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KJELLER REPORT

«RAMONA I»

A FORTRAN CODE FOR TRANSIENT ANALYSIS OF BOILING WATER REACTORS AND BOILING LOOPS

INSTITUTT FOR ATOMENERGI

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"RAMONA I"
A FORTRAN CODE FOR TRANSIENT ANALYSIS OF BOILING WATER REACTORS AND BOILING LOOPS

by

P. Bakstad and K.O. Solberg

November, 1968.

ABSTRACT

A boiling water reactor dynamics code RAMONA I is described. The physical model, with a new treatment of the vapour generating process where thermal "non-equilibrium" between the phases is a fundamental assumption, has been reported elsewhere [1]. This report describes the digital computer programme and some modifications and improvements in the model described in [1].

The code calculates the space-time behaviour of a boiling water reactor or an electrically heated loop for several disturbances which may be chosen by the user. By numerical Laplace transform, transfer functions may be calculated to facilitate frequency domain studies.

The report contains a detailed description of the code, input and output, and sample calculations. The programme is coded in 3600 FORTRAN for a CDC-3600 computer.

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1. INTRODUCTION

The present report describes the latest version of the boiling water reactor dynamics code RAMONA named RAMONA I. The essential features of the mathematical model have been discussed in ref.[1] and a knowledge of the model as presented there will be assumed.

The first version of this dynamics code, RAMONA [2], has been in use at IFA*) for about three years, but due to several shortcomings as a "production code", a new version has been prepared.

The version RAMONA I is a completely revised code, although the mathematical model is essentially unchanged; several improvements with regard to its ease and flexibility of operation, speed, accuracy, output presentation etc, have been implemented, the most important of which are listed below.

- Thermodynamic quantities such as densities, heat of evaporation etc, are calculated from rational approximations as functions of local pressure and temperature within the programme.
- Local pressures are calculated from a quasistationary approximation (neglecting acceleration head).
- By an option, two different slip correlations are available, Solberg's formula and the Bankoff-Jones correlation. A constant slip can also be used.
- By an option, three two-phase friction correlations are available, the Lottes-Flinn correlation, the Becker correlation and the modified Martinelli-Nelson correlation.

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- An approximate steady state from which a dynamic calculation can be started, is now calculated by the VOIFLO programme (converted into a subroutine) [3].
- The length of each (spatial) subsection in the core may, by an option, be put proportional to the steady state fluid velocity; this may increase accuracy and speed of computation by integrating more closely along the characteristics of the partial differential equations involved.
- A second order integration routine with automatic step change (local error control) and output control is used to integrate the equations in time.
- The data input and output presentations are significantly improved.
- The line-printer may be used, optionally, to plot up to five of fourteen important dynamic variables in the same diagram.
- Optionally, the transfer function between any of the same fourteen dynamic variables may be calculated by numerical Laplace transformation.

In section 2 the essential characteristics of the new version as listed above, will be discussed in more detail. Further, the structure of the programme, the flow of computations etc, will be reviewed.

Section 3 is meant to serve as a guide to the user describing input/output, timing, hints to the user etc.

In Appendices are given a summary of equations, nomenclature and sample calculations.

2. DESCRIPTION OF THE "RAMONA I" PROGRAMME

2.1 Essential Differences from the First Version Described in Ref.[1]

As pointed out in the introduction, the mathematical model is essentially unchanged from the first version [1]. Therefore, only the modifications introduced will be described in some detail here, and a knowledge of the content of ref.[I] will be assumed.

2.1.1 The calculation of thermodynamic quantities

In the new version, the thermodynamic quantities:

saturation temperature (°C)
heat of evaporation (Ws/kg)
density of water (kg/m³)
density of steam (kg/m³)

specific heat of water at constant pressure (Ws/kg°C)
dynamic viscosity of water (kg/ms)
thermal conductivity of water (W/m°C)

are calculated as functions of pressure (or temperature). Polynomial rational approximations of minimax type are used. Except for the thermal conductivity, these were calculated by AB Atomenergi, Studsvik, Sweden, and may be found in ref.[4].

Approximations for both light water (H_2O) and heavy water (D_2O) are available and contained in the subroutines LIGHTWAT and HEAVYWAT, cf. section 2.2. The accuracy is better than 0.1 % (compared to Steam Tables [5]) for pressures in the range 1 to 100 ata.

As the water density is strongly temperature-dependent (at constant pressure), when the temperature deviates significantly from the saturation value, the following linear approximation is used to account for this dependence:

$$\rho_f(T_f,p) = \rho_f(p)\Big|_s + \left(\frac{\partial\rho_f}{\partial T}\right)_p (T_f - T_s) \qquad (2.1)$$

$\rho_f(p)\Big|_s$ is the density of water as a function of pressure along the saturation curve, and $(\partial\rho_f/\partial T)_p$ is the derivative taken at constant pressure, otherwise cf. Nomenclature. The following least square approximation is used to calculate $(\partial\rho_f/\partial T)_p$:

$$-\left(\frac{\partial\rho_f}{\partial T}\right)_p = 0.8071 + 0.1774\cdot10^{-6}p - 0.5289\cdot10^{-14}p^2 \qquad (2.2)$$

For $(T_s - T_f) \leq 50°C$ and $5. < p(ata) < 80.$, this approximation agrees with the Steam Tables [5] within about 2%. The correlation equations (2.1) and (2.2) is programmed in the subroutine THERMO (cf. section 2.2).

In cases where the system or local pressures are time-dependent (cf. section 3), the subroutines LIGHTWAT resp. HEAVYWAT are called only when the system pressure deviates more than 1 at. from a reference pressure. For smaller deviations, linear approximations along the saturation curve are used, as for instance:

$$\rho_f(p)\Big|_s = \rho_f(p^o)\Big|_s + \left(\frac{\partial\rho_f}{\partial p}\right)_s \Delta p \qquad (2.3)$$

The derivatives are calculated numerically by LIGHTWAT resp. HEAVYWAT. This is done to save computer time as the calculation of the rational approximations for each time step would be very time consuming. If the system pressure deviates more than 1 at. from the reference pressure, new rational approximations are calculated and the "last" pressure is taken as the new reference. Initially the reference pressure is equal to the given nominal pressure.

2.1.2 Spatially dependent pressure

Optionally, local pressures can be calculated and the corresponding pressure-dependent thermodynamic quantities are determined as variables along the flow loop. The momentum balance is used to calculate two pressures, one at core inlet and one at riser inlet. To avoid numerical instability, the acceleration head is neglected, only gravity head and friction head are taken into account. This may, therefore, be regarded as a "quasistationary" approximation.

The local pressures are calculated by assuming linear pressure variation from the drum pressure (which by definition is equal to the system pressure) through the downcomer and to the core inlet pressure (accounting for the forced circulation head in the lower plenum), further, linear variation from core inlet to riser inlet and from riser inlet to drum, or upper plenum, is assumed.

By calculating the thermodynamic quantities from local pressures, the "spatial flashing" effect as well as the inlet subcooling due to the local pressure increase are taken into account.

2.1.3 Slip correlations

Optionally, the user can choose among the following three possibilities:

1) constant slip
2) Solberg's slip formula
3) the Bankoff-Jones slip correlation.

In the case of constant slip, the input is the constant slip required. Solberg's slip formula requires several parameters as input. The formula is given below:

$$v_g = Sv_f + v^o$$

$$S = S_1 + S_2\,\alpha^r \qquad (2.4)$$

$$v^o = -\cos\varphi\; v_o^o \sqrt{\left|\frac{g(t)}{g^o}\right|}$$

S_1, S_2, r and v_o^o are input. cos φ is the angle between the gravity vector and the flow direction, equal + 1 in downcomer 1, equal - 1 in core and riser, and in downcomer 2 (cf. input description):

$$\cos \varphi = \frac{L_C + L_R - L_{D1}}{L_{D2}} \tag{2.5}$$

A part of the downcomer, or return path, can be longer than the vertical distance, thus having an inclination angle given by φ. This has been introduced to be able to study the real geometry which can be met for hydraulic loops, and also for the possibility of investigating the effect of an increased inertial length as for instance a spiral-shaped downcomer in a natural circulation reactor. One can by this obtain a dynamic stabilizing result.

The Bankoff-Jones slip correlation as given in ref.[7] looks as follows:

$$\begin{aligned} S &= \frac{1 - \alpha}{K - \alpha + (1 - K)\alpha^r} \\ K &= 0.71 + 0.09 \left[\frac{p(\text{psia})}{1000}\right] \\ r &= 3.33 + 0.18 \left[\frac{p(\text{psia})}{1000}\right] + 0.46 \left[\frac{p(\text{psia})}{1000}\right]^2 \end{aligned} \tag{2.6}$$

The necessary conversion from "N/m^2" to "psia" is accomplished by:

$$1 \ N/m^2 = 14.50 \cdot 10^{-5} \ \text{psia} \tag{2.7}$$

The user has the choice between the above three possibilities with respect to slip in core and riser. In the case of carry-under, the slip in the downcomers are always calculated from Solberg's formula, slightly modified:

$$\begin{aligned} S &= 1 - 0.3(1 - \alpha)^2 \\ v_o^o &= 0.35 \end{aligned} \tag{2.8}$$

2.1.4 Two-phase friction correlations

Optionally, the user can choose between:

1) The Becker correlation
2) The Lottes-Flinn correlation
3) The modified Martinelli-Nelson correlation.

The Becker correlation for the two-phase friction multiplier R is given by [8]:

$$R = 1. + A_F \left(\frac{X}{p(ata)}\right)^{0.96} \tag{2.9}$$

Becker recommends the value $A_F = 2400$. The conversion from "N/m^2" to "ata" is accomplished by:

$$1.N/m^2 = \frac{1.}{0.9807 \cdot 10^5} \text{ ata} \tag{2.10}$$

A_F is input to the code if the Becker correlation is used.

The Lottes-Flinn correlation requires no input:

$$R = \left[\frac{1 - X}{1 - \alpha}\right]^2 \tag{2.11}$$

Finally, the modified Martinelli-Nelson correlation is programmed from the following equations [6]:

$$R = \Phi^2 \cdot \Omega \tag{2.12}$$

The mass flow correlation Ω is given by:

$$\Omega = \begin{cases} 1.36 + 0.5\left[\frac{p}{1000}\right] + 0.1\left[\frac{G}{10^6}\right] - 0.714\left[\frac{p}{1000}\right]\left[\frac{G}{10^6}\right] ; & \frac{G}{10^6} \leq 0.7 \\ 1.26 - 0.4\left[\frac{p}{1000}\right] + 0.119\left[\frac{10^6}{G}\right] + 0.28\left[\frac{p}{1000}\right]\left[\frac{10^6}{G}\right] ; & \frac{G}{10^6} > 0.7 \end{cases} \tag{2.13}$$

The mass velocity G is in units of "$lbs/hr.ft^2$", the conversion factor to MKS units is:

$$1 \text{ kg/sec m}^2 = 7.382 \cdot 10^2 \text{ lbs/hr.ft}^2 \tag{2.14}$$

p is in units of "psia". The mass flow correction is only applied in the core and the core inlet mass flow is used in eq.(2.13).

Φ^2, given graphically in for instance [6] as a function of quality and and pressure, has been fitted by the following least squares approximation:

$$\Phi^2 = 1 + 5.62 \cdot 10^3 X - 4.92 \cdot 10^1 X^2 + 6.85 \cdot 10^{-6} X^2 \cdot p - 2.71 \cdot 10^{-13} X^2 p^2 - - 6.58 \cdot 10^2 X \cdot \ln p + 1.92 \cdot 10^1 X(\ln p)^2 \tag{2.15}$$

Here again p is in "psia", the conversion to "N/m^2" is given by eq.(2.7). For 1. < p(ata) < 100 and 0. < X < 0.8, the error is of the order 5% or less.

The single phase friction factor used in the code is given by:

$$f = \frac{G_1}{2 \cdot D_h \cdot Re^{G_2}} \tag{2.16}$$

G_1 and G_2 are input. G_1 = 0.184 and G_2 = 0.2 give Weisbach's formula for smooth pipes (D_h = hydraulic diameter).

2.1.5 Steady state calculation by VOIFLO

In the first version of the code the steady state required to start a dynamic calculation was obtained by essentially a dynamics calculation. Starting with zero power, no void and a fixed circulation rate, the power and subcooling were increased linearly to the nominal values and then integration in time continued until a steady state was reached.

As this was a time consuming procedure, and as convergence problems were met in some cases, the steady state code VOIFLO has now been converted into a subroutine and used to calculate an approximate steady state. A familiarity with the VOIFLO model as described in [3] will be assumed in the following.

As the subcooled boiling model used in VOIFLO is completely different from the one used in RAMONA I, and the methods for calculating pressure losses, slip, friction etc. are different, the steady state void distribution, velocity distribution etc. obtained from VOIFLO will not be a "true" steady state for the RAMONA model. Since an understanding of how the input for the VOIFLO calculation is derived from the RAMONA input may be valuable for the interpretation of the VOIFLO results, the relations used are summarized in Appendix B.

The two-phase friction correlation used in VOIFLO is the Becker correlation. If the RAMONA I code is run with this correlation (IMULT = 1*)), the actual value of A_F is used in VOIFLO. But, if the Lottes-Flinn or the modified Martinelli-Nelson correlations are required, VOIFLO is called with A_F = 2400.

The slip correlation used in VOIFLO is based on "volume quality", otherwise it is similar to Solberg's formula (eq.(2.4)) with $v_o^o = 0$. In the case that Solberg's formula is used, S_o, S_1 and S_2 in VOIFLO are put

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*) cf. section 3.2.

equal to Solberg's S_1, S_2 and r respectively, neglecting that volume quality is not equal to void fraction, cf. eq.(2.9) in [3]. If Bankoff-Jones' slip correlation is requested, VOIFLO uses the values:

$$S_o = 1.30$$
$$S_1 = 2.03 \qquad (2.17)$$
$$S_2 = 3.04$$

evaluated from experimental data [3].

It is seen that in general the VOIFLO steady state will deviate from the RAMONA I steady state. However, for many cases VOIFLO will give a good approximation from which a dynamic calculation may be started in a short time. If a very accurate steady state is required before starting the actual dynamic calculation (for instance when transfer functions are required and usually in REACTOR case, cf. section 3), an option ISTEADY is available. By putting ISTEADY = 1 a "true" steady state is calculated in much the same way as in the first version of RAMONA, but starting from the VOIFLO steady state. The integration continues until the core inlet velocity, the core exit void fraction and the steam load have levelled off or until maximum 10 sec real time. Note that in this calculation a superficial inertia term is included during the first second, obtained by multiplying the momentum derivative (from time $t \leq 1$ sec) with t^2 (in order to stabilize the flow).

The VOIFLO steady state is always printed out in standard format. as described in [3].

2.1.6 Variable spatial step length in core

Consider the special case of equal velocity of water and steam, i.e., slip ratio equal one. In this case it is well known that the requirement for numerical stability of a first order integration scheme such as Euler's for integrating the partial differential equations describing the transport of mass and energy is (after replacing space derivatives by "backward differences"):

$$v \frac{\Delta t}{\Delta z} \leq 1 \qquad (2.18)$$

Here v is the (local) velocity, Δt is the time step and Δz the spatial step.

In the case where the equal sign is valid, the mathematical characteristics are followed and it is well known that this is an optimal case with respect to accuracy and speed of calculation.

From eq.(2.18) it is seen that in the case where the local velocity varies along the flow path, the spatial step should vary proportionally to the velocity (when the time step is fixed for each spatial integration cycle).

Another approach would be to vary the time step Δt simultaneously with the spatial integration, this would amount to the characteristics methods of integrating hyperbolic partial differential equations. This is, however, less convenient from a programming point of view.

An option, ISTEP, is provided in RAMONA I which in accordance with this brief investigation allows the use of a variable spatial step distribution in the core. The step length distribution is calculated such that the steps are proportional to the VOIFLO steady state water velocity (neglecting the effect of slip). In the riser and downcomers constant steps are used in all cases.

The variable step distribution is obtained by putting ISTEP = 1. One should expect to gain in speed and accuracy by using this option compared to a calculation with a constant step distribution. A larger time step will be allowed and the number of spatial steps in the core will be decreased.

Note that in the case ISTEP = 1, the number of spatial steps in the core will usually be less than n_c, the number used by VOIFLO and given as input. This is because the code starts with a step:

$$\Delta z = \frac{L_c}{n_c} \tag{2.19}$$

at core inlet and increases it towards the exit. (The final Δz at core inlet may deviate slightly from Δz given above as a small adjustment of all Δz's will usually be necessary to fit the length of the channel).

2.1.7 Integration method

In RAMONA I the Euler method of integration in time with a fixed step, has been replaced by the modified Euler method which in the case of one differential equation, $y' = f(x,y)$, is given by (h = integration step):

$$\begin{aligned} k_1 &= hf(x_n, y_n) \\ k_2 &= hf(x_n + \tfrac{1}{2}h,\ y_n + \tfrac{1}{2}k_1) \\ y_{n+1} &= y_n + k_2 \end{aligned} \tag{2.20}$$

The error control works in much the same way as in the well-known D2 KIRA MERSON routine [9]. The error is controlled by requiring not too large deviation between k_1 and k_2. For one equation the test is as follows, the extension to several equations is trivial:

$$\begin{aligned} &\text{If } |k_1 - k_2| < \frac{1}{8} \cdot \text{ACC } |y_{n+1}|, \text{ double the step} \\ &\text{If } |k_1 - k_2| > \text{ACC} \cdot |y_{n+1}|, \text{ halve the step} \end{aligned} \qquad (2.21)$$

In addition, halving the step is stopped if the step becomes less than a step HMIN.

ACC and HMIN may be read into the programme, if not, the values ACC = 0.01 and HMIN = 0.002 are used.

