrieben und eine Anleitung zum Einbau des Programmsystems ist angegeben.

Zusammenfassung

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1. INTRODUCTION

The FORTRAN-IV program HADA has been developed to compute the thermohydraulic parameters for Advanced Pressurized Light Water Reactors (APWRs) with tight fuel rod lattices based on the data of a Pressurized Light Water Reactor. The first version of HADA was released for users' application in 1985/1/, and successfully used in the first parametric study for APWR design/2/. This version has the following functions:

- Power ratio - computation of the power fraction K for a given pressure drop Δp,
- Computing the design parameters of a reactor with a homogeneous core with spacers formed by six spiral ribs,
- Computing the design parameters of a reactor with a radially heterogeneous core consisting of the seed (loose lattices, grid spacers) and the blanket (tight lattices, spiral rib spacers).

After the release of the first version, various improvements were made. The main modifications are as follows:

- The use of the water enthalpy, rather than the water temperature, for the equation giving the limitation due to the hot channel factor $F_{\Delta H}$.
- The introduction of the factor $C_{\Delta H}$, which ensures that the minimum value of the ratio between the critical heat flux and the hot channel heat flux (DNBR) is always equal to or greater than 1.3.

The details of the modifications are given in Reference /6/, where the modified version is temporarily called HADA-2. The recent parametric study in 1986 /6//7/ was carried out by using this version.

After the above modifications, the following new functions have been added to the program to the present:

- For the computation of the design parameters of a reactor with a homogeneous core, grid spacers, as well as spiral rib spacers, can be used with either fixed linear heat rating or fixed core height.
- Computing the design parameters of a reactor with a radially homogeneous but axially heterogeneous core (multiple stacked core) /4//5/.

- Introduction of the iteration scheme to ensure the same reactor thermal output as the reference one in case that the previous version gives a higher thermal output because of lower core pressure drop.

- An arbitrary axial power distribution in place of the chopped cosine one can be given by input in the form of numerical table.

- The total head of pump and/or the heat transfer characteristics of heat exchanger can be changed by input, if necessary.

In addition to the above modifications, some additions are made to the calculations of the pressure drop by spacer grids and the critical heat flux.

In this report, the modifications after 1986 and the usage of the present version are described for user's convenience. As for the physical background and the mathematical formulation of the problem, users should refer to the previous reports /2//6/.

2. NEW FEATURES OF HADA-2 CODE

2.1 MODIFICATION OF HOMOGENEOUS REACTOR CALCULATION

2.1.1 Spacers

In the original version of HADA, the fuel rod spacers are made of six spiral ribs integral with the rod cladding. In the present version of the code (HADA-2), in addition to this type of spacers, a user can make a computation of a homogeneous core with grid spacers as well. The core pressure drop is calculated in the same method as that in the seed of heterogeneous reactor. However, the solidity and the modified drag coefficient are calculated with different methods.

SOLIDITY: For defining the solidity ε, a user can select either of the following two ways:

- give the parameters shown in Figure 1 on page 117.

  In this case, the solidity is calculated by

(1) $$\varepsilon = \frac{AG}{\frac{\sqrt{3}}{4} p^2 - \frac{\pi d^2}{8}},$$

where

(2) $$AG = 0.75 \times (p - d - SG - 0.0001) \times BG.$$

- give the parameters G1 and G2 in the following equation:

  (3) $$\varepsilon = G1 - G2 \times (p - d),$$

  which is similar to Eq. (74) in Reference /2/.

MODIFIED DRAG COEFFICIENT: The modified drag coefficient is calculated by

(4) $$C_V = 7.997 + \frac{167.12}{Re^{0.264}} + \frac{6.375 \times 10^{10}}{Re^{2.79}}.$$

When the product $\varepsilon^2 C_V$ is greater than 5.2, the relation

(5) $$C_V = \frac{5.2}{\varepsilon^2}$$

replaces the above equation.

Instead of the above method, a user can define the product $\varepsilon^2 C_V$ as follows:

(6) $$\frac{1}{2} \varepsilon^2 C_V = \frac{1}{2} (0.8189 + \frac{17.114}{Re^{0.264}} + \frac{0.6528 \times 10^{10}}{Re^{2.79}}).$$

The maximum value of the product is also 5.2.

2.1.2 Linear Heat Rating and Core Height

A user can specify the linear heat rating q_L and the core height L_C by one of the following three methods.

- use the original method /2/.

  The linear heat rating is calculated by

  (7) $$q_L = [-372.27 + 744.11 \frac{p}{d} + 236.67 (\frac{p}{d})^2] \times 10^{10}.$$

  The core height is determined by

(8) $$L_C = \frac{Q}{n_T q_L},$$

where Q and n_T are the reactor thermal output and the total number of fuel rods, respectively.

- specify the absolute value of linear heat rating by input.

  In this case, the core height is calculated by the above equation.

- specify the absolute value of core height by input.

  In this case, the linear heat rating is calculated by

(9) $$q_L = \frac{Q}{n_T L_C}.$$

2.2 COMPUTATION OF MULTIPLE STACKED CORE (JAERI DESIGN)

We consider a radially homogeneous reactor with an axial power distribution shown in Figure 2 on page 117. The definition of the parameters used in this section is summarized in Table 1 on page 7. The whole core is axially divided into three kinds of parts: inner core, inner blanket and outer blanket. We assume that the rod diameter and its pitch are the same in the whole core (both in the inner cores and the blankets). The power distribution in an inner core is represented by the chopped cosine distribution with the axial power form factor φ_{ax}. On the other hand, that in an outer blanket is assumed to be:

(10) $$f_B(x) = A \bullet \exp(-R_{KB} \bullet x),$$

where x is a distance from the boundary between the inner core and the blanket. In the inner blanket, the power distribution is assumed to be:

(11) $$f_{IB}(x) = f_B(x) + f_B(L_{IB} - x),$$

where x is again the distance from the boundary and L_{IB} is the thickness of inner blanket. The parameter R_{KB} is calculated from the input value φ_{ax2} as follows:

(12) $$\varphi_{ax2} = \exp(-R_{KB} \bullet L_B),$$

where L_B is the thickness of outer blanket.

Since the rod diameter and its pitch are the same in the whole core, the thermohydraulic parameters of the system can be computed in the same way as for the homogeneous reactor by using the whole core quantities L_C and q_L, which are the height of the whole core and the average linear heat rating over the whole core, respectively. In the calculation of local quantities such as the critical heat flux and the DNBR, the following relations are used:

(13) $$L_C = (NAC - 1) \bullet L_{IB} + NAC \bullet L_{IC} + 2 \bullet L_B,$$

(14) $$q_L \bullet L_C = q_{LB} \bullet 2 \bullet R \bullet (NAC - 1) \bullet L_{IB} + NAC \bullet q_{LIC} \bullet L_{IC} + 2 \bullet q_{LB} \bullet L_B,$$

where

(15) $$R = \frac{q_{LIB}/2}{q_{LB}},$$

In the above equations, NAC is the number of inner cores, and L and q_L are the thickness and the average linear heat rating of each part, respectively. The subscripts IC, IB and B indicate the inner core, the inner blanket and the outer blanket, respectively.

From the above relations and the input values (R_1, R_2, R_3 and φ_{ax2}) the thickness and the average linear heat rating of each part are obtained as follows:

(16) $$L_{IC} = \frac{L_C}{(NAC - 1) \bullet R_1 + NAC + 2 \bullet R_2},$$

(17) $$L_{IB} = L_{IC} \bullet R_1,$$

(18) $$L_B = L_{IC} \bullet R_2,$$

(19) $$q_{LIC} = \frac{q_L \bullet L_C}{2 \bullet R_3 \bullet \{R \bullet (NAC - 1) \bullet L_{IB} + L_B\} + NAC \bullet L_{IC}},$$

(20) $$q_{LB} = q_{LIC} \bullet R_3,$$

and

(21) $$q_{LIB} = 2 \bullet q_{LB} \bullet R.$$

The parameter R can be written by using the input parameters as follows:

(22) $$R = \frac{q_{LIB}/2}{q_{LB}} = \frac{R_2}{R_1} \frac{1 - (\varphi_{ax2})^{\frac{R_1}{R_2}}}{1 - \varphi_{ax2}}.$$

The hot spot heat flux distribution at the surface of the fuel rod in the inner core is:

(23) $$\phi_{HS,C}(x) = F_q O_P \frac{q_{LIC}}{\pi d} \cos \frac{\pi x}{L_C'} ,$$

of which the average value is

$$\frac{F_q O_P}{\varphi_{ax}} \frac{q_{LIC}}{\pi d} ,$$

and the peak value is

$$\frac{F_q O_P q_{LIC}}{\pi d} .$$

That in the outer blanket is:

(24) $$\phi_{HS,B}(x) = \frac{F_q O_P}{\varphi_{ax}} \frac{q_{LB}}{\pi d} \frac{\ln \varphi_{ax2}}{\varphi_{ax2} - 1} \exp(-R_{KB} \bullet x),$$

of which the average value is

$$\frac{F_q O_P}{\varphi_{ax}} \frac{q_{LB}}{\pi d} ,$$

and the peak value is

$$\frac{F_q O_P}{\varphi_{ax}} \frac{q_{LB}}{\pi d} \frac{\ln \varphi_{ax2}}{\varphi_{ax2} - 1} .$$

The nominal heat flux distribution at the surface of the fuel rods in the highest rated coolant channels is described by similar equations to Eqs. (23) and (24) with F_{qN} in place of F_q .

The critical heat flux is calculated by using the same correlations as in Reference /6/. These correlations are applied in the following two ways by user's choice:

- As the coolant channel inlet, the inlet of each part (each inner core, each blanket) is taken.

- The lowest part of the whole core is taken as the inlet in the CHF calculation.

The deformation of the axial heat flux distribution caused by the insertion of the control rods is taken into account in the inner core region. The same assumption for the deformation is used as in Reference /2/. The local quantities are calculated at all axial nodes (not only in the upper half). The position x in the print out shows the distance from the inlet of the whole core.

Parameter	Definition	Note
NAC	Number of inner cores	Input
φ_{ax}	Axial form factor in the inner core	Input
φ_{ax2}	Axial form factor in the outer blanket	Input (see Eq.(12))
F_q	Hot channel factor for heat flux in the inner core	Input (see Eqs.(22) and (23))
F_{qN}	Factor for the maximal heat flux in the inner core accounting the axial and radial power distribution	Input
O_P	Over power factor	Input
d	Diameter of fuel rod	Input
L_C	Total core height including inner cores, inner blankets and outer blankets	
L_{IC}	Thickness of the inner core	
L_{IB}	Thickness of the inner blanket	
L_B	Thickness of the outer blanket	
q_L	Average linear heat rating over the whole core	
q_{LIC}	Average linear heat rating in the inner core	
q_{LIB}	Average linear heat rating in the inner blanket	
q_{LB}	Average linear heat rating in the outer blanket	
R_1	L_{IB}/L_{IC}	Input
R_2	L_B/L_{IC}	Input
R_3	q_{LB}/q_{LIC}	Input
R	$(q_{LIB}/2)/q_{LB}$	

Table 1. Definition of parameters used in the computation of multiple stacked core

2.3 REACTOR POWER ITERATION

In the case of reactors with rather loose lattices using grid spacers, we sometimes obtain higher thermal output Q than that from the reference PWR plant Q_0 ($K=Q/Q_0>1.0$) because of lower core pressure drop. In order to get the results with the same thermal output for comparison, we have introduced a new power iteration scheme which is quite similar to the $C_{\Delta H}$ iteration in Reference /6/. For this purpose, Eq. (3) in Reference /6/ is modified as follows:

$$H_{2H} = H_1 + P_{R\Delta H} C_{\Delta H} \frac{F_{\Delta H} O_P}{K'} (H_2 - H_1). \tag{25}$$

The factor $P_{R\Delta H}$ is determined by iteration. For the first iteration, it is put equal to one. Then the ratio K is calculated. If this ratio is greater than one, the calculation is repeated with a higher values of $P_{R\Delta H}$ until K equals one. This iteration scheme is also applied to a heterogeneous reactor calculation.

2.4 AXIAL POWER DISTRIBUTION

In the previous version, the axial power distribution is assumed to be described by the chopped cosine distribution in both cases with and without the control rod insertion. On the other hand, the present version, if required, makes a computation with an arbitrary distribution given by a user in the form of numerical table. In this case, the local quantities such as the critical heat flux and the DNBR are calculated at the center of each axial segment.

Let f_i be a relative power in the i-th axial segment given by a user. The program normalizes them as follows:

$$\frac{\sum_{i=1}^{NC} f_i}{NC} = 1, \tag{26}$$

where NC is the number of axial segments. Note that all axial segments have the same length. Then, the axial form factor (peak/average) φ_{ax} is obtained by

$$\varphi_{ax} = \max f_i. \tag{27}$$

The hot spot heat flux at the surface of the i-th axial segment of the fuel rod is:

(28) $$\phi_{HS}(i) = F_q O_P \frac{q_L}{\pi d} \frac{f_i}{\varphi_{ax}} ,$$

of which the average value is

$$\frac{F_q O_P}{\varphi_{ax}} \frac{q_L}{\pi d} ,$$

and the peak value is

$$\frac{F_q O_P q_L}{\pi d} .$$

The hot channel water enthalpy corresponding to the i-th segment is:

(29) $$H_{HS}(i) = H_1 + F_{\Delta H} O_P (H_{2u} - H_1) \frac{\{\sum_{j=1}^{i-1} f_j + \frac{f_i}{2}\}}{NC} .$$

On the other hand, the nominal heat flux distribution at the surface of the fuel rod in the highest rated coolant channels is:

(30) $$\phi_N(i) = F_{qN} O_P \frac{q_L}{\pi d} \frac{f_i}{\varphi_{ax}} ,$$

The nominal water enthalpy distribution in these channels is:

(31) $$H_N(i) = H_1 + \frac{F_{qN}}{\varphi_{ax}} O_P (H_{2u} - H_1) \frac{\{\sum_{j=1}^{i-1} f_j + \frac{f_i}{2}\}}{NC} .$$

In this case, the local quantities are calculated at all axial segments (not only in the upper half of the core). The position x in the print out shows the distance from the inlet of the core.

2.5 VARIOUS ADDITIONS

SYSTEM PARAMETERS: In the original version, the total pressure head of pump H_T and the average total heat transfer coefficient times the total surface of heat exchanger KF are assumed to be represented by Eqs. (21) and (10) in Reference /2/, respectively. They are written as follows:

(32) $$H_T = PC0 + PC1 \times V - PC2 \times V^2,$$

with PC0=111.678,
PC1=22.244,

PC3=4.0524,

and

(33) $$KF = \frac{KF_0}{SG1 + SG2 \times (Q/Q_0)^{SG3} + SG4 \times (M_0/M)^{SG5}},$$

with SG1=0.58,
SG2=0.18,
SG3=0.24,
SG4=0.24,
SG5=0.8.

The values of parameters in the above equations have been determined on the basis of the modern PWR plant of German design. In the present version, the values of these parameters can be replaced by input, if necessary.

CRITICAL HEAT FLUX CORRELATIONS: By the HADA code, the Dalle Donne-Hame correlation/3/ is mainly used as the critical heat flux correlation for both reactors with spiral rib spacers or grid spacers. In this correlation, the effect of spacer grids is taken into account by the V factor. Recently, a new correction factor for this effect has been proposed by D.C. Groenveld/8/ as follows:

(34) $$K_3 = 1 + A \bullet \exp(B \bullet L_p/D_h),$$

where

$A = 1.5 \times K_G^{0.5}(0.001 \times G)^{0.2}$,

$B = 0.10$,

$K_G = \varepsilon^2 C_V$,

L_p = distance from upstream spacer plane (m),

D_h = hydraulic equivalent diameterep (m),

and

G = mass flux ($kg/m^2/s$).

A user can use this correction factor, if he likes.

3. MATHEMATICAL BACKGROUND

The program HADA computes the solution of a nonlinear algebraic system by iteration. This system is given by a set of equations:

(35) $$F_j(x_i) = 0.$$

The elements of the solution vector $x_i (i = 1, \ldots, n)$ are the zeroes of the (n) relations F_j. For solving this equations, a simple Newton method is used as usually. In the first order Taylor approximation, one has:

(36) $$F_j(x_i + \delta x_i) \simeq F_j(x_i) + \frac{\partial F_j(x_i)}{\partial x_k} \delta x_k.$$

The condition $F_j(x_i + \delta x_i) \rightarrow 0$ is forced by setting the left hand side of the equations system equal to zero:

(37) $$\frac{\partial F_j(x_i)}{\partial x_k} \delta x_k = -F_j(x_i).$$

Starting with an initial estimate x_i^0, one obtains a series of approximations to the solution:

(38) $$\frac{\partial F_j(x_i^\nu)}{\partial x_k} \delta x_k^{\nu+1} = -F_j(x_i^\nu),$$

and

(39) $$x_k^{\nu+1} = x_k^\nu + \delta x_k^{\nu+1},$$

which is considered as adequate, if the related increment of all elements is less then a given positive number ε:

(40) $$\max_k |\delta x_k^\nu / x_k^\nu| < \varepsilon.$$

The linear algebraic system (linear relative to δx) is solved by using a Gauß algorithm (with or without pivot search). The matrix of coefficients is:

(41.1) $$a_j^k = \frac{\partial F_j(x_i^\nu)}{\partial x_k}$$

and the right hand sides are:

(41.2) $$b_j = -F_j(x_i^\nu).$$

Five different methods based on the Gauß algorithm are available in the program:

- straightforward algorithm without any computational improvements,
- pivot method (only rows are exchanged),
- pivot method (rows and columns are exchanged),
- Gauß algorithm for a system with symmetrical coefficient matrix,
- Gauß algorithm for a symmetrical system using a reordered coefficient matrix.

The last two methods don't solve the original equations (41), but a derived system which is obtained by multiplication from the left with the transposed coefficient matrix. From

(42) $$a_j^k \delta x_k = b_j,$$

we get the derived system:

(43) $$a_j^l a_l^k \delta x_k = a_j^l b_l.$$

The new matrix of coefficients is symmetrical:

(44.1) $$s_j = a_j^l a_l^k.$$

The new right hand sides are:

(44.2) $$c_j = a_j^l b_l.$$

These two equations describe a new linear system replacing Eq. (42):

(45) $$s_j^k \delta x_k = c_j.$$

To compute the elements of the coefficient matrix, we need the partial derivatives of the functions. They are approximated numerically by a first order Taylor expansion.

For $|x_k| \le 10^{-6}$, we use:

$$f_1 = F_j(x_1, x_2, \ldots, x_k - 0.001, \ldots, x_n),$$

$$f_2 = F_j(x_1, x_2, \ldots, x_k + 0.001, \ldots, x_n),$$

$$\Delta x = 0.002,$$

and for For $|x_k| > 10^{-6}$:

$$f_1 = F_j(x_1, x_2, \ldots, 0.999 \times x_k, \ldots, x_n),$$

$$f_2 = F_j(x_1, x_2, \ldots, 1.001 \times x_k, \ldots, x_n),$$

$$\Delta x = 0.002 \times x_k.$$

The derivatives are then calculated from

$$\frac{\partial F_j(x_i)}{\partial x_k} = \frac{(f_2 - f_1)}{\Delta x} \quad (46)$$

In the testphase, the increment Δx and the accuracy of the calculation have been varied, but the presented values and double precision arithmetic proved to be optimal.

4. INPUT DATA

The input parameters are divided into five groups

1. problem identification
   (unit 47)

2. control parameters for the input flow and programmable options
   (unit 05)

3. common physical parameters
   (unit INP)

4. special physical parameters
   (unit JNP)

5. physical parameters for the computation of the critical heat flux
   (unit 05).

All data except character strings and parts of third and fifth groups are read without format control (with the free format) as follows:

```
READ(...,*,...) ...
```

This means that, if there are more than one input datum per line required, successive data must be separated by at least one blank or a comma and may be entered in the same input line or, if necessary in continuation lines. It is not allowed to replace zeroes by blanks as in formatted read. Hence, as many data as required must be present. The input data set should **NOT** be line numbered, to avoid misinterpreting in the case of continuation lines (the line numbers are treated as input data !).

4.1 PROBLEM IDENTIFICATION (UNIT 47)

A text of up to 55 characters can be entered as a problem identification. This text and the current date and time are used as header lines in all output data sets. If there are more characters than the allowed maximum , truncation occurs.

4.2 CONTROL PARAMETERS AND OPTIONS (UNIT 05)

The data of this group is read from the system input stream (unit 05) named SYSIN (IBM standards). The following values are required in particular:

1. line	INP	integer	unit number associated to the data set containing the common physical parameters.
2. line	IOP1	integer	option controlling the computation of the pumping power in the primary circuit. =1 constant pumping power: $H_T = H_{T0} \times M_0/M$, =2 pumping power is computed using a given pump characteristic: $H_T = PC0 + (PC1 - PC2 \times V) \times V$. Other values are not allowed.
	IOP2	integer	option selecting the reactor type. =0 computation of the power fraction K for a given pressure drop Δp, =1 computing the design parameters of a reactor with a homogeneous core, =2 computing the design parameters of a reactor with a heterogeneous core. Other values are not allowed.
	IOP3	integer	option controlling the construction of the linear system. <0 the coefficient matrix is constructed in

inverse order as the functional equations,
≥ 0 the coefficient matrix is constructed in the same order as the functional equations (use this method only).

IOP4 integer option selecting the solution method.
- =1 Gauß algorithm without improvements (use this method),
- =2 Gauß algorithm with pivot search (rows),
- =3 Gauß algorithm with pivot search (rows and columns),
- =4 Gauß algorithm for a symmetrisized coefficient matrix,
- =5 Gauß algorithm for a symmetrisized coefficient matrix with reordering of the original matrix.

3. line IDR2 integer parameter controlling the output of the results. This parameter is divided into two subparameters:

IDR2 and IMOD = IDR2/10.

The subparameter IMOD denotes the number of iteration steps between successive dumps of the actual results. IDR2 controls the type and the extent of this output in correspondence to the following table :

IDR2 IMOD = 0

- ≤ 0 only the mean results are printed,
- =1 the initial estimate is printed and after each iteration step the actual accuracy,
- =2 as 1, and at the beginning of the iteration the coefficient matrix is printed before entering the elimination step,
- =3 as 1,2, and at the beginning of the iteration the coefficient matrix is printed after leaving the elimination step,

IDR2 IMOD = IDR2/10

=10 as 1,2,3, and after solving the linear
=20 system the actual solutions are printed
=30 out every IMOD iteration step.
...

IDR3 integer parameter controlling the output of the heat flux calculations.
<1 Only the most important results are printed,
≥1 additionally local data as a function of the axial position is printed into a separate data set.

The following input line is only necessary for IOP2 > 0. If IOP2 = 0, a special physical parameter must be present instead (see "Computation of the Power Ratio (IOP2=0, Unit 05)" on page 20).

4. line JNP integer unit number associated to the data set containing the special physical parameters

5. line GENAU real parameter denoting the required accuracy. The iteration is terminated, if the condition of Eq. (40) comes true (the boundary ε corresponds to GENAU).

DMAX real upper boundary for the increment of the solution vector. After each iteration step the condition of Eq. (40) is tested against DMAX. If any of the increments is greater than DMAX, the solution is divided by two, until Eq. (40) is met. In most cases a value of 0.5 will result in good convergence of the iteration. But in some cases a smaller value may be required to suppress problems of divergency.

ITMX integer maximum number of iteration steps. Non-convergent iterations are stopped after ITMX steps. Depending on the results, the computation may be repeated with a greater value of ITMX or with updated parameters.

4.3 COMMON PHYSICAL PARAMETERS (UNIT INP)

The data of this group is read from unit INP, which must be assigned to the data set containing the input. At first, the program reads the following data by the read statement with the namelist "SYSTEM". The default values of parameters are shown in the parentheses, which correspond to those in the modern PWR plant of German design.

&SYSTEM

PC0 (111.678 m)

PC1 (22.244 m/(m/s))

PC2 (4.0524 $m/(m/s)^2$)

These three parameters define the pump characteristics:

$$H_T = PC0 + (PC1 - PC2 \times V) \times V.$$

SG1 (0.58)

SG2 (0.18)

SG3 (0.24)

SG4 (0.24)

SG5 (0.80)

These five parameters (SG1-SG5) define the heat transfer coefficient times the total surface area of the heat exchangers in the whole system:

$$KF = \frac{KF_0}{SG1 + SG2 \times (Q/Q_0)^{SG3} + SG4 \times (M_0/M)^{SG5}}$$

NLP (4) number of primary coolant loop.