It may be observed that the modified Euler method is of second order, i.e., the local error term $O(h^3)$. For this method the stability requirement corresponding to eq.(2.18) for the first order Euler method, will be:

$$v \cdot \frac{\Delta t}{\Delta z} \leq 2 \qquad (2.22)$$

2.1.8 Programming, input and output improvements

Compared to the first version of RAMONA, much effort has been put into producing convenient and easily understandable input and output.

Each group of input data are headed by an "information card" which defines the type of data to be read in next, an example is the information card

GEOMETRICAL DATA,

after which data defining the geometry of the loop follow. Some information cards are optional, such as

SPACER DATA

or

POWER DISTRIBUTION DATA.

After the first follow data defining spacer positions and velocity head losses. After the last follow data defining the power distribution. If there is no "SPACER DATA" information card, this will be interpreted as there being no spacers, and if there is no "POWER DISTRIBUTION DATA" information card, the result will be a constant power distribution.

The sequence or order of the information cards is in general immaterial, however, each information card (with a few exceptions) has to be followed by data cards punched according to the instructions found in section 3. For details cf. section 3.2, Input Description.

The output from RAMONA I is self-explanatory. All output is supplied with text in a clear and lucid way. In addition to "small" and/or "large" output at specified time intervals as described in section 3, the line printer may be used for plotting of several dynamic variables, and transfer functions may be requested as described in the following sections.

With respect to programming, the new version is an improvement over the first one in several respects. All time-independent variables are calculated once and for all in a subroutine AUXSUB and referenced through numbered COMMON. An attempt has been made to use programme mnemonics which directly relate to the corresponding mathematical symbols used in the model as described in [1]. Finally, in all subroutines which are called frequently, the use of parameter lists is avoided, COMMON blocks are used instead (which saves computer time).

2.1.9 Plotting of dynamic variables

For convenience and rapid review of results, the line printer may be used for plotting of up to five dynamic variables in the same diagram. Scaling factors have to be supplied with the request for plotting. The maximum five variables are plotted with symbols (*, O, I, X and +). Nomenclature is provided for each variable immediately following the diagram.

The five variables may be chosen between the following fourteen dynamic variables:

Identification	Description, units		Programme mnemonics
1	Core inlet water velocity	(m/sec)	VI
2	Riser exit water velocity	(")	VF(NTØT)
3	Average void in core	(none)	VC
4	Average void in riser	(")	VR
5	Void fraction at core exit	(none)	ALFA(NDC2)
6	Void fraction at riser exit	(none)	ALFA(NTØT)
7	Heat to coolant flow	(W)	QHEAT
8	Steam load	(kg/sec)	WSL
9	Pressure deviation	(N/m^2)	Y(1)
10	Max. fuel zone temperature	(^{o}C)	FC
11	Nuclear power	(W)	Y(NKIN)

Identification	Description, units		Programme mnemonics
12	Void reactivity	(none)	RHØV
13	Doppler reactivity	(")	RHØD
14	Excess reactivity	(")	RHØEX

For further details, reference is made to section 3.

2.1.10 Transfer functions

To facilitate the study of the dynamics in the frequency domain, provisions are made for the calculation of transfer functions between any of the fourteen dynamic variables listed in the previous section.

The method is based on numerically Laplace transforming the variables for which transfer functions are requested, and is patterned after the method used in the Swedish programme HYDRO [4]. The mathematical and numerical details are given in the work report [10] and only the essential features of the method will be described here.

A subroutine LAPTRANS calculates the Laplace transform of each function appearing in the transfer functions specified by the user. Let y(t) be one such function. To make the initial condition zero, the transform

$$L\left[y(t) - y(o)\right] = \int_0^\infty e^{-st}\left[y(t) - y(o)\right] dt \Big|_{s = i\omega} \qquad (2.23)$$

is calculated numerically. The programme calculates y(t) in steps Δt specified by the user and stores it in an array. Note that the step Δt does not need to be equal to the steps for which "small" and "large" output, as described in section 3, are requested.

As the programme calculates y(t) only up to a maximum time T, least square technique is used to try to fit to the function y(t) for $t_o < t < T$, where t_o is specified by the user, the following expression:

$$y(t) = y_1 + y_2\, e^{-\lambda t} \sin(\omega_o t + \varphi) \qquad (2.24)$$

This is an exponentially damped sinusoidal oscillation where the five parameters y_1, y_2, λ, ω_o and φ are determined from least square fitting.

If y(t) represents the response to a step or a similar "hard" disturbance, the assumption inherent in eq.(2.24) is that the resonant part of the transfer function can be described by a second order transfer function of the form:

$$\frac{\text{Const.}}{(\lambda + i\omega)^2 + \omega_o^2} \tag{2.25}$$

This will be true if, as is often the case, a complex conjugated pair of poles is dominating other pole-zeros.

If the least square fitting does not converge, y_1 is put equal to $y(T)$ and y_2 is put equal to zero.

When the function $y(t)$ is approximated by the expression (2.24), the transform is given by:

$$\Delta y(i\omega) = \int_0^T e^{-i\omega t}\, \tilde{y}(t)dt + \frac{y_1 - y(o)}{i\omega} + $$

$$+ y_2 \frac{e^{-T(\lambda + i\omega)}}{(\lambda + i\omega)^2 + \omega_o^2}\left[(\lambda + i\omega)\sin(\omega_o T + \varphi) + \omega_o \cos(\omega_o T + \varphi)\right] \tag{2.26}$$

where

$$\tilde{y}(t) = y(t) - y_1$$

Here the last term is the result of analytically calculating the integral from T to ∞. The first integral above is calculated numerically by LAPTRANS using a "Filon-Trapezoidal" formula, which may be found in Lanczos [11], and which is correct if $y(t)$ may be assumed to vary linearly between the given points:

$$\int_0^T e^{-i\omega t}\, \tilde{y}(t)dt = \sigma^2(-\tfrac{i\omega}{2})\, S(-i\omega) + \frac{\sigma(-i\omega) - 1}{-i\omega}\left[\tilde{y}(o) - e^{-i\omega T}\, \tilde{y}(T)\right] \tag{2.27}$$

where

$$\sigma(-i\omega) = \frac{\sin \omega \Delta t}{\omega \Delta t}$$

$$S(-i\omega) = \frac{T}{N} \sum_{k=0}^{N}{}'' \; e^{-i\omega k \Delta t}\; \tilde{y}(k\,\Delta t) \tag{2.28}$$

Here $T = N \cdot \Delta t$ and Σ'' indicates that the first and last terms are taken with half weight.

Note that t_o has to be chosen sufficiently large and still smaller than T as we want to neglect the high frequency part of the transform in the least square fitting. It is, as is well known, the behaviour for small times which determines the high frequency response.

LAPTRANS calculates for each function the phase and gain of the transform for a set of frequencies specified by the user. The user specifies a lower frequency, ω_1, and an upper frequency, ω_2, and the programme calculates the transforms for 10 frequencies per decade in this interval, approximately evenly spaced on a logarithmic scale: 1., 1.25, 1.6, 2., 2.5, 3.2, 4., 5., 6.3, 8. (rad/sec). Finally, the required transfer functions are calculated by dividing gains and subtracting phases. The gain is finally given in decibel (db) and the phase normalized to the range: $-360^\circ < \varphi \leq 0^\circ$.

All transfer functions are relative ones, i.e., the transfer function from, for instance, heat to coolant flow $Q(t)$ to core inlet velocity $v_{in}(t)$ is given by:

$$H(i\omega) = L\left[\frac{(v_{in}(t) - v_{in}(o))/v_{in}(o)}{(Q(t) - Q(o))/Q(o)}\right]_{S=i\omega} \qquad (2.29)$$

In the special cases where the initial value is zero, i.e. for Δp, pressure deviation, and reactivities, ρ_v, ρ_d and ρ_{ex}, the following normalization factors are used:

$$\text{For } \Delta p\text{:} \quad 1 \text{ ata} = 0.9807 \cdot 10^5 \text{ N/m}^2$$
$$\text{"} \quad \rho\text{:} \quad 1 \text{ pcm} = 10^{-5} \qquad (2.30)$$

For further details, consult section 3 and the work report [10].

2.2 Structure of the Programme, Main Programmes and Subroutines

RAMONA I is written in 3600 FORTRAN for the CDC-3600 computer and runs under the DRUM SCOPE Operating System. It consists of a MAIN programme and two OVERLAYS. All variables common to two or more routines are stored in COMMON blocks.

The MAIN programme consists of the master programme RAMONA and five subroutines which are called from both OVERLAY 1 and OVERLAY 2:

MAIN

RAMONA, master programme.

THERMO, calls LIGHTWAT/HEAVYWAT, calculates thermodynamic quantities as function of pressure (local) and temperature.

LIGHTWAT, calls RATAPP, calculates the thermodynamic variables listed in section 2.1.1 for H_2O.

HEAVYWAT, similar to LIGHTWAT, but for D_2O.

RATAPP, evaluates rational approximations.

RSUM, is an auxiliary subroutine which is summing elements of an array.

OVERLAY 1

MAIN1, this is essentially a steering programme, is also printing the transfer functions.

READ, reads, checks and prints out the input data.

AUXSUB, calculates time-independent auxiliary quantities, prepares input data for VOIFLO and calls VOIFLO. From VOIFLO output it calculates RAMONA I steady state.

VOIFLO, (with six small functions and subroutines [3]) calculates an approximate steady state.

STEPSIZE, calculates the non-equidistant spatial steps in core (if required); called from AUXSUB.

INTPOL1, uses linear interpolation to convert functions given in constant steps to variable steps, called from AUXSUB.

DISTRIB, calculates normalized fraction of power or reactivity in each section in core; called from MAIN1.

PRINT1, prints nomenclature used during "dynamic" output; called from MAIN1.

LAPTRANS, calculates the Laplace transform of a function given in equidistant points; called from MAIN1.

LSQNL, standard non-linear least squares subroutine, used by LAPTRANS.

MATINV, subroutine for matrix inversion, used by LSQNL.

DERV, called from LSQNL, calculates partial derivatives of the function to be fitted, eq.(2.24).

OVERLAY 2

MAIN2, this is a steering programme for the actual dynamic calculation. Calls FUNC PRINT, EULMERS and STEADY.

EVAP,	calculates evaporation and condensation rate, called from HYDRO2.
HYDRO1,	calculates external disturbances, water temperature and void distributions; calls DISTURB and THERMO.
HYDRO2,	contains the essential parts of the hydrodynamic model.
FUEL,	calculates fuel surface temperature, average temperature, heat to coolant flow and fuel temperature derivatives in REACTOR case.
HEATTR,	calculates boiling and non-boiling heat transfer coefficients according to Jens-Lottes and Colburn correlations. Called from TCAN and FUEL.
TCAN,	calculates canning surface temperature in LOOP case.
DISTURB,	calculates ramp and sinusoidal external disturbances; called from HYDRO1 and KINETICS.
KINETICS,	contains the neutron kinetics model, calls REACTIV.
REACTIV,	calculates void, Doppler and moderator temperature reactivities.
STEADY,	calculates the initial steady state of the fuel and kinetics models.
EULMERS,	integrates first order differential equations by the modified Euler method. It has step and output control à la Merson; calls FUNC.
FUNC,	calculates the derivatives required by EULMERS by calling other routines containing the fuel, kinetics and hydrodynamics models.
SLIP,	calculates the slip ratio in each subsection according to the requested formula; called from HYDRO2.
FRICMULT,	calculates the two-phase friction multiplier, called from HYDRO2.
PRINT,	prints "dynamic" output, "small" and "large" output at requested intervals, calls PLOT.
ST PLOT,	plotting subroutine. Has three entries: ST PLOT and END PLOT are called from MAIN2, PLOT is called from PRINT.
MINMAX,	calculates largest and smallest element of an array, called from PRINT.

2.3 Flow of the Computations

The flow of the computations are briefly described below. As will be seen, the breaking of the programme into overlays has no influence on computer time as the time consuming integration of the equations describing the dynamics, are within the second overlay. Further, the data required are in core at all times (numbered COMMON).

First the input data are read, checked for obvious errors and edited by the READ routine. Next AUXSUB is called. This routine calculates VOIFLO input, calls VOIFLO, calculates initial values from VOIFLO results and calculates time-independent auxiliary quantities. It also calculates normalized power and void reactivity coefficient distributions.

Next the dynamic calculation starts. If the option ISTEADY equals 1 (cf. section 3), the hydrodynamic equations are integrated using the LOOP option and constant pressure case, until the hydrodynamic variables have levelled off. The MAIN2 programme calls the routine EULMERS which calls FUNC, which in turn calls HYDRO1, TCAN and HYDRO2. TCAN calculates the canning temperature which is required by EVAP. HYDRO2, which contains the main part of the hydrodynamics, starts with the calculation of steam load or system pressure derivative depending on whether system pressure is constant or not. Next, from the integrated momentum balance, the downcomer inlet flow is determined and in the case of carry-under, the void fraction at downcomer inlet calculated. Following this, the general equations for each subsection are utilized to calculate steam and water velocity distributions in the loop. Simultaneously, new derivatives of energy and steam mass are calculated together with the derivative of total momentum which allows a new integration step to be taken.

Consider now a dynamics calculation in the REACTOR case. Steady state hydrodynamics is obtained from VOIFLO and, if ISTEADY = 1, by a LOOP case dynamic calculation. Then STEADY is called which calculates initial values for the neutron kinetics and fuel models. STEADY calls HEATTR and REACTIV. Next the initial steady state is printed by calling PRINT. The essential difference between the dynamic calculation in the REACTOR case and the LOOP case, is that in the former FUNC calls in turn HYDRO1, FUEL, HYDRO2 and KINETICS, instead of HYDRO1, TCAN and HYDRO2.

The dynamic calculation now continues, interrupted by printing up to a time limit given as input (if not divergence starts). When the dynamics calculation is finished, MAIN2 calls END PLOT, and the plotting performed on the line printer (if requested). Finally, control is transferred to OVERLAY 1 and (if requested) transfer functions calculated and printed.

3. USE OF THE PROGRAMME

3.1 Types of Transient Responses which may be Simulated

This section is essentially a reproduction of section 2.1.2 in ref.[1]. As it directly concerns the user, it is included here. From studying [1], the reader is assumed familiar with the socalled LOOP/REACTOR option. In the LOOP case, the hydraulics of the loop can be studied separately by bypassing the fuel and neutron kinetics models, the heat to coolant flow is specified by the user. In the REACTOR case, the complete model with hydrodynamics, fuel and neutron kinetics is solved. In the LOOP case the amount of input data required and computer time are significantly reduced.

The main operating data which are input, are:

Q^o_{TOT} = total power

or { Q^o_{SUB} = subcooler power
ΔT_{SUB} = core inlet subcooling in ^oC }

$P^o_{reactor}$ = steam drum, or system, pressure.

Initially, the steam load, feedwater flow and temperature, and the external system pressure are calculated from the main operating data.

The dynamic behaviour of a given reactor or electrically heated loop can now be studied by applying external disturbances. These can be introduced at any time $t \geq 0$ as a limited ramp (or in the limit, a step) or sequences of limited ramps, and/or sinusoidal variations in:

1) Gravity acceleration. May be used in the study of marine reactors.
2) Steam valve setting. Applies only in the case of no pressure control. The relation between the steam valve coefficient, K_p (m^4), and the steam load, $w_{s\ell}$ (kg/sec) is:

$$w_{s\ell} = \sqrt{\rho_g (K^o_p + \delta K_p)(p_{reactor} - p_{secondary})} \qquad (3.1)$$
$$= 0 \text{ if } p_{reactor} < p_{secondary}$$

where $K_p = K^o_p + \delta K_p$ and δK_p can be specified as a disturbance. The driving pressure is the difference between the reactor pressure and constant secondary system pressure (calculated from a steady state balance). This option allows, for instance, simulating the effect of a sudden increase in the steam demand.

3) Feedwater massflow and temperature. Allows simulating the effect of changing subcooling, e.g. cold water accident, loss of control over pumps.

4) Control rod reactivity. Applies only in the REACTOR case, and makes it possible to study the effect of control rod reactivity manipulations.

5) Heat to coolant flow. Applies only in the LOOP case where the heat to coolant flow is an independent variable. To study hydraulic stability, the power can be increased in a sequence of steps until divergent oscillations are observed.

6) Forced circulation pump head. In the case of forced circulation, the pump head can be disturbed to study for instance the effect of pump failure or to obtain a measure of the stiffness of the hydraulic loop.

3.2 Input Description

Each group of input data are headed by an information card as explained in section 2.1.8. Only the first five characters on the card are checked, the text has to start in col. 1. The interpretation of the geometrical data is shown on Figs. 1 and 2. Note that the pressure "loss" coefficients are referred to pressure change in local velocity heads, and a pressure decrease in the direction of flow is negative. The pressure change from core to riser is calculated from a momentum balance (Romie's method), but can be adjusted by adding a spacer at core exit.

The format used on input is with a few exceptions:

INTEGER "I12"

REAL NUMBER "E12.5"

and the programme mnemonics are throughout determining whether a variable is of type INTEGER or REAL. Below the units are indicated, although MKSA units are used throughout.

Input RAMONA I

Math. Symbol	Programme Mnemonics	Description, Remarks, Units
1. Input data following the information card "TEXT":		
		CARD 1 (10A8): Problem identification, up to 80 alphanumeric characters.