IOPTIN (0) option to read data with the free format,

=0 read the data with the free format and use them in the calculation,

=1 skip the following free formatted input. (All free formatted data can be read in the present namelist input).

Meanings of the following parameters are given below.

Q0	(3.765D9 W)
OP	(1.0)
FDHO	(1.6)
CDHO	(1.0)
AKS$	(0.94)
ALC	(0.0)
DN	(1.707 W)
EAT$	(0.774)
P20	(158.26 bar)
T20	(326.12 °C)
POS	(64.5 bar)
DM0	(1.88D4 kg/s)
DK0	(1.55927D8 W/°C)
T10	(291.14 °C)
P10	(159.65 bar)
HR	(70.6 m)
DNEL	(5.4D7 W)
HT0	(89.6 m)
QEL0	(1.3D9 W)

&END

When IOPTIN = 0, the following data, which are part of the above input, are read with the free format.

1\. line Q0 real Q_0 [W]
thermal power of the reference Pressurized Light Water Reactor.

2\. line OP real O_p [–]
power plant overpower factor.

FDHO real $F_{\Delta H}$ [–]
hot channel factor for the enthalpy rise in the core.

CDHO real $C_{\Delta H}$ [–]
initial value of parameter to force a DNB ratio of at least 1.3. If CDHO < 0, the absolute value of CDHO is taken as $C_{\Delta H}$, and the iteration to force a DNB ratio ≥ 1.3 is not carried out.

AKS real K' [–]

part of the total mass flow rate cooling the core.

3. line	ALC	real	L_P [m] =0.0 use Eq. (35) in Reference /2/ for the fuel rod total length L_R, >0.0 total length of the axial reflectors: $L_R = L_C + L_P$.
4. line	DN	real	N [W] total pumping power for the primary circuit.
	ETA	real	η [–] efficiency of the water pumps in the primary circuit.
5. line	P20	real	P_{20} [bar] water pressure at the outlet of the reference PWR.
6. line	T20	real	T_{20} [°C] average water temperature at the outlet of the reference PWR.
7. line	POS	real	P_{0s} [bar] saturation pressure at the turbine of the reference PWR.
8. line	DMO	real	M_0 [kg/s] total mass flow rate in the primary circuit of the reference PWR.
9. line	DKO	real	KF_0 [W/°C] heat transfer coefficient times the average total surface of the heat exchangers in the reference PWR.
10.line	T10	real	T_0 [°C] average water temperature at the inlet of the reference PWR.
11.line	P10	real	P_{10} [bar] water pressure at the inlet of the reference

PWR.

12.line	HR	real	H_{R0} [m] pressure head available for the rest of the primary circuit (besides the core) in the case of the reference PWR.
13.line	DNEL	real	N_{el} [W] total electrical power for internal use in the plant.
14.line	HTO	real	H_{T0} [m] total pressure head of the water pumps in the primary circuit of the reference PWR.
15.line	QELO	real	Q_{el0} [W] net electrical power of the reference PWR.

4.4 SPECIAL PHYSICAL PARAMETERS (UNIT 05, JNP)

The number of the required parameters and their meaning depend on the value of IOP2. For IOP2 = 0, the data is read from unit 05 (system input stream). For IOP2 > 0, the data of this group is read from unit JNP, which must be assigned to the data set containing the input.

4.4.1 Computation of the Power Ratio (IOP2=0, Unit 05)

In this case, the power ratio K for an Advanced Pressurized Light Water Reactor is computed from the data of the reference Pressurized Water Reactor (common physical parameters) and a fixed value for the pressure drop over the core.

4. line	DPC	real	Δp_c [bar] required pressure drop over the core of the Advanced Pressurized Water Reactor.
5. line	GENAU	real	the same as the 5th line
	DMAX	real	in "Control Parameters and Options (Unit 05)" on page 14.
	ITMX	integer	

4.4.2 Reactor with a Homogeneous Core (Unit JNP)

For an Advanced Pressurized Water Reactor with a homogeneous core, the geometry and special factors are read from unit JNP, which must be assigned to the corresponding data set.

1. line P real p [m]
   fuel rod pitch.

2. line D real d [m]
   fuel rod diameter.

3. line AK0 real K_0 [–]
   >0 spiral rib spacers are used. K_0 is a aspect ratio for the spiral spacer ribs.
   <0 grid spacers are used. The solidity ε and the modified drag coefficient C_V are calculated in the following two ways:
   =-1 As for ε, see the description of 7th line.

$$C_V = 7.997 + \frac{167.12}{Re^{0.264}} + \frac{6.375 \times 10^{10}}{Re^{2.79}},$$

   When the product $\varepsilon^2 C_V$ calculated is greater than 5.2, then the relation

$$C_V = \frac{5.2}{\varepsilon^2}$$

   replaces the above equation.
   =-2 the product $\varepsilon^2 C_V$ is calculated by

$$\frac{1}{2}\varepsilon^2 C_V = \frac{1}{2}(0.8189 + \frac{17.114}{Re^{0.264}} + \frac{0.6528 \times 10^{10}}{Re^{2.79}}).$$

   The maximum value of the product is also 5.2.

4. line AK1 real K_1 [–]
   ratio denoting the part of the total core cross section which is occupied by fuel rods and the subchannels between them.

   AKL$ real K_{KL} [–]
   >10 absolute value of linear heat rating [W/m],

<0 core height [m],

otherwise

correction factor for the relationship between average fuel rod linear rating and p/d ratio (Eq. (31) in Reference /2/).

5. line AK2 real K_2 [–]

fraction of the "non-useful" cross section area (interface between fuel elements, control and structure rods) occupied by flowing water.

6. line DEQ real D_{eq} [m]

equivalent diameter, diameter of a circle with the same area as the cross section of the core.

When AK0 > 0 (spiral rib spacers),

7. line HZUD real H/d [–]

pitch to diameter ratio for the spiral rib spacers.

When AK0 < 0 (grid spacers),

7. line NGI integer NGI

number of grids including top and bottom ones,

SG real see Figure 1 on page 117. [m],

BG real see Figure 1 on page 117. [m],

SCLAD real thickness of cladding [m].

The parameters SG and BG are used to calculate solidity ε. When BG > 1.0, the solidity is calculated by

ε=SG-BG*(p-d),

which is similar to Eq. (74) in Reference /2/ .

8. line AKI real K_I [–]

inlet pressure drop coefficient.

RK real K_R [m]

average roughness height of the surface of fuel rod.

4.4.3 Reactor with a Heterogeneous Core (unit JNP)

For an Advanced Pressurized Water Reactor with a heterogeneous core, the geometry and special factors are read from a data set assigned to unit JNP. In this case, the reactor core is divided into two zones (seed and blanket).

1. line	RK1	real	K_1 [–] ratio of cross section area of seed to cross section area of blanket.
	AKLS$	real	K_{KLs} [–] correction factor for the relationship between seed fuel rod linear rating and p/d ratio.
	AKLB$	real	K_{KLb} [–] correction factor for the relationship between blanket fuel rod linear rating and p/d ratio.
2. line	RK2S	real	K_{2s} [–] ratio denoting the part of the seed cross section which is occupied by fuel rods and relative cooling water.
3. line	RK2B	real	K_{2b} [–] ratio denoting the part of the blanket cross section which is occupied by fuel rods and relative cooling water.
4. line	RK3	real	K_3 [–] power ratio seed over blanket.
5. line	QVS	real	q_{vs} [W/m^3] average volume power density (seed).
6. line	DS	real	d_s [m] fuel rod diameter (seed).
7. line	DEQ	real	D_{eq} [m] equivalent diameter, diameter of a circle with the same area as the cross section of the core.
8. line	ALSC	real	L_{sC} [m]

axial distance of spacer grids in the active core region (seed).

9. line	ALSR	real	L_{sR} [m] axial distance of spacer grids in the fission gas plenum region (seed).
10.line	DKI	real	K_I [–] inlet pressure drop coefficient.
11.line	RKS	real	K_{Rs} [m] average roughness height on the surface of seed fuel rod.
	RKB	real	K_{Rb} [m] average roughness height on the surface of blanket fuel rod.
12.line	RKO	real	K_O [–] aspect ratio for the spiral spacer ribs (blanket).
13.line	HZUDB	real	H/d [–] pitch to diameter ratio for the spiral rib spacers (blanket).

4.5 PHYSICAL PARAMETERS FOR THE CHF COMPUTATIONS (UNIT 05)

This group of data is read again from unit 05 (system input stream). The input stream contains options and parameters for the critical heat flux correlations. Four different correlations are available according to Reference /2/. The computation of the critical heat flux is done for a singular rod. At first, the program reads the following data by the read statement with the namelist "DNBR", which specify the values of parameters used in the case of computation of multiple stacked core.

&DNBR

IBLT	(0)	=0 the same as in the previous version. The parameters in the namelist are read again by the program later with the free format. =1 multiple stacked core. The critical heat flux is calculated by setting the coolant inlet

		at the bottom of each part (inner core,blanket).
		=2 multiple stacked core. The critical heat flux is calculated by setting the coolant inlet at the lowest part of the whole core.
NAC	(1)	number of inner cores.
RR1	(1.0)	R_1 [–] (inner blanket height) / (inner core height)
RR2	(0.6)	R_2 [–] (outer blanket height) / (inner core height)
RR3	(0.2)	R_3 [–] (average linear heat rating in outer blanket) / (average linear heat rating in inner core).
FIAX2	(0.1)	φ_{ax2} [–] axial power form factor in the blanket.
		Meanings of the following parameters are given below.
FIAX	(1.48)	
FQ	(2.1)	
AK4	(0.1)	
NC	(40)	
OP	(1.12)	
Q10	(0.0)	
Q20	(9.157)	
Q40	(6.507)	
Q1N	(1.748)	
Q2N	(7.540)	
Q4N	(8.783)	
FQN	(1.776)	

&END

When IBLT = 0 (not multiple stacked core), the following data are read with the free format.

6. line	FIAX	real	φ_{ax} [–] form factor accounting for the axial power distribution. If $\varphi_{ax} \leq 0$, the axial power distribution is given in the form of table in the 15th and 16th lines.
7. line	AK	real	K [W/m^2] 2.37×10^6 constant used in the Shippingport relation.

			This parameter must be present as a dummy entry (its value has no importance), but it is not used in the latest version of the program.
8. line	H0	real	H_0 [J/kg] 1.588×10^6 enthalpy base (depending on pressure) for the Shippingport relation. As the previous parameter this datum must be present as a dummy entry.
9. line	FQ	real	F_q [–] hot channel factor for the heat flux at the fuel rod surface.
10.line	AK4	real	K_4 [–] ratio between the shortening of the core active length due to insertion of the control rods and core active length without control rod insertion. This value has no meaning if $\varphi_{ax} \leq 0$.
11.line	NC	integer	N_c [–] number of axial nodes or axial segments for the computation of the local heat fluxes.
12.line	OP	real	O_p [–] overpower factor for the fuel rod under consideration.
13.line	Q10	real	option for Columbia-EPRI correlation. >0.0 the same as in /6/, =0.0 V factor is set to be one.
	Q20	real	option for Dalle Donne-Hame correlation for grids. >0.0 the same as in /3/, =0.0 modified on the basis of /8/, <0.0 the same as above, but the distance from the upstream grid is set to be the distance between two grids(more conservative assumption).
	Q40	real	a dummy entry.
	Q1N	real	Q_1 1.748
	Q2N	real	Q_2 7.540

	Q4N	real	Q4 8.783 parameters used in the latter version of our CHF correlation /3/.
14.line	FQN	real	F_{qN} [–] factor for the maximal heat flux accounting for the axial and radial power distribution.

The following two lines are required when $\varphi_{ax} \leq 0.0$ (an arbitrary axial power distribution is given by input).

15.line	AXDISA	real	f_i [–] axial power distribution (NC entries).
16.line	AXDISB	real	f_i [–] axial power distribution deformed by control rod insertion (NC entries).

5. OUTPUT

The program uses four output data sets associated to units 06, 08, 09 and 10. The first one, assigned to the system output data set (named SYSPRINT on IBM-systems), is used for the printing of system error messages. The second data set (unit 08) must be assigned to an existing file (named PROJECT.APWRD.DATA in the examples) with the following (or corresponding) DCB attributes

record format RECFM=VBS
record length LRECL=2996
block size BLKSIZE=3000.

This data set is used as a result pool and contains the main results of consecutive runs. Data may be retrieved from this file by using one of the existing utility programs (see " 7. Utility Programs" on page 95).

The input data, the main results, and, if required, the matrix, vector, and solution dumps are printed out to unit 09.

The local results of the critical heat flux calculation are printed out to unit 10.

The output in units 09 and 10 is self-explaining; the same variable names are used as in " 4. Input Data" on page 13 for the input parameters. The variable names of the output parameters are explained in References /2//6/, so that no more detailed description is necessary here. In " 6. Examples" on page 28, the output data of three sample runs are listed.

In the case of multiple stacked cores (JAERI design), the results of critical heat flux calculated by both method (IBLT = 1 and 2) are printed out to units 09 and 10, regardless of the input value of IBLT. The ordering of outputs is as follows: at first, the results by specified method by IBLT are printed out, and next those by the alternative method are printed. In this case and the case with the arbitrary axial power distribution given in the table form, the local quantities are calculated and printed out at all axial nodes or segments. The position x in the print out shows the distance from the inlet of the core.

6. EXAMPLES

To demonstrate the use of the program, three sample runs are presented. The first sample is for a homogeneous reactor with the water pumping power and steam generator heat transfer from the default characteristics. In this sample, the core height is specified by input, and the axial power distribution is described by the chopped cosine distribution with the axial form factor $\varphi_{ax} = 1.45$. The input data and the control statements are shown at first. The used load module must be generated at first as described in " 8. Installing the Programs" on page 105. For this sample, the entire output is shown (units 09 and 10 in this order).

The second sample is similar to the first one except that the axial power distribution is given by input in the form of numerical table. In this case, the print out of the local result (unit 10) is omitted.

The third sample is for a reactor with a double stacked core. The water pumping power and steam generator heat transfer are specified by input. In this case, the print out of the local result (unit 10) is omitted.

The example of hetrogeneous reactor is presented in /1/.

6.1 SAMPLE 1, HOMOGENEOUS CORE, CHOPPED COSINE DISTRIBUTION (KFK DESIGN)

CONTROL STATEMENTS AND INPUT:

```
Starting in column 1
↓
//PROJECT1 JOB (...,...,.....),....,MSGCLASS=A,TIME=(1,00)
//*
// EXEC PGM=HADA
//STEPLIB DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//*******************************************************************
//*
//*   ALLOCATE FILE 6 TO GET FORTRAN ERROR MESSAGES
//*
//FT06F001 DD DUMMY
//*T06F001 DD SYSOUT=*,
//*         DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//*******************************************************************
//*
//*           UNIT 8      DATA POOL FOR RESULT
//*
//FT08F001 DD DISP=(MOD,PASS),DSN=PROJECT.APWRD.DATA
//*******************************************************************
//**
//**          UNIT 9       MAIN RESULT
//**
//FT09F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//FT10F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//*******************************************************************
//**
//**          UNIT 47      PROBLEM IDENTIFICATION
//**
//FT47F001 DD *
HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.
//*******************************************************************
//**
//**          UNIT INP     COMMON PHYSICAL PARAMETERS
//**
//FT01F001 DD *
 &SYSTEM
```

```
 &END
3.765E9                      Q0 IN W
1.00,1.65,-1.0000,0.97       OP,FDHO,CDH,K'
0.0                          ALC FUER LR=1.1885*LC+0.02 OR LC + ALC
1.7E7,0.774                  N  IN W,       ETA (NEU 8.9.83)
158.26                       P20  IN BAR
326.12                       T20  IN GRD C
64.5                         POS  IN BAR
1.8800E4                     MO  IN KG/S
1.55927E8                    KFO  IN W/GRD C
291.14                       T10  IN GRD C
159.65                       P10  IN BAR
70.6                         HR  IN M
5.4D7                        NEL  IN W
89.6                         HTO  IN M
1.3E9                        NEL  IN W
//******************************************************************
//**
//**         UNIT JNP        SPECIAL PHYSICAL PARAMETERS
//**
//FT02F001 DD *
11.8000E-3                   P  IN M
9.5E-3                       D  IN M                        2 REAL 9.9.83
-1.                          K0
.875052,-3.5                 K1,KL   LINEAR RATING
.904265                      K2
3.88910                      DEQ  IN M                      1 REAL 9.9.83
12,.4D-3,2.2D-3,.64D-3       NGI,SG,BG,SCLAD IN M
1.2,5.D-6                    KI,RK
//******************************************************************
//**
//**         UNIT 05         SYSIN
//**
//FT05F001 DD *
1                            INP
2,1,1,1                      IOP1,IOP2,IOP3,IOP4 .,1,.,. HOMOGEN   <===
1,2                          IDR1,IDR2
2                            JNP                  2     HOMOGEN   <===
1.D-5,.5,20                  EPS,DMAX,IMAX
 &DNBR
 &END
1.45                         PHIAX                        4 REAL 9.9.83
2.37D6                       K
```

```
1588.D3                       HO
2.3                           FQ                              7 REAL 9.9.83
.1                            K4
40                            NC
1.12                          OP
1.000,1.000,6.507,1.748,7.540,8.783  (JMP$,JMP2$,Q4)ALT,(Q1,Q2,Q4)NEU
2.07930                       FQN                             5 REAL 12.9.83
//
```

Main results (unit 09)

TITEL :

HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.   08.06.89   08.34.26

EINGABEPARAMETER

```
Q0      =     3.76500E+09  W
POS     =      64.500      BAR
P20     =      158.26      BAR
T20     =      326.12      GRD C
KF0     =     1.55927E+08  WATT/GRD
N       =     1.70000E+07  WATT
P10     =      159.65      BAR
M0      =      18800.      KG/S
FDH0    =      1.6500
CDH     =      1.0000
OPF     =      1.0000
T10     =      291.14      GRD C
HR      =      70.600      M
NEL     =     5.40000E+07  W
ALC     =     0.00000E+00  M
```

CONSTANT PUMP CHARACTERISTICS

```
    HT =  111.68 + (  22.24 -    4.05 * V ) * V
    WHERE  V = M / RO / 4
```

KF IS CALCULATED AS

```
    KF = KF0 / (0.580 + 0.180*(Q/Q0)**0.240 + 0.240*(M0/M)**0.800
```

EPSI = 0.28399141750077277

```
P       =     1.18000E-02  M
D       =     9.50000E-03  M
DH      =     6.66148E-03  M
K0      =     -1.0000
K1      =     0.87505
K2      =     0.90426
DEQ     =      3.8891      M
H/D     =     0.00000E+00
KI      =      1.2000
RK      =     5.00000E-06  M
P/D     =      1.2421
B       =     0.00000E+00  M
KL      =      1.0000      -         12.09.1983
```

```
 RLC     =       3.5000      M
 RLR     =       4.1798      M
 AT      =       10.395      QM
 NT      =       86203
 VM/VROD  =       0.92087       CORE,       0.70121       CELL
 VM/VFUEL =        1.2300       CORE,       0.93659       CELL
NGI=12

 HOMOGENEOUS REACTOR
 EPS     =     1.00000E-03   %
 DELTA   =       50.000      %
```

ANFANGSWERTE

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	***********	***********
K	1	-	1.0000	0.00000E+00
Q	2	W	2.45770E+09	0.00000E+00
T1	3	GRD C	291.14	0.00000E+00
RO1	4	KG/CBM	745.55	0.00000E+00
P1	5	BAR	159.65	0.00000E+00
H1	6	J/KG	1.28910E+06	0.00000E+00
T2	7	GRD C	326.12	0.00000E+00
RO2	8	KG/CBM	664.73	0.00000E+00
H2	9	J/KG	1.49004E+06	0.00000E+00
TS	10	GRD C	280.40	0.00000E+00
PS	11	BAR	64.500	0.00000E+00
TQ	12	GRD C	308.63	0.00000E+00
ROQ	13	KG/CBM	709.37	0.00000E+00
PQ	14	BAR	158.95	0.00000E+00
M	15	KG/S	18736.	0.00000E+00
KF	16	W/GRD	1.55825E+08	0.00000E+00
HT	17	M	91.473	0.00000E+00
HC	18	M	21.350	0.00000E+00
DP	19	BAR	1.3900	0.00000E+00
Y	20	-	1.4412	0.00000E+00
TSU	21	GRD C	336.49	0.00000E+00
RO2U	22	KG/CBM	631.28	0.00000E+00
H2U	23	J/KG	1.56116E+06	0.00000E+00
TQU	24	GRD C	308.63	0.00000E+00
ROQU	25	KG/CBM	709.37	0.00000E+00
NY	26	QM/S	1.26052E-07	0.00000E+00
U	27	M/S	4.5533	0.00000E+00
RE	28	-	2.40628E+05	0.00000E+00
LAM	29	-	1.97272E-02	0.00000E+00

```
ITER =   0 ABS :    1.31250E+09    2 *** REL :     0.50000       2
ITER =   1 ABS :    1.01615E+08    2 *** REL :     2.75636E-02   2
ITER =   2 ABS :    4.39442E+05    2 *** REL :     1.04442E-03  28
ITER =   3 ABS :     284.67        2 *** REL :     2.10145E-05  28
```

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	***********	***********
K	1	-	1.0060	1.10907E-08
Q	2	W	3.78773E+09	41.756
T1	3	GRD C	291.65	1.24336E-06
RO1	4	KG/CBM	744.69	1.19477E-05
P1	5	BAR	160.28	-3.57297E-08
H1	6	J/KG	1.29175E+06	1.51336E-03
T2	7	GRD C	327.39	1.16058E-08
RO2	8	KG/CBM	660.99	-7.77667E-07
H2	9	J/KG	1.49833E+06	6.23687E-04
TS	10	GRD C	280.80	7.32912E-07
PS	11	BAR	64.889	7.15349E-07
TQ	12	GRD C	309.52	6.27483E-07
ROQ	13	KG/CBM	707.42	-7.04358E-07
PQ	14	BAR	159.27	-1.78648E-08
M	15	KG/S	18335.	2.81178E-04
KF	16	W/GRD	1.55134E+08	0.39003
HT	17	M	95.058	1.20574E-07
HC	18	M	27.640	-9.32642E-07
DP	19	BAR	2.0186	-3.57297E-08
Y	20	-	1.4571	-6.26527E-08
TSU	21	GRD C	337.88	-8.08796E-08
RO2U	22	KG/CBM	626.16	-7.71460E-07
H2U	23	J/KG	1.57143E+06	3.07569E-04
TQU	24	GRD C	314.76	5.81240E-07
ROQU	25	KG/CBM	695.08	-6.06774E-07
NY	26	QM/S	1.26141E-07	-1.25214E-16
U	27	M/S	4.5475	7.37065E-08
RE	28	-	2.40152E+05	4.27055E-03
LAM	29	-	2.07249E-02	-2.29895E-11

```
 IPOW=1     PRDH= 1.0000000000000000
ITER =    4 ABS :     9.22413E+06     2 *** REL :      2.43527E-03    2
ITER =    5 ABS :      1588.4         2 *** REL :      6.83857E-05   28
```

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	************	************
K	1	-	1.0036	1.92751E-09
Q	2	W	3.77850E+09	7.2571
T1	3	GRD C	291.45	3.59058E-07
RO1	4	KG/CBM	745.07	1.09409E-05
P1	5	BAR	160.28	3.84785E-07
H1	6	J/KG	1.29069E+06	-2.16575E-03
T2	7	GRD C	327.14	-2.21443E-07
RO2	8	KG/CBM	661.75	-8.39807E-08
H2	9	J/KG	1.49665E+06	-9.00189E-04
TS	10	GRD C	280.64	1.27216E-07
PS	11	BAR	64.731	1.24324E-07
TQ	12	GRD C	309.29	6.88079E-08
ROQ	13	KG/CBM	707.94	9.46105E-07
PQ	14	BAR	159.27	1.92393E-07
M	15	KG/S	18346.	-7.70559E-05
KF	16	W/GRD	1.55167E+08	-0.13981
HT	17	M	95.047	3.21400E-06
HC	18	M	27.637	4.86024E-06
DP	19	BAR	2.0193	3.84785E-07
Y	20	-	1.4587	-2.80511E-08
TSU	21	GRD C	337.62	-1.82842E-07
RO2U	22	KG/CBM	627.11	-3.80031E-07
H2U	23	J/KG	1.56953E+06	-4.58865E-04
TQU	24	GRD C	314.54	8.81084E-08
ROQU	25	KG/CBM	695.63	-1.39299E-06
NY	26	QM/S	1.26132E-07	2.24004E-16
U	27	M/S	4.5465	-9.99164E-09
RE	28	-	2.40115E+05	-0.36833
LAM	29	-	2.07251E-02	2.03163E-09