2. Input data following the information card "GEOMETRICALDATA":

CARD 1 (6E12.5):

A_c	AC	Flow area core	(m^2)
A_R	AR	" " riser	"
A_{UP}	AUP	" " upper plenum	"
A_{D1}	AD1	" " downcomer 1	"
A_{D2}	AD2	" " downcomer 2	"
A_{LP}	ALP	" " lower plenum	"

CARD 2 (6E12.5):

L_c	HC	Length (height) of core	(m)
L_R	HR	" " " riser	"
L_{UP}	HUP	" " " upper plenum	"
L_{D1}	HD1	" " " downcomer 1	"
L_{D2}	HD2	" " " downcomer 2	"
L_{LP}	HLP	" " " lower plenum	"

CARD 3 (4E12.5):

D_c	HDC	Hydraulic diameter of core	(m)
D_R	HDR	" " " riser	"
D_{D1}	HDD1	" " " downcomer 1	"
D_{D2}	HDD2	" " " downcomer 2	"

CARD 4 (5E12.5):

Pressure difference in local velocity heads at:

$L_{c,i}$	VHCI	core inlet (using mom.flow at core inlet)
$L_{R,o}$	VHRØ	riser outlet(" " " " riser outlet)
$L_{D1,i}$	VHD1I	downc.1 inlet(" " " " downc. 1 inlet)
$L_{D1,2}$	VHD12	downc.1 → 2 (" " " " " outlet)
$L_{D2,LP}$	VHD2LP	downc.2 → lower pl.(using mom,flow at downc. 2 outlet)

		<u>CARD 5 (5I12):</u>
n_c	NC	Number of subsections in core, $n_c \leq 60$
n_R	NR	" " " " riser, $n_R \leq 40$
n_{D1}	ND1	" " " " downcomer 1
n_{D2}	ND2	" " " " downcomer 2
n_o	NO	Subsection where feedwater is returned; upper plenum is no. 1 a.s.o., cf. Fig. 2.
		<u>CARD 6 (3E12.5):</u>
g^o	GRO	Gravity acceleration (nominal) (m/sec^2)
h^o	WLEVO	Water level above riser outlet (nominal) (m)
P_H	PH	Heated perimeter (total) (m)

Observe the following restrictions checked by the programme:

a) All flow areas positive

b) All lengths greater than 0.01 (m)

c) All hydraulic diameters positive

d) $n_c \leq 60$; $n_{TOT} = n_c + n_R + n_{D1} + n_{D2} + 2 \leq 100$, $n_R \leq 40$

e) g^o positive

f) h^o positive and less than L_{UP}.

In REACTOR case, the heated perimeter is calculated from the NUCLEAR FUEL DATA and the value read in from CARD 6 is insignificant.

3. <u>Input data following the information card "SPACER DATA". This information card with data is optional, no spacer data means no spacers:</u>

		<u>CARD 1 (I12):</u>
	ISPAC	Total no. of spacers (ISPAC ≤ 10)
		<u>CARD 2 and the following (6E12.5)</u>:
z_1	ZSP(1)	Position spacer no.1 rel. to core inlet (m)
⋮	⋮	⋮
z_{ISPAC}	ZSP(ISPAC)	" " ISPAC " " " " "

⋮

CARD 3 and the following (6E12.5):

L_1	VHSP(1)	Velocity heads (local) spacer no. 1
⋮	⋮	⋮
L_{ISPAC}	VHSP(ISPAC)	" " " " " ISPAC

The following restrictions are checked by the programme:

a) If no "SPACER DATA", ISPAC = 0

b) ISPAC ≤ 10

c) $z_1 \leq L_c + L_R$, i.e., spacers allowed in core and riser.

4. Input data following the information card "TWO-PHASE FLOW DATA":

CARD 1 (I12):

OPTION 1 Moderator type.	IMOD	IMOD = 0, light water moderator IMOD = 1, heavy " "

CARD 2 (I12):

OPTION 2 Two-phase friction corr.	IMULT	IMULT = 1, the Becker correlation = 2, the Lottes-Flinn correlation = 3, the Modified Martinelli-Nelson correlation

CARD 3 (E12.5) only if IMULT = 1:

A_F	CTP(1)	Coefficient in the Becker correlation, eq.(2.9).

CARD 4 (I12):

OPTION 3 Slip correlation	ISLIP	ISLIP = 1, constant slip ratio = 2, Solberg's slip formula, eq.(2.4) = 3, the Bankoff-Jones correlation, eq.(2.6).

CARD 5 (E12.5) only if ISLIP = 1:

S	CSL(1)	Constant slip ratio equal S.

CARD 6 (4E12.5) only if ISLIP = 2:

S_1	CSL(1)	Solberg's slip formula:
S_2	⋮	$v_g = Sv_f + v^o$
r	⋮	$S = S_1 + S_2\alpha^r$
v_o^o	CSL(4)	$v_o^o = -\cos\varphi \cdot v_o^o\sqrt{\left\|\frac{g(t)}{g^o}\right\|}$ (m/sec)

		CARD 7 (I12):
OPTION 4		
Carry-under	ICU	ICU = 0, neglect carry-under = 1, carry-under correlation.
		CARD 8 (2E12.5) only if ICU = 1:
C_1	CU(1)	Carry-under correlation:
C_2	CU(2)	$\alpha_{cu} = \alpha_R \cdot (1 - \frac{C_1}{W_1}) \cdot C_2 \cdot \frac{W_{g,R}}{W_R}$ cf.[1] and Appendix A.
		CARD 9 (5E12.5):
κ	KAPPA	Coefficients in the expressions
R_o	RO	for evaporation and condensation (watt/m^3 °C)
R_1	R1	rates, cf. eq.(A3.20) in Appendix A (watt/m^3 °C)
G_1	G1	Single phase friction factor:
G_2	G2	$f = \frac{G_1}{2 \cdot D_h \cdot Re^{G_2}}$

The programme checks the following:

a) That the options have only the values given above.

b) $r > 0$ if ISLIP = 2

c) $0 \leq \kappa \leq 1$

d) R_o, R_1, G_1, and $G_2 \geq 0$.

5. Input data following the information card "HEAD FORCED CIRCULATION". This information card is optional, if no such card, no forced circulation head.

		CARD 1 (3E12.5):	
H_o	HO	Nominal forced circulation	(N/m^2)
H_1	H1	head equals:	(Nsec/m^3)
H	H2	$H = H_o + H_1 v_{in} + H_2 v_{in} \lvert v_{in} \rvert$	(Nsec^2/m^4)

If no "HEAD FORCED CIRCULATION" card, the "internal" option IPUMP = 0, else IPUMP = 1.

6. Input data following the information card "PØWER DISTRIBUTION DATA". This information card is optional; if no such card, constant power distribution

		CARD 1 (I12):
	IPDIST	No. of equidistant points where power distribution is given (IPDIST ≤ 60).
		CARD 2 and the following (6E12.5):
P^*_1	UP(1)	Power distribution (unnormalized) in
P^*_2	UP(2)	equidistant points starting at core inlet
⋮	⋮	and ending at core outlet, cf. Fig. 4
P^*_{IPDIST}	UP(IPDIST)	

The programme checks the following:

a) If no "POWER DIST----" card, IPDIST = 0

b) All $P^*_k \geq 0$.

7. If a REACTOR case calculation is requested, the information card "REACTOR CASE" must be present.

8. Input data following the information card "NUCLEAR FUEL DATA". Mandatory only in REACTOR case.

		CARD 1 (6E12.5):	
R_{ca}	RCA	Radius of canning	(m)
R_F	RF	" " fuel rods	"
C_F	CF	Specific heat of fuel	(watt sec/°C kg)
ρ_F	RHØFF	Density of fuel	(kg/m³)
ϵ_1	EPSILØN1	Heat conductivity in fuel:	(watt/°C m)
ϵ_2	EPSILØN2	$\lambda_F = \frac{\epsilon_1}{1 + \epsilon_2 T}$; T (°C)	($°C^{-1}$)
		CARD 2 (2E12.5):	
K_{g+ca}	RKGAP	Heat transfer coefficient gap to canning	(watt/m² °C)
δ	DELTA	Fraction of heat promptly generated in the coolant.	
		CARD 3 (I12):	
ν	NY	Number of fuel rods.	

The programme checks the following:

a) $R_{ca} > R_F$

b) ν positive integer

c) $0. \leq \delta \leq 1.$

9. Input data following the information card "NEUTRON KINETICS DATA". Mandatory only in REACTOR case.

CARD 1 (6E12.5):

ρ_M	RHØM	Moderator temperature reactivity: $\rho_T = \rho_M \langle T_f \rangle_{core} - \rho_T^o$	$(^oC^{-1})$
D_1	D1	Doppler reactivity:	$(^oC^{-1})$
D_2	D2	$\rho_D = D_1 \langle T_f \rangle + D_2 \langle T_f \rangle^2 - \rho_D^o$	$(^oC^{-2})$
A_1	A1	Void reactivity:	
A_2	A2	$\rho_V = A_1 \langle \alpha \rangle_{core} + A_2 \langle \alpha \rangle^2_{core} - \rho_V^o$	
ℓ^*	RNLIFE	Prompt neutron lifetime	(sec)
		CARD 2 (I12):	
m	IM	Number of delayed neutron groups: $1 \leq m \leq 10$	
		CARD 3 and the following (6E12.5):	
β_1	BETA(1)	Delayed neutron fractions	
⋮	⋮	⋮	
β_m	BETA(IM)		
		CARD 4 and the following (6E12.5):	
λ_1	RLAMBDA(1)	Decay constants	(sec^{-1})
⋮	⋮	⋮	
λ_m	RLAMBDA(IM)		(sec^{-1})

The programme checks that: $1 \leq m \leq 10$.

10. Input data following the information card "VOID REACTIVITY DISTRIBUTION". The card is optional; if no such card, the void reactivity coefficient distribution is constant.

CARD 1 (I12):

IVREAC	No. of equidistant points where void reactivity coefficient distribution is given (cf. power distribution).

		CARD 2 and the following (6E12.5):
ρ^*_L	UVR(1)	Unnormalized void reactivity coefficient distribution.
⋮	⋮	
ρ^*_{IVREAC}	UVR(IVREAC)	

The following is checked by the programme:

a) All $\rho^*_k \geq 0$.

b) If no "VOID REACT----" card, IVREAC = 0.

11. If the "prompt jump" approximation is to be used, the information card "PROMPT JUMP APPRØXIMATIØN" should be present.

12. Input data following the information card "NOMINAL OPERATING CONDITIONS":

		CARD 1 (6I12):
OPTION 1 Subcooling	ITEMP	ITEMP = 0, nominal subcooler power input = 1, subcooling in degrees input
OPTION 2 System pressure	IPRES	IPRES = 0, constant system pressure)ideal pressure controller) = 1, varying system pressure (no pressure controller)
OPTION 3 Local pressure	IPLØC	IPLØC = 0, no local pressure dependence = 1, local " "
OPTION 4 Spatial step in core	ISTEP	ISTEP = 0, constant spatial step in core = 1, spatial step in core proportional VOIFLO water velocity
OPTION 5 Recirculation	IFLØW	IFLØW = 0, core inlet velocity from momentum balance = 1, no iteration on core inlet velocity, $v^{(g)}_{in}$, in VOIFLO steady state calculation = 2, constant core inlet velocity equal $v^{(g)}_{in}$ also under dynamic conditions ("true" forced circulation).
OPTION 6 Steady state calculation	ISTEADY	ISTEADY = 0, start "actual" dynamic calculation from VOIFLO steady state = 1, integrate LOOP case to obtain true steady state, before "actual" dynamic calculation starts.

		CARD 2 (5E12.5):	
Q_{TOT}	QTØTO	Nominal power	(watt)

Q^o_{SUB} / ΔT^o_{SUB}	QSUBO / DTSUBO	Nominal subcooling:	
		Q^o_{SUB} given if ITEMP = 0 or:	(watt)
		ΔT^o_{SUB} " " ITEMP = 1	(^oC)
$p^o_{reactor}$	PRESSO	Nominal system pressure	(N/m^2)
$v^{(g)}_{in}$	VGUESS	Core inlet velocity (guess if IFLOW = $\{^0_1$, wanted v_{in} if IFLOW = 2)	(m/sec)
K^o_p	RKPO	Main steam valve coefficient, only required if IPRES = 1	(m^4)

The programme is checking that:

a) $Q^o_{TOT} \geq Q^o_{SUB} \geq 0$

b) $0.981 \cdot 10^5 \leq p^o\ (N/m^2) \leq 100 \cdot 10^5$

c) Options have only values specified above.

13. Input data following the information card "INTEGRATION SPECIFICATION". This information card is optional, cf. section 2.1.7:

CARD 1 (3E12.5):

ACC	Local relative "accuracy" as defined in sect. 2.1.7.
HMIN	Minimum timestep allowed by the integration routine.
HGUESS	Initial guess for starting the integration. The integration routine halves (or doubles) the step until the accuracy requirement is satisfied. Halving is stopped if the step becomes less than HMIN, cf. section 2.1.7.

Note: if no "INTEGRATION SPECIFICATION" card, the values ACC = 0.01, HMIN = 0.002, HGUESS = 0.01 (sec) are used.

Next follows information cards and data defining disturbances. As disturbances may be used a sequence of limited ramps (or in the limit, steps) and (or) sinusoidal variations, cf. Fig. 3. The information cards defining disturbances are optional. Any number of disturbances may be applied.

14. Input data following the information card "GRAVITY DISTURBANCE". This information card is optional:

CARD 1 (6E12.5):

$t_{g,o}$	TGO	The disturbance starts at time $t_{g,o}$	(sec)
g_r	GRAMP	Ramp coefficient (relative value)	(sec^{-1})

$g_{r,max}$	GRAMPMAX	Ramp max. (relative value)	
$\delta_{t,g}$	DELTG	Interval between each new ramp	(sec)
g_{sin}	GSIN	Relative amplitude of sinusoidal dist.	
τ_g	TAUG	Period of oscillation, cf. Fig. 3	(sec)

15. Input data following the information card "FORCED CIRCULATION DISTURBANCE". The information is optional:

CARD 1 (6E12.5):

$t_{H,o}$	THO	
H_r	HRAMP	
$H_{r,max}$	HRAMPMAX	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
δt_H	DELTH	
H_{sin}	HSIN	
τ_H	TAUH	

Note that obviously no forced circulation disturbance can be applied if one has no forced circulation.

16. Input data following the information card "FLOW DISTURBANCE, FEEDWATER". This information card is optional:

CARD 1 (6E12.5):

$t_{w,o}$	TWO	
$w_{fw,r}$	WFWRAMP	
$w_{fw,max}$	WFWMAX	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
δt_w	DELTW	
$w_{fw,sin}$	WFWSIN	
τ_w	TAUW	

17. Input data following the information card "TEMPERATURE DISTURBANCE, FEEDWATER". This information card is optional (allowed if ITEM=0):

CARD 1 (6E12.5):

$t_{T,o}$	TTO	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
$T_{fw,r}$	TFWRAMP	

$T_{fw,max}$	TFWMAX	
δt_T	DELTT	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
$T_{fw,sin}$	TFWSIN	
τ_T	TAUT	

The programme checks if a feedwater temperature disturbance is requested when the subcooler temperature is given as input. In that case, an error message is printed and the case terminated.

18. Input data following the information card "STEAM LOAD DISTURBANCE". This information card is optional. Present only if IPRES = 1:

CARD 1 (6E12.5):

$t_{K,o}$	TKO	
$K_{p,r}$	RKPRAMP	
$K_{p,max}$	RKPMAX	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
δt_K	DELTK	
$K_{p,sin}$	RKPSIN	
τ_K	TAUK	

The programme checks if a steam load disturbance is requested when the system pressure should be constant. In that case, an error message will be printed and the case terminated.

19. Input data following the information card "CONTROL ROD REACTIVITY DISTURBANCE". This information card is optional. Present only in REACTOR case:

CARD 1 (6E12.5):

$t_{\rho,o}$	TRO	
ρ_r	RHØRAMP	
ρ_{max}	RHØMAX	Note that in this case ρ_r, ρ_{max} and ρ_{sin} are
δt_ρ	DELTR	(obviously) absolute values.
ρ_{sin}	RHØSIN	
τ_ρ	TAUR	

The programme checks if a reactivity disturbance is requested in the LOOP case. If so, an error message will be printed and the case terminated.

20. Input data following the information card "HEAT TO COOLANT FLOW DISTURBANCE". This information card is optional. Present only in LOOP case:

CARD 1 (6E12.5):

$t_{Q,o}$	TQO	Cf. "GRAVITY DISTURBANCE" and Fig. 3.
Q_r	QRAMP	
Q_{max}	QMAX	
δt_Q	DELTQ	
Q_{sin}	QSIN	
τ_Q	TAUQ	

The programme checks if a heat to coolant flow disturbance is requested in the REACTOR case. If so, an error message is printed and the case terminated.

Note that for all disturbances the period of the sinusoid has to be different from zero if the relative amplitude is different from zero. If not, the case will be terminated with an error message.

21. Input data following the information card "TRANSFER FUNCTION CALCULATION". This information card is optional:

CARD 1 (24I3) NB!

INRT(1)	Calculate the transfer function from INRT(1)
INRT(2)	to INRT(2).
INRT(3)	Calculate the transfer function from INRT(3)
INRT(4)	to INRT(4).
⋮	⋮
	Up to 12 transfer functions involving up to 4 different dynamic variables according to the table, sect. 2.1.9, may be calculated.

CARD 2 (I12):

N	Number of frequencies appearing on the next card, ($2 \leq N \leq 10$).

CARD 3 and the following (6E12.5):

ØMEGA(1)	Two frequencies for specification of range for the set

ω_2	ØMEGA(2)	of basic frequencies, cf. sect. 2.1.10. ω_1 = lower frequency, ω_2 = upper frequency (rad/sec)
ω_3 ⋮ ω_N	ØMEGA(3) ⋮ ØMEGA(N)	Additional frequencies (rad/sec) for which transfer functions should be calculated.
		CARD 4 (2E12.5):
Δt_{TR}	STEPTR	The time step or sampling interval used for the transfer functions calculation (sec)
t_o	TO	Least square fitting starts at $t = t_o$ (sec)

Notes:

a) Transfer functions between maximum 4 dynamic variables according to the table in sect. 2.1.9, may be requested. This means maximum 12 transfer functions.

b) The number of additional frequencies is limited to 7.

c) ω_1 and ω_2 should be chosen such that the interval contains not more than 30 frequencies (3 decades).

d) Δt_{TR} should be chosen with the sampling theorem in mind (two samples per period of the highest frequency present in the data). $\Delta t_{TR} = \Delta t_1 = \Delta t_2$ (Δt_1 and Δt_2 defined below) is optimal with respect to computer time.

e) Maximum 500 samples (for each function) is allowed in the present version.