IPOW=2 PRDH= 1.0060366786123589

ITER = 6 ABS : 1.34089E+07 2 *** REL : 3.54874E-03 2

ITER = 7 ABS : 4191.0 2 *** REL : 9.49362E-05 28

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	************	************
K	1	-	1.0000	-1.21407E-10
Q	2	W	3.76509E+09	-0.45710
T1	3	GRD C	291.16	2.12178E-07
RO1	4	KG/CBM	745.63	1.39737E-05
P1	5	BAR	160.28	6.14319E-07
H1	6	J/KG	1.28915E+06	-3.85197E-03
T2	7	GRD C	326.76	-3.32714E-07
RO2	8	KG/CBM	662.86	2.45707E-07
H2	9	J/KG	1.49421E+06	-1.62066E-03
TS	10	GRD C	280.40	-9.42756E-09
PS	11	BAR	64.502	-7.83078E-09
TQ	12	GRD C	308.96	-6.02680E-08
ROQ	13	KG/CBM	708.69	9.67820E-07
PQ	14	BAR	159.27	3.07159E-07
M	15	KG/S	18361.	-2.00911E-04
KF	16	W/GRD	1.55216E+08	-0.32999
HT	17	M	95.032	5.05311E-06
HC	18	M	27.631	7.88330E-06
DP	19	BAR	2.0204	6.14319E-07
Y	20	-	1.4610	-2.56467E-08
TSU	21	GRD C	337.25	-2.35401E-07
RO2U	22	KG/CBM	628.49	-1.75679E-07
H2U	23	J/KG	1.56677E+06	-8.47667E-04
TQU	24	GRD C	314.20	-1.16118E-08
ROQU	25	KG/CBM	696.43	9.51324E-07
NY	26	QM/S	1.26121E-07	-1.56179E-16
U	27	M/S	4.5450	-5.59408E-08
RE	28	-	2.40061E+05	-0.78497
LAM	29	-	2.07254E-02	4.33034E-09

CONVERGENCE REACHED AFTER 3 ITERATIONS OVER THE REACTOR POWER: PRDH = 1.014872

ERGEBNISSE

```
       Q      =     3.76509E+09   W
       K      =      1.0000
       PS     =      64.502       BAR
       TS     =      280.40       GRD C
       P1     =      160.28       BAR
       T1     =      291.16       GRD C
       T2     =      326.76       GRD C
       M      =      18361.       KG/S
       NP     =     1.76098E+07   W
       QNT    =     1.30066E+09   W
     QNT/QEL0 =      1.0005
```

*********** ZUSATZ 08.09.1983 *********

```
       KS     =     0.97000       -
       ETA    =     0.77400       -
       MS     =      17810.       KG/S
       NPEL   =     2.27517E+07   W
```

HOMOGENEOUS REACTOR WITH GRID SPACERS

```
       LC     =      3.5000       M
       LR     =      4.1798       M
       T2U    =      337.25       GRD C
       U      =      4.5450       M/S
       RE     =     2.40061E+05
       LAMBDA =     2.07254E-02
       DIST   =     0.37998
       $K     =      1.1569       (=CV*EPS*EPS)
       DP     =      2.0204       BAR
       DPTOT  =      2.3309       BAR

       DPP    =      6.9488       BAR
```

****

```
       PRDH   =      1.0149
```

CDH	=	1.0000	

CHF-CALCULATIONS

LC	=	3.5000	M
T1	=	291.16	GRD C
RO1	=	745.63	KG/CBM
P1	=	160.28	BAR
H1	=	1.28915E+06	J/KG
T2	=	337.25	GRD
P2	=	158.26	BAR
ROQ	=	696.43	KG/CBM
U	=	4.5450	M/S
QL	=	12479.	W/M
D	=	9.50000E-03	M
DH	=	6.66148E-03	M
PZUD	=	1.2421	

EINGABEDATEN

FIAX	=	1.4500	
AK	=	2.37000E+06	
HO	=	1.58800E+06	J/KG
FQ	=	2.3000	
K4	=	0.10000	
NC	=	40	
OP	=	1.1200	
Q1O	=	1.0000	
Q2O	=	1.0000	
Q4O	=	6.5070	
Q1N	=	1.7480	
Q2N	=	7.5400	
Q4N	=	8.7830	
FQN	=	2.0793	

ERGEBNISSE

X	=	1.4371
PI/2X	=	1.0931
LC'	=	3.8257

```
RLCR   =    3.150
RLCR'  =    3.476
V1     =   0.70000E+00 WSC-2
CG'    =   0.80219E+00 COLUMBIA-EPRI
V2     =   0.85680E+00 EIGENE,NEU
```

OVERPOWER FACTOR : 1.0000

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
0	0.00	325.87	348.92	1.973E+06	2.05	1.99	1.657E+06	1.72	1.56	2.352E+06	2.45	2.37	2.160E+06	2.25	2.18
1	0.09	328.09	348.89	1.869E+06	1.95	1.89	1.590E+06	1.66	1.50	2.233E+06	2.33	2.25	2.047E+06	2.13	2.06
2	0.17	330.24	348.87	1.769E+06	1.86	1.80	1.526E+06	1.60	1.45	2.117E+06	2.22	2.14	1.937E+06	2.04	1.96
3	0.26	332.32	348.84	1.672E+06	1.78	1.72	1.464E+06	1.56	1.40	2.004E+06	2.13	2.05	1.830E+06	1.95	1.88
4	0.35	334.31	348.80	1.577E+06	1.71	1.65	1.403E+06	1.52	1.37	1.894E+06	2.05	1.97	1.726E+06	1.87	1.80
5	0.44	336.21	348.77	1.484E+06	1.65	1.58	1.344E+06	1.49	1.34	1.785E+06	1.98	1.90	1.625E+06	1.80	1.73
6	0.52	338.01	348.73	1.393E+06	1.59	1.53	1.286E+06	1.47	1.33	1.679E+06	1.92	1.84	1.525E+06	1.75	1.68
7	0.61	339.70	348.69	1.303E+06	1.55	1.49	1.229E+06	1.46	1.32	1.574E+06	1.87	1.79	1.427E+06	1.69	1.63
8	0.70	341.27	348.65	1.215E+06	1.50	1.45	1.172E+06	1.45	1.32	1.469E+06	1.82	1.75	1.330E+06	1.65	1.59
9	0.79	342.72	348.60	1.127E+06	1.47	1.42	1.115E+06	1.45	1.32	1.366E+06	1.78	1.71	1.235E+06	1.61	1.55
10	0.87	344.04	348.55	1.041E+06	1.44	1.39	1.058E+06	1.46	1.34	1.263E+06	1.75	1.68	1.140E+06	1.58	1.52
11	0.96	345.25	348.50	9.545E+05	1.41	1.37	1.000E+06	1.48	1.37	1.161E+06	1.72	1.66	1.046E+06	1.55	1.50
12	1.05	346.32	348.44	8.688E+05	1.39	1.35	9.421E+05	1.51	1.41	1.059E+06	1.69	1.64	9.526E+05	1.52	1.48
13	1.14	346.73	348.38	7.833E+05	1.37	1.33	8.826E+05	1.54	1.47	9.565E+05	1.67	1.63	8.592E+05	1.50	1.46
14	1.22	346.71	348.31	6.977E+05	1.36	1.33	8.214E+05	1.60	1.54	8.537E+05	1.66	1.62	7.656E+05	1.49	1.45
15	1.31	346.68	348.24	6.119E+05	1.34	1.32	7.579E+05	1.67	1.65	7.503E+05	1.65	1.62	6.718E+05	1.48	1.45
16	1.40	346.66	348.16	5.257E+05	1.34	1.32	6.912E+05	1.76	1.80	6.459E+05	1.64	1.62	5.774E+05	1.47	1.45
17	1.49	346.63	348.07	4.388E+05	1.33	1.32	6.204E+05	1.89	2.04	5.403E+05	1.64	1.63	4.823E+05	1.47	1.46
18	1.57	346.61	347.96	3.511E+05	1.33	1.33	5.438E+05	2.06	2.44	4.332E+05	1.64	1.65	3.861E+05	1.47	1.47
19	1.66	346.58	347.84	2.622E+05	1.34	0.00	4.587E+05	2.34	0.00	3.244E+05	1.65	0.00	2.886E+05	1.47	0.00
20	1.75	346.55	347.69	1.721E+05	1.34	0.00	3.600E+05	2.81	0.00	2.134E+05	1.66	0.00	1.895E+05	1.48	0.00

MINIMALWERTE

CORRELATION	SMMIN	X	POS			
COLUMBIA-EPRI :	1.3327	1.5750	18	1.3197	1.4000	16
EDLUND :	1.4515	0.70000	8	1.3173	0.70000	8
WSC-2 :	1.6416	1.4875	17	1.6215	1.3125	15
EIGENE,NEU :	1.4653	1.4875	17	1.4503	1.3125	15

X$ = 9.72363E-02 X$ = 9.45153E-02

OVERPOWER FACTOR : 1.1200

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
0	0.00	329.52	348.92	1.977E+06	1.84	1.78	1.657E+06	1.54	1.40	2.352E+06	2.18	2.11	2.160E+06	2.01	1.95
1	0.09	331.90	348.89	1.874E+06	1.74	1.69	1.590E+06	1.48	1.34	2.233E+06	2.08	2.01	2.047E+06	1.91	1.84
2	0.17	334.20	348.87	1.773E+06	1.66	1.61	1.526E+06	1.43	1.29	2.117E+06	1.99	1.91	1.937E+06	1.82	1.75
3	0.26	336.41	348.84	1.676E+06	1.59	1.53	1.464E+06	1.39	1.25	2.004E+06	1.90	1.83	1.830E+06	1.74	1.68
4	0.35	338.51	348.80	1.580E+06	1.53	1.47	1.403E+06	1.36	1.22	1.894E+06	1.83	1.76	1.726E+06	1.67	1.61
5	0.44	340.49	348.77	1.487E+06	1.48	1.42	1.344E+06	1.33	1.20	1.785E+06	1.77	1.70	1.625E+06	1.61	1.55
6	0.52	342.35	348.73	1.396E+06	1.43	1.37	1.286E+06	1.31	1.19	1.679E+06	1.72	1.65	1.525E+06	1.56	1.50
7	0.61	344.07	348.69	1.306E+06	1.38	1.33	1.229E+06	1.30	1.18	1.574E+06	1.67	1.60	1.427E+06	1.51	1.45
8	0.70	345.65	348.65	1.217E+06	1.35	1.30	1.172E+06	1.30	1.18	1.469E+06	1.63	1.56	1.330E+06	1.47	1.42
9	0.79	346.84	348.60	1.130E+06	1.31	1.27	1.115E+06	1.30	1.18	1.366E+06	1.59	1.53	1.235E+06	1.44	1.38
10	0.87	346.81	348.55	1.043E+06	1.29	1.24	1.058E+06	1.30	1.20	1.263E+06	1.56	1.50	1.140E+06	1.41	1.36
11	0.96	346.79	348.50	9.568E+05	1.26	1.22	1.000E+06	1.32	1.22	1.161E+06	1.53	1.48	1.046E+06	1.38	1.34
12	1.05	346.76	348.44	8.709E+05	1.24	1.21	9.421E+05	1.34	1.26	1.059E+06	1.51	1.47	9.526E+05	1.36	1.32
13	1.14	346.73	348.38	7.852E+05	1.23	1.19	8.826E+05	1.38	1.31	9.565E+05	1.49	1.46	8.592E+05	1.34	1.31
14	1.22	346.71	348.31	6.995E+05	1.21	1.19	8.214E+05	1.42	1.38	8.537E+05	1.48	1.45	7.656E+05	1.33	1.30
15	1.31	346.68	348.24	6.135E+05	1.20	1.18	7.579E+05	1.49	1.47	7.503E+05	1.47	1.45	6.718E+05	1.32	1.29
16	1.40	346.66	348.16	5.271E+05	1.20	1.18	6.912E+05	1.57	1.61	6.459E+05	1.47	1.45	5.774E+05	1.31	1.30
17	1.49	346.63	348.07	4.400E+05	1.19	1.18	6.204E+05	1.68	1.82	5.403E+05	1.47	1.46	4.823E+05	1.31	1.30
18	1.57	346.61	347.96	3.520E+05	1.19	1.19	5.438E+05	1.84	2.18	4.332E+05	1.47	1.47	3.861E+05	1.31	1.31
19	1.66	346.58	347.84	2.630E+05	1.20	0.00	4.587E+05	2.09	0.00	3.244E+05	1.48	0.00	2.886E+05	1.31	0.00
20	1.75	346.55	347.69	1.726E+05	1.20	0.00	3.600E+05	2.51	0.00	2.134E+05	1.49	0.00	1.895E+05	1.32	0.00

MINIMALWERTE

CORRELATION	SMMIN	X	POS			
COLUMBIA-EPRI :	1.1932	1.5750	18	1.1815	1.4000	16
EDLUND :	1.2960	0.70000	8	1.1761	0.70000	8
WSC-2 :	1.4657	1.4875	17	1.4478	1.3125	15
EIGENE,NEU :	1.3083	1.4875	17	1.2949	1.3125	15

X$ = 0.15408 X$ = 0.15105

Local results from CHF calculations (unit 10)

TITEL :

HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.   08.06.89 08.34.26

OVERPOWER FACTOR : 1.0000

POS	X	T(X)	P(X)	H(X)	HFG(X)	ALFA(X)	RE(X)	PHIN(X)	TW(X)	TW1	TW2
		CORRELATION		PHICHF(X)	PHIHS(X)	PHIHSCR(X)	SM(X)	SMCR(X)	X$X(X)		X$XR(X)
LOKALES SIEDEN : 0.000 M, TB = 348.92											
0	0.00	325.87	159.27	1.5182E+06	9.3581E+05	3.4402E+04	2.4912E+05	8.6942E+05	348.92	351.14	348.92
		COLUMBIA-EPRI :		1.97266E+06	9.61699E+05	1.06056E+06	2.051	1.994	-0.13782		-0.13782
		EDLUND :		1.65704E+06			1.723	1.564			
		WSC-2 :		2.35161E+06			2.445	2.368			
		EIGENE,NEU :		2.15978E+06			2.246	2.181			
LOKALES SIEDEN : 0.087 M, TB = 348.89											
1	0.09	328.09	159.22	1.5365E+06	9.3621E+05	3.4569E+04	2.5087E+05	8.6717E+05	348.89	353.17	348.89
		COLUMBIA-EPRI :		1.86947E+06	9.59218E+05	1.05724E+06	1.949	1.888	-0.11983		-0.11798
		EDLUND :		1.59033E+06			1.658	1.500			
		WSC-2 :		2.23285E+06			2.328	2.247			
		EIGENE,NEU :		2.04671E+06			2.134	2.065			
LOKALES SIEDEN : 0.175 M, TB = 348.87											
2	0.17	330.24	159.17	1.5547E+06	9.3661E+05	3.4752E+04	2.5258E+05	8.6046E+05	348.87	355.00	348.87
		COLUMBIA-EPRI :		1.76936E+06	9.51786E+05	1.04732E+06	1.859	1.795	-0.10194		-9.82817E-02
		EDLUND :		1.52608E+06			1.603	1.446			
		WSC-2 :		2.11725E+06			2.224	2.142			
		EIGENE,NEU :		1.93707E+06			2.035	1.964			
LOKALES SIEDEN : 0.262 M, TB = 348.84											
3	0.26	332.32	159.12	1.5726E+06	9.3701E+05	3.4952E+04	2.5423E+05	8.4930E+05	348.84	356.62	348.84
		COLUMBIA-EPRI :		1.67196E+06	9.39443E+05	1.03085E+06	1.780	1.715	-8.42539E-02		-7.88444E-02
		EDLUND :		1.46387E+06			1.558	1.403			
		WSC-2 :		2.00439E+06			2.134	2.051			
		EIGENE,NEU :		1.83046E+06			1.948	1.876			
LOKALES SIEDEN : 0.350 M, TB = 348.80											
4	0.35	334.31	159.07	1.5902E+06	9.3741E+05	3.5171E+04	2.5583E+05	8.3376E+05	348.80	358.02	348.80
		COLUMBIA-EPRI :		1.57693E+06	9.22251E+05	1.00793E+06	1.710	1.645	-6.68515E-02		-5.97867E-02
		EDLUND :		1.40334E+06			1.522	1.370			
		WSC-2 :		1.89392E+06			2.054	1.971			
		EIGENE,NEU :		1.72648E+06			1.872	1.800			
LOKALES SIEDEN : 0.437 M, TB = 348.77											
5	0.44	336.21	159.02	1.6074E+06	9.3781E+05	3.5411E+04	2.5736E+05	8.1391E+05	348.77	359.20	348.77
		COLUMBIA-EPRI :		1.48395E+06	9.00301E+05	9.78712E+05	1.648	1.585	-4.98231E-02		-4.12253E-02
		EDLUND :		1.34416E+06			1.493	1.344			
		WSC-2 :		1.78549E+06			1.983	1.903			

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            EIGENE,NEU     :  1.62480E+06                                      1.805      1.734
LOKALES SIEDEN :       0.525 M, TB =      348.73
    6    0.52 338.01  158.97  1.6240E+06       9.3820E+05    3.5674E+04      2.5881E+05  7.8987E+05   348.73    360.15 348.73
            COLUMBIA-EPRI :  1.39275E+06   8.73704E+05  9.43376E+05    1.594      1.532               -3.32547E-02  -2.32741E-02
            EDLUND         :  1.28600E+06                                      1.472      1.327
            WSC-2          :  1.67879E+06                                      1.921      1.844
            EIGENE,NEU     :  1.52509E+06                                      1.746      1.677
LOKALES SIEDEN :       0.612 M, TB =      348.69
    7    0.61 339.70  158.92  1.6399E+06       9.3860E+05    3.5963E+04      2.6019E+05  7.6175E+05   348.69    360.88 348.69
            COLUMBIA-EPRI :  1.30305E+06   8.42598E+05  9.02142E+05    1.546      1.487               -1.72301E-02  -6.04273E-03
            EDLUND         :  1.22858E+06                                      1.458      1.318
            WSC-2          :  1.57351E+06                                      1.867      1.793
            EIGENE,NEU     :  1.42706E+06                                      1.694      1.628
LOKALES SIEDEN :       0.700 M, TB =      348.65
    8    0.70 341.27  158.87  1.6551E+06       9.3900E+05    3.6277E+04      2.6147E+05  7.2969E+05   348.65    361.38 348.65
            COLUMBIA-EPRI :  1.21460E+06   8.07144E+05  8.55268E+05    1.505      1.448               -1.83015E-03   1.03635E-02
            EDLUND         :  1.17160E+06                                      1.452      1.317
            WSC-2          :  1.46937E+06                                      1.820      1.750
            EIGENE,NEU     :  1.33041E+06                                      1.648      1.586
LOKALES SIEDEN :       0.787 M, TB =      348.60
    9    0.79 342.72  158.82  1.6694E+06       9.3940E+05    3.6617E+04      2.6266E+05  6.9388E+05   348.60    361.67 348.60
            COLUMBIA-EPRI :  1.12717E+06   7.67525E+05  8.03047E+05    1.469      1.415                1.28675E-02   2.58447E-02
            EDLUND         :  1.11478E+06                                      1.452      1.325
            WSC-2          :  1.36610E+06                                      1.780      1.714
            EIGENE,NEU     :  1.23490E+06                                      1.609      1.550
LOKALES SIEDEN :       0.875 M, TB =      348.55
   10    0.87 344.04  158.77  1.6828E+06       9.3979E+05    3.6984E+04      2.6376E+05  6.5448E+05   348.55    361.74 348.55
            COLUMBIA-EPRI :  1.04054E+06   7.23945E+05  7.45806E+05    1.437      1.388                2.67891E-02   4.03066E-02
            EDLUND         :  1.05781E+06                                      1.461      1.342
            WSC-2          :  1.26344E+06                                      1.745      1.684
            EIGENE,NEU     :  1.14026E+06                                      1.575      1.520
LOKALES SIEDEN :       0.962 M, TB =      348.50
   11    0.96 345.25  158.71  1.6952E+06       9.4019E+05    3.7374E+04      2.6475E+05  6.1170E+05   348.50    361.61 348.50
            COLUMBIA-EPRI :  9.54486E+05   6.76629E+05  6.83903E+05    1.411      1.365                3.98646E-02   5.36618E-02
            EDLUND         :  1.00036E+06                                      1.478      1.369
            WSC-2          :  1.16112E+06                                      1.716      1.661
            EIGENE,NEU     :  1.04625E+06                                      1.546      1.496
LOKALES SIEDEN :       1.050 M, TB =      348.44
   12    1.05 346.32  158.66  1.7064E+06       9.4059E+05    3.7785E+04      2.6565E+05  5.6577E+05   348.44    361.30 348.44
            COLUMBIA-EPRI :  8.68802E+05   6.25821E+05  6.17724E+05    1.388      1.347                5.20287E-02   6.58294E-02
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            EDLUND        :  9.42097E+05                                 1.505       1.409
            WSC-2         :  1.05890E+06                                 1.692       1.643
            EIGENE,NEU    :  9.52636E+05                                 1.522       1.477
LOKALES SIEDEN :      1.137 M, TB =     348.38
   13   1.14 346.73  158.61  1.7165E+06       9.4098E+05   3.7962E+04     2.6600E+05  5.1692E+05   348.38    360.35 348.38
            COLUMBIA-EPRI :  7.83282E+05   5.71784E+05  5.47683E+05  1.370       1.334                    6.32206E-02   7.67363E-02
            EDLUND        :  8.82599E+05                                 1.544       1.465
            WSC-2         :  9.56524E+05                                 1.673       1.630
            EIGENE,NEU    :  8.59178E+05                                 1.503       1.464
LOKALES SIEDEN :      1.225 M, TB =     348.31
   14   1.22 346.71  158.56  1.7253E+06       9.4138E+05   3.7956E+04     2.6598E+05  4.6540E+05   348.31    358.97 348.31
            COLUMBIA-EPRI :  6.97726E+05   5.14796E+05  4.74218E+05  1.355       1.325                    7.33848E-02   8.63172E-02
            EDLUND        :  8.21388E+05                                 1.596       1.542
            WSC-2         :  8.53737E+05                                 1.658       1.623
            EIGENE,NEU    :  7.65647E+05                                 1.487       1.455
LOKALES SIEDEN :      1.312 M, TB =     348.24
   15   1.31 346.68  158.51  1.7328E+06       9.4178E+05   3.7949E+04     2.6596E+05  4.1148E+05   348.24    357.53 348.24
            COLUMBIA-EPRI :  6.11930E+05   4.55151E+05  3.97789E+05  1.344       1.320                    8.24710E-02   9.45153E-02
            EDLUND        :  7.57864E+05                                 1.665       1.649
            WSC-2         :  7.50282E+05                                 1.648       1.622
            EIGENE,NEU    :  6.71811E+05                                 1.476       1.450
LOKALES SIEDEN :      1.400 M, TB =     348.16
   16   1.40 346.66  158.46  1.7390E+06       9.4217E+05   3.7943E+04     2.6595E+05  3.5543E+05   348.16    356.03 348.16
            COLUMBIA-EPRI :  5.25691E+05   3.93158E+05  3.18872E+05  1.337       1.320                    9.04344E-02   0.10128
            EDLUND        :  6.91241E+05                                 1.758       1.803
            WSC-2         :  6.45896E+05                                 1.643       1.625
            EIGENE,NEU    :  5.77432E+05                                 1.469       1.451
LOKALES SIEDEN :      1.487 M, TB =     348.07
   17   1.49 346.63  158.41  1.7438E+06       9.4257E+05   3.7937E+04     2.6593E+05  2.9755E+05   348.07    354.48 348.07
            COLUMBIA-EPRI :  4.38803E+05   3.29135E+05  2.37963E+05  1.333       1.323                    9.72363E-02   0.10658
            EDLUND        :  6.20433E+05                                 1.885       2.037
            WSC-2         :  5.40306E+05                                 1.642       1.633
            EIGENE,NEU    :  4.82271E+05                                 1.465       1.455
LOKALES SIEDEN :      1.575 M, TB =     347.96
   18   1.57 346.61  158.36  1.7472E+06       9.4297E+05   3.7930E+04     2.6591E+05  2.3814E+05   347.96    352.88 347.96
            COLUMBIA-EPRI :  3.51055E+05   2.63414E+05  1.55565E+05  1.333       1.331                    0.10284       0.11038
            EDLUND        :  5.43822E+05                                 2.065       2.444
            WSC-2         :  4.33228E+05                                 1.645       1.647
            EIGENE,NEU    :  3.86078E+05                                 1.466       1.465
LOKALES SIEDEN :      1.662 M, TB =     347.84
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   19    1.66 346.58  158.31  1.7444E+06        9.4261E+05   3.7924E+04      2.6590E+05  1.7749E+05   347.84    351.26 347.84
               COLUMBIA-EPRI :  2.62228E+05   1.96334E+05  1.55565E+05   1.336       0.0000E+00        0.10723         0.11038
               EDLUND        :  4.58731E+05                              2.336       0.0000E+00
               WSC-2         :  3.24359E+05                              1.652       0.0000E+00
               EIGENE,NEU    :  2.88593E+05                              1.470       0.0000E+00
LOKALES SIEDEN :       1.750 M, TB =     347.69
   20    1.75 346.55  158.26  1.7472E+06        9.4297E+05   3.7917E+04      2.6588E+05  1.1593E+05   347.69    349.61 347.69
               COLUMBIA-EPRI :  1.72092E+05   1.28240E+05  1.55565E+05   1.342       0.0000E+00        0.11038         0.11038
               EDLUND        :  3.59968E+05                              2.807       0.0000E+00
               WSC-2         :  2.13382E+05                              1.664       0.0000E+00
               EIGENE,NEU    :  1.89544E+05                              1.478       0.0000E+00
        NKD =    107
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OVERPOWER FACTOR : 1.1200

POS	X	T(X) / CORRELATION	P(X)	H(X) / PHICHF(X)	HFG(X) / PHIHS(X)	ALFA(X) / PHIHSCR(X)	RE(X) / SM(X)	PHIN(X) / SMCR(X)	TW(X) / X$X(X)	TW1	TW2 / X$XR(X)
LOKALES SIEDEN : 0.000 M, TB = 348.92											
0	0.00	329.52	159.27	1.5457E+06	9.3581E+05	3.4687E+04	2.5200E+05	8.6942E+05	348.92	354.58	348.92
		COLUMBIA-EPRI :		1.97710E+06	1.07710E+06	1.18783E+06	1.836	1.784	-0.10845		-0.10845
		EDLUND :		1.65704E+06			1.538	1.397			
		WSC-2 :		2.35161E+06			2.183	2.114			
		EIGENE,NEU :		2.15978E+06			2.005	1.947			
LOKALES SIEDEN : 0.087 M, TB = 348.89											
1	0.09	331.90	159.22	1.5662E+06	9.3621E+05	3.4908E+04	2.5389E+05	8.6717E+05	348.89	356.74	348.89
		COLUMBIA-EPRI :		1.87367E+06	1.07432E+06	1.18411E+06	1.744	1.689	-8.83411E-02		-8.62772E-02
		EDLUND :		1.59033E+06			1.480	1.339			
		WSC-2 :		2.23285E+06			2.078	2.006			
		EIGENE,NEU :		2.04671E+06			1.905	1.844			
LOKALES SIEDEN : 0.175 M, TB = 348.87											
2	0.17	334.20	159.17	1.5865E+06	9.3661E+05	3.5155E+04	2.5573E+05	8.6046E+05	348.87	358.68	348.87
		COLUMBIA-EPRI :		1.77333E+06	1.06600E+06	1.17300E+06	1.664	1.607	-6.83542E-02		-6.42643E-02
		EDLUND :		1.52608E+06			1.432	1.291			
		WSC-2 :		2.11725E+06			1.986	1.912			
		EIGENE,NEU :		1.93707E+06			1.817	1.754			
LOKALES SIEDEN : 0.262 M, TB = 348.84											
3	0.26	336.41	159.12	1.6066E+06	9.3701E+05	3.5435E+04	2.5751E+05	8.4930E+05	348.84	360.38	348.84
		COLUMBIA-EPRI :		1.67571E+06	1.05218E+06	1.15455E+06	1.593	1.535	-4.85868E-02		-4.25426E-02
		EDLUND :		1.46387E+06			1.391	1.253			
		WSC-2 :		2.00439E+06			1.905	1.831			
		EIGENE,NEU :		1.83046E+06			1.740	1.675			
LOKALES SIEDEN : 0.350 M, TB = 348.80											
4	0.35	338.51	159.07	1.6263E+06	9.3741E+05	3.5751E+04	2.5921E+05	8.3376E+05	348.80	361.83	348.80
		COLUMBIA-EPRI :		1.58047E+06	1.03292E+06	1.12888E+06	1.530	1.472	-2.91394E-02		-2.12459E-02
		EDLUND :		1.40334E+06			1.359	1.223			
		WSC-2 :		1.89392E+06			1.834	1.760			
		EIGENE,NEU :		1.72648E+06			1.671	1.607			
LOKALES SIEDEN : 0.437 M, TB = 348.77											
5	0.44	340.49	159.02	1.6456E+06	9.3781E+05	3.6111E+04	2.6083E+05	8.1391E+05	348.77	363.03	348.77
		COLUMBIA-EPRI :		1.48730E+06	1.00834E+06	1.09616E+06	1.475	1.418	-1.01107E-02		-5.05159E-04
		EDLUND :		1.34416E+06			1.333	1.200			
		WSC-2 :		1.78549E+06			1.771	1.699			

	EIGENE,NEU :			1.62480E+06			1.611	1.548			
LOKALES SIEDEN :	0.525 M, TB =	348.73									
6	0.52	342.35	158.97	1.6642E+06	9.3820E+05	3.6518E+04	2.6235E+05	7.8987E+05	348.73	363.98	348.73
	COLUMBIA-EPRI :			1.39591E+06	9.78548E+05	1.05658E+06	1.427	1.371	8.40280E-03	1.95524E-02	
	EDLUND :			1.28600E+06			1.314	1.185			
	WSC-2 :			1.67879E+06			1.716	1.646			
	EIGENE,NEU :			1.52509E+06			1.559	1.497			
LOKALES SIEDEN :	0.612 M, TB =	348.69									
7	0.61	344.07	158.92	1.6820E+06	9.3860E+05	3.6981E+04	2.6376E+05	7.6175E+05	348.69	364.67	348.69
	COLUMBIA-EPRI :			1.30602E+06	9.43710E+05	1.01040E+06	1.384	1.331	2.63073E-02	3.88036E-02	
	EDLUND :			1.22858E+06			1.302	1.177			
	WSC-2 :			1.57351E+06			1.667	1.601			
	EIGENE,NEU :			1.42706E+06			1.512	1.453			
LOKALES SIEDEN :	0.700 M, TB =	348.65									
8	0.70	345.65	158.87	1.6990E+06	9.3900E+05	3.7505E+04	2.6507E+05	7.2969E+05	348.65	365.10	348.65
	COLUMBIA-EPRI :			1.21740E+06	9.04002E+05	9.57900E+05	1.347	1.296	4.35122E-02	5.71308E-02	
	EDLUND :			1.17160E+06			1.296	1.176			
	WSC-2 :			1.46937E+06			1.625	1.562			
	EIGENE,NEU :			1.33041E+06			1.472	1.416			
LOKALES SIEDEN :	0.787 M, TB =	348.60									
9	0.79	346.84	158.82	1.7151E+06	9.3940E+05	3.7988E+04	2.6606E+05	6.9388E+05	348.60	365.10	348.60
	COLUMBIA-EPRI :			1.12980E+06	8.59628E+05	8.99413E+05	1.314	1.266	5.99306E-02	7.44220E-02	
	EDLUND :			1.11478E+06			1.297	1.183			
	WSC-2 :			1.36610E+06			1.589	1.530			
	EIGENE,NEU :			1.23490E+06			1.437	1.384			
LOKALES SIEDEN :	0.875 M, TB =	348.55									
10	0.87	346.81	158.77	1.7300E+06	9.3979E+05	3.7981E+04	2.6605E+05	6.5448E+05	348.55	364.04	348.55
	COLUMBIA-EPRI :			1.04299E+06	8.10819E+05	8.35303E+05	1.286	1.242	7.54797E-02	9.05717E-02	
	EDLUND :			1.05781E+06			1.305	1.198			
	WSC-2 :			1.26344E+06			1.558	1.504			
	EIGENE,NEU :			1.14026E+06			1.406	1.357			
LOKALES SIEDEN :	0.962 M, TB =	348.50									
11	0.96	346.79	158.71	1.7439E+06	9.4019E+05	3.7975E+04	2.6603E+05	6.1170E+05	348.50	362.89	348.50
	COLUMBIA-EPRI :			9.56764E+05	7.57825E+05	7.65971E+05	1.263	1.222	9.00813E-02	0.10548	
	EDLUND :			1.00036E+06			1.320	1.222			
	WSC-2 :			1.16112E+06			1.532	1.483			
	EIGENE,NEU :			1.04625E+06			1.381	1.336			
LOKALES SIEDEN :	1.050 M, TB =	348.44									
12	1.05	346.76	158.66	1.7565E+06	9.4059E+05	3.7968E+04	2.6601E+05	5.6577E+05	348.44	361.66	348.44
	COLUMBIA-EPRI :			8.70907E+05	7.00920E+05	6.91850E+05	1.243	1.206	0.10366	0.11906	

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            EDLUND          :  9.42097E+05                                      1.344      1.258
            WSC-2           :  1.05890E+06                                      1.511      1.467
            EIGENE,NEU      :  9.52636E+05                                      1.359      1.319
LOKALES SIEDEN :       1.137 M, TB =     348.38
   13   1.14 346.73  158.61  1.7677E+06       9.4098E+05    3.7962E+04     2.6600E+05  5.1692E+05    348.38     360.35 348.38
            COLUMBIA-EPRI :  7.85214E+05   6.40398E+05   6.13405E+05    1.226      1.194                 0.11615         0.13123
            EDLUND          :  8.82599E+05                                      1.378      1.308
            WSC-2           :  9.56524E+05                                      1.494      1.456
            EIGENE,NEU      :  8.59178E+05                                      1.342      1.307
LOKALES SIEDEN :       1.225 M, TB =     348.31
   14   1.22 346.71  158.56  1.7776E+06       9.4138E+05    3.7956E+04     2.6598E+05  4.6540E+05    348.31     358.97 348.31
            COLUMBIA-EPRI :  6.99478E+05   5.76571E+05   5.31124E+05    1.213      1.186                 0.12750         0.14191
            EDLUND          :  8.21388E+05                                      1.425      1.377
            WSC-2           :  8.53737E+05                                      1.481      1.449
            EIGENE,NEU      :  7.65647E+05                                      1.328      1.299
LOKALES SIEDEN :       1.312 M, TB =     348.24
   15   1.31 346.68  158.51  1.7861E+06       9.4178E+05    3.7949E+04     2.6596E+05  4.1148E+05    348.24     357.53 348.24
            COLUMBIA-EPRI :  6.13499E+05   5.09769E+05   4.45523E+05    1.203      1.182                 0.13763         0.15105
            EDLUND          :  7.57864E+05                                      1.487      1.473
            WSC-2           :  7.50282E+05                                      1.472      1.448
            EIGENE,NEU      :  6.71811E+05                                      1.318      1.295
LOKALES SIEDEN :       1.400 M, TB =     348.16
   16   1.40 346.66  158.46  1.7930E+06       9.4217E+05    3.7943E+04     2.6595E+05  3.5543E+05    348.16     356.03 348.16
            COLUMBIA-EPRI :  5.27069E+05   4.40336E+05   3.57137E+05    1.197      1.181                 0.14651         0.15858
            EDLUND          :  6.91241E+05                                      1.570      1.609
            WSC-2           :  6.45896E+05                                      1.467      1.451
            EIGENE,NEU      :  5.77432E+05                                      1.311      1.295
LOKALES SIEDEN :       1.487 M, TB =     348.07
   17   1.49 346.63  158.41  1.7984E+06       9.4257E+05    3.7937E+04     2.6593E+05  2.9755E+05    348.07     354.48 348.07
            COLUMBIA-EPRI :  4.39982E+05   3.68631E+05   2.66518E+05    1.194      1.185                 0.15408         0.16446
            EDLUND          :  6.20433E+05                                      1.683      1.818
            WSC-2           :  5.40306E+05                                      1.466      1.458
            EIGENE,NEU      :  4.82271E+05                                      1.308      1.300
LOKALES SIEDEN :       1.575 M, TB =     347.96
   18   1.57 346.61  158.36  1.8022E+06       9.4297E+05    3.7930E+04     2.6591E+05  2.3814E+05    347.96     352.88 347.96
            COLUMBIA-EPRI :  3.52023E+05   2.95024E+05   1.74233E+05    1.193      1.191                 0.16032         0.16867
            EDLUND          :  5.43822E+05                                      1.843      2.182
            WSC-2           :  4.33228E+05                                      1.468      1.471
            EIGENE,NEU      :  3.86078E+05                                      1.309      1.308
LOKALES SIEDEN :       1.662 M, TB =     347.84
```

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   19   1.66 346.58  158.31  1.7991E+06        9.4261E+05   3.7924E+04      2.6590E+05  1.7749E+05   347.84    351.26 347.84
              COLUMBIA-EPRI :  2.62971E+05   2.19894E+05  1.74233E+05   1.196      0.0000E+00         0.16519          0.16867
              EDLUND        :  4.58731E+05                              2.086      0.0000E+00
              WSC-2         :  3.24359E+05                              1.475      0.0000E+00
              EIGENE,NEU    :  2.88593E+05                              1.312      0.0000E+00
LOKALES SIEDEN :       1.750 M, TB =      347.69
   20   1.75 346.55  158.26  1.8022E+06        9.4297E+05   3.7917E+04      2.6588E+05  1.1593E+05   347.69    349.61 347.69
              COLUMBIA-EPRI :  1.72595E+05   1.43629E+05  1.74233E+05   1.202      0.0000E+00         0.16867          0.16867
              EDLUND        :  3.59968E+05                              2.506      0.0000E+00
              WSC-2         :  2.13382E+05                              1.486      0.0000E+00
              EIGENE,NEU    :  1.89544E+05                              1.320      0.0000E+00
        NKD =     133
RC001 1 DATENSATZ

      NA =     72 ZEICHEN TITELZEILE:
              HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.     08.06.89  08.34.26
RC003 NR =   137 WOERTER REAL*4
RC004 NI =     8 WOERTER INTEGER*4
RC002 NEU GESCHRIEBEN
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6.2 SAMPLE 2, HOMOGENEOUS CORE, ARBITRARY AXIAL POWER DISTRIBUTION (KFK DESIGN)

CONTROL STATEMENTS AND INPUT:

```
Starting in column 1
↓
//PROJECT2 JOB (...,...,.....),....,MSGCLASS=A,TIME=(1,00)
//*
// EXEC PGM=HADA
//STEPLIB DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//*******************************************************************
//*
//*   ALLOCATE FILE 6 TO GET FORTRAN ERROR MESSAGES
//*
//FT06F001 DD DUMMY
//*T06F001 DD SYSOUT=*,
//*          DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//*******************************************************************
//*
//*            UNIT 8       DATA POOL FOR RESULT
//*
//FT08F001 DD DISP=(MOD,PASS),DSN=PROJECT.APWRD.DATA
//*******************************************************************
//**
//**           UNIT 9        MAIN RESULT
//**
//FT09F001 DD SYSOUT=*,
//           DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//FT10F001 DD SYSOUT=*,
//           DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//*******************************************************************
//**
//**           UNIT 47       PROBLEM IDENTIFICATION
//**
//FT47F001 DD *
HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.
//*******************************************************************
//**
//**           UNIT INP     COMMON PHYSICAL PARAMETERS
//**
//FT01F001 DD *
```

```
 &SYSTEM
 &END
3.765E9                      Q0 IN W
1.00,1.65,-1.0000,0.97       OP,FDH0,CDH,K'
0.0                          ALC FUER LR=1.1885*LC+0.02 OR LC + ALC
1.7E7,0.774                  N  IN W,       ETA (NEU 8.9.83)
158.26                       P20  IN BAR
326.12                       T20  IN GRD C
64.5                         POS  IN BAR
1.8800E4                     M0  IN KG/S
1.55927E8                    KF0  IN W/GRD C
291.14                       T10  IN GRD C
159.65                       P10  IN BAR
70.6                         HR  IN M
5.4D7                        NEL  IN W
89.6                         HT0  IN M
1.3E9                        NEL  IN W
//*****************************************************************
//**
//**          UNIT JNP       SPECIAL PHYSICAL PARAMETERS
//**
//FT02F001 DD *
11.8000E-3                   P  IN M
9.5E-3                       D  IN M                         2 REAL 9.9.83
-1.                          K0
.875052,-3.5                 K1,KL   LINEAR RATING
.904265                      K2
3.88910                      DEQ  IN M                       1 REAL 9.9.83
12,.4D-3,2.2D-3,.64D-3       NGI,SG,BG,SCLAD IN M
1.2,5.D-6                    KI,RK
//*****************************************************************
//**
//**          UNIT 05        SYSIN
//**
//G.FT05F001 DD *
1                            INP
2,1,1,1                      IOP1,IOP2,IOP3,IOP4 .,1,.,. HOMOGEN   <===
1,2                          IDR1,IDR2
2                            JNP                   2     HOMOGEN   <===
1.D-5,.5,20                  EPS,DMAX,IMAX
 &DNBR
 &END
-1.20                        PHIAX                         4 REAL 9.9.83
```

```
2.37D6                    K
1588.D3                   HO
2.3                       FQ                             7 REAL 9.9.83
.1                        K4
40                        NC
1.12                      OP
1.000,9.000,6.507,1.748,7.540,8.783  (JMP$,JMP2$,Q4)ALT,(Q1,Q2,Q4)NEU
2.07930                   FQN                            5 REAL 12.9.83
0.3606,0.4790,0.5921,0.6986,0.7974,0.8872,0.9671,1.037,1.094,1.131,
1.164,1.193,1.199,1.200,1.200,1.200,1.200,1.200,1.200,1.200,
1.200,1.200,1.200,1.200,1.200,1.200,1.200,1.199,1.193,1.164,
1.131,1.094,1.037,0.9671,0.8872,0.7974,0.6986,0.5921,0.4790,0.3606
0.3606,0.4790,0.5921,0.6986,0.7974,0.8872,0.9671,1.037,1.094,1.131,
1.164,1.193,1.199,1.200,1.200,1.200,1.200,1.200,1.200,1.200,
1.200,1.200,1.200,1.200,1.200,1.200,1.200,1.199,1.193,1.164,
1.131,1.094,1.037,0.9671,0.8872,0.7974,0.6986,0.5921,0.4790,0.3606
//
```

Main results (unit 09)

TITEL :

HOMOGENEOUS REACTOR - 24 CONTROL ROD PER ELEMENT.   24.07.89   15.30.59

Since the following six pages of outputs are the same as those of Sample 1, they are omitted here.

ERGEBNISSE

```
Q          =    3.76509E+09  W
K          =     1.0000
PS         =     64.502      BAR
TS         =     280.40      GRD C
P1         =     160.28      BAR
T1         =     291.16      GRD C
T2         =     326.76      GRD C
M          =     18361.      KG/S
NP         =    1.76098E+07  W
QNT        =    1.30066E+09  W
QNT/QELO   =     1.0005
```

*********** ZUSATZ 08.09.1983 *********

```
KS         =    0.97000      -
ETA        =    0.77400      -
MS         =     17810.      KG/S
NPEL       =    2.27517E+07  W
```

HOMOGENEOUS REACTOR WITH GRID SPACERS

```
LC         =     3.5000      M
LR         =     4.1798      M
T2U        =     337.25      GRD C
U          =     4.5450      M/S
RE         =    2.40061E+05
LAMBDA     =    2.07254E-02
DIST       =    0.37998
$K         =     1.1569      (=CV*EPS*EPS)
DP         =     2.0204      BAR
DPTOT      =     2.3309      BAR

DPP        =     6.9488      BAR
```

****

```
PRDH       =     1.0149
```

CDH	=	1.0000	

CHF-CALCULATIONS

LC	=	3.5000	M
T1	=	291.16	GRD C
RO1	=	745.63	KG/CBM
P1	=	160.28	BAR
H1	=	1.28915E+06	J/KG
T2	=	337.25	GRD
P2	=	158.26	BAR
ROQ	=	696.43	KG/CBM
U	=	4.5450	M/S
QL	=	12479.	W/M
D	=	9.50000E-03	M
DH	=	6.66148E-03	M
PZUD	=	1.2421	

EINGABEDATEN

FIAX	=	-1.2000	
AK	=	2.37000E+06	
H0	=	1.58800E+06	J/KG
FQ	=	2.3000	
K4	=	0.10000	
NC	=	40	
OP	=	1.1200	
Q10	=	1.0000	
Q20	=	9.0000	
Q40	=	6.5070	
Q1N	=	1.7480	
Q2N	=	7.5400	
Q4N	=	8.7830	
FQN	=	2.0793	

AXIAL POWER DISTRIBUTION IS GIVEN BY INPUT AS FOLLOWS:

	AXIAL DISTRIBUTION		DISTORTED BY CONTROL ROD	
POS.		CUMULATIVE		CUMULATIVE
1	3.60600E-01	3.60600E-01	3.60600E-01	3.60600E-01
2	4.79000E-01	8.39600E-01	4.79000E-01	8.39600E-01

3	5.92100E-01	1.43170E+00	5.92100E-01	1.43170E+00
4	6.98600E-01	2.13030E+00	6.98600E-01	2.13030E+00
5	7.97400E-01	2.92770E+00	7.97400E-01	2.92770E+00
6	8.87200E-01	3.81490E+00	8.87200E-01	3.81490E+00
7	9.67100E-01	4.78200E+00	9.67100E-01	4.78200E+00
8	1.03700E+00	5.81900E+00	1.03700E+00	5.81900E+00
9	1.09400E+00	6.91300E+00	1.09400E+00	6.91300E+00
10	1.13100E+00	8.04400E+00	1.13100E+00	8.04400E+00
11	1.16400E+00	9.20800E+00	1.16400E+00	9.20800E+00
12	1.19300E+00	1.04010E+01	1.19300E+00	1.04010E+01
13	1.19900E+00	1.16000E+01	1.19900E+00	1.16000E+01
14	1.20000E+00	1.28000E+01	1.20000E+00	1.28000E+01
15	1.20000E+00	1.40000E+01	1.20000E+00	1.40000E+01
16	1.20000E+00	1.52000E+01	1.20000E+00	1.52000E+01
17	1.20000E+00	1.64000E+01	1.20000E+00	1.64000E+01
18	1.20000E+00	1.76000E+01	1.20000E+00	1.76000E+01
19	1.20000E+00	1.88000E+01	1.20000E+00	1.88000E+01
20	1.20000E+00	2.00000E+01	1.20000E+00	2.00000E+01
21	1.20000E+00	2.12000E+01	1.20000E+00	2.12000E+01
22	1.20000E+00	2.24000E+01	1.20000E+00	2.24000E+01
23	1.20000E+00	2.36000E+01	1.20000E+00	2.36000E+01
24	1.20000E+00	2.48000E+01	1.20000E+00	2.48000E+01
25	1.20000E+00	2.60000E+01	1.20000E+00	2.60000E+01
26	1.20000E+00	2.72000E+01	1.20000E+00	2.72000E+01
27	1.20000E+00	2.84000E+01	1.20000E+00	2.84000E+01
28	1.19900E+00	2.95990E+01	1.19900E+00	2.95990E+01
29	1.19300E+00	3.07920E+01	1.19300E+00	3.07920E+01
30	1.16400E+00	3.19560E+01	1.16400E+00	3.19560E+01
31	1.13100E+00	3.30870E+01	1.13100E+00	3.30870E+01
32	1.09400E+00	3.41810E+01	1.09400E+00	3.41810E+01
33	1.03700E+00	3.52180E+01	1.03700E+00	3.52180E+01
34	9.67100E-01	3.61851E+01	9.67100E-01	3.61851E+01
35	8.87200E-01	3.70723E+01	8.87200E-01	3.70723E+01
36	7.97400E-01	3.78697E+01	7.97400E-01	3.78697E+01
37	6.98600E-01	3.85683E+01	6.98600E-01	3.85683E+01
38	5.92100E-01	3.91604E+01	5.92100E-01	3.91604E+01
39	4.79000E-01	3.96394E+01	4.79000E-01	3.96394E+01
40	3.60600E-01	4.00000E+01	3.60600E-01	4.00000E+01

FIAXA =1.2000000000000006 (AXIAL FORM FACTOR (PEAK/AVERAGE))

FIAXB =1.2000000000000006 (AXIAL FORM FACTOR (PEAK/AVERAGE) WITH CONTROL RODS)

ERGEBNISSE