22. Input data following the information card "OUTPUT INFORMATION". This information card is mandatory:

		CARD 1 (2I12):
OPTION 1 Output of tables	ITAB	ITAB = 0, "small" output every Δt_1 resp. Δt_2 (sec), "large" output only at t = 0 (sec). ITAB = k, "large" output every $k \cdot \Delta t_1$, resp. $k\Delta t_2$ (sec) (tables of the spatial variation of several variables). "small" output as for ITAB = 0.
OPTION 2 Plotting	IPLOT	IPLOT = 0, no plotting = 1, plotting of selected variables (sect.2.1.9) on the line printer.

		CARD 2 (5I12) only if IPLOT = 1
	INR(1) INR(2) ⋮ INR(5)	Plotting of the dynamic variables INR(1), INR(2), ... INR(5) according to the list in sect. 2.1.9. Less than 5 may be plotted by leaving the rest of the card blank.
		CARD 3 (5E12.5) only if IPLOT = 1
	AMIN(1) AMIN(2) ⋮ AMIN(5)	Lower limit for each of the (maximum) 5 variables listed on card 2. This lower limit will correspond to the left hand boundary on the graph.
		CARD 4 (5E12.5) only if IPLOT = 1
	AMAX(1) AMAX(2) ⋮ AMAX(5)	Upper limit for each of the (maximum) variables listed on card 2. This upper limit will correspond to the right hand boundary on the graph. (Cf. note below).
		CARD 5 (E12.5) only if IPLOT = 1
Δt_{PL}	XSC	The time step corresponding to the distance between successive lines on the line printer (sec).
		CARD 6 (4E12.5):
Δn_c	NNC	Tabular output for each Δn_c subsection in core
Δn_R	NNR	" " " " Δn_R " " riser
Δn_{D1}	NND1	" " " " Δn_{D1} " " downc. 1
Δn_{D2}	NND2	" " " " Δn_{D2} " " downc. 2
		CARD 7 (4E12.5):
Δt_1	STEP1	The time step between output ("large" or "small")
t_1	HALT1	is:
Δt_2	STEP2	Δt_1 for $t < t_1$
t_2	HALT2	Δt_2 for $t_1 \le t \le t_2$

Notes:

a) Each of the maximum five variables to be plotted are normalized by using AMAX and AMIN to fit the range (0,1) by the linear transformation:

$$\tilde{y}(t) = \frac{y(t) - AMIN}{AMAX - AMIN} \qquad (3.2)$$

The line printer allows an additional 10%, so actually the range represented in the graph is (0,1.1). Data falling outside this range will be suppressed.

b) $\Delta t_{PL} = \Delta t_1 = \Delta t_2$ is optimal with respect to computer time, although the saving is not significant.

c) Irrespective of the value of Δn_c etc, the values relating to the last subsection in each section along the flow path (core, riser, etc) will be printed.

23. Finally, each data set (defining one transient calculation) has to be ended by the information card "FINISH".

Several cases may be run consecutively. Only the group of data to be changed from the previous case need to be read in (a group of data being defined by one information card). There are, however, two exceptions from this rule: First, the information card "REACTOR CASE" has to be read in for each REACTOR case calculation. This is to allow a LOOP case calculation to follow a REACTOR case calculation. Second, the disturbances have to be redefined for each case as the internal options set for each required disturbance, are reset to "no disturbance".

To facilitate the presentation of input data, the information cards are listed in the following table:

INFORMATION CARDS

No.	Information card	Optional	Mandatory	Remarks
1	TEXT	X		
2	GEØMETRICAL DATA		X	
3	SPACER DATA	X		
4	TWØ-PHASE FLØW DATA		X	
5	HEAD FØRCED CIRCULATIØN	X		
6	PØWER DISTRIBUTIØN DATA	X		
7	REACTØR CASE	X		Defines REACTOR case.
8	NUCLEAR FUEL DATA		X	Mandatory only in REACTOR case.
9	NEUTRØN KINETICS DATA		X	Mandatory only in REACTOR case.
10	VØID REACTIVITY DISTRIBUTIØN	X		
11	PRØMPT JUMP APPRØXIMATIØN	X		
12	NØMINAL ØPERATING CØND.		X	

(cont.)

(cont.)

No.	Information card	Optional	Mandatory	Remarks
13	INTEGRATIØN SPECIFICATIØN	X		
14	GRAVITY DISTURBANCE	X		
15	FØRCED CIRCULATIØN DIST.	X		
16	FLØW DIST., FEEDWATER	X		
17	TEMPERATURE DIST., FEEDW.	X		Present only if ITEMPT = 0
18	STEAM LØAD DISTURBANCE	X		Present only if IPRES = 1
19	CØNTRØL RØD REACT. DIST.	X		Present only in REACTOR case
20	HEAT TØ CØØLANT FLØW DIST.	X		Present only in LOOP case
21	TRANSFER FUNC. CALCULATIØN	X		
22	ØUTPUT INFØRMATIØN		X	
23	FINISH		X	

As seen from the table, the input data required are much less than one might think after a first look at the input description.

It is reminded that only the first five characters on the information cards are read (starting in Col. 1).

3.3 Output Description

The first output from RAMONA I is a selfexplanatory listing of the input data. Each group of data is headed by the standard information card TEXT. These groups of data are concluded with a table of the thermal variables calculated from rational approximations within the programme.

Next, on a new page, follows the result of the VOIFLO calculation according to the standard output format described in [3]. After this follows a list of the nomenclature and units used in the output from the dynamics calculation.

Next follows the RAMONA I "steady state" as calculated from the VOIFLO steady state. As already explained, in general this will only be an approximate steady state for the RAMONA I model.

If the option ISTEADY equals one, a "true" steady state is calculated before the actual dynamics calculation starts.

For time intervals specified under the information card "OUTPUT INFORMATION", the value of a number of variables are printed. Every ITAB time step (if ITAB $\neq$ 0), the spatial variation of ("large" output) the following variables are printed:

quality	(none)
void fraction	(none)
water velocity	(m/sec)
slip ratio	(none)
subcooling	($^\circ$C)
water temp.	($^\circ$C)
evaporation rate	(kg/sec m^3)
surface heat flux x 10^{-4}	(watt/m^2)

The heat flux is multiplied with the factor 10^{-4} to obtain numerical values given in watt/cm^2 (most common units for heat flux) still using MKSA units throughout.

The "small" output which is printed for each time step (Δt_1 resp. Δt_2), consists of the following variables:

Math. Symbol	Output Mnemonics	Description and Units
t	T	Time (sec)
Q_{TOT}	Q	Heat to coolant flow (watt)
Δp	DP	System pressure relative to nominal (N/m^2)
w_{sl}	SL	Steam load (kg/sec)
w_{fw}	FW	Feedwater flow (kg/sec)
T_{fw}	FT	Feedwater temperature ($^\circ$C)
g	GR	Gravity acceleration (m/sec^2)
h	WL	Water level in upper plenum (m)
v_{in}	VI	Core inlet velocity (m/sec)
$\langle\alpha\rangle_c$	VC	Average void in core (none)
$\langle\alpha\rangle_R$	VR	Average void in riser (none)
$\langle\alpha\rangle_{D1}$	V1	Average void in downcomer 1 (none)
$\langle\alpha\rangle_{D2}$	V2	Average void in downcomer 2 (none)
H	H	Pump head (N/m^2)
$T_{ca,max}$	CA	Max. canning surface temperature ($^\circ$C)
$T_{FS,max}$	FS *)	Max. fuel " " ($^\circ$C)
$T_{FC,max}$	FC *)	Max. fuel centre zone " ($^\circ$C)

N	N *)	Nuclear power (watt)
	RC *)	Controlled reactivity (none)
	RD *)	Doppler reactivity (none)
	RT *)	Moderator temp. reactivity (none)
	RV *)	Void reactivity (none)
	RE *)	Excess reactivity (none)

Variables with a *) appear only in REACTOR case.

When the dynamic calculation is finished, either because the time t exceeds the upper limit t_2, or because an instability develops and the dynamic variables get out of bounds, the plotting of the selected variables takes place if requested. Selfexplanatory text is provided.

Finally, if requested, the transfer functions are tabulated, also provided with selfexplanatory text. The gain is given in decibel and the phase in degrees normalized to $360^\circ < \varphi \leq 0^\circ$. If the least square fit discussed in section 2.1.10 converges, the values λ and ω_o (rad/sec) are printed (for each function in the order they are appearing on the data card 1 under the information card "TRANSFER FUNCTIONS CALCULATION").

3.4 Operational Characteristics

As already described, the RAMONA I programme consists of a main programme and two overlays. The locations used are as follows:

Numbered CØMMØN:	15763_8
MAIN :	4404_8
OVERLAY 1 :	32430_8
OVERLAY 2 :	34635_8

It is written 3600 FORTRAN for a one bank (32K) CD 3600 computer and runs under the DRUM SCOPE Operating System. No programmer tapes are required. Input is on logical unit 5 and output on logical unit 6. It is available as a library tape. An Operating Instruction will be available to the user.

The running time depends on several factors such as the number of subsections in the hydraulic loop, the LOOP/REACTOR option, the accuracy requirement and minimum step in the numerical integration, the type of transient to be calculated and so on. Experience so far indicates that the conversion factor from real time in the model to computer time will be in the range 15 - 60 very much depending on the above factors (cf. also section 3.5).

The plotting consumes virtually no computer time and a transfer function calculation of the order 20 sec to 1 min, depending on the number of points and frequencies, and number of iterations in the least square fitting involved.

3.5 Hints to the User

In the following will be discussed some special features of the programme and some hints given to the user.

a) From the discussion in section 2.1.6 and the fact that the computer time is roughly proportional to the number of subsections, it follows that one should ordinarily use ISTEP = 1, giving spatial steps of increasing length in the positive flow direction along the core. In that case the number of subsections in the core will normally be less than the input number NC, how much may be seen from the "large" output.

b) As stated in section 2.1.7, if no information card "INTEGRATION DATA" is used, the programme uses the values ACC = 0.01, HMIN = 0.002 and HGUESS = 0.01. This means that the smallest integration step which may be used will be (underlined):

$$0.01 \rightarrow 0.005 \rightarrow 0.0025 \rightarrow \underline{0.00125} \text{ (sec)}$$

It seems from experience so far that with ACC = 0.01, this lower limit 0.00125 will often be used at least under severe disturbances. There are also indications that in many cases a larger ACC (for instance ACC = 0.1) and/or a larger HMIN (for instance HMIN = 0.01) will not influence the results significantly, but lessen the computer time significantly. Special values for ACC, HMIN and HGUESS may be inserted by using the abovementioned information card.
When choosing a value for ACC, it should be recalled that ACC is the relative and local difference between integration with the first order Euler method and the second order modified Euler method. Hence, the local relative <u>error</u> will be significantly less than ACC.
If, for some reason, one should want to use a <u>constant</u> time step in the integration, this can be achieved by making ACC very small and HMIN = HGUESS equal to the required step.

c) The option ISTEADY may be used for several purposes. In a LOOP calculation where the steady state calculated from VOIFLO is expected to be reasonably good, one may use ISTEADY = 0 and start the actual transient calculation from the VOIFLO steady state.
In a REACTOR case calculation one would ordinarily use ISTEADY = 1 to avoid a "superficial" reactivity disturbance at t = 0 due to inaccurate steady state.
Further, experience has shown that in some cases with high power density, where the loop is close to instability, the LOOP case calculation with ISTEADY = 0 may diverge due to a "superficial" hydraulic disturbance at t = 0. In such a case it may improve the situation to use ISTEADY = 1 since, as explained in sect. 2.1.5, in this case a superficial "inertia" term is added during the approach to steady state.

d) The option IFLOW may have three values. Usually, in a dynamic calculation one would use IFLOW = 0. In some cases, however, one may be interested in calculating the void and velocity distributions along the heated channel for a specified core inlet velocity (steady state value). In such a case one uses IFLOW = 2 (and eventually ISTEADY = 1). In this case the iteration on inlet velocity in VOIFLO is bypassed as the programme puts EPS = 10^6 (cf. [3] and the momentum equation bypassed in the RAMONA I model). The guess for inlet velocity, $v_{in}^{(g)}$, should now equal the wanted core inlet velocity.
Finally, if one expects the VOIFLO model, with its input data calculated as explained in Appendix B, not to be able to predict reasonably well the recirculation rate, the use of IFLOW = 1 has the only effect of bypassing the "VOIFLO" recirculation calculation. (EPS = 10^6.)

e) Note that the (unnormalized) power and void reactivity coefficient distributions given as input, represent in the model the values at equidistant points, starting at core inlet and ending at core outlet. The model then assumes that the variation is <u>linear</u> between points and evaluates the relative power or void reactivity in each subsection from this assumption. Hence, the values given are <u>not</u> the power and void reactivity coefficients in each subsection. The maximum number of values is therefore 61, cf. Fig. 4.

f) From Appendix A it may be seen that in the case of constant inlet subcooling in degrees (ITEMP = 1), this is achieved by adjusting the feedwater temperature T_{fw}. Hence, it follows that this option "breaks down" in the case of carry-under and flow reversal (in the sense that constant subcooling in degrees will not be maintained).

g) Note that if the subcooling is different from zero, putting $n_o = 1$, i.e. returning the feedwater in upper plenum, will usually lead to trouble. This is because inherent in the model is the assumption of complete mixing of feedwater and recirculating water in the section n_o. Hence, with a large upper plenum a strong condensation effect can take place. To simulate feedwater return at downcomer inlet, put $n_o = 2$.

4. SAMPLE PROBLEMS.

4.1 Sample Problem No. 1

The first sample problem is a recalculation of the marine reactor, cold water accident used as an example in [1]. From Fig. 18 in [1], it can be seen that increasing the feedwater flow four times in the course of one second, leads to a large peak in nuclear power, the peak value decreasing with increasing degree of thermal "non-equilibrium".

The input data for this sample problem are almost identical to those used to obtain the results shown in Fig. 18 of [1]. Except that now the spatial step in the core is proportional to the steady state water velocity, and the thermal data may differ slightly as a consequence of the fact that these are now calculated by the programme.

From the output in Appendix D, it is observed that the response is almost identical to that calculated with the first version RAMONA.

The computer time for this calculation was 4 min and 56 sec. Note that this time includes a dynamic calculation to obtain "exact" steady state.

4.2 Sample Problem No. 2

The second sample calculation is a recalculation of case 1 of the "Caline" calculations summarized in Table II of [1]. The response to a step in power is calculated for conditions slightly below the stability limit and a transfer function from power (or heat to coolant flow) to average void in core is calculated to demonstrate this feature of the model.

Note that the thermal variables used in sample problem no. 2 deviate slightly from those used to obtain the results shown in Table II of [1]. In this sample problem the thermal variables are those corresponding to a pressure of 80 ata (no local pressure dependence in this case), while those used in [1] were based on pressure which was measured at core inlet.

The cost of this calculation was 5 min and 27 sec.

5. ACKNOWLEDGEMENT

The authors wish to express their gratitude to Miss J. Årseth who has been responsible for the coding. Parts of this work has been of an advanced nature and has been performed in an extremely skilful way. We feel that without Miss Årseth's assistance, the RAMONA I programme could not have been completed in a reasonable time.

6. REFERENCES

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APPENDIX A

Summary of Equations

This appendix gives a summary of the most important equations describing the "RAMONA I" model. For details, the reader is referred to [1]. Note that for convenience the numeration of the subsections in the flow loop now starts with upper plenum as section no. 1 (earlier version this was no. 0). Some places this results in a change in indices compared to the description to be found in [1].

A1. Neutron Kinetics

Point kinetics:

$$\frac{d\Phi}{dt} = \frac{\rho_{ex} - \beta}{\ell^*}\Phi + \sum_{i=1}^{m} \lambda_i C_i \qquad \text{(A1.1)}$$

$$\frac{dC_i}{dt} = \frac{\beta_i}{\ell^*}\Phi - \lambda_i C_i \qquad \text{(A1.2)}$$

Prompt jump approximation:

$$\Phi = \frac{\ell^*}{\beta - \rho_{ex}} \sum_{i=1}^{m} \lambda_i C_i \qquad \text{(A1.3)}$$

Reactivities:

$$\rho_{ex} = \rho_V + \rho_D + \rho_T + \rho_C \qquad \text{(A1.4)}$$

$$\left.\begin{aligned} \rho_V &= A_1 \langle\alpha\rangle_{core} + A_2 \langle\alpha\rangle^2_{core} - \rho_V^o \\ \langle\alpha\rangle_{core} &= \sum_{core} \alpha_k \rho_k \qquad \Big(\sum_{core} \rho_k = 1\Big) \end{aligned}\right\} \qquad \text{(A1.5)}$$

$$\left.\begin{aligned} \rho_D &= D_1 \langle T_F\rangle + D_2 \langle T_F\rangle^2 - \rho_D^o \\ \langle T_F\rangle &= \text{axially and radially averaged fuel temperature} \end{aligned}\right\} \qquad \text{(A1.6)}$$

$$\left.\begin{aligned} \rho_T &= \rho_M \langle T_f \rangle_{core} - \rho_T^{o} \\ \langle T_f \rangle &= \text{axially averaged water temperature in core} \end{aligned}\right\} \quad (A1.7)$$

A2. Fuel Thermodynamics

An average fuel rod (circular) is divided in n_c axial sections and four annular zones of equal area.

Heat conductivity:

$$\lambda_F = \frac{\epsilon_1}{1 + \epsilon_2 T_F} \quad ; \quad T_F \ (^{o}C) \qquad (A2.1)$$

$T_{i,k}$ is the temperature in annular zone no. i (i = 0,1,2,3) and axial section (in core) no. k (k = 1,2,....,n_c).

$$\lambda_{i,k} = \frac{\epsilon_1}{1 + \epsilon_2 \left[T_{i,k} - (T_{i,k} - T_{i+1,k}) \frac{\sqrt{i+1} - \sqrt{i}}{\sqrt{i+2} - \sqrt{i}} \right]} \qquad (A2.2)$$

$T_{i,k}$ determined from:

$$\frac{dT_{i,k}}{dt} = \frac{1}{H_{F,k}} \left\{ \Phi(1-\delta)P_k + A_{4,k} \left[\lambda_{i-1,k}\, b_i (T_{i-1,k} - T_{i,k}) - \lambda_{i,k}\, b_{i+1} (T_{i,k} - T_{i+1,k}) \right] \right\} \qquad (A2.3)$$

$$\left.\begin{aligned} A_{4,k} &= 16\,\pi\,\Delta z_{C,k}\,\nu \\ H_{F,k} &= \rho_F C_F \,\Delta z_{C,k}\,\pi\, R_F^2\,\nu \\ b_i &= \frac{\sqrt{i}}{\sqrt{i+1} - \sqrt{i-1}} \quad ; \quad b_o = 0 \end{aligned}\right\} \quad (A2.4)$$

P_k = relative power in section no. k in core

$$\sum_{core} P_k = 1$$

Heat to coolant flow:

$$\left.\begin{aligned} Q_k &= B_{4,k}\, \lambda_{3,k}\, (T_{3,k} - T_{4,k}) + \Phi \cdot \delta \cdot P_k \\ B_{4,k} &= 4\, \pi\, \nu\, b_4\, \Delta z_{C,k} \end{aligned}\right\} \qquad (A2.5)$$

Heat transfer:

$$\left.\begin{aligned} Q_k &= A_{S,k} \left[K_B (T_{ca,k} - T_{s,k}) \right]^4 && \text{(boiling heat tr.)} \\ Q_k &= A_{S,k}\, K_{NB} (T_{ca,k} - T_{f,k}) && \text{(nonboiling heat tr.)} \end{aligned}\right\} \qquad (A2.6)$$

$$\left.\begin{aligned} K_B &= 1.266\, e^{-1.61 \cdot 10^{-7}\, p} \\ K_{NB} &= 0.023\, \frac{|\rho_f\, v_{in}|^{0.8}\, C_p^{0.4}\, \lambda_f^{0.6}}{D_c^{0.2}\, \eta_f^{0.4}} \end{aligned}\right\} \qquad (A2.7)$$

$$A_{S,k} = 2\, \pi\, R_{ca}\, \nu\, \Delta z_{C,k}$$

$T_{ca,k}$ is taken as the <u>smallest</u> of the two calculated from boiling resp. nonboiling conditions. By equating the heat flow on both sides of the fuel surface, an equation for $T_{4,k}$ is obtained:

$$T_{4,k} = \frac{T_{3,k} \left[B_{4,k} \lambda_{3,k} - A_{S,k} K_{g+ca} \left(1 - \frac{2 - \sqrt{3}}{\sqrt{5} - \sqrt{3}}\right) \right] + A_{S,k} K_{g+ca} T_{ca,k}}{B_{4,k}\, \lambda_{3,k} + A_{S,k}\, K_{g+ca} \frac{2 - \sqrt{3}}{\sqrt{5} - \sqrt{3}}} \qquad (A2.8)$$

Fuel surface temperature:

$$T_{FS,k} = T_{3,k} - (T_{3,k} - T_{4,k}) \frac{2 - \sqrt{3}}{\sqrt{5} - \sqrt{3}} \qquad (A2.9)$$

The equations derived for steady state conditions may be found in [1].

A3. Hydrodynamics

1) Mass balances (section no. k):

$$\frac{dm_{g,k}}{dt} = w_{g,k-1} - w_{g,k} + \Psi_k \qquad (A3.1)$$

$$\frac{dm_{f,k}}{dt} = w_{f,k-1} - w_{f,k} - \Psi_k \qquad (A3.2)$$

Further:

$$\frac{m_{g,k}}{\rho_{g,k}} - \frac{m_{f,k}}{\rho_{f,k}} = V_k \qquad (A3.3)$$

2) Total volume flow:

$$W_k = W_{f,k} + W_{g,k} = \frac{w_{f,k}}{\rho_{f,k}} + \frac{w_{g,k}}{\rho_{g,k}} \qquad (A3.4)$$

3) From eqs.(A2.1 - 4) neglecting only the spatial variation of the water density (contrary to the development in [1]):

$$W_k = W_{k-1} + \gamma_k \Psi_k + \dot{p}(m_{g,k}\gamma_{gp} + m_{f,k}\gamma_{fp}) + W_{g,k-1}\left(\frac{\rho_{g,k-1}}{\rho_{g,k}}\right) \qquad (A3.5)$$

Here:

$$\left.\begin{aligned} \gamma_k &= \gamma_{g,k} - \gamma_{f,k} = \frac{1}{\rho_{g,k}} - \frac{1}{\rho_{f,k}} \\ \gamma_{gp} &= \frac{d}{dp}\left(\frac{1}{\rho_g}\right)_{sat.curve} \quad \text{(at system pressure)} \\ \gamma_{fp} &= \frac{d}{dp}\left(\frac{1}{\rho_f}\right)_{T_f const} = 0 \quad \text{(in present version)} \end{aligned}\right\} \qquad (A3.6)$$

4) Slip correlations in core and riser:

$$v_{f,k} = S_k v_{g,k} + v_k^o \qquad (A3.7)$$

a) Constant slip ratio:

$$\left.\begin{aligned} S_k &= S \\ v_k^o &= 0 \end{aligned}\right\} \qquad (A3.8)$$

b) Solberg's slip formula:

$$\left.\begin{aligned} S_k &= S_1 + S_2\,\alpha_k^r \\ v_k^o &= -\cos\varphi\; v_o^o \sqrt{\frac{g(t)}{g^o}} \quad ; \quad \cos\varphi = -1 \end{aligned}\right\} \qquad (A3.9)$$

c) Bankoff-Jones correlation:

$$\left.\begin{aligned} v_k^o &= 0 \\ S_k &= \frac{1 - \alpha_k}{K - \alpha_k + (1 - K)\alpha_k^r} \\ K &= 0.71 + 0.09\left(\frac{p(psia)}{1000}\right) \end{aligned}\right\} \qquad (A3.10)$$

$$r = 3.33 + 0.18\left(\frac{p(psia)}{1000}\right) + 0.46\left(\frac{p(psia)}{1000}\right)^2$$

$$(1N/m^2 = 14.50 \cdot 10^{-5} \text{ psia})$$

In downcomer 1 and 2:

$$\left.\begin{aligned} S_k &= 1 - 0.3(1 - \alpha_k)^2 \\ v_o^o &= 0.35 \quad ; \quad \cos\varphi = 1, \text{ in downcomer 1} \\ &= \frac{L_C + L_R + L_{D1}}{L_{D2}}, \text{ in downcomer 2} \end{aligned}\right\} \qquad (A3.11)$$

5) Additional equations:

$$\alpha_k = \frac{m_{g,k}}{\rho_{g,k} V_k} \qquad (A3.12)$$

$$v_{f,k} = \frac{W_k/A_k - \alpha_k v_k^o}{1 + (S_k - 1)\alpha_k} \qquad (A3.13)$$

$$W_{g,k} = A_k\,\alpha_k\,v_{g,k} \qquad (A3.14)$$

$$W_{f,k} = W_k - W_{g,k} \qquad (A3.15)$$

$$\frac{dm_{g,k}}{dt} = \rho_{g,k-1} W_{g,k-1} - \rho_{g,k} W_{g,k} + \Psi_k \qquad (A3.16)$$

$$m_{f,k} = \rho_{f,k} V_k - \frac{\rho_{f,k}}{\rho_{g,k}} m_{g,k} \tag{A3.17}$$

6) The evaporation and condensation rates, note that the formulas are slightly changed from those in [1] to remove a discontinuity which occurred as $\alpha \to 0$:

$$\Psi_k = \Psi_{SF,k} + \Psi_{B,k} \tag{A3.18}$$

$$\Psi_{SF,k} = \frac{Q_k}{h_{fg,k} + C_{p,k}(T_{s,k} - T_{f,k}) \frac{\rho_{f,k}}{\rho_{g,k}} + \frac{1}{2} C_{p,k}(T_{ca,k} - T_{s,k})(\frac{\rho_{f,k}}{\rho_{g,k}} - 1)} \tag{A3.19}$$

$$\Psi_{B,k} = \frac{V_k}{h_{fg,k}} \left[(T_{f,k} - T_{s,k}) + \kappa \left| T_{f,k} - T_{s,k} \right| \right] x \left[R_o + R_1 \alpha_k (1 - \alpha_k) \right] \tag{A3.20}$$

7) Energy balance:

$$\frac{dE_k}{dt} = Q_k + W_{E,k-1} - W_{E,k} \tag{A3.21}$$

$$W_{E,k} = W_{g,k} \rho_{g,k} e_{g,k} + W_{f,k} \rho_{f,k} e_{f,k} + W \cdot p \tag{A3.22}$$

$$E_k = m_{g,k} e_{g,k} + m_{f,k} e_{f,k} \tag{A3.23}$$

$$e_{g,k} = h_{fg,k} - p \cdot \gamma_k \qquad (p = \text{system pressure}) \tag{A3.24}$$

$$e_{f,k} = C_{V,k} (T_{f,k} - T_s^o) \tag{A3.25}$$

hence,

$$T_{f,k} = T_s^o + \frac{E_k - m_{g,k} e_{g,k}}{m_{f,k} C_{V,k}} \tag{A3.26}$$

The thermodynamic variables ρ_g, ρ_f, T_s, h_{fg}, C_p, η and λ are calculated as functions of local pressure and temperature as explained in section 2.1.1 It is assumed that $C_p = C_V$ for water.

8) System pressure:

Equation (A2.3) applied to the whole flow loop yields an equation for the system (or upper plenum) pressure:

$$\frac{dp}{dt} = \left[\gamma_1 \Psi_{tot} + W_{fw} - W_{sl}\right]\left[-\gamma_{gp}\ m_{g,tot} - \gamma_{fp}\ m_{f,tot}\right]^{-1} \qquad (A3.27)$$

"tot" refers to summation over the whole reactor tank volume, and index "1" refers to upper plenum. The denominator represents the total "compressibility".

9) Two-phase friction multiplier:

a) Becker correlation:

$$R_k = 1 + A_F \left(\frac{X_k}{p(ata)}\right)^{0.96} \quad ; \quad A_F = 2400 \qquad (A3.28)$$

$(1\ N/m^2 = 1/0.9807\cdot 10^5\ ata)$

b) Lottes-Flinn correlation:

$$R_k = \left(\frac{1 - X_k}{1 - \alpha_k}\right)^2 \qquad (A3.29)$$

c) Modified Martinelli-Nelson:

$$R_k = \Omega \cdot \Phi_k^2 \qquad (A3.30)$$

$$\Omega_{core} = \begin{cases} 1.36 + 0.5[\frac{p}{1000}] + 0.1[\frac{G}{10^6}] - 0.714[\frac{p}{1000}][\frac{G}{10^6}]; & \frac{G}{10^6} \le 0.7 \\ 1.26 - 0.4[\frac{p}{1000}] + 0.119[\frac{10^6}{G}] + 0.28[\frac{p}{1000}][\frac{10^6}{G}]; & \frac{10^6}{G} > 0.7 \end{cases} \qquad (A3.31)$$

G[lbs/hr ft^2] "mass velocity" $\rho\cdot v$

P[psia] system pressure

$$\left(\begin{matrix} 1\ kg/sec\cdot m^2 = 7.382\cdot 10^2\ lbs/hr\ ft^2 \\ 1\ N/m^2 = 14.50\cdot 10^{-5}\ psia \end{matrix}\right)$$

The mass velocity at core inlet is used. Further, in other parts of the loop than the core, $\Omega = 1$.

$$\Phi_k^2 = 1. + 5.62\cdot10^3\ X_k - 4.92\cdot10^1\ X_k^2 + 6.85\cdot10^{-6}\ X_k^2\cdot p - 2.71\cdot10^{-13}\ X_k^2\cdot p^2 - 6.85\cdot10^2\ X_k\ \ell n\ p + 1.92\cdot10^1\ X_k(\ell n\ p)^2 \qquad (A.3.32)$$

p in "psia".

10) Single phase friction factor:

$$f = \frac{G_1}{2\cdot D_h\cdot Re^{G_2}} \qquad (D_h = \text{hydr.diam.}) \qquad (A3.33)$$

A Reynolds number is calculated for each section (core, riser etc) of the loop. Friction neglected in lower plenum.

11) Integral momentum equation:

$$\frac{d}{dt}\ I/\rho_{f,1} = D - L - F \qquad (A3.34)$$

From:

$$i/\rho_f = (1-\alpha)v_f + \frac{\rho_g}{\rho_f}\alpha\ v_g \qquad (A3.35)$$

it follows:

$$(i/\rho_f)_k = \frac{W_k}{A_k}\left[1-(1-d_k)\ \frac{S_k\alpha_k}{1+(S_k-1)\alpha_k}\right] - v_k^o\left[\alpha_k(1-d_k)(1-\frac{S_k\alpha_k}{1+(S_k-1)\alpha_k}\right] \qquad (A3.36)$$

Hence:

$$I/\rho_{f,1} = \sum_{k=2}^{n_{tot}}\left[W_kC_k - v_k^o(1-d_k)D_k\right] \quad ; \quad d_k = \frac{\rho_{g,k}}{\rho_{f,k}} \qquad (A3.37)$$

$$\left.\begin{aligned} C_k &= \frac{\Delta z_k}{A_k}\left[1-(1-d_k)\ \frac{S_k\alpha_k}{1+(S_k-1)\alpha_k}\right] \\ D_k &= \Delta z_k\alpha_k\left[(1-d_k)\ \frac{S_k\alpha_k}{1+(S_k-1)\alpha_k}\right] \end{aligned}\right\} \qquad (A3.38)$$

From eq.(A3.37) using eq.(A3.5) one obtains for the downcomer inlet volume flow:

$$W_1 = \frac{1/\rho_{f,1} - \sum_{k=2}^{n_{tot}} \left[C_k \sum_{i=2}^{k} (\gamma_i \Psi_i + \dot{p}\, \eta_i) + \delta_{no} W_{fw} \right] - v_k^o D_k}{\sum_{k=2}^{n_{tot}} D_k} \qquad \text{(A3.39)}$$

$$\delta_{no} = \begin{cases} 0, \text{ if } n_o = 1 \\ 1, \text{ if } k \geq n_o \\ 0, \text{ if } k < n_o \end{cases} \qquad \text{(A.3.40)}$$

Note that the spatial variation of ρ_g and ρ_f has been neglected to obtain eq.(A3.39). This was done to minimize the changes necessary from the first version. Further, some of the definitions above differ by a factor $1/\rho_{f,1}$ from those in [1] for the same reason. Observe also that the sums start with k = 2 as, for convenience, the first section (upper plenum) is now no. 1 instead of no. 0 as in [1].

Friction, gravity and acceleration losses are calculated from:

$$D = \left[g(t) \sum_{k=2}^{n_{tot}} \cos \varphi_k \, \Delta z_k [\rho_{f,k} - \alpha_k (\rho_{f,k} - \rho_{g,k})] + H \right] \frac{1}{\rho_{f,1}} \qquad \text{(A3.41)}$$

$$F = \sum_{k=2}^{n_{tot}} f_k R_k \frac{\Delta z_k}{A_k^2} \left[(W_{f,k} + d_k \cdot W_{g,k}) \left| W_{f,k} + d_k \cdot W_{g,k} \right| \right] \qquad \text{(A3.42)}$$

$$L = \frac{1}{\rho_{f,1}} \left[- \sum_{\text{singularities}} \Delta p + \sum_{\substack{\text{exit const.} \\ \text{area parts}}} U - \sum_{\substack{\text{entrance const.} \\ \text{area parts}}} U \right] \qquad \text{(A3.43)}$$

$$H = H_o + H_1 v_{in-} + H_2 v_{in} |v_{in}| \qquad \text{(A3.44)}$$

For more details, cf. [1]. Note that in this version the space dependence of the water density is taken into account in the gravity head (may be significant in cases with high subcooling, cf. section 2.1.1).

12) Carry-under:

In the case of carry-under, the void fraction at downcomer inlet is calculated from (R - riser exit)

$$\alpha_{cu} = \alpha_R (1 - \frac{C_1}{W_1}) \cdot C_2 \cdot \frac{W_{g,R}}{W_R} \qquad \text{(A3.45)}$$

if: $\alpha_{cu} > 1$, $\alpha_{cu} \rightarrow 1$

": $\alpha_{cu} < 0$, $\alpha_{cu} \rightarrow 0$

13) Water level upper plenum is calculated from:

$$h = \frac{L_{UP}(1 - \alpha_1)}{1 - \frac{A_R}{A_{UP}} \alpha_R} \qquad \text{(A3.46)}$$

14) Subcooling:

The feedwater temperature is in the case of constant subcooling in degrees (ΔT^o_{SUB}):

$$Q_{SUB} = \left[\Delta T^o_{SUB} - T^o_s + T_{s,UP}\right] A_{LP}\, C_{p,LP}\, \rho_{f,LP}\, v_{f,LP}$$

$$T_{fw} = T_{s,UP} - \frac{Q_{SUB}}{C_{p,n_o} \cdot w_{fw}} \qquad \text{(A3.47)}$$

When the subcooler power (Q^o_{SUB}) is given, T_{fw} is calculated from:

$$T_{fw} = T^o_{fw} = T^o_s - \frac{Q^o_{SUB}}{C^o_p \cdot w^o_{s\ell}} \qquad \text{(A3.48)}$$

and

$$w^o_{s\ell} = \frac{Q^o_{TOT} - Q^o_{SUB}}{h^o_{fg}} \qquad \text{(A3.49)}$$

In all cases, the feedwater mass flow is (initially) put equal to the steam load ($w_{s\ell}$). In the case where ΔT^o_{SUB} is given, the steam load is calculated from eq.(A3.49) with Q^o_{SUB} calculated from "VOIFLO" steady state.