```
RLCR   =     3.500
V1     =    0.70000E+00 WSC-2
CG'    =    0.80219E+00 COLUMBIA-EPRI
V2     =    0.85680E+00 EIGENE,NEU
```

OVERPOWER FACTOR : 1.0000

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
1	0.04	291.57	299.53	6.028E+06	20.86	20.86	1.114E+07	38.55	38.55	6.370E+06	22.04	22.04	6.373E+06	22.05	22.05
2	0.13	292.53	303.09	5.695E+06	14.83	14.83	6.539E+06	17.03	17.03	6.031E+06	15.71	15.71	5.955E+06	15.51	15.51
3	0.22	293.75	306.78	5.334E+06	11.24	11.24	5.114E+06	10.78	10.78	5.649E+06	11.90	11.90	5.524E+06	11.64	11.64
4	0.31	295.21	310.56	5.006E+06	8.94	8.94	4.342E+06	7.75	7.75	5.297E+06	9.46	9.46	5.140E+06	9.18	9.18
5	0.39	296.89	314.39	4.707E+06	7.37	7.37	3.830E+06	5.99	5.99	4.975E+06	7.79	7.79	4.795E+06	7.50	7.50
6	0.48	298.77	318.19	4.432E+06	6.23	6.23	3.453E+06	4.86	4.86	4.678E+06	6.58	6.58	4.483E+06	6.30	6.30
7	0.57	300.82	321.94	4.176E+06	5.39	5.39	3.156E+06	4.07	4.07	4.402E+06	5.68	5.68	4.197E+06	5.41	5.41
8	0.66	303.01	325.61	3.937E+06	4.74	4.74	2.914E+06	3.51	3.51	4.145E+06	4.99	4.99	3.933E+06	4.73	4.73
9	0.74	305.32	329.09	3.709E+06	4.23	4.23	2.706E+06	3.09	3.09	3.900E+06	4.45	4.45	3.684E+06	4.20	4.20
10	0.83	307.70	332.21	3.478E+06	3.84	3.84	2.516E+06	2.78	2.78	3.653E+06	4.03	4.03	3.436E+06	3.79	3.79
11	0.92	310.13	335.27	3.274E+06	3.51	3.51	2.357E+06	2.53	2.53	3.435E+06	3.68	3.68	3.219E+06	3.45	3.45
12	1.01	312.58	338.26	3.091E+06	3.23	3.23	2.222E+06	2.32	2.32	3.240E+06	3.39	3.39	3.026E+06	3.17	3.17
13	1.09	315.03	340.76	2.895E+06	3.01	3.01	2.087E+06	2.17	2.17	3.032E+06	3.16	3.16	2.823E+06	2.94	2.94
14	1.18	317.45	343.11	2.718E+06	2.83	2.83	1.969E+06	2.05	2.05	2.844E+06	2.96	2.96	2.639E+06	2.74	2.74
15	1.27	319.83	345.39	2.560E+06	2.66	2.66	1.867E+06	1.94	1.94	2.677E+06	2.78	2.78	2.477E+06	2.58	2.58
16	1.36	322.17	347.63	2.420E+06	2.52	2.52	1.778E+06	1.85	1.85	2.529E+06	2.63	2.63	2.335E+06	2.43	2.43
17	1.44	324.47	349.00	2.296E+06	2.39	2.39	1.700E+06	1.77	1.77	2.398E+06	2.49	2.49	2.208E+06	2.30	2.30
18	1.53	326.71	348.98	2.183E+06	2.27	2.27	1.631E+06	1.70	1.70	2.279E+06	2.37	2.37	2.095E+06	2.18	2.18
19	1.62	328.91	348.96	2.082E+06	2.17	2.17	1.569E+06	1.63	1.63	2.173E+06	2.26	2.26	1.993E+06	2.07	2.07
20	1.71	331.06	348.93	1.990E+06	2.07	2.07	1.514E+06	1.57	1.57	2.076E+06	2.16	2.16	1.901E+06	1.98	1.98
21	1.79	333.15	348.91	1.906E+06	1.98	1.98	1.463E+06	1.52	1.52	1.987E+06	2.07	2.07	1.817E+06	1.89	1.89
22	1.88	335.19	348.88	1.829E+06	1.90	1.90	1.417E+06	1.47	1.47	1.906E+06	1.98	1.98	1.740E+06	1.81	1.81
23	1.97	337.16	348.86	1.758E+06	1.83	1.83	1.375E+06	1.43	1.43	1.832E+06	1.90	1.90	1.670E+06	1.74	1.74
24	2.06	339.08	348.83	1.693E+06	1.76	1.76	1.336E+06	1.39	1.39	1.763E+06	1.83	1.83	1.605E+06	1.67	1.67
25	2.14	340.93	348.81	1.632E+06	1.70	1.70	1.300E+06	1.35	1.35	1.699E+06	1.77	1.77	1.545E+06	1.61	1.61
26	2.23	342.71	348.79	1.576E+06	1.64	1.64	1.267E+06	1.32	1.32	1.640E+06	1.71	1.71	1.489E+06	1.55	1.55
27	2.32	344.41	348.76	1.523E+06	1.58	1.58	1.235E+06	1.28	1.28	1.585E+06	1.65	1.65	1.438E+06	1.49	1.49
28	2.41	346.04	348.74	1.473E+06	1.53	1.53	1.206E+06	1.25	1.25	1.532E+06	1.59	1.59	1.389E+06	1.45	1.45
29	2.49	346.85	348.71	1.421E+06	1.49	1.49	1.175E+06	1.23	1.23	1.478E+06	1.55	1.55	1.338E+06	1.40	1.40
30	2.58	346.83	348.67	1.350E+06	1.45	1.45	1.134E+06	1.22	1.22	1.404E+06	1.51	1.51	1.269E+06	1.36	1.36
31	2.67	346.80	348.64	1.280E+06	1.41	1.41	1.094E+06	1.21	1.21	1.331E+06	1.47	1.47	1.202E+06	1.33	1.33
32	2.76	346.77	348.60	1.211E+06	1.38	1.38	1.053E+06	1.20	1.20	1.258E+06	1.44	1.44	1.135E+06	1.29	1.29
33	2.84	346.75	348.55	1.127E+06	1.36	1.36	1.004E+06	1.21	1.21	1.171E+06	1.41	1.41	1.055E+06	1.27	1.27
34	2.93	346.72	348.49	1.035E+06	1.34	1.34	9.499E+05	1.23	1.23	1.075E+06	1.39	1.39	9.671E+05	1.25	1.25
35	3.02	346.70	348.43	9.381E+05	1.32	1.32	8.918E+05	1.25	1.25	9.746E+05	1.37	1.37	8.752E+05	1.23	1.23

36	3.11	346.67	348.36	8.359E+05	1.31	1.31	8.289E+05	1.30	1.30	8.683E+05	1.36	1.36	7.784E+05	1.22	1.22
37	3.19	346.64	348.28	7.284E+05	1.30	1.30	7.608E+05	1.36	1.36	7.566E+05	1.35	1.35	6.772E+05	1.21	1.21
38	3.28	346.62	348.19	6.160E+05	1.30	1.30	6.865E+05	1.45	1.45	6.399E+05	1.35	1.35	5.717E+05	1.20	1.20
39	3.37	346.59	348.09	4.989E+05	1.30	1.30	6.045E+05	1.57	1.57	5.183E+05	1.35	1.35	4.623E+05	1.20	1.20
40	3.46	346.57	347.96	3.773E+05	1.31	1.31	5.122E+05	1.77	1.77	3.920E+05	1.36	1.36	3.490E+05	1.21	1.21

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
***************		***********	*********	***			
COLUMBIA-EPRI	:	1.2982	3.2812	38	1.2982	3.2812	38
EDLUND	:	1.2013	2.7562	32	1.2013	2.7562	32
WSC-2	:	1.3485	3.2812	38	1.3485	3.2812	38
EIGENE,NEU	:	1.2043	3.3687	39	1.2043	3.3687	39

X$ = 0.10283 X$ = 0.10283

OVERPOWER FACTOR : 1.1200

POS	X	T(X)	TW	COLUMBIA-EPRI			EDLUND			WSC-2			EIGENE,NEU		
				CHF	SM	SMLWR	CHF	SM	SMLWR	CHF	SM	SMLWR	CHF	SM	SMLWR
1	0.04	291.62	300.53	6.032E+06	18.64	18.64	1.114E+07	34.42	34.42	6.370E+06	19.68	19.68	6.373E+06	19.69	19.69
2	0.13	292.69	304.52	5.702E+06	13.26	13.26	6.539E+06	15.21	15.21	6.031E+06	14.03	14.03	5.955E+06	13.85	13.85
3	0.22	294.06	308.65	5.343E+06	10.05	10.05	5.114E+06	9.62	9.62	5.649E+06	10.63	10.63	5.524E+06	10.39	10.39
4	0.31	295.69	312.88	5.015E+06	8.00	8.00	4.342E+06	6.92	6.92	5.297E+06	8.45	8.45	5.140E+06	8.20	8.20
5	0.39	297.57	317.15	4.716E+06	6.59	6.59	3.830E+06	5.35	5.35	4.975E+06	6.95	6.95	4.795E+06	6.70	6.70
6	0.48	299.67	321.40	4.440E+06	5.58	5.58	3.453E+06	4.34	4.34	4.678E+06	5.87	5.87	4.483E+06	5.63	5.63
7	0.57	301.95	325.58	4.184E+06	4.82	4.82	3.156E+06	3.64	3.64	4.402E+06	5.07	5.07	4.197E+06	4.83	4.83
8	0.66	304.39	329.66	3.945E+06	4.24	4.24	2.914E+06	3.13	3.13	4.145E+06	4.45	4.45	3.933E+06	4.23	4.23
9	0.74	306.96	333.53	3.716E+06	3.78	3.78	2.706E+06	2.76	2.76	3.900E+06	3.97	3.97	3.684E+06	3.75	3.75
10	0.83	309.60	336.98	3.485E+06	3.43	3.43	2.516E+06	2.48	2.48	3.653E+06	3.60	3.60	3.436E+06	3.39	3.39
11	0.92	312.28	340.36	3.280E+06	3.14	3.14	2.357E+06	2.26	2.26	3.435E+06	3.29	3.29	3.219E+06	3.08	3.08
12	1.01	315.00	343.66	3.097E+06	2.89	2.89	2.222E+06	2.08	2.08	3.240E+06	3.03	3.03	3.026E+06	2.83	2.83
13	1.09	317.70	346.39	2.901E+06	2.70	2.70	2.087E+06	1.94	1.94	3.032E+06	2.82	2.82	2.823E+06	2.62	2.62
14	1.18	320.35	348.95	2.723E+06	2.53	2.53	1.969E+06	1.83	1.83	2.844E+06	2.64	2.64	2.639E+06	2.45	2.45
15	1.27	322.96	349.10	2.565E+06	2.38	2.38	1.867E+06	1.73	1.73	2.677E+06	2.49	2.49	2.477E+06	2.30	2.30
16	1.36	325.51	349.08	2.425E+06	2.25	2.25	1.778E+06	1.65	1.65	2.529E+06	2.35	2.35	2.335E+06	2.17	2.17
17	1.44	328.00	349.06	2.301E+06	2.14	2.14	1.700E+06	1.58	1.58	2.398E+06	2.23	2.23	2.208E+06	2.05	2.05
18	1.53	330.42	349.03	2.188E+06	2.03	2.03	1.631E+06	1.51	1.51	2.279E+06	2.12	2.12	2.095E+06	1.94	1.94
19	1.62	332.78	349.01	2.087E+06	1.94	1.94	1.569E+06	1.46	1.46	2.173E+06	2.02	2.02	1.993E+06	1.85	1.85
20	1.71	335.07	348.98	1.995E+06	1.85	1.85	1.514E+06	1.41	1.41	2.076E+06	1.93	1.93	1.901E+06	1.76	1.76
21	1.79	337.29	348.96	1.910E+06	1.77	1.77	1.463E+06	1.36	1.36	1.987E+06	1.84	1.84	1.817E+06	1.69	1.69
22	1.88	339.42	348.94	1.833E+06	1.70	1.70	1.417E+06	1.32	1.32	1.906E+06	1.77	1.77	1.740E+06	1.62	1.62
23	1.97	341.48	348.91	1.762E+06	1.64	1.64	1.375E+06	1.28	1.28	1.832E+06	1.70	1.70	1.670E+06	1.55	1.55
24	2.06	343.44	348.89	1.696E+06	1.57	1.57	1.336E+06	1.24	1.24	1.763E+06	1.64	1.64	1.605E+06	1.49	1.49
25	2.14	345.31	348.86	1.636E+06	1.52	1.52	1.300E+06	1.21	1.21	1.699E+06	1.58	1.58	1.545E+06	1.43	1.43
26	2.23	346.93	348.84	1.579E+06	1.47	1.47	1.267E+06	1.18	1.18	1.640E+06	1.52	1.52	1.489E+06	1.38	1.38
27	2.32	346.90	348.82	1.526E+06	1.42	1.42	1.235E+06	1.15	1.15	1.585E+06	1.47	1.47	1.438E+06	1.33	1.33
28	2.41	346.88	348.79	1.476E+06	1.37	1.37	1.206E+06	1.12	1.12	1.532E+06	1.42	1.42	1.389E+06	1.29	1.29
29	2.49	346.85	348.76	1.424E+06	1.33	1.33	1.175E+06	1.10	1.10	1.478E+06	1.38	1.38	1.338E+06	1.25	1.25
30	2.58	346.83	348.73	1.353E+06	1.30	1.30	1.134E+06	1.09	1.09	1.404E+06	1.34	1.34	1.269E+06	1.22	1.22
31	2.67	346.80	348.69	1.283E+06	1.26	1.26	1.094E+06	1.08	1.08	1.331E+06	1.31	1.31	1.202E+06	1.18	1.18
32	2.76	346.77	348.65	1.214E+06	1.24	1.24	1.053E+06	1.07	1.07	1.258E+06	1.28	1.28	1.135E+06	1.16	1.16
33	2.84	346.75	348.60	1.129E+06	1.21	1.21	1.004E+06	1.08	1.08	1.171E+06	1.26	1.26	1.055E+06	1.13	1.13
34	2.93	346.72	348.54	1.037E+06	1.20	1.20	9.499E+05	1.09	1.09	1.075E+06	1.24	1.24	9.671E+05	1.11	1.11
35	3.02	346.70	348.48	9.405E+05	1.18	1.18	8.918E+05	1.12	1.12	9.746E+05	1.22	1.22	8.752E+05	1.10	1.10

36	3.11	346.67	348.41	8.380E+05	1.17	1.17	8.289E+05	1.16	1.16	8.683E+05	1.21	1.21	7.784E+05	1.09	1.09
37	3.19	346.64	348.33	7.302E+05	1.16	1.16	7.608E+05	1.21	1.21	7.566E+05	1.21	1.21	6.772E+05	1.08	1.08
38	3.28	346.62	348.24	6.176E+05	1.16	1.16	6.865E+05	1.29	1.29	6.399E+05	1.20	1.20	5.717E+05	1.08	1.08
39	3.37	346.59	348.13	5.003E+05	1.16	1.16	6.045E+05	1.41	1.41	5.183E+05	1.21	1.21	4.623E+05	1.08	1.08
40	3.46	346.57	348.00	3.783E+05	1.17	1.17	5.122E+05	1.58	1.58	3.920E+05	1.21	1.21	3.490E+05	1.08	1.08

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
***************		***********	*********	***			
COLUMBIA-EPRI	:	1.1622	3.2812	38	1.1622	3.2812	38
EDLUND	:	1.0726	2.7562	32	1.0726	2.7562	32
WSC-2	:	1.2040	3.2812	38	1.2040	3.2812	38
EIGENE,NEU	:	1.0752	3.3687	39	1.0752	3.3687	39

X$ = 0.16028 X$ = 0.16028

6.3 SAMPLE 3, MULTIPLE STACKED CORE (JAERI DESIGN)

CONTROL STATEMENTS AND INPUT:

```
Starting in column 1
↓
//PROJECT3 JOB (....,...,.....),....,MSGCLASS=A,TIME=2
// EXEC PGM=HADA
//STEPLIB  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//*******************************************************************
//FT06F001 DD DUMMY
//FT08F001 DD DSN=PROJECT.APWRD.DATA,DISP=(MOD,PASS)
//FT09F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//FT10F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=3857,RECFM=FBA)
//*******************************************************************
//**
//**          UNIT 47       PROBLEM IDENTIFICATION
//**
//FT47F001 DD *
2-FLAT, HC=.5M,HIB=HOB=.3M,QLB:QLC=0.07,QLC=20,P=1.30
//*******************************************************************
//**
//**          UNIT INP      COMMON PHYSICAL PARAMETERS
//**
//FT01F001 DD *   ( INP )
 &SYSTEM
  PC0=210.88,PC1=-23.163,PC2=0.,
  SG1=0.7,SG2=0.1,SG3=0.23,SG4=0.2,SG5=0.8,
  NLP=3
 &END
2.587E9                   Q0 IN W
1.00,1.60,1.0000,0.95     OP,FDHO,CDH,K'
0.500                     ALC FUER LR= LC+ALC
1.7E7,0.774               N  IN W,       ETA (NEU 8.9.83)
155.00                    P20  IN BAR
325.00                    T20  IN GRD C
61.3                      P0S  IN BAR
1.2525E4                  M0  IN KG/S
0.98397E8                 KF0  IN W/GRD C
289.00                    T10  IN GRD C
```

```
156.86                    P10  IN BAR
56.0                      HR  IN M
5.4D7                     NEL  IN W
81.3                      HT0  IN M
1.3E9                     NEL  IN W
//******************************************************************
//**
//**          UNIT JNP     SPECIAL PHYSICAL PARAMETERS
//**
//FT02F001 DD *     ( JNP )
13.0-3                    P  IN M
9.5E-3                    D  IN M                         2 REAL 9.9.83
-1.                       K0
.87103   ,-1.9            K1,KL   LIMITAZIONE DELLA POTENZA
.36700                    K2
5.02420                   DEQ  IN M                       1 REAL 9.9.83
7  0.6957 95.39  .655D-3  H/D OR NGI,SG,BG,SCLAD IN M
1.2,5.D-6                 KI,RK
//******************************************************************
//**
//**          UNIT 05      SYSIN
//**
//FT05F001 DD *
1                         INP
2,1,1,1                   IOP1,IOP2,IOP3,IOP4 .,1,.,. HOMOGEN   <===
1,2                       IDR1,IDR2
2                         JNP                 2      HOMOGEN   <===
1.D-5,.5,20               EPS,DMAX,IMAX
 &DNBR
  FIAX=1.2,
    FQ=1.92,
   AK4=0.0,
    OP=1.12,
   FQN=1.92,
   RR1=0.6,
   RR2=0.6,
   RR3=0.07,
   FIAX2=0.2,
   NAC=2,
   NC=10,
   IBLT=1
 &END
 //
```

Main results (unit 09)

TITEL :

2-FLAT, HC=.5M,HIB=HOB=.3M,QLB:QLC=0.07,QLC=20,P=1.30 08.06.89 08.31.18

```
EINGABEPARAMETER

Q0      =     2.58700E+09  W
POS     =      61.300      BAR
P20     =      155.00      BAR
T20     =      325.00      GRD C
KF0     =     9.83970E+07  WATT/GRD
N       =     1.70000E+07  WATT
P10     =      156.86      BAR
M0      =      12525.      KG/S
FDH0    =      1.6000
CDH     =      1.0000
OPF     =      1.0000
T10     =      289.00      GRD C
HR      =      56.000      M
NEL     =     5.40000E+07  W
ALC     =     0.50000      M

CONSTANT PUMP CHARACTERISTICS
    HT =  210.88 + ( -23.16 -     0.00 * V ) * V
    WHERE  V = M / RO / 3

KF IS CALCULATED AS
    KF = KF0 / (0.700 + 0.100*(Q/Q0)**0.230 + 0.200*(M0/M)**0.800

EPSI = 0.36183499999999996

P       =     1.30000E-02  M
D       =     9.50000E-03  M
DH      =     1.01157E-02  M
K0      =     -1.0000
K1      =     0.87103
K2      =     0.36700
DEQ     =      5.0242      M
H/D     =     0.00000E+00
KI      =      1.2000
RK      =     5.00000E-06  M
P/D     =      1.3684
B       =     0.00000E+00  M
KL      =      1.0000      -         12.09.1983
```

```
 RLC     =      1.9000      M
 RLR     =      2.4000      M
 AT      =      17.269      QM
 NT      =     117988
 VM/VROD  =       1.1770      CORE,        1.0648      CELL
 VM/VFUEL =       1.5837      CORE,        1.4327      CELL
NGI=7

 HOMOGENEOUS REACTOR
 EPS     =     1.00000E-03  %
 DELTA   =      50.000      %
```

ANFANGSWERTE

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	***********	***********
K	1	-	1.0000	0.00000E+00
Q	2	W	6.14963E+10	0.00000E+00
T1	3	GRD C	289.00	0.00000E+00
RO1	4	KG/CBM	749.11	0.00000E+00
P1	5	BAR	156.86	0.00000E+00
H1	6	J/KG	1.27806E+06	0.00000E+00
T2	7	GRD C	325.00	0.00000E+00
RO2	8	KG/CBM	666.87	0.00000E+00
H2	9	J/KG	1.48361E+06	0.00000E+00
TS	10	GRD C	277.04	0.00000E+00
PS	11	BAR	61.300	0.00000E+00
TQ	12	GRD C	307.00	0.00000E+00
ROQ	13	KG/CBM	712.35	0.00000E+00
PQ	14	BAR	155.93	0.00000E+00
M	15	KG/S	12586.	0.00000E+00
KF	16	W/GRD	9.84737E+07	0.00000E+00
HT	17	M	81.155	0.00000E+00
HC	18	M	24.607	0.00000E+00
DP	19	BAR	1.8600	0.00000E+00
Y	20	-	1.3614	0.00000E+00
TSU	21	GRD C	330.10	0.00000E+00
RO2U	22	KG/CBM	651.53	0.00000E+00
H2U	23	J/KG	1.51722E+06	0.00000E+00
TQU	24	GRD C	307.00	0.00000E+00
ROQU	25	KG/CBM	712.35	0.00000E+00
NY	26	QM/S	1.26081E-07	0.00000E+00
U	27	M/S	1.7052	0.00000E+00
RE	28	-	1.36808E+05	0.00000E+00
LAM	29	-	1.86916E-02	0.00000E+00

ITER =	0	ABS :	5.88771E+10	2	*** REL :	0.50000	19
ITER =	1	ABS :	2.81220E+10	2	*** REL :	0.50000	19
ITER =	2	ABS :	1.27349E+10	2	*** REL :	0.50000	2
ITER =	3	ABS :	5.03089E+09	2	*** REL :	0.50000	2
ITER =	4	ABS :	1.17313E+09	2	*** REL :	0.30522	2
ITER =	5	ABS :	3.48161E+06	2	*** REL :	4.21872E-03	20
ITER =	6	ABS :	9447.4	2	*** REL :	2.74205E-05	28

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	************	************
K	1	-	1.0336	-2.72589E-10
Q	2	W	2.67387E+09	-0.70519
T1	3	GRD C	292.69	-5.19827E-08
RO1	4	KG/CBM	741.83	2.87409E-07
P1	5	BAR	155.24	2.19501E-08
H1	6	J/KG	1.29755E+06	-3.45383E-04
T2	7	GRD C	326.77	-2.13613E-08
RO2	8	KG/CBM	661.71	6.33334E-08
H2	9	J/KG	1.49508E+06	-1.40312E-04
TS	10	GRD C	279.22	-1.82042E-08
PS	11	BAR	63.358	-1.67097E-08
TQ	12	GRD C	309.73	-3.66720E-08
ROQ	13	KG/CBM	705.98	-8.94607E-07
PQ	14	BAR	155.12	1.09751E-08
M	15	KG/S	13536.	-1.50404E-05
KF	16	W/GRD	9.95201E+07	-1.61981E-02
HT	17	M	69.992	2.11037E-07
HC	18	M	3.3443	3.00433E-07
DP	19	BAR	0.24329	2.19501E-08
Y	20	-	1.2608	1.43975E-09
TSU	21	GRD C	331.58	-2.15431E-08
RO2U	22	KG/CBM	646.75	7.04383E-08
H2U	23	J/KG	1.52739E+06	-1.49989E-04
TQU	24	GRD C	312.14	-3.67629E-08
ROQU	25	KG/CBM	700.36	1.37741E-06
NY	26	QM/S	1.26098E-07	-2.32629E-16
U	27	M/S	1.8653	-5.73822E-09
RE	28	-	1.49638E+05	-8.09950E-02
LAM	29	-	2.04335E-02	1.20459E-09