15) Steam load:

In the case of constant system pressure, $w_{s\ell}$ is calculated from eq. (A3.27) with $dp/dt = 0$ ($w_{s\ell} = \rho_{g,1} W_{s\ell}$). In the case of no pressure controller:

$$w_{s\ell} = \sqrt{\rho_{g,1} K_p (p - p_{sec})} \quad \text{if } p \geq p_{sec}$$
$$= 0 \quad \text{if } p < p_{sec} \qquad (A.3.50)$$

$p = p_{reactor}$ = system or upper plenum pressure.

APPENDIX B

"VOIFLO" Input Data Calculation

Referring to the VOIFLO input description [3], section 7.2, and the RAMONA I input description in section 3.2, using for convenience programme mnemonics, the conversion to VOIFLO input is as follows:

CARD 20

U(1) = AC

U(2) = AR

$$U(3) = \frac{HD1 + HD2}{\frac{HD1}{AD1} + \frac{HD2}{AD2}}$$

} Momentum conservation when "lumping" into one downcomer.

U(4) = HC

U(5) = HR

U(6) = WLEVO

U(7) = HD1 + HD2

CARD 30

U(8) = HC + HR + WLEVO

U(9) = PH

U(10) = HDC

U(11) = HDR

$$U(12) = \frac{HD1 + HD2}{\frac{HD1}{HDD1} + \frac{HD2}{HDD2}}$$

} Equivalent hydraulic diameter.

U(13) = PRESSO

U(14) = GRO

CARD 40

U(15) = RGR

U(16) = RFR

U(17) = HFGR

U(18) = CPR

U(19) = TSDER

} Thermodynamic variables at nominal pressure calculated by LIGHTWAT/HEAVYWAT. If PLOC = 0, U(19) is put equal zero.

U(20) = H0

U(21) = H1

CARD 50

U(22) = H2

If IPUMP $\neq$ 0, else U(20) = U(21) = U(22) = 0.

U(23) = 0.

⋮

U(28) = 0.

CARD 60

U(29) = -0.5 [VHD1I + VHD12 + VHD2LP(AD1/AD2)^2][U(3)/AD1]^2

U(30) = -0.5 VHCI

U(31) = 1.

U(32) = 0.5 VHRO

$$U(33) = -0.5 \sum_{K=1}^{J} VHSP(K)$$

$$U(34) = -0.5 \sum_{K=J+1}^{ISPAC} VHSP(K)$$

J = [ISPAC/2]

The ISPAC number of spacers (if ISPAC > 0) totally is "lumped" into 2.

CARD 70

U(36) = AC/AR

U(37) = CSL(1)

U(38) = 0.

U(39) = 1.

If ISLIP = 1, i.e. constant slip.

U(37) = CSL(1)

U(38) = CSL(2)

U(39) = CSL(3)

If ISLIP = 2, i.e. Solberg's slip formula.

U(37) = 1.30

U(38) = 2.03

U(39) = 3.04

If ISLIP = 3, i.e. the Bankoff-Jones correlation.

U(40) = CTP(1) — If IMULT = 1, i.e. the Becker correlation.

U(40) = 2400. — If IMULT = 2 or 3, i.e. the Lottes-Flinn or Mod. Martinelli-Nelson correlations.

U(41) = 0.023

U(42) = G1

<u>CARD 80</u>

U(43) = 1.3

U(44) = WCØNDR

U(45) = ETHAR

$$U(46) = \frac{\sum_{K=1}^{J} ZSP(K) \cdot VHSP(K)}{\sum_{K=1}^{J} VHSP(K)}$$

$$U(47) = \frac{\sum_{K=J+1}^{ISPAC} ZSP(K) \cdot VHSP(K)}{\sum_{K=J+1}^{ISPAC} VHSP(K)}$$

The position of the two "lumped" spacers are found by weighting with the velocity heads.
U(46) or U(47) are not allowed to become greater than U(4).

The remaining VOIFLO input is directly obtained from the corresponding RAMONA I input.

APPENDIX C

Programme Symbols and Nomenclature

The variables defined in the input and output descriptions as well as those defined in the nomenclature of [1] are in general not repeated here.

C1. The Main Variables

"RAMONA I" integrates a large set of differential equations of the form:

$$\frac{dy_i}{dt} = f_i(t, y_1, y_2 \cdots\cdots y_{n_{max}}); \quad i = 1,2 \cdots n_{max} \qquad (C1.1)$$

or in FORTRAN symbols:

$$\frac{d}{dX} Y(I) = F(I) \quad ; \quad I = 1,2 \cdots\cdots NMAX \qquad (C1.2)$$

The Y(I)'s are the main variables as defined in the following table.

Main Variable	Math. Symbol	Description
Y(1)	Δp	System pressure deviation from nominal
Y(2)	M_g	Total steam mass in the reactor
Y(3)	E	Total internal energy in water and steam.
Y(4)	I/ρ_f	Total momentum
Y(5)	$m_{g,1}$	[F(5) ≡ 0.]
⋮	⋮	
Y(4+K)	$m_{g,k}$	Steam mass distribution
Y(4+NTOT)	$m_{g,n_{tot}}$	
Y(5+NTOT)	E_1	[F(5+NTOT) ≡ 0.]
⋮	⋮	
Y(4+NTOT+K)	E_k	Internal energy distribution
⋮	⋮	
Y(4+2·NTOT)	$E_{n_{tot}}$	

Y(5+2·NTOT)	$T_{o,1}$	[F(4+2·NTOT+5·K)≡0.]
⋮	⋮	
Y(9+2·NTOT)	$T_{4,1}$	Axial and radial temperature distribution in the fuel rods
⋮	⋮	
Y(2·NTOT+5·K+ +I)	$T_{i,k}$	$T_{i,k}$ is the temperature in radial zone no. i and axial zone no. k.
⋮	⋮	
Y(4+2·NTOT+ +5·NC)	T_{4,n_c}	
Y(5+2·NTOT+5·NC)	Φ	Nuclear power
Y(6+2·NTOT+5·NC)	C_1	
⋮	⋮	
Y(5+2·NTOT+5·NC+K)	C_k	Precursor densities
⋮	⋮	
Y(5+2·NTOT+5·NC+IM)	C_m	

Comments:

a) As seen from above, the time derivative of $m_{g,1}$ and E_1 are identically zero. Instead, M_g and E are included as main variables and $m_{g,1}$ and E_1 calculated from:

$$m_{g,1} = M_g - \sum_{k=2}^{n_{tot}} m_{g,k}$$

$$E_1 = E - \sum_{k=2}^{n_{tot}} E_k \qquad \text{(C1.3)}$$

Further, as the fuel temperature $T_{4,k}$ is calculated by iteration as explained in [1], the derivative is put equal zero. Obviously, the effect of putting a derivative to zero, is that this quantity is not affected by the integration procedure.

b) In the present version the following limitations are valid:

$n_{tot} \leq 100$, total number of subsections in flow loop.

$n_c \leq 60$, subsections in core

$n_R \leq 40$, subsections in riser
$m \leq 10$, number of delayed neutron groups

This means that the maximum number of main variables or differential equations to be integrated, is:

$$n_{max} = 5 + 2 \cdot n_{tot} + 5 \cdot n_c + m = 515$$

C2 The Secondary Variables

All other variables than the main, are defined as secondary variables. Below the most important secondary variables are listed, grouped according to the part they play in the programme. The variables defined in the input and output descriptions are in general not repeated here.

C2.1. Auxiliary variables

Secondary Varibale	Definition and Comments
AUXH(1)	$1/L_C$
2	$A_{UP} \cdot L_{UP} + A_{D1} \cdot L_{D1} + A_{D2} \cdot L_{D2} + A_{LP} \cdot L_{LP} + A_C \cdot L_C + A_R \cdot L_R$
3	A_R/A_{UP}
4	$H_1 \cdot A_{LP}/A_C$
5	$H_2(A_{LP}/A_C)^2$
6	$L_{D1}/n_{D1} = \Delta z_{D1}$
7	$L_{D2}/n_{D2} = \Delta z_{D2}$
8	$L_R/n_R = \Delta z_R$
9	$\Delta z_{D1}/A^2_{D1}$
10	$\Delta z_D \, / A^2_{D2}$
11	$\Delta z_R/A^2_R$
12	$1./A^2_C$
13	$[-0.5 \; L_{D1,i} - 1.]/A_{D1}$
14	$[-0.5 \; L_{D1,2} + 1.-(A_{D1}/A_{D2})^2]/A_{D1}$

15	$[-0.5\ L_{D2,LP} + 1.-(A_{D2}/A_{LP})^2]/A_{D2}$
16	$[-0.5\ L_{C,i}\cdot(A_{LP}/A_C)^2 + 1.]/A_{LP}$
17	$[-(A_{LP}/A_C)^2]/A_{LP}$
18	$[1.+(A_C/A_R)(A_C/A_R-1.)]/A_C$
19	$[-(A_C/A_R)^2]/A_C$
20	$[-0.5\ L_{R,\sigma} + 1.]/A_R$
21	$[-0.5\ L_1]/A_C$
⋮	⋮
30	$[-0.5\ L_{ISPAC}]/A_C$ (or A_R if $z_k > L_C$)
31	$1./(L_{D1} + L_{D2})$
32	$1./L_C$
AUXH(33)	$1./L_R$
SIGN(K)	$\cos \varphi_k$
BS(1) ... BS(5)	$BS(I+1) = b_i = \dfrac{\sqrt{i}}{\sqrt{i+1} - \sqrt{i-1}}$
DS(1) ... DS(4)	$DS(I) = \dfrac{\sqrt{i} - \sqrt{i-1}}{\sqrt{i+1} - \sqrt{i-1}}$
DS(5)	1. - DS(4)
ASDZ	$2\pi\ R_{ca}\ \nu$
A4DZ	$16\ \pi\ \nu$
B4DZ	$4\pi\ \nu\ b_4$
HFINV	$(\rho_F C_F\ \pi\ R_F^2\ \nu)^{-1}$
AUXF(1)	$K_{g+ca} \cdot DS(5)$
2	$K_{g+ca} \cdot DS(4)$
3	B4DZ/ASDZ
4	$(1.-\delta)$
AUXF(5)	AUXF(4)/ASDZ — REACTOR case 1./PH — LOOP case

AUXK(1)	β_1/ℓ^*
2	β_2/ℓ^*
⋮	⋮
10	β_{10}/ℓ^*
11	$\Sigma\, \beta_i/\ell$
12	0.
AUXK(13)	$1./\ell^*$
DELV(K)	V_k , volume of k'th subsection
DELZ(K)	Δz_k, length " " "
DELZC(K)	$\Delta z_{C,k}$, " " " " in core
PØWER(K)	P_k , relative power in k'th subsection in core
PØWDZ(K)	$P_k/\Delta z_{C,k}$
DZA(K)	$\Delta z_k/A_k$
AA(K)	A_k , area of k'th subsection
ND	$n_{D1} + n_{D2}$
NDC	ND + n_C
NDCR	NDC + n_R
NTØT	n_{tot} = NDCR + 2
NDP1	ND + 1
NDP2	ND + 2
NDP3	ND + 3
NMAX	$\begin{cases} 4 + 2\cdot n_{tot} & \text{, LOOP case} \\ 5 + 2\cdot n_{tot} + 5\cdot n_C + m, & \text{REACTOR case} \end{cases}$
NNO	2 · NTØT
NN3	NNO + 3
NKIN	5 + NNO + $5\cdot n_C$
NTØTP4	NTØT + 4
NDC2	NDC + 2
NDC3	NDC + 3

ND1P1	$n_{D1} + 1$
ND1P2	$n_{D1} + 2$
NØSPC	number of spacers in core
PSEC	p_{sec} ,
NØSP(1) ⋮ NØSP(10)	NOSP(I), is the number on the subsection in which spacer no. i is positioned
PRESSOO	the pressure around which first order Taylor expansions are used to calculate thermodynamic quantities, cf. section 2.1.1.

C2.2 Hydrodynamic variables

Secondary Variable	Definition and Comments
ALFA(K)	α_k , void fraction in subsection no. k
RMF(K)	$m_{f,k}$, mass of water " " " "
TF(K)	$T_{f,k}$, temp.of water " " " "
TS(K)	$T_{s,k}$, saturation temp. in " " "
PSI(K)	Ψ_k , evap.or cond.rate " " " "
PSISF(K)	$\Psi_{SF,k}$, surface term of above, k refers to core
W(K)	W_k , total volume flow out of subsection no. k
WG(K)	$W_{g,k}$, steam " " " " " " "
WF(K)	$W_{f,k}$, water " " " " " " "
VF(K)	$v_{f,k}$, water velocity " " " " "
VG(K)	$v_{g,k}$, steam " " " " " "
WE(K)	$W_{E,k}$, total internal energy flow out of subsect. no. k
WEF(K)	$W_{Ef,k}$, water " " " " " " " "
EF(K)	$e_{f,k}$, specific internal energy of water, subsect. no. k
EG(K)	$e_{g,k}$, " " " " steam, " " "
CP(K)	$C_{p,k}$, " heat of water const.press, " " "

CV(K)	$C_{V,k}$	, specific heat of water const. vol., subsect no. k
RHØF(K)	$\rho_{f,k}$	, density of water
RHØG(K)	$\rho_{g,k}$	, " " steam
DGF(K)	$\rho_{g,k}/\rho_{f,k}$	
GAMMA(K)	$\gamma_k = 1./\rho_{g,k} - 1./\rho_{f,k}$	
HFG(K)	$h_{fg,k}$	, heat of evaporation
SS(K)	S_k	, cf. eq.(A3.7)
VVO(K)	v_k^o	, cf. " "
RTPHASE(K)	R_k	, two-phase friction multiplier, subsection no. k
QUALITY(K)	X_k	, quality, " " "
Q(K)	Q_k	, heat to coolant flow in subsection no. k <u>in core</u>
GAMMAFP	γ_{fp}	, cf. eq.(A3.6)
GAMMAGP	γ_{gp}	, " " "
WCØND	λ_f	, thermal conductivity of water
ETHA	η_f	, dynamic viscosity of water (μ_f in [1])
GR	$g(t)$	, gravity acceleration (may be time-dependent)
WFWO	w_{fw}^o	, feedwater mass flow (steady state)
WFW	w_{fw}	, " " "
WWFW	W_{fw}	, " volume "
WSLO	$w_{s\ell}^o$	, steam load mass " (steady state)
WSL	$w_{s\ell}$	, " " " "
WWSL	$W_{s\ell}$	, " " volume "
TFWO	T_{fw}^o	, feedwater temperature (steady state)
TFW	T_{fw}	, " "
WEFW	$W_{E,fw}$	, " energy flow
WESL	$W_{E,s\ell}$	, steam load " "
QTØT	Q_{TOT}	, total power
QSUB	Q_{SUB}	, " subcooler power

DTSUB	ΔT_{SUB}, subcooling in degrees
PUMP	$H \equiv \Delta p_{pump}$, pump head
PRESSLPI	$\Delta p_{LP,i}$, pressure (rel.to nominal) at lower pl. inlet*)
PRESSCI	$\Delta p_{C,i}$, " " " " " core " *)
PRESSRI	$\Delta p_{R,i}$, " " " " " riser " *)

*) neglecting acceleration head.

C2.3 Fuel variables

Secondary Variable	Definition and Comments
TFS(K)	$T_{FS,k}$, fuel surface temperature in axial section no. k
TM(K)	$\bar{T}_k$, average fuel temp. in axial section no. k
TCA(K)	$T_{ca,k}$, canning " " " " " "
INT(K)	integer: 1 if boiling, 0 if non-boiling heat tr.
CØND(1)	$\lambda_{F,-1} \equiv 0$
⋮	
CØND(I)	$\lambda_{F,i-2}$, thermal conductivity in annular zone (i-2)
⋮	
CØND(5)	$\lambda_{F,3}$, " " " " " 3

C2.4 Neutron kinetics variables

Secondary Variables	Definition and Comments
RHØV	ρ_V , void reactivity, steady state value subtracted
RHØD	ρ_D , Doppler " , " " " "
RHØT	ρ_T , moderator " , " " " "
RHØC	ρ_C , controller "
RHØEX	ρ_{ex} , excess "
RHØVO	ρ_V^o } steady state values
RHØDO	ρ_D^o } steady state values
RHØTO	ρ_T^o } steady state values

VREAC(K) ρ_k , void reactivity coefficient distribution, $\sum_{core} \rho_k = 1$

C2.5 "Internal" options

Some "internal" options are set by the programme according to the information cards read in.

Secondary Variable	Definition and Comments
IPRØMPT	IPROMP = 0, "complete" kinetics
	= 1, "prompt jump" approximation
IPUMP	IPUMP = 0, no forced circulation head
	= 1, forced " "
IGRAV	IGRAV = 0, no gravity acceleration disturbance
	= 1, gravity " "
IPUMPD	IPUMPD = 0, no forced circulation (pump) disturbance
	= 1, forced " " "
IFWFLØW	IFWFLØW= 0, no feedwater flow disturbance
	= 1, feedwater " "
IFWTEMP	IFWTEMP= 0, no feedwater temperature disturbance
	= 1, feedwater " "
ISTLØAD	ISTLØAD= 0, no steam load disturbance
	= 1, steam " "
ICØNTR	ICØNTR = 0, no control rod reactivity disturbance
	= 1, control " " "
IQTØT	IQTØT = 0, no power (heat to coolant flow) disturbance
	= 1, power " " " " "
ITRANS	ITRANS = 0, no transfer function calculation
	= 1, transfer " "
IRLØØP	= 0, "REACTØR" case
	= 1, "LØØP" case

PBa/KOS/jet
7.1.1969.