```
 IPOW=1     PRDH= 1.0000000000000000
ITER =    7 ABS :     3.41277E+07     2 *** REL :      1.27634E-02   11
ITER =    8 ABS :      59273.         2 *** REL :      2.10048E-04   28
ITER =    9 ABS :      65.893         2 *** REL :      4.32998E-05   28
```

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	***********	***********
K	1	-	1.0204	-7.02459E-10
Q	2	W	2.63968E+09	-1.8173
T1	3	GRD C	291.61	-7.92420E-08
RO1	4	KG/CBM	743.92	-6.56283E-07
P1	5	BAR	155.24	1.22440E-08
H1	6	J/KG	1.29182E+06	-1.29763E-04
T2	7	GRD C	325.41	-8.55853E-09
RO2	8	KG/CBM	665.70	2.47527E-08
H2	9	J/KG	1.48623E+06	-5.52195E-05
TS	10	GRD C	278.37	-4.53756E-08
PS	11	BAR	62.548	-4.30608E-08
TQ	12	GRD C	308.51	-4.39003E-08
ROQ	13	KG/CBM	708.78	6.41730E-07
PQ	14	BAR	155.12	6.12198E-09
M	15	KG/S	13578.	-1.45410E-05
KF	16	W/GRD	9.95969E+07	-1.45885E-02
HT	17	M	69.952	2.65906E-08
HC	18	M	3.3422	1.70797E-07
DP	19	BAR	0.24382	1.22440E-08
Y	20	-	1.2676	3.33805E-09
TSU	21	GRD C	330.21	-6.37262E-09
RO2U	22	KG/CBM	651.15	2.02275E-08
H2U	23	J/KG	1.51802E+06	-4.32661E-05
TQU	24	GRD C	310.91	-4.28073E-08
ROQU	25	KG/CBM	703.25	-1.59248E-06
NY	26	QM/S	1.26077E-07	3.03138E-16
U	27	M/S	1.8634	2.22415E-09
RE	28	-	1.49509E+05	2.08415E-04
LAM	29	-	2.04354E-02	2.26750E-13

IPOW=2   PRDH= 1.0335781062109666

ITER = 10 ABS :   5.07065E+07   2 *** REL :   1.92093E-02   2

ITER = 11 ABS :   1.23400E+05   2 *** REL :   1.87030E-04   28

ITER = 12 ABS :   161.65   2 *** REL :   9.53559E-05   28

LOESUNGSVEKTOR UND ERREICHTE GENAUIGKEIT

NAME	NR	EINHEIT	WERT	ZUWACHS
****	**	*******	***********	***********
K	1	-	1.0007	-2.24468E-11
Q	2	W	2.58885E+09	-5.80700E-02
T1	3	GRD C	289.99	-6.50301E-09
RO1	4	KG/CBM	746.99	-3.29096E-07
P1	5	BAR	155.24	-5.52303E-09
H1	6	J/KG	1.28331E+06	8.14782E-05
T2	7	GRD C	323.35	5.82203E-09
RO2	8	KG/CBM	671.54	-1.62522E-08
H2	9	J/KG	1.47310E+06	3.69036E-05
TS	10	GRD C	277.09	-1.47770E-09
PS	11	BAR	61.344	-1.37599E-09
TQ	12	GRD C	306.67	-3.40492E-10
ROQ	13	KG/CBM	712.91	8.18196E-07
PQ	14	BAR	155.12	-2.76152E-09
M	15	KG/S	13640.	2.92777E-06
KF	16	W/GRD	9.97109E+07	3.29413E-03
HT	17	M	69.893	-9.23769E-08
HC	18	M	3.3391	-7.38885E-08
DP	19	BAR	0.24461	-5.52303E-09
Y	20	-	1.2773	5.51097E-10
TSU	21	GRD C	328.15	4.37420E-09
RO2U	22	KG/CBM	657.58	-1.33137E-08
H2U	23	J/KG	1.50414E+06	2.91001E-05
TQU	24	GRD C	309.07	-1.06441E-09
ROQU	25	KG/CBM	707.51	-1.32215E-06
NY	26	QM/S	1.26067E-07	2.35920E-16
U	27	M/S	1.8606	3.87642E-09
RE	28	-	1.49298E+05	-5.01854E-04
LAM	29	-	2.04386E-02	2.38139E-11

CONVERGENCE REACHED AFTER 3 ITERATIONS OVER THE REACTOR POWER: PRDH = 1.085319

NZT	=	5	: NUMBER OF ZONE
RLIC	=	0.50000	: INNER CORE HEIGHT (M)
RLIB	=	0.30000	: INNER BLANKET HEIGHT (M)
RLB	=	0.30000	: OUTER BLANKET HEIGHT (M)

```
 QLC     =      20241.       : LINEAR HEAT IN CORE ( W/M )
 QLB     =      1416.9       : LINEAR HEAT IN OUTER BLANKET ( W/M )
 RR      =      1.0000       : QLIB/2 / QLB
 RRR1    =      24290.       : QLC * FIAX
 RRR2    =      2850.5       : LOG(FIAX2) / (FIAX2-1) * QLB
 RRR     =      1.6765       : LOG(FIAX2) / (FIAX2-1) / FIAX
RPOWER 1.93726937269372715E-02 0.48062730627306277 0.51937269372693730 0.98062730627306280 1.0000000000000000

*** ICICL =  1:   CDH =1.0000      DNBR =2.3218     AT X =1.6000     POS.  32

*** CONVERGENCE REACHED: NO MORE ITERATIONS NEEDED
```

```
ERGEBNISSE

Q        =     2.58885E+09  W
K        =      1.0007
PS       =      61.344      BAR
TS       =      277.09      GRD C
P1       =      155.24      BAR
T1       =      289.99      GRD C
T2       =      323.35      GRD C
M        =      13640.      KG/S
NP       =     1.59161E+07  W
QNT      =     8.68752E+08  W
QNT/QELO =     0.66827

*********** ZUSATZ 08.09.1983 *********

KS       =     0.95000      -
ETA      =     0.77400      -
MS       =      12958.      KG/S
NPEL     =     2.05634E+07  W

HOMOGENEOUS REACTOR WITH GRID SPACERS

LC       =      1.9000      M
LR       =      2.4000      M
T2U      =      328.15      GRD C
U        =      1.8606      M/S
RE       =     1.49298E+05
LAMBDA   =     2.04386E-02
DIST     =     0.40000
$K       =      1.9891      (=CV*EPS*EPS)
DP       =     0.24461      BAR
DPTOT    =     0.41428      BAR

DPP      =      5.1200      BAR

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PRDH     =      1.0853
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CDH     =       1.0000

CHF-CALCULATIONS

LC      =       1.9000       M
T1      =       289.99       GRD C
RO1     =       746.99       KG/CBM
P1      =       155.24       BAR
H1      =     1.28331E+06    J/KG
T2      =       328.15       GRD
P2      =       155.00       BAR
ROQ     =       707.51       KG/CBM
U       =       1.8606       M/S
QL      =       11548.       W/M
D       =     9.50000E-03    M
DH      =     1.01157E-02    M
PZUD    =       1.3684

EINGABEDATEN

FIAX    =       1.2000
AK      =     2.37000E+06
HO      =     1.58800E+06    J/KG
FQ      =       1.9200
K4      =     0.00000E+00
NC      =          10
OP      =       1.1200
Q1O     =       1.0000
Q2O     =       9.1570
Q4O     =       6.5070
Q1N     =       1.7480
Q2N     =       7.5400
Q4N     =       8.7830
FQN     =       1.9200

***** FLAT CORE ( JAERI) *****

NAC     =           2        : NUMBER OF CORE
IBLT    =           1
RR1     =     0.60000        : RLIB / RLIC
```

```
RR2     =     0.60000       : RLB / RLIC
RR3     =     7.00000E-02   : QLB / QLC
FIAX2   =     0.20000       : PARAMETER FOR BLANKET POWER DISTRIBUTION

NZT     =         5         : NUMBER OF ZONE
RLIC    =     0.50000       : INNER CORE HEIGHT ( M )
RLIB    =     0.30000       : INNER BLANKET HEIGHT ( M )
RLB     =     0.30000       : OUTER BLANKET HEIGHT ( M )
QLC     =      20241.       : LINEAR HEAT IN CORE ( W/M )
QLB     =      1416.9       : LINEAR HEAT IN OUTER BLANKET ( W/M )
RR      =      1.0000       : QLIB/2 / QLB
RRR1    =      24290.       : QLC * FIAX
RRR2    =      2850.5       : LOG(FIAX2) / (FIAX2-1) * QLB
RRR     =      1.6765       : LOG(FIAX2) / (FIAX2-1) / FIAX
RPOWER 1.937269372693727l5E-02 0.48062730627306277 0.51937269372693730 0.98062730627306280 1.0000000000000000

ERGEBNISSE

X       =      1.0267
PI/2X   =      1.5299
LC'     =     0.76494
RLCR    =      0.500
RLCR'   =      0.765
V1      =     0.70000E+00 WSC-2
CG'     =     0.48694E+00 COLUMBIA-EPRI
V2      =     0.12090E+01 EIGENE,NEU
```

OVERPOWER FACTOR : 1.0000

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
1	0.05	290.09	292.75	5.464E+06	136.72	0.00	8.553E+06	214.00	0.00	8.168E+06	204.36	0.00	6.250E+06	156.38	0.00
2	0.10	290.22	293.71	5.369E+06	102.74	0.00	6.154E+06	117.76	0.00	7.795E+06	149.15	0.00	6.068E+06	116.10	0.00
3	0.15	290.39	294.95	5.326E+06	77.93	0.00	5.216E+06	76.33	0.00	7.559E+06	110.61	0.00	5.958E+06	87.18	0.00
4	0.20	290.61	296.57	5.316E+06	59.48	0.00	4.717E+06	52.79	0.00	7.411E+06	82.92	0.00	5.895E+06	65.97	0.00
5	0.25	290.91	298.70	5.328E+06	45.59	0.00	4.414E+06	37.77	0.00	7.321E+06	62.64	0.00	5.865E+06	50.19	0.00
6	0.30	291.29	301.47	5.355E+06	35.04	0.00	4.215E+06	27.58	0.00	7.271E+06	47.58	0.00	5.858E+06	38.33	0.00
7	0.35	293.52	346.96	8.673E+06	9.78	9.78	8.416E+06	9.49	9.49	1.255E+07	14.14	14.14	9.727E+06	10.97	10.97
8	0.40	296.27	347.05	7.325E+06	6.89	6.89	5.846E+06	5.50	5.50	1.018E+07	9.58	9.58	8.061E+06	7.58	7.58
9	0.45	299.42	347.11	6.416E+06	5.37	5.37	4.696E+06	3.93	3.93	8.662E+06	7.26	7.26	6.960E+06	5.83	5.83
10	0.50	302.81	347.14	5.699E+06	4.47	4.47	3.972E+06	3.12	3.12	7.508E+06	5.89	5.89	6.108E+06	4.79	4.79
11	0.55	306.29	347.15	5.077E+06	3.90	3.90	3.439E+06	2.64	2.64	6.544E+06	5.03	5.03	5.383E+06	4.13	4.13
12	0.60	309.71	347.14	4.501E+06	3.53	3.53	3.006E+06	2.36	2.36	5.684E+06	4.46	4.46	4.722E+06	3.70	3.70
13	0.65	312.92	347.10	3.941E+06	3.30	3.30	2.627E+06	2.20	2.20	4.878E+06	4.09	4.09	4.092E+06	3.43	3.43
14	0.70	315.79	347.03	3.373E+06	3.17	3.17	2.278E+06	2.14	2.14	4.094E+06	3.85	3.85	3.468E+06	3.26	3.26
15	0.75	318.24	346.94	2.780E+06	3.13	3.13	1.939E+06	2.19	2.19	3.306E+06	3.73	3.73	2.828E+06	3.19	3.19
16	0.80	320.16	346.80	2.140E+06	3.17	3.17	1.589E+06	2.36	2.36	2.491E+06	3.70	3.70	2.153E+06	3.19	3.19
17	0.85	320.57	330.63	7.116E+06	45.37	0.00	5.336E+06	34.03	0.00	1.015E+07	64.72	0.00	7.780E+06	49.61	0.00
18	0.90	320.93	330.01	5.762E+06	40.69	0.00	3.560E+06	25.13	0.00	7.779E+06	54.93	0.00	6.139E+06	43.35	0.00
19	0.95	321.27	330.02	4.905E+06	35.89	0.00	2.859E+06	20.92	0.00	6.398E+06	46.81	0.00	5.140E+06	37.61	0.00
20	1.00	321.60	330.67	4.404E+06	31.09	0.00	2.520E+06	17.79	0.00	5.628E+06	39.73	0.00	4.569E+06	32.26	0.00
21	1.05	321.96	331.99	4.150E+06	26.46	0.00	2.358E+06	15.03	0.00	5.244E+06	33.44	0.00	4.282E+06	27.30	0.00
22	1.10	322.36	334.09	4.060E+06	22.14	0.00	2.295E+06	12.52	0.00	5.104E+06	27.83	0.00	4.178E+06	22.78	0.00
23	1.15	324.22	346.91	7.360E+06	8.30	8.30	5.755E+06	6.49	6.49	1.060E+07	11.95	11.95	8.059E+06	9.09	9.09
24	1.20	326.50	347.00	6.372E+06	6.00	6.00	4.067E+06	3.83	3.83	8.774E+06	8.26	8.26	6.827E+06	6.42	6.42
25	1.25	329.07	347.06	5.634E+06	4.72	4.72	3.301E+06	2.76	2.76	7.505E+06	6.29	6.29	5.939E+06	4.97	4.97
26	1.30	331.80	347.09	5.021E+06	3.94	3.94	2.814E+06	2.21	2.21	6.508E+06	5.11	5.11	5.221E+06	4.10	4.10
27	1.35	334.56	347.10	4.474E+06	3.44	3.44	2.453E+06	1.88	1.88	5.663E+06	4.35	4.35	4.597E+06	3.53	3.53
28	1.40	337.20	347.09	3.962E+06	3.11	3.11	2.157E+06	1.69	1.69	4.905E+06	3.85	3.85	4.025E+06	3.16	3.16
29	1.45	339.63	347.05	3.463E+06	2.90	2.90	1.897E+06	1.59	1.59	4.197E+06	3.52	3.52	3.480E+06	2.91	2.91
30	1.50	341.74	346.98	2.960E+06	2.79	2.79	1.656E+06	1.56	1.56	3.512E+06	3.30	3.30	2.942E+06	2.77	2.77
31	1.55	343.49	346.89	2.436E+06	2.75	2.75	1.419E+06	1.60	1.60	2.829E+06	3.19	3.19	2.394E+06	2.70	2.70
32	1.60	344.83	346.75	1.874E+06	2.78	2.78	1.173E+06	1.74	1.74	2.127E+06	3.16	3.16	1.819E+06	2.70	2.70
33	1.65	344.89	346.09	5.326E+06	45.58	0.00	2.905E+06	24.86	0.00	7.565E+06	64.74	0.00	5.600E+06	47.92	0.00
34	1.70	344.89	346.01	4.168E+06	46.64	0.00	1.929E+06	21.58	0.00	5.527E+06	61.85	0.00	4.243E+06	47.48	0.00
35	1.75	344.88	345.93	3.247E+06	47.51	0.00	1.468E+06	21.48	0.00	4.092E+06	59.87	0.00	3.226E+06	47.20	0.00

36	1.80	344.88	345.86	2.521E+06	48.23	0.00	1.179E+06	22.57	0.00	3.057E+06	58.50	0.00	2.458E+06	47.03	0.00
37	1.85	344.88	345.80	1.951E+06	48.81	0.00	9.751E+05	24.40	0.00	2.299E+06	57.53	0.00	1.876E+06	46.95	0.00
38	1.90	344.87	345.73	1.506E+06	49.28	0.00	8.202E+05	26.84	0.00	1.737E+06	56.84	0.00	1.434E+06	46.91	0.00

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
***************		***********	*********	***			
COLUMBIA-EPRI	:	2.7466	1.5500	31	2.7466	1.5500	31
EDLUND	:	1.5578	1.5000	30	1.5578	1.5000	30
WSC-2	:	3.1554	1.6000	32	3.1554	1.6000	32
EIGENE,NEU	:	2.6989	1.6000	32	2.6989	1.6000	32

X$ = -6.08375E-04 X$ = -6.08375E-04

OVERPOWER FACTOR : 1.1200

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
1	0.05	290.10	293.09	5.468E+06	122.16	0.00	8.553E+06	191.07	0.00	8.168E+06	182.47	0.00	6.250E+06	139.63	0.00
2	0.10	290.25	294.15	5.375E+06	91.83	0.00	6.154E+06	105.14	0.00	7.795E+06	133.17	0.00	6.068E+06	103.66	0.00
3	0.15	290.44	295.54	5.332E+06	69.66	0.00	5.216E+06	68.15	0.00	7.559E+06	98.76	0.00	5.958E+06	77.84	0.00
4	0.20	290.69	297.36	5.322E+06	53.17	0.00	4.717E+06	47.13	0.00	7.411E+06	74.04	0.00	5.895E+06	58.90	0.00
5	0.25	291.02	299.74	5.334E+06	40.76	0.00	4.414E+06	33.72	0.00	7.321E+06	55.93	0.00	5.865E+06	44.81	0.00
6	0.30	291.45	302.85	5.361E+06	31.32	0.00	4.215E+06	24.63	0.00	7.271E+06	42.48	0.00	5.858E+06	34.22	0.00
7	0.35	293.94	347.02	8.665E+06	8.72	8.72	8.403E+06	8.46	8.46	1.253E+07	12.62	12.62	9.717E+06	9.78	9.78
8	0.40	297.01	347.11	7.319E+06	6.15	6.15	5.838E+06	4.90	4.90	1.017E+07	8.55	8.55	8.052E+06	6.76	6.76
9	0.45	300.52	347.17	6.410E+06	4.79	4.79	4.689E+06	3.51	3.51	8.653E+06	6.47	6.47	6.953E+06	5.20	5.20
10	0.50	304.30	347.21	5.694E+06	3.99	3.99	3.967E+06	2.78	2.78	7.501E+06	5.25	5.25	6.102E+06	4.27	4.27
11	0.55	308.16	347.21	5.073E+06	3.48	3.48	3.435E+06	2.35	2.35	6.538E+06	4.48	4.48	5.377E+06	3.69	3.69
12	0.60	311.94	347.20	4.497E+06	3.15	3.15	3.002E+06	2.10	2.10	5.678E+06	3.98	3.98	4.717E+06	3.30	3.30
13	0.65	315.49	347.16	3.937E+06	2.94	2.94	2.624E+06	1.96	1.96	4.873E+06	3.64	3.64	4.088E+06	3.06	3.06
14	0.70	318.65	347.09	3.370E+06	2.83	2.83	2.275E+06	1.91	1.91	4.090E+06	3.44	3.44	3.464E+06	2.91	2.91
15	0.75	321.32	347.00	2.778E+06	2.80	2.80	1.936E+06	1.95	1.95	3.303E+06	3.32	3.32	2.825E+06	2.84	2.84
16	0.80	323.42	346.86	2.138E+06	2.83	2.83	1.587E+06	2.10	2.10	2.489E+06	3.30	3.30	2.150E+06	2.85	2.85
17	0.85	323.87	335.07	6.904E+06	39.31	0.00	5.066E+06	28.84	0.00	9.847E+06	56.06	0.00	7.523E+06	42.83	0.00
18	0.90	324.26	334.37	5.592E+06	35.25	0.00	3.390E+06	21.37	0.00	7.547E+06	47.58	0.00	5.936E+06	37.42	0.00
19	0.95	324.63	334.37	4.761E+06	31.10	0.00	2.728E+06	17.82	0.00	6.207E+06	40.55	0.00	4.971E+06	32.47	0.00
20	1.00	324.99	335.08	4.275E+06	26.95	0.00	2.407E+06	15.17	0.00	5.459E+06	34.42	0.00	4.418E+06	27.85	0.00
21	1.05	325.38	336.54	4.029E+06	22.94	0.00	2.253E+06	12.83	0.00	5.087E+06	28.96	0.00	4.141E+06	23.57	0.00
22	1.10	325.82	338.86	3.942E+06	19.19	0.00	2.194E+06	10.68	0.00	4.951E+06	24.11	0.00	4.040E+06	19.67	0.00
23	1.15	327.83	346.97	7.117E+06	7.16	7.16	5.423E+06	5.46	5.46	1.025E+07	10.32	10.32	7.765E+06	7.82	7.82
24	1.20	330.28	347.06	6.162E+06	5.18	5.18	3.846E+06	3.23	3.23	8.485E+06	7.13	7.13	6.578E+06	5.53	5.53
25	1.25	333.04	347.12	5.448E+06	4.07	4.07	3.127E+06	2.34	2.34	7.258E+06	5.43	5.43	5.723E+06	4.28	4.28
26	1.30	335.94	347.16	4.855E+06	3.40	3.40	2.670E+06	1.87	1.87	6.294E+06	4.41	4.41	5.031E+06	3.52	3.52
27	1.35	338.83	347.16	4.326E+06	2.97	2.97	2.330E+06	1.60	1.60	5.476E+06	3.75	3.75	4.429E+06	3.04	3.04
28	1.40	341.56	347.15	3.831E+06	2.68	2.68	2.051E+06	1.44	1.44	4.743E+06	3.32	3.32	3.878E+06	2.72	2.72
29	1.45	344.03	347.11	3.349E+06	2.50	2.50	1.806E+06	1.35	1.35	4.059E+06	3.04	3.04	3.353E+06	2.51	2.51
30	1.50	344.90	347.04	2.863E+06	2.40	2.40	1.578E+06	1.33	1.33	3.397E+06	2.85	2.85	2.835E+06	2.38	2.38
31	1.55	344.90	346.95	2.356E+06	2.37	2.37	1.354E+06	1.36	1.36	2.736E+06	2.75	2.75	2.307E+06	2.32	2.32
32	1.60	344.89	346.81	1.812E+06	2.40	2.40	1.121E+06	1.49	1.49	2.057E+06	2.72	2.72	1.753E+06	2.32	2.32
33	1.65	344.89	346.13	4.886E+06	37.33	0.00	2.376E+06	18.15	0.00	6.943E+06	53.05	0.00	5.072E+06	38.75	0.00
34	1.70	344.89	346.04	3.825E+06	38.22	0.00	1.619E+06	16.17	0.00	5.073E+06	50.68	0.00	3.842E+06	38.39	0.00
35	1.75	344.88	345.96	2.982E+06	38.95	0.00	1.250E+06	16.33	0.00	3.756E+06	49.06	0.00	2.921E+06	38.16	0.00

36	1.80	344.88	345.89	2.315E+06	39.56	0.00	1.015E+06	17.35	0.00	2.806E+06	47.94	0.00	2.226E+06	38.03	0.00
37	1.85	344.88	345.82	1.793E+06	40.05	0.00	8.469E+05	18.92	0.00	2.110E+06	47.14	0.00	1.699E+06	37.96	0.00
38	1.90	344.87	345.76	1.385E+06	40.45	0.00	7.175E+05	20.96	0.00	1.594E+06	46.58	0.00	1.298E+06	37.93	0.00

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
****************		************	**********	***			
COLUMBIA-EPRI	:	2.3715	1.5500	31	2.3715	1.5500	31
EDLUND	:	1.3257	1.5000	30	1.3257	1.5000	30
WSC-2	:	2.7246	1.6000	32	2.7246	1.6000	32
EIGENE,NEU	:	2.3218	1.6000	32	2.3218	1.6000	32

X$ = 4.24555E-02 X$ = 4.24555E-02

***** FLAT CORE (JAERI) *****

```
NAC    =       2        : NUMBER OF CORE
IBLT   =       1
RR1    =  0.60000       : RLIB / RLIC
RR2    =  0.60000       : RLB / RLIC
RR3    =  7.00000E-02   : QLB / QLC
FIAX2  =  0.20000       : PARAMETER FOR BLANKET POWER DISTRIBUTION

NZT    =       5        : NUMBER OF ZONE
RLIC   =  0.50000       : INNER CORE HEIGHT ( M )
RLIB   =  0.30000       : INNER BLANKET HEIGHT ( M )
RLB    =  0.30000       : OUTER BLANKET HEIGHT ( M )
QLC    =   20241.       : LINEAR HEAT IN CORE ( W/M )
QLB    =   1416.9       : LINEAR HEAT IN OUTER BLANKET ( W/M )
RR     =   1.0000       : QLIB/2 / QLB
RRR1   =   24290.       : QLC * FIAX
RRR2   =   2850.5       : LOG(FIAX2) / (FIAX2-1) * QLB
RRR    =   1.6765       : LOG(FIAX2) / (FIAX2-1) / FIAX
RPOWER 1.93726937269372715E-02 0.48062730627306277 0.51937269372693730 0.98062730627306280 1.0000000000000000
```

ERGEBNISSE

```
X      =   1.0267
PI/2X  =   1.5299
```

```
LC'     =     0.76494
RLCR    =      0.500
RLCR'   =      0.765
V1      =     0.70000E+00 WSC-2
CG'     =     0.48694E+00 COLUMBIA-EPRI
V2      =     0.12090E+01 EIGENE,NEU
```

OVERPOWER FACTOR : 1.0000

POS	X	T(X)	TW	COLUMBIA-EPRI CHF	SM	SMLWR	EDLUND CHF	SM	SMLWR	WSC-2 CHF	SM	SMLWR	EIGENE,NEU CHF	SM	SMLWR
1	0.05	290.09	292.75	5.464E+06	136.72	0.00	8.553E+06	214.00	0.00	8.168E+06	204.36	0.00	6.250E+06	156.38	0.00
2	0.10	290.22	293.71	5.369E+06	102.74	0.00	6.154E+06	117.76	0.00	7.795E+06	149.15	0.00	6.068E+06	116.10	0.00
3	0.15	290.39	294.95	5.326E+06	77.93	0.00	5.216E+06	76.33	0.00	7.559E+06	110.61	0.00	5.958E+06	87.18	0.00
4	0.20	290.61	296.57	5.316E+06	59.48	0.00	4.717E+06	52.79	0.00	7.411E+06	82.92	0.00	5.895E+06	65.97	0.00
5	0.25	290.91	298.70	5.328E+06	45.59	0.00	4.414E+06	37.77	0.00	7.321E+06	62.64	0.00	5.865E+06	50.19	0.00
6	0.30	291.29	301.47	5.355E+06	35.04	0.00	4.215E+06	27.58	0.00	7.271E+06	47.58	0.00	5.858E+06	38.33	0.00
7	0.30	291.29	336.21	9.103E+06	13.51	13.51	9.950E+06	14.76	14.76	1.340E+07	19.88	19.88	1.032E+07	15.31	15.31
8	0.35	293.52	346.96	7.670E+06	8.65	8.65	6.532E+06	7.36	7.36	1.083E+07	12.21	12.21	8.519E+06	9.60	9.60
9	0.40	296.27	347.05	6.754E+06	6.35	6.35	5.180E+06	4.87	4.87	9.254E+06	8.71	8.71	7.391E+06	6.95	6.95
10	0.45	299.42	347.11	6.047E+06	5.06	5.06	4.367E+06	3.66	3.66	8.085E+06	6.77	6.77	6.537E+06	5.48	5.48
11	0.50	302.81	347.14	5.442E+06	4.27	4.27	3.783E+06	2.97	2.97	7.119E+06	5.58	5.58	5.819E+06	4.56	4.56
12	0.55	306.29	347.15	4.888E+06	3.75	3.75	3.321E+06	2.55	2.55	6.267E+06	4.81	4.81	5.174E+06	3.97	3.97
13	0.60	309.71	347.14	4.356E+06	3.42	3.42	2.927E+06	2.30	2.30	5.479E+06	4.30	4.30	4.566E+06	3.58	3.58
14	0.65	312.92	347.10	3.827E+06	3.21	3.21	2.573E+06	2.16	2.16	4.723E+06	3.96	3.96	3.972E+06	3.33	3.33
15	0.70	315.79	347.03	3.283E+06	3.09	3.09	2.239E+06	2.11	2.11	3.975E+06	3.74	3.74	3.374E+06	3.17	3.17
16	0.75	318.24	346.94	2.708E+06	3.05	3.05	1.910E+06	2.15	2.15	3.215E+06	3.62	3.62	2.755E+06	3.11	3.11
17	0.80	320.16	346.80	2.085E+06	3.09	3.09	1.568E+06	2.33	2.33	2.424E+06	3.60	3.60	2.098E+06	3.11	3.11
18	0.80	320.16	331.93	6.538E+05	3.57	0.00	7.491E+05	4.09	0.00	7.322E+05	3.99	0.00	6.450E+05	3.52	0.00
19	0.85	320.57	330.63	5.634E+05	3.59	0.00	6.801E+05	4.34	0.00	6.271E+05	4.00	0.00	5.540E+05	3.53	0.00
20	0.90	320.93	330.01	5.112E+05	3.61	0.00	6.374E+05	4.50	0.00	5.662E+05	4.00	0.00	5.014E+05	3.54	0.00
21	0.95	321.27	330.02	4.940E+05	3.61	0.00	6.207E+05	4.54	0.00	5.451E+05	3.99	0.00	4.835E+05	3.54	0.00
22	1.00	321.60	330.67	5.105E+05	3.60	0.00	6.291E+05	4.44	0.00	5.619E+05	3.97	0.00	4.990E+05	3.52	0.00
23	1.05	321.96	331.99	5.611E+05	3.58	0.00	6.617E+05	4.22	0.00	6.167E+05	3.93	0.00	5.481E+05	3.49	0.00
24	1.10	322.36	334.09	6.475E+05	3.53	0.00	7.171E+05	3.91	0.00	7.116E+05	3.88	0.00	6.325E+05	3.45	0.00
25	1.10	322.36	346.78	2.067E+06	3.07	3.07	1.500E+06	2.23	2.23	2.363E+06	3.51	3.51	2.062E+06	3.06	3.06
26	1.15	324.22	346.91	2.468E+06	2.78	2.78	1.694E+06	1.91	1.91	2.847E+06	3.21	3.21	2.474E+06	2.79	2.79
27	1.20	326.50	347.00	2.700E+06	2.54	2.54	1.801E+06	1.69	1.69	3.129E+06	2.94	2.94	2.713E+06	2.55	2.55
28	1.25	329.07	347.06	2.796E+06	2.34	2.34	1.841E+06	1.54	1.54	3.242E+06	2.72	2.72	2.809E+06	2.35	2.35
29	1.30	331.80	347.09	2.782E+06	2.18	2.18	1.828E+06	1.43	1.43	3.219E+06	2.53	2.53	2.792E+06	2.19	2.19
30	1.35	334.56	347.10	2.681E+06	2.06	2.06	1.771E+06	1.36	1.36	3.088E+06	2.37	2.37	2.684E+06	2.06	2.06
31	1.40	337.20	347.09	2.508E+06	1.97	1.97	1.681E+06	1.32	1.32	2.870E+06	2.25	2.25	2.502E+06	1.96	1.96
32	1.45	339.63	347.05	2.274E+06	1.90	1.90	1.562E+06	1.31	1.31	2.581E+06	2.16	2.16	2.259E+06	1.89	1.89
33	1.50	341.74	346.98	1.987E+06	1.87	1.87	1.417E+06	1.33	1.33	2.233E+06	2.10	2.10	1.963E+06	1.85	1.85
34	1.55	343.49	346.89	1.650E+06	1.86	1.86	1.246E+06	1.41	1.41	1.833E+06	2.07	2.07	1.620E+06	1.83	1.83
35	1.60	344.83	346.75	1.264E+06	1.88	1.88	1.046E+06	1.55	1.55	1.388E+06	2.06	2.06	1.233E+06	1.83	1.83

36	1.60	344.83	346.18	3.133E+05	2.05	0.00	4.525E+05	2.96	0.00	3.348E+05	2.19	0.00	3.012E+05	1.97	0.00
37	1.65	344.89	346.09	2.408E+05	2.06	0.00	3.880E+05	3.32	0.00	2.564E+05	2.19	0.00	2.311E+05	1.98	0.00
38	1.70	344.89	346.01	1.849E+05	2.07	0.00	3.330E+05	3.73	0.00	1.964E+05	2.20	0.00	1.772E+05	1.98	0.00
39	1.75	344.88	345.93	1.420E+05	2.08	0.00	2.860E+05	4.19	0.00	1.505E+05	2.20	0.00	1.359E+05	1.99	0.00
40	1.80	344.88	345.86	1.090E+05	2.09	0.00	2.459E+05	4.70	0.00	1.153E+05	2.21	0.00	1.042E+05	1.99	0.00
41	1.85	344.88	345.80	8.366E+04	2.09	0.00	2.115E+05	5.29	0.00	8.833E+04	2.21	0.00	7.992E+04	2.00	0.00
42	1.90	344.87	345.73	6.419E+04	2.10	0.00	1.820E+05	5.95	0.00	6.768E+04	2.21	0.00	6.128E+04	2.00	0.00

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
****************		************	**********	***			
COLUMBIA-EPRI	:	1.8599	1.5500	34	1.8599	1.5500	34
EDLUND	:	1.3082	1.4500	32	1.3082	1.4500	32
WSC-2	:	2.0587	1.6000	35	2.0587	1.6000	35
EIGENE,NEU	:	1.8266	1.5500	34	1.8266	1.5500	34

X$ = -1.28197E-02 X$ = -1.28197E-02

OVERPOWER FACTOR :   1.1200

POS		T(X)	TW	COLUMBIA-EPRI			EDLUND			WSC-2			EIGENE,NEU		
	X			CHF	SM	SMLWR	CHF	SM	SMLWR	CHF	SM	SMLWR	CHF	SM	SMLWR
1	0.05	290.10	293.09	5.468E+06	122.16	0.00	8.553E+06	191.07	0.00	8.168E+06	182.47	0.00	6.250E+06	139.63	0.00
2	0.10	290.25	294.15	5.375E+06	91.83	0.00	6.154E+06	105.14	0.00	7.795E+06	133.17	0.00	6.068E+06	103.66	0.00
3	0.15	290.44	295.54	5.332E+06	69.66	0.00	5.216E+06	68.15	0.00	7.559E+06	98.76	0.00	5.958E+06	77.84	0.00
4	0.20	290.69	297.36	5.322E+06	53.17	0.00	4.717E+06	47.13	0.00	7.411E+06	74.04	0.00	5.895E+06	58.90	0.00
5	0.25	291.02	299.74	5.334E+06	40.76	0.00	4.414E+06	33.72	0.00	7.321E+06	55.93	0.00	5.865E+06	44.81	0.00
6	0.30	291.45	302.85	5.361E+06	31.32	0.00	4.215E+06	24.63	0.00	7.271E+06	42.48	0.00	5.858E+06	34.22	0.00
7	0.30	291.45	341.75	9.107E+06	12.06	12.06	9.950E+06	13.18	13.18	1.340E+07	17.75	17.75	1.032E+07	13.67	13.67
8	0.35	293.94	347.02	7.673E+06	7.72	7.72	6.532E+06	6.57	6.57	1.083E+07	10.90	10.90	8.519E+06	8.57	8.57
9	0.40	297.01	347.11	6.756E+06	5.68	5.68	5.180E+06	4.35	4.35	9.254E+06	7.77	7.77	7.391E+06	6.21	6.21
10	0.45	300.52	347.17	6.048E+06	4.52	4.52	4.367E+06	3.27	3.27	8.085E+06	6.05	6.05	6.537E+06	4.89	4.89
11	0.50	304.30	347.21	5.443E+06	3.81	3.81	3.783E+06	2.65	2.65	7.119E+06	4.99	4.99	5.819E+06	4.08	4.08
12	0.55	308.16	347.21	4.889E+06	3.35	3.35	3.321E+06	2.28	2.28	6.267E+06	4.30	4.30	5.174E+06	3.55	3.55
13	0.60	311.94	347.20	4.357E+06	3.05	3.05	2.927E+06	2.05	2.05	5.479E+06	3.84	3.84	4.566E+06	3.20	3.20
14	0.65	315.49	347.16	3.828E+06	2.86	2.86	2.573E+06	1.92	1.92	4.723E+06	3.53	3.53	3.972E+06	2.97	2.97
15	0.70	318.65	347.09	3.284E+06	2.76	2.76	2.239E+06	1.88	1.88	3.975E+06	3.34	3.34	3.374E+06	2.83	2.83
16	0.75	321.32	347.00	2.709E+06	2.73	2.73	1.910E+06	1.92	1.92	3.215E+06	3.24	3.24	2.755E+06	2.77	2.77
17	0.80	323.42	346.86	2.085E+06	2.76	2.76	1.568E+06	2.08	2.08	2.424E+06	3.21	3.21	2.098E+06	2.78	2.78
18	0.80	323.42	336.53	6.540E+05	3.18	0.00	7.491E+05	3.65	0.00	7.322E+05	3.56	0.00	6.450E+05	3.14	0.00
19	0.85	323.87	335.07	5.636E+05	3.21	0.00	6.801E+05	3.87	0.00	6.271E+05	3.57	0.00	5.540E+05	3.15	0.00
20	0.90	324.26	334.37	5.114E+05	3.22	0.00	6.374E+05	4.02	0.00	5.662E+05	3.57	0.00	5.014E+05	3.16	0.00
21	0.95	324.63	334.37	4.942E+05	3.23	0.00	6.207E+05	4.05	0.00	5.451E+05	3.56	0.00	4.835E+05	3.16	0.00
22	1.00	324.99	335.08	5.107E+05	3.22	0.00	6.291E+05	3.97	0.00	5.619E+05	3.54	0.00	4.990E+05	3.15	0.00
23	1.05	325.38	336.54	5.613E+05	3.20	0.00	6.617E+05	3.77	0.00	6.167E+05	3.51	0.00	5.481E+05	3.12	0.00
24	1.10	325.82	338.86	6.478E+05	3.15	0.00	7.171E+05	3.49	0.00	7.116E+05	3.46	0.00	6.325E+05	3.08	0.00
25	1.10	325.82	346.84	2.068E+06	2.74	2.74	1.500E+06	1.99	1.99	2.363E+06	3.13	3.13	2.062E+06	2.73	2.73
26	1.15	327.83	346.97	2.469E+06	2.49	2.49	1.694E+06	1.70	1.70	2.847E+06	2.87	2.87	2.474E+06	2.49	2.49
27	1.20	330.28	347.06	2.701E+06	2.27	2.27	1.801E+06	1.51	1.51	3.129E+06	2.63	2.63	2.713E+06	2.28	2.28
28	1.25	333.04	347.12	2.796E+06	2.09	2.09	1.841E+06	1.38	1.38	3.242E+06	2.42	2.42	2.809E+06	2.10	2.10
29	1.30	335.94	347.16	2.783E+06	1.95	1.95	1.828E+06	1.28	1.28	3.219E+06	2.25	2.25	2.792E+06	1.96	1.96
30	1.35	338.83	347.16	2.681E+06	1.84	1.84	1.771E+06	1.21	1.21	3.088E+06	2.12	2.12	2.684E+06	1.84	1.84
31	1.40	341.56	347.15	2.509E+06	1.76	1.76	1.681E+06	1.18	1.18	2.870E+06	2.01	2.01	2.502E+06	1.75	1.75
32	1.45	344.03	347.11	2.275E+06	1.70	1.70	1.562E+06	1.17	1.17	2.581E+06	1.93	1.93	2.259E+06	1.69	1.69
33	1.50	344.90	347.04	1.988E+06	1.67	1.67	1.417E+06	1.19	1.19	2.233E+06	1.88	1.88	1.963E+06	1.65	1.65
34	1.55	344.90	346.95	1.650E+06	1.66	1.66	1.246E+06	1.25	1.25	1.833E+06	1.85	1.85	1.620E+06	1.63	1.63
35	1.60	344.89	346.81	1.265E+06	1.68	1.68	1.046E+06	1.39	1.39	1.388E+06	1.84	1.84	1.233E+06	1.63	1.63

36	1.60	344.89	346.21	3.134E+05	1.83	0.00	4.525E+05	2.64	0.00	3.348E+05	1.96	0.00	3.012E+05	1.76	0.00
37	1.65	344.89	346.13	2.408E+05	1.84	0.00	3.880E+05	2.96	0.00	2.564E+05	1.96	0.00	2.311E+05	1.77	0.00
38	1.70	344.89	346.04	1.850E+05	1.85	0.00	3.330E+05	3.33	0.00	1.964E+05	1.96	0.00	1.772E+05	1.77	0.00
39	1.75	344.88	345.96	1.421E+05	1.86	0.00	2.860E+05	3.74	0.00	1.505E+05	1.97	0.00	1.359E+05	1.78	0.00
40	1.80	344.88	345.89	1.090E+05	1.86	0.00	2.459E+05	4.20	0.00	1.153E+05	1.97	0.00	1.042E+05	1.78	0.00
41	1.85	344.88	345.82	8.369E+04	1.87	0.00	2.115E+05	4.72	0.00	8.833E+04	1.97	0.00	7.992E+04	1.79	0.00
42	1.90	344.87	345.76	6.421E+04	1.88	0.00	1.820E+05	5.32	0.00	6.768E+04	1.98	0.00	6.128E+04	1.79	0.00

MINIMALWERTE

CORRELATION		SMMIN	X	POS			
****************		************	**********	***			
COLUMBIA-EPRI	:	1.6611	1.5500	34	1.6611	1.5500	34
EDLUND	:	1.1680	1.4500	32	1.1680	1.4500	32
WSC-2	:	1.8381	1.6000	35	1.8381	1.6000	35
EIGENE,NEU	:	1.6309	1.5500	34	1.6309	1.5500	34

X$ = 2.87840E-02 X$ = 2.87840E-02

7. UTILITY PROGRAMS

All main results of a run are appended to an existing data set, so that the results of many runs can be accumulated in this data pool. To retrieve and present these results, some utility programs are necessary.

7.1 CREATING THE DATA POOL

To create and initiate the data pool, the program INIT must be used as demonstrated in the following example:

```
//PROJECTL JOB (....,...,.....),....,TIME=(,30),MSGCLASS=A
// EXEC PGM=IEFBR14
//DD1 DD DSN=PROJECT.APWRH.DATA,DISP=(OLD,DELETE)
// EXEC PGM=INIT
//STEPLIB  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//FT08F001 DD DSN=PROJECT.APWRD.DATA,UNIT=DISK,VOL=SER=BAT00C,
// DCB=(LRECL=2996,RECFM=VBS,BLKSIZE=3000),
// DISP=(NEW,CATLG),SPACE=(CYL,(10,10))
```

7.2 LISTING THE RESULTS

With the program LISTP, accumulated results may be listed in a sorted manner as shown in Reference /6/. Another version of this code named LISTD lists the results of homegeneous reactors with the same rod diameter. These programs request, as input, first the unit number assigned to the data pool, and then one or more group indicators in successive lines as shown below.

```
//PROJECTL JOB (....,...,.....),....,TIME=(,30),MSGCLASS=A
//LIST EXEC PGM=LISTP
//STEPLIB  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//*  LIST REACTORS WITH EQUAL ROD PITCH
//FT05F001 DD *
8          INPUT UNIT OF PROJECT.APWRS.DATA
2
3          DP-ITER.(1), HOMOGEN(2), HETEROGEN(3), JAERI(4)
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRD.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
```

```
//FT10F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
```

7.3 DELETING ENTRIES

With the program DELT the results of certain runs may be deleted from the data pool. To do this the original data set is copied to a new one by excluding the specified entries. As first input line, the unit numbers of the input and output data sets are required. Then in consecutive lines as many entry numbers as desired may be marked for exclusion. As the numbers of the entries (the record number in the data set) are changed during deletion, it is useful to start with the greatest number going down to the lowest one. In the following example, deleting is demonstrated.

```
//PROJECTD JOB (...,...,.....),....,TIME=(,30),MSGCLASS=A
//DELT EXEC PGM=DELT
//STEPLIB DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//FT05F001 DD *
8,18     EINGABEEINHEIT PROJECT.APWRD.DATA, AUSGABEEINHEIT
88
87
32
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRD.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT18F001 DD DISP=SHR,DSN=PROJECT.APWRH.DATA
```

7.4 LISTING A SPECIFIED ENTRY

With the program OUT1, one or more entries may be listed as they are present in the data pool. The first input to this program is again the unit number. Then one or more entry numbers may be specified in consecutive lines. The following example demonstrates the usage of OUT1 :

```
//PROJECTD JOB (...,...,.....),....,TIME=(,30),MSGCLASS=A
//OUT1 EXEC PGM=OUT1
//STEPLIB DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//FT05F001 DD *
8          EINGABEEINHEIT PROJECT.APWRD.DATA,AUSGABEEINHEIT
31
75
```

```
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRD.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
```

7.5 COMPRESSING THE DATA POOL

The program COMP is used to omit entries with the same input data. Like the program DELT, this program uses two different data sets for input and output, so that the original data set remains unaffected. The program requires, as input, only the unit numbers assigned to the data pools.

```
//PROFECTC JOB (....,....,.....),....,TIME=(,30),MSGCLASS=A
//COMP EXEC PGM=COMP
//STEPLIB  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//FT05F001 DD *
8,18       EINGABEEINHEIT PROJECT.APWRD.DATA,AUSGABEEINHEIT
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRD.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT18F001 DD DISP=SHR,DSN=PROJECT.APWRH.DATA
```

7.6 PLOTTING THE RESULTS

With the program PLOT, specified entries or group of entries may be selected as input for the plot routines. This program needs Calcomp/ Versatec plotter software and it is therefore restricted in usage. The following example shows the different commands and their meaning. The presented input stream was used to plot the figures in Reference /2/.