APPENDIX D

Sample problems, Listing

Part 1

Test RAMONA I. Ship reactor, cold water accident.

INPUT DATA SAMPLE PROBLEM No.1. P. BAKSTAD 1 3

TEXT					
TEST RAMØNA I.SHIPREACTØR, CØLD WATER ACCIDENT. FEBR.1968.					
REACTØR CASE					
GEØMETRICAL DATA					
1.115	1.51	5.19	3.67	0.5495	2.0
1.75	1.58	2.12	1.38	1.9508	1.53
0.0278	0.3	10.0	10.0		
-4.932	0.0	0.0	0.0	0.0	
25	5	1	1	9	
9.81	0.77	118.3			
SPACER DATA					
3					
0.857	1.166	1.754			
-0.3	-0.3	-0.3212			
TWØ-PHASE FLØW					
0					
1					
2500.0					
2					
1.0	3.6	2.0	0.35		
0					
0.85	5.0 E+6	4.0 E+7	0.184	0.2	
PØWER					

2 3

```
              25|
0.0             |0.0        |0.0         |0.0         |0.0         |1.64
2.1             |2.6        |2.94        |3.22        |3.39        |3.97
3.23            |3.05       |2.81        |2.56        |2.3         |2.05
1.8             |1.56       |1.31        |1.08        |0.85        |0.66
0.51            |           |            |            |            |
NUCLEAR FUEL DATA
7.95         E-3|7.25    E-3|330.0       |1.05     E+4|6.241       |1.587      E-3
4.2          E+3|4.0     E-2|            |            |            |
            2368|           |            |            |            |
NEUTRON KINETICS DATA
-3.75        E-4|-2.45   E-5|0.0         |-2.37    E-1|0.0         |4.32       E-5
               6|           |            |            |            |
3.054        E-4|8.8     E-4|2.6787   E-3|1.2967   E-3|1.4135   E-3|2.0930     E-4
4.3478          |1.6393     |4.3478   E-1|1.6077   E-1|4.4010   E-2|1.7950     E-2
VOID REACTIVITY
              25|           |            |            |            |
0.0             |0.0        |0.0         |0.0         |0.0         |1.1
2.62            |3.9        |4.9         |5.7         |6.3         |6.7
6.72            |6.58       |6.2         |5.6         |4.9         |4.15
3.5             |2.8        |2.3         |1.8         |1.3         |0.9
0.5             |           |            |            |            |
INTEGRATION     |           |            |            |            |
```

```
0.1       0.002     0.01
NØMINAL
         0         1         1         1         0         1
5.9    E+71.538  E+74.927  E+61.0       6.08   E-6
FLØW DISTURBANCE,FEEDWATER
0.0       4.0       4.0       10.0      0.0       1.0
ØUTPUT INFØRMATIØN
         4         1
         1         9         7        11
0.0       -1.0   E+50.0       0.0
2.0       1.0    E+54.0    E+84.0    E+8
0.05
         2         2         2         2
0.05      2.0       0.2       4.0
FINISH
```

TEST RAMONA ,SHIPREACTOR,COLD WATER ACCIDENT

GEOMETRICAL DATA

****

FLOW AREA OF CORE	=	1,11500+000	LENGTH (HEIGHT) OF CORE	=	1,75000+000
RISER	=	1,51000+000	RISER	=	1,58000+000
UPPER PLENUM	=	5,19000+000	UPPER PLENUM	=	2,12000+000
DOWNCOMER 1	=	3,67000+000	DOWNCOMER 1	=	1,38000+000
DOWNCOMER 2	=	5,49500-001	DOWNCOMER 2	=	1,95080+000
LOWER PLENUM	=	2,00000+000	LOWER PLENUM	=	1,53000+000

PRESSURE DIFFERENCE IN LOCAL VELOCITY HEADS			NUMBER OF SUBSECTIONS IN		
CORE INLET	=	-4,93200+000	CORE	=	25
RISER OUTLET	=	0,00000+000	RISER	=	5
DOWNCOMER INLET	=	0,00000+000	DOWNCOMER 1	=	1
DOWNCOMER 1-2	=	0,00000+000	DOWNCOMER 2	=	1
DOWNCOMER 2-LOW.PL.	=	0,00000+000	SUBSECTION WHERE FEEDWATER IS RETURNED	=	9

HYDRAULIC DIAMETER OF					
CORE	=	2,78000-002	GRAVITY ACCELERATION (NOMINAL)	=	9,81000+000
RISER	=	3,00000-001	WATER LEVEL (NOMINAL)	=	7,70000-001
DOWNCOMER 1	=	1,00000+001	HEATED PERIMETER (TOTAL)	=	1,18300+002
DOWNCOMER 2	=	1,00000+001			

SPACER DATA

****

POSITION SPACER NR. 1	=	8,57000-001	VELOCITY HEADS SPACER NR. 1	=	-3,00000-001
POSITION SPACER NR. 2	=	1,16600+000	VELOCITY HEADS SPACER NR. 2	=	-3,00000-001
POSITION SPACER NR. 3	=	1,74500+000	VELOCITY HEADS SPACER NR. 3	=	-3,21200-001

TWO-PHASE FLOW DATA
****

IMOD = 0	LIGHT WATER MODERATOR					
IMULT= 1	BECKERS CORRELATION					
	COEFFICIENT	2.50000+003				
ISLIP= 2	SOLBERGS SLIP FORMULA					
	COEFFICIENTS	1.00000+000	3.60000+000	2.00000+000	3.50000-001	
ICU = 0	NEGLECT CARRY-UNDER					
COEFFICIENTS FOR EVAPORATION RATE		8.50000-001	5.00000+006	4.00000+007		
COEFFICIENTS IN SINGLE PHASE FRICTION FACTOR		1.84000-001	2.00000-001			

POWER DISTRIBUTION DATA
****

NUMBER OF POINTS WHERE POWER DISTRIBUTION IS GIVEN = 25

POWER DISTRIBUTION IN EQUIDISTANT POINTS

0.00000+000	0.00000+000	0.00000+000	0.00000+000	0.00000+000	1.64000+000
2.10000+000	2.60000+000	2.94000+000	3.22000+000	3.39000+000	3.97000+000
3.23000+000	3.05000+000	2.81000+000	2.56000+000	2.30000+000	2.05000+000
1.80000+000	1.56000+000	1.31000+000	1.08000+000	8.50000-001	6.60000-001
5.10000-001					

NUCLEAR FUEL DATA
****

RADIUS OF CANNING.	7.95000-003
RADIUS OF FUEL ROD	7.25000-003
SPECIFIC HEAT OF FUEL.	3.30000+002
DENSITY OF FUEL	1.05000+004
EPSILON1	6.24100+000
EPSILON2	1.58700-003
HEAT TRANSFER GAP - CANNING.	4.20000+003
FRACTION OF HEAT PROMPTLY GENERATED IN THE COOLANT .	4.00000-002
NUMBER OF FUEL RODS	2368

NEUTRON KINETICS DATA
****

COEFFICIENT(S) FOR MODERATOR TEMP. REACTIVITY	-3.75000-004	
DOPPLER REACTIVITY	-2.45000-005	0.00000+000
VOID REACTIVITY	-2.37000-001	0.00000+000
NEUTRON LIFETIME (EFFECTIVE)	4.32000-005	

DELAYED NEUTRON FRACTIONS

3.05400-004 .	8.80000-004	2.67870-003	1.29670-003	1.41350-003	2.09300-004

DECAY CONSTANTS

4.34780+000	1.63930+000	4.34780-001	1.60770-001	4.40100-002	1.79500-002

VOID REACTIVITY DISTRIBUTION DATA
****

NUMBER OF POINTS WHERE VOID REACTIVITY DISTRIBUTION IS GIVEN = 25

DISTRIBUTION IN EQUIDISTANT POINTS

0.00000+000	0.00000+000	0.00000+000	0.00000+000	0.00000+000	1.10000+000
2.62000+000	3.90000+000	4.90000+000	5.70000+000	6.30000+000	6.70000+000
6.72000+000	6.58000+000	6.20000+000	5.60000+000	4.90000+000	4.15000+000
3.50000+000	2.80000+000	2.30000+000	1.80000+000	1.30000+000	9.00000-001
5.00000-001					

INTEGRATION SPECIFICATION
****

LOCAL RELATIVE ACCURACY	=	1.00000-001
MINIMUM INTEGRATION STEP	=	2.00000-003
INITIAL GUESS --- --	=	1.00000-002

NOMINAL OPERATING CONDITIONS
****

ITEMP	= 0	NOMINAL SUBCOOLER POWER GIVEN
IPRES	= 1	VARYING DRUM PRESSURE
IPLOC	= 1	THERMAL VARIABLES SPATIALLY DEPENDENT
ISTEP	= 1	SPATIAL STEP IN CORE PROPORTIONAL TO (STEADY STATE) WATER VEL.
IFLOW	= 0	CORE INLET VEL. FROM MOM. BALANCE
ISTEADY	= 1	INTEGRATE LOOP-CASE TO ACHIEVE STEADY STATE AND RESET TIME TO ZERO

NOMINAL POWER	5.90000+007
NOMINAL SUBCOOLER POWER	1.53800+007
NOMINAL PRESSURE	4.92700+006
CORE INLET VELOCITY (GUESS)	1.00000+000
MAIN STEAM VALVE COEFFICIENT	6.08000-006

FLOW DISTURBANCE, FEEDWATER
****

DISTURBANCE STARTS AT =	0.00000+000
RAMP (RELATIVE VALUES) =	4.00000+000
RAMP MAX. --- -- =	4.00000+000
TIME INTERVAL =	1.00000+001
AMPLITUDE (REL.) OF SINUS =	0.00000+000
PERIOD OF OSCILLATION =	1.00000+000

```
OUTPUT INFORMATION
******************

ITAB   =  4                         LARGE OUTPUT EVERY ITAB STEP SMALL OUTPUT
IPLOT  =  1                         PLOTTING

OUTPUT FOR EACH  2. SECTION IN CORE
  --     -   --  2.     --    - RISER
  --     -   --  2.     --    - DOWNCOMER1
  --     -   --  2.     --    - DOWNCOMER2

THE TIME BETWEEN OUTPRINT IS  5.000-002  FOR TIME LESS THAN  2.0000+000  AND
                              2.000-001  FOR TIME GR.  THAN  2.0000+000  AND LESS THAN  4.0000+000 (SEC)


THERMAL VARIABLES CALCULATED FROM RATIONAL
APPROXIMATIONS WITHIN THE PROGRAM
******************************************

                                                                      VALUE AT              PRESSURE DERIV.
                                                                   NOMINAL PRESS.           ALONG SAT. CURVE

SATURATION TEMPERATURE    (DEGR. C)                                 2.63018+002               1.25963-005
DENSITY OF WATER          (KG/MMM)                                  7.79263+002              -2.01004-005
  --       - STEAM        (KG/MMM)                                  2.50144+001               5.33656-006
HEAT OF VAPORIZATION      (WATT.SEC/KG)                             1.64493+006              -7.12527-002
SPESIFIC HEAT OF WATER    (WATT.SEC/KG.DEGR C)                      5.00349+003               1.47667-004
VISCOSITY     -   --      (KG/M.SEC)                                1.03684-004              -5.20043-012
THERMAL COND. -   --      (WATT/M.DEGR C)                           5.99925-001              -1.67759-008
```

STANDARD VOIFLO OUTPUT (REF.KR-85)
****

GENERAL INPUT DATA.

1,1150+000	1.5100+000	8,4836-001	1,7500+000	1,5800+000	7,7000-001	3,3308+000
4,1000+000	1.1830+002	2,7800-002	3,0000-001	1,0000+001	4,9270+006	9,8100+000
2,5014+001	7,7926+002	1,6449+006	5,0035+003	1,2596-005	0,0000+000	0,0000+000
0,0000+000	0,0000+000	0,0000+000	0,0000+000	0,0000+000	0,0000+000	0,0000+000
-0,0000+000	2,4660+000	1,0000+000	0,0000+000	1,5000-001	4,6060-001	0,0000+000
7,3841-001	1,0000+000	3,6000+000	2,0000+000	2,5000+003	2,3000-002	1,8400-001
1,3000+000	5,9993-001	1,0368-004	8,5700-001	1,2673+000		

NUMBER OF POINTS IN CORE AND RISER.

26	6

INPUT POWER DISTRIBUTION,UNNORMALIZED.

0,0000+000	0,0000+000	0,0000+000	0,0000+000	0,0000+000	1,6400+000	2,1000+000
2,6000+000	2,9400+000	3,2200+000	3,3900+000	3,9700+000	3,2300+000	3,0500+000
2,8100+000	2,5600+000	2,3000+000	2,0500+000	1,8000+000	1,5600+000	1,3100+000
1,0800+000	8,5000-001	6,6000-001	5,1000-001			

QTOT= 5,9000+007	VI = 1,3033+000	SUB = 2,6068-001	TI = 3,0681+000
TSCB= 3,0053+000	TD = 2,8926+000	TT = 2,8926+000	ZSCB= 2,9721-001
ZD = 3,4730-001	ZT = 3,4730-001	ML = 6,9266-001	ZB = 8,8017-001

POSITION	QUALITY	VOID FRACTION	WATER VELOCITY	SLIP RATIO	PRESSURE
0,0000+000	0,0000+000	0,0000+000	1,3033+000	1,0000+000	2,8077+004
1,4000-001	0,0000+000	0,0000+000	1,3033+000	1,0000+000	2,6957+004
2,8000-001	0,0000+000	0,0000+000	1,3033+000	1,0000+000	2,5836+004
4,2000-001	5,1900-004	1,5905-002	1,3237+000	1,0009+000	2,4699+004
5,6000-001	2,0055-003	5,8230-002	1,3811+000	1,0125+000	2,3553+004
7,0000-001	3,8966-003	1,0466-001	1,4500+000	1,0425+000	2,2436+004
8,4000-001	6,0845-003	1,4864-001	1,5215+000	1,0923+000	2,1356+004
9,8000-001	9,8219-003	2,0469-001	1,6226+000	1,2006+000	2,0051+004
1,1200+000	1,3660-002	2,4535-001	1,7034+000	1,3270+000	1,9038+004
1,2600+000	1,6816-002	2,7077-001	1,7571+000	1,4350+000	1,8073+004
1,4000+000	1,9301-002	2,8742-001	1,7937+000	1,5201+000	1,6308+004
1,5400+000	2,1131-002	2,9828-001	1,8180+000	1,5820+000	1,5393+004
1,6800+000	2,2353-002	3,0501-001	1,8333+000	1,6229+000	1,4492+004
1,7500+000	2,2780-002	3,0727-001	1,8385+000	1,6371+000	1,4046+004
0,0000+000	2,2780-002	3,0727-001	1,3576+000	1,6371+000	1,4412+004
6,3200-001	2,2945-002	3,0814-001	1,3591+000	1,6426+000	1,0999+004
1,2640+000	2,3111-002	3,0900-001	1,3605+000	1,6481+000	7,5897+003
1,5800+000	2,3194-002	3,0943-001	1,3612+000	1,6508+000	5,8867+003

MEAN VOID IN CORE= 1,5501-001

PI =-3,2640+003 PS1 =-2,3369+002 PS2 =-8,2910+002 PCR = 3,6590+002
PRO = 0,0000+000 PDI = 0,0000+000 PDB = 3,1341+004

NOMENCLATURE

			UNIT
T	=	TIME	SEC
Q	=	HEAT TO COOLANT FLOW	WATT
SP	=	SYSTEM PRESSURE REL. TO NOMINAL	N/MM
SL	=	STEAM LOAD	KG/SEC
FW	=	FEEDWATER FLOW	KG/SEC
FT	=	FEEDWATER TEMPERATURE	DEGR. C
GR	=	GRAVITY ACCELERATION	M/SECSEC
WL	=	WATER LEVEL IN UPPER PLENUM	M
VI	=	CORE INLET VELOCITY	M/SEC
VC	=	AVERAGE VOID IN CORE	NONE
VR	=	-- - - RISER	--
V1	=	-- - - DOWNCOMER1	--
V2	=	-- - - DOWNCOMER2	--
H	=	PUMP HEAD	N/MM
CA	=	MAX. CANNING SURFACE TEMP.	DEGR. C
FS	=	MAX. FUEL SURFACE TEMP.	DEGR. C
FC	=	MAX. FUEL CENTER ZONE TEMP.	DEGR. C
N	=	NUCLEAR POWER	WATT
RC	=	CONTROLLED REACTIVITY	NONE
RD	=	DOPPLER --	--
RT	=	MODERATOR TEMP. --	--
RV	=	VOID --	--
RE	=	EXCESS --	--