```
//PROJECTP JOB (....,....,.....),....,TIME=(,30),MSGCLASS=A
//*MAIN LINES=50
//PLOT EXEC PGM=PLOT
//STEPLIB  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//PLOTWK01 DD UNIT=SYSSQ,SPACE=(CYL,(10,5))
//PLOTWK02 DD UNIT=SYSSQ,SPACE=(CYL,(10,5))
//VECTR1   DD UNIT=SYSSQ,SPACE=(CYL,(10,5)),DISP=(MOD,PASS),
//            DSN=&&VECTR1
//VECTR2   DD UNIT=SYSSQ,SPACE=(CYL,(10,5)),DISP=(MOD,PASS),
//            DSN=&&VECTR2
//PLOTLOG  DD SYSOUT=*
```

```
//COMM     DD SYSOUT=*
//FT01F001 DD *
KOM
KOM
KOM                  BESCHREIBUNG DER EINGABEDATEN
KOM
KOM  INI PLOTTERNUMMER,XMAX,YMAX,PLOTFAKTOR
KOM      0,1,2,3,4,... 0 = DUMMY-PLOT
KOM                    1 = BILDSCHIRM GA
KOM                    2 = BILDSCHIRM T4015
KOM                    3 = SPEICHERBILDSCHIRM KSG
KOM                    4 = CALCOMP,STATOS,XYNETICS,VERSATEC
KOM                   >4 = PLOTAUSGABE ERFOLGT UEBER EINHEIT 9
KOM      XMAX              ZEICHNUNGSLAENGE IN CM (FUER FAKTOR 1)
KOM      YMAX              ZEICHNUNGSHOEHE  IN CM (FUER FAKTOR 1)
KOM      PLOTFAKTOR    1   PLOTTEREINHEIT = 1CM
KOM                   <1   VERKLEINERUNG
KOM                   >1   VERGROESSERUNG
KOM
KOM
KOM  NPL
KOM
KOM
KOM  GRP INDEX,TEXT1,TEXT2
KOM      INDEX             GRUPPENINDEX
KOM                      1 HOMOGENE REAKTOREN
KOM                      2 HETEROGENE REAKTOREN
KOM                      3 1 UND 2
KOM
KOM
KOM  FIG NUMMER,TEXT1,TEXT2
KOM      NUMMER            ABBILDUNGSNUMMER
KOM
KOM
KOM  PAR NPAR,NAME=,EINHEIT,UMRECHNUNGSFAKTOR DARSTELLUNG/INTERN
KOM      NPAR              INDEX DES PARAMETERWERTS
KOM
KOM
KOM  XAX TEXT ,EINHEIT,UMRECHNUNGSFAKTOR,STARTWERT,ENDWERT,ACHSENLAENGE
KOM      BEISPIEL      1.E2 CM/M  WERT IN M WIRD IN CM DARGESTELLT.
KOM                DIE ACHSE BEGINNT BEI 0.7 CM
KOM                                     UND ENDET BEI 1.2 CM.
KOM                          DIE GEZEICHNETE ACHSENLAENGE IST 10 CM.
```

```
KOM
KOM
KOM  YAX TEXT ,EINHEIT,UMRECHNUNGSFAKTOR,STARTWERT,ENDWERT,ACHSENLAENGE
KOM
KOM
KOM  TXT X-KOORD.,Y-KOORD.,HOEHE,TEXT,WINKEL
KOM
KOM
KOM  PLT TYP,OPTION,NX,NY
KOM      TYP :       DPI          DP-ITERATION
KOM                  HOM          HOMOGENER KERN
KOM                  HET          HETEROGENER KERN
KOM      OPTION :    POW          KONSTANTE PUMPLEISUNG
KOM                  CHR          KONSTANTE PUMPENCHARAKTERISTIK
KOM                  NX           INDEX DES ABSZISSENWERTES
KOM                  NY           INDEX DES ORDINATENWERTES
KOM
KOM
KOM  SYM TYP,OPTION,NX,NY,NSYM
KOM
KOM
KOM  ADI NN,NN WERTEPAARE IN INTERNEN EINHEITEN
KOM
KOM
KOM  ADD NN,NN WERTEPAARE IN DARSTELLUNGSEINHEITEN
KOM
KOM
KOM  ADZ NN,NN WERTEPAARE IN PLOTTEREINHEITEN
KOM
KOM
KOM  MIT FIG WIRD EIN EINZELPLOT EROEFFNET, DIESES KOMMANDO
KOM  MUSS DESHALB STETS ALS ERSTES ERSCHEINEN.
KOM  DIE KOMMANDOS PAR,XAX,YAX KOENNEN IN BELIEBIGER REIHEN-
KOM  FOLGE ANGESCHLOSSEN WERDEN, FEHLT DAS KOMMANDO PAR, SO
KOM  WERDEN ALLE DATEN FUER DIE AUSGEWAEHLTE DATENGRUPPE DAR-
KOM  GESTELLT (ALS EINE KURVE).
KOM  DIE GRUPPE PLT,ADI,ADD,ADZ,SYM SCHLIESST IN BELIEBIGER
KOM  REIHENFOLGE DIE KOMMANDOSEQUENZ AB. DAMIT EIN SINNVOLLER
KOM  PLOT ERSTELLT WERDEN KANN, MUSS MINDESTENS EINES DAVON
KOM  VORHANDEN SEIN.
KOM
KOM  EIN NEUES EINZELBILD KANN DURCH FIG ODER DURCH INI
KOM  EROEFFNET WERDEN, WOBEI INI NUR DANN ANZUGEBEN IST, WENN
```

```
KOM  DIE GRUNDPARAMETER GEAENDERT WERDEN SOLLEN.
KOM
KOM     DARSTELLUNG DER ERGEBNISSE
KOM
KOM
KOM     1. BILD QELNET VS. D MIT P ALS PARAMETER
KOM
KOM
PRT
GRP 1,HOMOGENEOUS CORE,CONSTANT PUMP CHARACTERISTICS
PAR 15, P=,CM,1.E2
XAX ROD DIAMETER D,CM,1.E2,0.7,1.2,10.
YAX NET PLANT ELECTRICAL POWER QELNET,MW,1.E-6,800.,1300.,10.
PLT HOM,CHR,16,42
NPL
YAX DNB RATIO,-,1.,1.2,1.7,10.
PLT HOM,CHR,16,101
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
ADD 4,0.7,1.301,1.2,1.301,1.2,1.299,0.7,1.299
NPL
YAX DNB RATIO WITH CONTROL ROD,-,1.,1.2,1.7,10.
PLT HOM,CHR,16,104
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
ADD 4,0.7,1.301,1.2,1.301,1.2,1.299,0.7,1.299
NPL
YAX DNB RATIO,-,1.,1.1,1.6,10.
PLT HOM,CHR,16,127
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
ADD 4,0.7,1.301,1.2,1.301,1.2,1.299,0.7,1.299
NPL
YAX DNB RATIO WITH CONTROL ROD,-,1.,1.1,1.6,10.
PLT HOM,CHR,16,130
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
ADD 4,0.7,1.301,1.2,1.301,1.2,1.299,0.7,1.299
NPL
YAX INLET TEMPERATURE T1,GRD C,1.,260.,310.,10.
PLT HOM,CHR,16,38
NPL
YAX OUTLET TEMPERATURE T2,GRD C,1.,316.,326.,10.
PLT HOM,CHR,16,39
NPL
YAX MASS FLOW RATE M,KG/S,1.,10000.,20000.,10.
PLT HOM,CHR,16,40
```

```
NPL
YAX PUMPING POWER NP,MW,1.E-6,15.,20.,10.
PLT HOM,CHR,16,41
NPL
YAX WATER TO FUEL ROD VOLUME RATIO VM/VF,-,1.,0.,1.,10.
PLT HOM,CHR,16,29
NPL
YAX CORE FRICTION PRESSURE DROP DP,BAR,1.,0.,10.,10.
PLT HOM,CHR,16,50
NPL
YAX ROD LINEAR POWER QL,W/CM,1.E-2,100.,200.,10.
PLT HOM,CHR,16,26
NPL
YAX CORE POWER DENSITY QV,W/CM**3,1.E-6,100.,300.,10.
PLT HOM,CHR,16,27
NPL
YAX VELOCITY U,M/S,1.,5.,10.,10.
PLT HOM,CHR,16,47
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING,CM,1.E2,0.,200.,10.
PLT HOM,CHR,16,107
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING,CM,1.E2,0.,100.,10.
PLT HOM,CHR,16,133
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
NPL
YAX CORE HEIGHT LC,CM,1.E2,120.,320.,10.
PLT HOM,CHR,16,44
GRP 2,HETEROGENEOUS CORE,CONSTANT PUMP CHARACTERISTICS
PAR 48, DS=,CM,1.E2
XAX SEED POWER DENSITY QVS,W/CM**3,1.E-6,100.,300.,10.
YAX NET PLANT ELECTRICAL POWER QELNET,MW,1.E-6,800.,1300.,10.
PLT HET,CHR,19,41
NPL
YAX DNB RATIO SEED,-,1.,1.5,2.0,10.
PLT HET,CHR,19,116
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX DNB RATIO SEED  WITH CONTROL ROD,-,1.,1.5,2.0,10.
PLT HET,CHR,19,119
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
```

```
YAX DNB RATIO SEED,-,1.,1.3,1.8,10.
PLT HET,CHR,19,142
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
NPL
YAX DNB RATIO SEED  WITH CONTROL ROD,-,1.,1.3,1.8,10.
PLT HET,CHR,19,145
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
NPL
YAX DNB RATIO BLANKET,-,1.,1.3,1.8,10.
PLT HET,CHR,19,198
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX DNB RATIO BLANKET WITH CONTROL ROD,-,1.,1.3,1.8,10.
PLT HET,CHR,19,201
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX DNB RATIO BLANKET,-,1.,1.1,1.6,10.
PLT HET,CHR,19,224
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
ADD 4,100.,1.301,300.,1.301,300.,1.299,100.,1.299
NPL
YAX DNB RATIO BLANKET WITH CONTROL ROD,-,1.,1.1,1.6,10.
PLT HET,CHR,19,227
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
ADD 4,100.,1.301,300.,1.301,300.,1.299,100.,1.299
NPL
YAX INLET TEMPERATURE T1,GRD C,1.,260.,310.,10.
PLT HET,CHR,19,37
NPL
YAX OUTLET TEMPERATURE T2,GRD C,1.,316.,326.,10.
PLT HET,CHR,19,38
NPL
YAX MASS FLOW RATE M,KG/S,1.,10000.,20000.,10.
PLT HET,CHR,19,39
NPL
YAX PUMPING POWER NP,MW,1.E-6,15.,20.,10.
PLT HET,CHR,19,40
NPL
YAX WATER TO FUEL ROD VOLUME RATIO VM/VF,-,1.,0.,1.5,10.
PLT HET,CHR,19,65
NPL
YAX CORE FRICTION PRESSURE DROP DP,BAR,1.,0.,10.,10.
PLT HET,CHR,19,63
```

```
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING SEED,CM,1.E2,0.,200.,10.
PLT HET,CHR,19,122
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING SEED,CM,1.E2,0.,100.,10.
PLT HET,CHR,19,148
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING BLANKET,CM,1.E2,0.,200.,10.
PLT HET,CHR,19,204,10
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1,0.
NPL
YAX POSITION OF INCIPIENT LOCAL BOILING BLANKET,CM,1.E2,0.,100.,10.
PLT HET,CHR,19,230
TXT 8.,-2.5,.21,OVERPOWER FACTOR 1.12,0.
NPL
YAX CORE HEIGHT LC,CM,1.E2,100.,500.,10.
PLT HET,CHR,19,43
NPL
YAX PITCH BLANKET PB,CM,1.E2,.8,1.8,10.
PLT HET,CHR,19,55
NPL
YAX PITCH SEED PS,CM,1.E2,.6,1.6,10.
PLT HET,CHR,19,46
NPL
YAX ROD DIAMETER BALNKET DB,CM,1.E2,.8,1.8,10.
PLT HET,CHR,19,57
NPL
YAX PITCH TO DIAMETER RATIO SEED PS/DS,-,1.,1.,1.5,10.
PLT HET,CHR,19,49
NPL
YAX PITCH TO DIAMETER RATIO BLANKET PB/DB,-,1.,.9,1.4,10.
PLT HET,CHR,19,58
NPL
YAX ROD LINEAR POWER SEED QLS,W/CM,1.E-2,150.,250.,10.
PLT HET,CHR,19,28
NPL
YAX ROD LINEAR POWER BLANKET QLB,W/CM,1.E-2,100.,200.,10.
PLT HET,CHR,19,54
NPL
YAX VELOCITY BLANKET UB,M/S,1.,5.,10.,10.
PLT HET,CHR,19,60
```

```
NPL
YAX VELOCITY SEED US,M/S,1.,6.,8.5,10.
PLT HET,CHR,19,51
GRP 3
PAR
XAX NET PLANT ELECTRICAL POWER QELNET,MW,1.E-6,800.,1300.,10.
YAX WATER TO FUEL ROD VOLUME RATIO VM/VF,-,1.,0.,1.,10.
PLS HOM,CHR,42,29,2
PLS HET,CHR,41,65,10
SYM 8.,2.,.21,2,0.
TXT 8.5,1.9,.21,HOM.,0.
SYM 8.,1.5,.21,10,0.
TXT 8.5,1.4,.21,HET.,0.
//FT05F001 DD *
8,1,0
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRS.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT20F001 DD DISP=(,DELETE),UNIT=SYSSQ,SPACE=(1,1),
//          DCB=(RECFM=FB,LRECL=80,BLKSIZE=3120)
//PLOTPARM DD *
 &PLOT XMAX=300. &END
//VERS EXEC SVPLOT
```

7.7 LISTING THE CONTENTS

With the program SHOW, selected variables of a specified entry may be listed. The following example demonstrates the usage:

```
//PROJECTS JOB (....,....,.....),....,TIME=(,30),MSGCLASS=A
//SHOW EXEC PGM=SHOW
//STEPLIB DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//FT05F001 DD *
8         EINGABEEINHEIT PROJECT.APWRS.DATA
48        REAKTORNUMMER
XF 149,230
//FT06F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
//FT08F001 DD DISP=SHR,DSN=PROJECT.APWRS.DATA
//FT09F001 DD SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=3857)
```

8. INSTALLING THE PROGRAMS

All programs, subroutines and functions are copied in a separate file. The following shows how the program library HADA.LOAD is to be generated.

```
//PROJECTG JOB (....,...,.....),....,MSGCLASS=H,REGION=2000K
//*
//*MAIN LINES=20
//**********************************************************************
//INPUTO EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUTO)
//            DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUT1)
//            DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUT2)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN     DD *
 ALIAS INPUT1,INPUT2
 NAME INPUTO(R)
//**********************************************************************
//COMPRS EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(COMPRS)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN     DD *
 NAME COMPRS(R)
//**********************************************************************
//IVGL EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(IVGL)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN     DD *
 NAME IVGL(R)
//**********************************************************************
//OUTPUT EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTPUT)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
```

```
//L.SYSIN    DD *
 NAME OUTPUT(R)
//*********************************************************************
//DELETE EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(DELETE)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 NAME DELETE(R)
//*********************************************************************
//OUTLST EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTLSTP)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 NAME OUTLST(R)
//*********************************************************************
//OUTHOM EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTHOMP)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTHET)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS OUTHET
 NAME OUTHOM(R)
//*********************************************************************
//OUTLIN EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTLIN)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 NAME OUTLIN(R)
//*********************************************************************
//OUTPLT EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTPLT)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(BILDER)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(KOMGET)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(EXINT)
```

```
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(EXTXT)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(EXREL)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(EXTRC)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS BILDER,STORE,STORP,ZEICHN,KOMGET,EXINT,EXTXT,EXREL,EXTRC
 NAME OUTPLT(R)
//*******************************************************************
//XACHSE EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(XACHSE)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(ENCODE)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(IENT)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(PLTEXT)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(LAENGE)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(YACHSE)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS YACHSE,ENCODE,IENT,PLTEXT,LAENGE
 NAME XACHSE(R)
//*******************************************************************
//PLTIN EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(PLTIN)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS PLTOF,NULLP
 NAME PLTIN(R)
//*******************************************************************
//OUTSHW EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTSHW)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(GETIND)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(IGET)
//              DD DISP=SHR,DSN=PROJECT.HADA.FORT(GET2)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS GETIND,IGET,GET2
 NAME OUTSHW(R)
```

```
//CHFCLC EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//*
//* VKFF1 IS THE SAME AS VKNEW. ONLY THE FAKTOR FF (F IN THE SUBROUTINE)
//* WAS SET = 1 ON THE BASIS OF THE EXPERIMENTAL RESULTS OF KWU-CHF TEST
//*
//C.SYSIN      DD DISP=SHR,DSN=PROJECT.HADA.FORT(CHFCLC)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SHIP)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(EDLD)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(WSC2)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(DDCR)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(EPRI)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(VKFF1)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(VKOLD)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(VKEPR)
//L.SYSLMOD    DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN      DD *
 ALIAS SHIP,EDLD,WSC2,DDCR,EPRI,VKNEW,VKOLD,VKEPR,$INV,NEWT,FRRK3
 NAME CHFCLC(R)
//*
//CHFCL2 EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN      DD DISP=SHR,DSN=PROJECT.HADA.FORT(CHFCL2)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(CHFCL3)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(CHFCL4)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SETDNB)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(DNBR)
//L.SYSLMOD    DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN      DD *
 ALIAS CHFCL3,CHFCL4,SETDNB,DNBR,CICLI
 NAME CHFCL2(R)
//*
//GAUSS EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN      DD DISP=SHR,DSN=PROJECT.HADA.FORT(GAUSS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(ELIMS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SOLVS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(GAUS0)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(GAUS1)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(GAUS2)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(ELIMN)
```

```
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SOLVN)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SETLIN)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SETIT)
//L.SYSLMOD    DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN      DD *
 ALIAS ELIMS,SOLVS,GAUS0,GAUS1,GAUS2,ELIMN,SOLVN,SETLIN,SETIT
 NAME GAUSS(R)
//*********************************************************************
//DMPMAT EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN      DD DISP=SHR,DSN=PROJECT.HADA.FORT(DMPMAT)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(XNEU)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SETMAT)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SETVEK)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(MAT)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(VEK)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SORT)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(TAUS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(EXCH)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(SMAX)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(IMAX)
//L.SYSLMOD    DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN      DD *
 ALIAS XNEU,SETMAT,SETVEK,MAT,VEK,SORT,TAUS,EXCH,SMAX,IMAX
 NAME DMPMAT(R)
//*********************************************************************
//EFPW EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN      DD DISP=SHR,DSN=PROJECT.HADA.FORT(EFPW)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(EFPD)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(EFS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(PSI0)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(PSI)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(Q)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(B)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(FI)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(PR)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(HR)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(HS)
//             DD DISP=SHR,DSN=PROJECT.HADA.FORT(PS)
//L.SYSLMOD    DD DISP=SHR,DSN=PROJECT.HADA.LOAD
```

```
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS EFPD,EFS,PSIO,PSI,Q,B,FI,PR,HR,HS,PS
 NAME EFPW(R)
//*******************************************************************
//ARG1 EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(ARG1)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(SUCHEN)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(PINV)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(RP)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(SUMME)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(FE)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(FL)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(FC)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS SUCHEN,PINV,RP,SUMME,FE,FL,FC
 NAME ARG1(R)
//*******************************************************************
//DRUCK EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(DRUCK)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(STOR8)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTREC)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS OUTREC,STOR8
 NAME DRUCK(R)
//F EXEC F7CL,PARM.L='NCAL'
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(F)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(DF)
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ALIAS DF
 NAME F(R)
//*******************************************************************
//**
//**                                      COMP
```

```
//**                                      |
//**                       +--------------+-------+
//**                       |              |       |
//**                     INPUT0         COMPRS  OUTPUT
//**                       |              |
//**                   +-------+         IVGL
//**                   |       |
//**                 INPUT1  INPUT2
//**
//COMP EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(COMP)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME COMP(R)
//*****************************************************************
//**
//**                                     DELT
//**                                      |
//**                       +--------------+-------+
//**                       |              |       |
//**                     INPUT0         DELETE  OUTPUT
//**                       |              |
//**                   +-------+         IVGL
//**                   |       |
//**                 INPUT1  INPUT2
//**
//DELT EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(DELT)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME DELT(R)
//*****************************************************************
//**
```

```
//**                                     INIT
//**
//INIT EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(INIT)
//L.SYSLMOD   DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN     DD *
 ENTRY MAIN
 NAME INIT(R)
//*******************************************************************
//**
//**                                     LIST
//**                                      |
//**                        +----------------+-------+
//**                        |                |       |
//**                      INPUT0           OUTLST  DATUM
//**                        |                |
//**                    +-------+        +-------+
//**                    |       |        |       |
//**                 INPUT1  INPUT2   OUTHOM  OUTHET
//**
//LIST EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN     DD DISP=SHR,DSN=PROJECT.HADA.FORT(LIST)
//L.SYSLIB    DD
//            DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD   DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN     DD *
 ENTRY MAIN
 NAME LISTP(R)
//*******************************************************************
//**
//**                                     OUT1
//**                                      |
//**                              +----------------+
//**                              |                |
//**                            INPUT0           OUTLIN
//**                              |
//**                          +-------+
//**                          |       |
//**                       INPUT1  INPUT2
```

```
//**
//OUT1 EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUT1)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME OUT1(R)
//*******************************************************************
//**
//**                                          PLOT
//**                                            |
//**             +-----------------------+-------------------+---------+
//**             |                       |         |         |         |
//**           INPUT0                  OUTPLT    ZEICHN    BILDER    DATUM
//**             |                       |                   |
//**         +--------+         +------+------+-------+       |
//**         |        |         |      |      |       |       |
//**      INPUT1   INPUT2    STORP  STORE  OUTHOM  OUTHET     |
//**                                                          |
//**             +-------------+-------+------+-------+------+------+
//**             |             |       |      |       |      |      |
//**           XACHSE       YACHSE  PLTIN  KOMGET  PLTEXT  NULLP  PLOTOF
//**             |             |       |      |
//**         +-------+-------+ |     DATUM    |
//**         |       |       | |              |
//**  ENCODE  PLTEXT  LAENGE  |           +------+------+
//**    |                     |           |      |      |
//**  IENT           +-------+-------+ EXINT  EXTXT  EXREL
//**                 |       |       |
//**              ENCODE  PLTEXT  LAENGE
//**                 |
//**              IENT
//**
//PLOT EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(PLOT)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
```

```
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME PLOT(R)
//********************************************************************
//**
//**                                        SHOW
//**                                          |
//**             +----------------------+---------+
//**             |                      |         |
//**           INPUT0                 OUTSHW    DATUM
//**             |                      |
//**         +--------+             +--------+
//**         |        |             |        |
//**       INPUT1  INPUT2         GETIND  LAENGE
//**                                |
//**                             +-----+
//**                             |     |
//**                           GET2  IGET
//**
//SHOW EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(SHOW)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME SHOW(R)
//********************************************************************
//**
//HADA EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(HADA)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME HADA(R)
```

The diffrent version of the LIST code named LISTD, which generates tables of the results with the same diameter, is produced in the following way:

```
//PROJECTL JOB (....,....,.....),....,MSGCLASS=H
//*
//*
//*******************************************************************
//LISTD EXEC F7CL
//C.SYSPRINT DD SYSOUT=N
//C.SYSIN    DD DISP=SHR,DSN=PROJECT.HADA.FORT(LIST)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUT0)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUT1)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(INPUT2)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTLSTD)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTHOMD)
//           DD DISP=SHR,DSN=PROJECT.HADA.FORT(OUTHET)
//L.SYSLIB   DD
//           DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSLMOD  DD DISP=SHR,DSN=PROJECT.HADA.LOAD
//L.SYSPRINT DD SYSOUT=H
//L.SYSIN    DD *
 ENTRY MAIN
 NAME LISTD(R)
```

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/4/ Y. Ishiguro, K. Okumura: Nucl. Technol. 84, 331 (1989).

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/6/ M. Cigarini, M. Dalle Donne: "Calculations for Advanced Pressurized Water Reactor with the Code HADA-2," KfK 4148, EUR 10532e (1986).

/7/ M. Cigarini, M. Dalle Donne: "Thermhydraulic Optimization of Homogeneous and Heterogeneous Advanced Pressurized Water Reactor," Nucl. Technol., 80, 107 (1988).

/8/ D. C. Groeneveld: "Recent Developments in Thermal Hydraulic Prediction Method," Preceedings of the Third International Topical Meeting on Nuclear Power Plant Termal Hydraulics and Operations (NUPTHO-3), Vol.1, p.A2-38, Seoul 14-17 Nov. 1988.

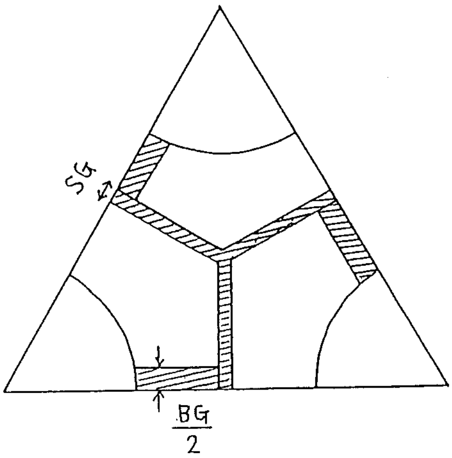

Figure 1. Geometry of grid.

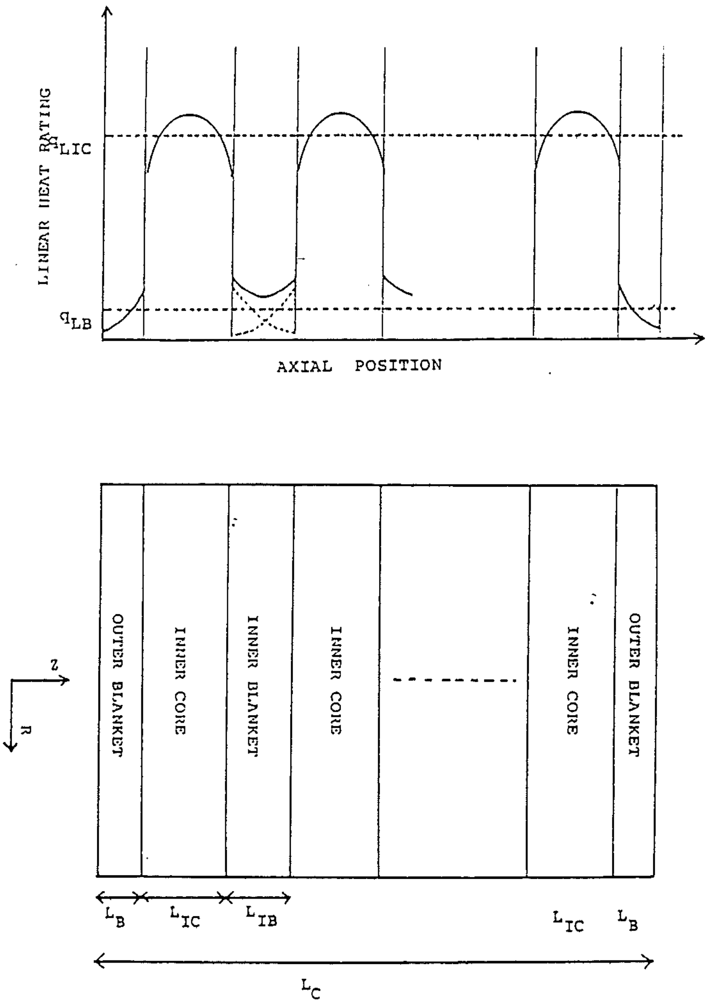

Figure 2. Conceptual illustration of multiple stacked core.