STEADY STATE BASED ON VOIFLO
****

T	=	0,0000+000	G	=	5,9000+007	DP	=	0,0000+000	SL	=	2,2662+001	FW =	2,6518+001
FT	=	1,4710+002	GR	=	9,8100+000	WL	=	7,6974-001	VI	=	1,3347+000	VC =	1,5392-001
VH	=	3,0713-001	V1	=	0,0000+000	V2	=	0,0000+000	H	=	0,0000+000	CA =	2,7328+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0.00000	0.66949	0.40549	0,13685	0.00000	263.018	0.000	
DOWNCOMER1								
1,38000	0.00000	0.00000	0.40549	-0,16315	0.14653	263.018	0.000	
DOWNCOMER2								
1,95080	0.00000	0.00000	2.70819	0,57082	0.35367	263.018	0.000	
LOWER PLENUM								
1,53000	0.00000	0.00000	0.74408	0,70000	0.51612	263.018	0.000	
CORE								
0,06797	0.00000	0.00000	1.33467	1,26224	3.11601	260.411	0.000	0.000
0,20391	0.00000	0.00000	1.33467	1,26224	2.68396	260.830	0.000	0.000
0,33985	0.00001	0.00020	1.36490	1,25643	2.25188	261.249	-0.041	5.817
0,47690	0.00093	0.02250	1.41661	1,24889	1.81731	261.670	12.965	32.353
0,61947	0.00283	0.06561	1.49399	1,24977	1.36785	262.105	18.335	44.404
0,76950	0.00524	0.11405	1.59328	1,26650	0.89609	262.562	22.366	52.318
0,92812	0.00832	0.16586	1.69814	1,30514	0.47696	262.966	21.854	48.963
1,09848	0.01288	0.22591	1.75891	1,38272	0.40393	263.022	18.467	40.762
1,27857	0.01651	0.26433	1.80526	1,44542	0.38548	263.023	14.388	31.375
1,46475	0.01895	0.28686	1.84157	1,48629	0.36684	263.023	10.189	21.930
1,65456	0.02047	0.29984	1.86421	1,51141	0.34812	263.023	6.014	12.847
1,75000	0.02096	0.30384	1.87073	1,51944	0.33877	263.023	4.299	9.230
RISER								
0,31600	0.02220	0.30590	1.34915	1,59629	0.30297	263.022	-0.373	
0,94800	0.02235	0.30713	1.34118	1,60056	0.23145	263.021	-0.285	
1,58000	0,02251	0.30837	1.33515	1,60447	0.15994	263.020	-0.197	

DYNAMIC CALCULATION STARTS
****

T	= 0.0000+000	G	= 5,9000+007	DP	= 0,0000+000	SL	= 2,6499+001	FW	= 2,6518+001
FT	= 1.4710+002	GR	= 9,8100+000	WL	= 7,7031-001	VI	= 1,3146+000	VC	= 1,5857-001
VR	= 3,0508-001	V1	= 0,0000+000	V2	= 0,0000+000	H	= 0,0000+000	CA	= 2,7328+002
FS	= 4,0959+002	FC	= 1,2015+003	N	= 5,9000+007	RC	= 0,0000+000	RD	= 0,0000+000
RT	= 0,0000+000	RV	= 4,0018-010	RE	= 0,0000+000				

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,66912	0,39939	0,12367	-0,00344	263,021	0,054	
DOWNCOMER1								
1,38000	0,00000	0,00000	0,39939	-0,17633	0,14280	263,021	0,000	
DOWNCOMER2								
1,95080	0,00000	0,00000	2,66745	0,56884	0,34953	263,021	0,000	
LOWER PLENUM								
1,53000	0,00000	0,00000	0,73288	0,70000	0,51167	263,021	0,000	
CORE								
0,06797	0,00000	0,00000	1,31459	1,26624	0,50502	263,021	0,000	0,000
0,20391	0,00000	0,00000	1,31459	1,26624	0,49172	263,021	0,000	0,000
0,33985	0,00000	0,00000	1,34495	1,26023	3,01290	260,487	-0,000	5,817
0,47690	0,00134	0,03199	1,38754	1,25593	2,62281	260,863	11,790	32,353
0,61947	0,00348	0,07903	1,45529	1,26299	2,06522	261,407	16,979	44,404
0,76950	0,00636	0,13320	1,54178	1,29089	1,40478	262,053	21,157	52,318
0,92812	0,00978	0,18591	1,63597	1,33836	0,73443	262,708	21,206	48,963
1,09848	0,01297	0,22637	1,71599	1,38843	0,21610	263,209	18,909	40,762
1,27857	0,01593	0,25839	1,78467	1,43647	-0,11763	263,525	17,032	31,375
1,46475	0,01862	0,28390	1,84285	1,48009	-0,21191	263,601	14,203	21,930
1,65456	0,02067	0,30145	1,88190	1,51313	-0,19118	263,562	9,585	12,847
1,75000	0,02089	0,30345	1,90261	1,51546	-0,16407	263,526	7,379	9,230
RISER								
0,31600	0,02171	0,30288	1,39176	1,58173	-0,06475	263,390	0,980	
0,94800	0,02197	0,30524	1,39787	1,58579	-0,02182	263,274	0,331	
1,58000	0,02219	0,30716	1,40153	1,58939	-0,01730	263,197	0,263	

T = 5,0000-002	C = 5,9005+007	DP = 5,0897+001	SL = 2,6500+001	FW = 3,1821+001
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7033-001	VI = 1,3132+000	VC = 1,5864-001
VR = 3,0499-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7328+002
FS = 4,0959+002	FC = 1,2015+003	N = 5,9050+007	RC = 0,0000+000	RD = -1,4188-009
RT = 3,7466-006	RV = 4,6778-006	RE = 8,4173-006		

T = 1,0000-001	C = 5,9027+007	DP = 1,5098+002	SL = 2,6500+001	FW = 3,7125+001
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7038-001	VI = 1,3120+000	VC = 1,5856-001
VR = 3,0496-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7328+002
FS = 4,0959+002	FC = 1,2015+003	N = 5,9359+007	RC = 0,0000+000	RD = -8,7031-008
RT = 1,5005-005	RV = 3,1988-005	RE = 4,6900-005		

T = 1,5000-001	C = 5,9066+007	DP = 2,7236+002	SL = 2,6501+001	FW = 4,2429+001
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7046-001	VI = 1,3111+000	VC = 1,5838-001
VR = 3,0492-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7328+002
FS = 4,0960+002	FC = 1,2016+003	N = 5,9947+007	RC = 0,0000+000	RD = -3,8740-007
RT = 3,3690-005	RV = 8,3361-005	RE = 1,1666-004		

T = 2,0000-001	C = 5,9128+007	DP = 4,1254+002	SL = 2,6502+001	FW = 4,7732+001
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7055-001	VI = 1,3105+000	VC = 1,5810-001
VR = 3,0486-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7328+002
FS = 4,0963+002	FC = 1,2016+003	N = 6,0866+007	RC = 0,0000+000	RD = -1,0574-006
RT = 5,9718-005	RV = 1,6909-004	RE = 2,2774-004		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.66900	0.39815	0.12093	-0.00197	263.025	0.031	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.39815	-0.17907	0.14803	263.021	0.000	
DOWNCOMER2								
1.95080	0.00000	0.00000	2.65916	0.56843	0.35497	263.021	0.000	
LOWER PLENUM								
1.53000	0.00000	0.00000	0.73060	0.70000	0.51723	263.021	0.000	
CORE								
0.06797	0.00000	0.00000	1.31050	1.26707	0.51056	263.021	0.000	-0.000
0.20391	0.00000	0.00000	1.31050	1.26707	0.49722	263.021	0.000	-0.000
0.33985	0.00000	0.00000	1.36500	1.25641	4.53918	258.966	-0.000	6.125
0.47690	0.00125	0.03012	1.40312	1.25271	3.30742	260.184	10.932	32.410
0.61947	0.00341	0.07760	1.46827	1.26005	2.27740	261.200	16.639	44.481
0.76950	0.00631	0.13241	1.55385	1.28836	1.45446	262.008	21.089	52.408
0.92812	0.00973	0.18534	1.64783	1.33607	0.74975	262.698	21.209	49.048
1.09848	0.01291	0.22589	1.72776	1.38627	0.22572	263.205	18.920	40.833
1.27857	0.01587	0.25793	1.79613	1.43436	-0.11146	263.524	16.964	31.430
1.46475	0.01855	0.28340	1.85399	1.47791	-0.20827	263.603	14.164	21.969
1.65456	0.02051	0.30028	1.89406	1.50940	-0.18839	263.564	9.550	12.870
1.75000	0.02119	0.30582	1.90747	1.52019	-0.16183	263.529	7.359	9.246
RISER								
0.31600	0.02160	0.30217	1.39962	1.57876	-0.06227	263.393	0.942	
0.94800	0.02194	0.30509	1.40384	1.58442	-0.01907	263.277	0.289	
1.58000	0.02216	0.30705	1.40645	1.58825	-0.01449	263.200	0.220	

```
T  =  2,5000-001    G  =  5,9223+007    DP =  5,2588+002    SL =  2,6502+001    FW =  5,3036+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7065-001    VI =  1,3101+000    VC =  1,5766-001
VR =  3,0479-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7329+002
FS =  4,0969+002    FC =  1,2017+003    N  =  6,2257+007    RC =  0,0000+000    RD = -2,3711-006
RT =  9,2888-005    RV =  3,0973-004    RE =  4,0024-004

T  =  3,0000-001    G  =  5,9345+007    DP =  6,2976+002    SL =  2,6503+001    FW =  5,8339+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7074-001    VI =  1,3099+000    VC =  1,5706-001
VR =  3,0471-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7329+002
FS =  4,0982+002    FC =  1,2019+003    N  =  6,4113+007    RC =  0,0000+000    RD = -4,7128-006
RT =  1,3308-004    RV =  5,2376-004    RE =  6,5212-004

T  =  3,5000-001    G  =  5,9621+007    DP =  7,0191+002    SL =  2,6503+001    FW =  6,3643+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7082-001    VI =  1,3097+000    VC =  1,5624-001
VR =  3,0463-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7329+002
FS =  4,1001+002    FC =  1,2023+003    N  =  6,9029+007    RC =  0,0000+000    RD = -8,4967-006
RT =  1,8005-004    RV =  8,3006-004    RE =  1,0016-003

T  =  4,0000-001    G  =  5,9990+007    DP =  7,4529+002    SL =  2,6504+001    FW =  6,8946+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7089-001    VI =  1,3096+000    VC =  1,5521-001
VR =  3,0455-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7330+002
FS =  4,1031+002    FC =  1,2028+003    N  =  7,5032+007    RC =  0,0000+000    RD = -1,4685-005
RT =  2,3350-004    RV =  1,2363-003    RE =  1,4551-003
```

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.66883	0.39788	0.12034	-0.00278	263.030	0.043	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.39788	-0.17966	0.15191	263.022	0.000	
DOWNCOMER2								
1.95080	0.00000	0.00000	2.65736	0.56834	0.35923	263.021	0.000	
LOWER PLENUM								
1.53000	0.00000	0.00000	0.73011	0.70000	0.52159	263.021	0.000	
CORE								
0.06797	0.00000	0.00000	1.30961	1.26725	0.51491	263.021	0.000	-0.000
0.20391	0.00000	0.00000	1.30961	1.26725	0.50154	263.021	0.000	-0.000
0.33985	0.00000	0.00000	1.38803	1.25216	6.47629	257.033	-0.000	6.549
0.47690	0.00101	0.02453	1.41876	1.24886	5.07206	258.424	9.034	32.868
0.61947	0.00295	0.06839	1.47524	1.25409	3.58272	259.899	14.738	45.108
0.76950	0.00582	0.12414	1.55365	1.28076	2.19460	261.272	19.822	53.144
0.92812	0.00936	0.18027	1.64331	1.32998	1.07211	262.379	20.752	49.737
1.09848	0.01271	0.22348	1.72120	1.38315	0.33466	263.100	18.927	41.409
1.27857	0.01576	0.25675	1.78836	1.43302	-0.08672	263.504	16.795	31.875
1.46475	0.01849	0.28278	1.84616	1.47746	-0.20524	263.604	14.268	22.281
1.65456	0.02047	0.29985	1.88687	1.50916	-0.18921	263.569	9.654	13.052
1.75000	0.02115	0.30541	1.90059	1.51994	-0.16308	263.534	7.446	9.376
RISER								
0.31600	0.02156	0.30172	1.39477	1.57867	-0.06327	263.398	0.956	
0.94800	0.02192	0.30481	1.39910	1.58463	-0.01994	263.282	0.302	
1.58000	0.02214	0.30682	1.40194	1.58855	-0.01527	263.205	0.232	

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T  =  4,5000-001    G  =  6,0558+007    DP =  7,5130+002    SL =  2,6504+001    FW =  7,4250+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7093-001    VI =  1,3094+000    VC =  1,5392-001
VR =  3,0449-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7331+002
FS =  4,1078+002    FC =  1,2037+003    N  =  8,4264+007    RC =  0,0000+000    RD = -2,4304-005
RT =  2,9307-004    RV =  1,7431-003    RE =  2,0119-003

T  =  5,0000-001    G  =  6,1379+007    DP =  7,1265+002    SL =  2,6503+001    FW =  7,9553+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7096-001    VI =  1,3090+000    VC =  1,5237-001
VR =  3,0445-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7332+002
FS =  4,1150+002    FC =  1,2050+003    N  =  9,7136+007    RC =  0,0000+000    RD = -3,9334-005
RT =  3,5794-004    RV =  2,3350-003    RE =  2,6536-003

T  =  5,5000-001    G  =  6,2644+007    DP =  6,6910+002    SL =  2,6503+001    FW =  8,4857+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7097-001    VI =  1,3076+000    VC =  1,5062-001
VR =  3,0441-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7334+002
FS =  4,1260+002    FC =  1,2070+003    N  =  1,1728+008    RC =  0,0000+000    RD = -6,2165-005
RT =  4,2762-004    RV =  2,9763-003    RE =  3,3418-003

T  =  6,0000-001    G  =  6,4567+007    DP =  6,6335+002    SL =  2,6503+001    FW =  9,0161+001
FT =  1,4710+002    GR =  9,8100+000    WL =  7,7100-001    VI =  1,3052+000    VC =  1,4879-001
VR =  3,0433-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  0,0000+000    CA =  2,7337+002
FS =  4,1422+002    FC =  1,2100+003    N  =  1,4800+008    RC =  0,0000+000    RD = -9,6500-005
RT =  5,0124-004    RV =  3,6097-003    RE =  4,0144-003
```

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,66878	0,39652	0,11733	-0,00359	263,030	0,056	
DOWNCOMER1								
1,38000	0,00000	0,00000	0,39652	-0,18267	0,15048	263,022	0,000	
DOWNCOMER2								
1,95080	0,00000	0,00000	2,64831	0,56789	0,35823	263,021	0,000	
LOWER PLENUM								
1,53000	0,00000	0,00000	0,72762	0,70000	0,52082	263,021	0,000	
CORE								
0,06797	0,00000	0,00000	1,30515	1,26817	0,51409	263,021	0,000	-0,000
0,20391	0,00000	0,00000	1,30515	1,26817	0,50062	263,021	0,000	-0,000
0,33985	0,00000	0,00000	1,40733	1,24870	8,34757	255,161	-0,000	7,272
0,47690	0,00082	0,02023	1,43404	1,24554	6,89637	256,598	7,931	35,372
0,61947	0,00248	0,05858	1,48612	1,24787	5,28657	258,194	13,428	48,534
0,76950	0,00503	0,11035	1,56083	1,26808	3,63597	259,830	18,524	57,163
0,92812	0,00837	0,16640	1,64887	1,31195	2,11948	261,331	19,951	53,506
1,09848	0,01176	0,21258	1,72624	1,36543	0,96493	262,468	18,857	44,549
1,27857	0,01497	0,24886	1,79117	1,41836	0,18578	263,230	16,195	34,304
1,46475	0,01788	0,27735	1,84298	1,46683	-0,14497	263,542	14,148	23,987
1,65456	0,02017	0,29738	1,88138	1,50441	-0,18237	263,560	10,048	14,054
1,75000	0,02097	0,30397	1,89447	1,51738	-0,16342	263,532	7,819	10,095
RISER								
0,31600	0,02151	0,30126	1,38913	1,57868	-0,06555	263,398	0,990	
0,94800	0,02190	0,30463	1,39378	1,58519	-0,02226	263,283	0,338	
1,58000	0,02214	0,30672	1,39716	1,58918	-0,01732	263,206	0,263	

T = 6,5000-001	G = 6,7349+007	DP = 7,5552+002	SL = 2,6504+001	FW = 9,5464+001
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7108-001	VI = 1,3010+000	VC = 1,4706-001
VR = 3,0414-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7341+002
FS = 4,1666+002	FC = 1,2145+003	N = 1,9170+008	RC = 0,0000+000	RD = -1,4796-004
RT = 5,7771-004	RV = 4,1657-003	RE = 4,5954-003		

T = 7,0000-001	G = 7,0987+007	DP = 1,0627+003	SL = 2,6505+001	FW = 1,0077+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7129-001	VI = 1,2954+000	VC = 1,4570-001
VR = 3,0379-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7347+002
FS = 4,2021+002	FC = 1,2211+003	N = 2,4530+008	RC = 0,0000+000	RD = -2,2300-004
RT = 6,5602-004	RV = 4,5509-003	RE = 4,9839-003		

T = 7,5000-001	G = 7,4954+007	DP = 1,6210+003	SL = 2,6509+001	FW = 1,0607+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7165-001	VI = 1,2893+000	VC = 1,4487-001
VR = 3,0318-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7356+002
FS = 4,2495+002	FC = 1,2300+003	N = 2,9461+008	RC = 0,0000+000	RD = -3,2429-004
RT = 7,3484-004	RV = 4,7196-003	RE = 5,1301-003		

T = 8,0000-001	G = 7,8255+007	DP = 2,4690+003	SL = 2,6513+001	FW = 1,1137+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7207-001	VI = 1,2846+000	VC = 1,4454-001
VR = 3,0226-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7365+002
FS = 4,3045+002	FC = 1,2407+003	N = 3,1923+008	RC = 0,0000+000	RD = -4,4432-004
RT = 8,1383-004	RV = 4,7111-003	RE = 5,0806-003		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0.66825	0,39028	0,10320	0,00741	263,041	-0,009	
DOWNCOMER1								
1,38000	0,00000	0,00000	0,39028	-0,19680	0,17281	263,023	0,000	
DOWNCOMER2								
1,95080	0,00000	0.00000	2,60659	0,56578	0,38127	263,022	0,000	
LOWER PLENUM								
1,53000	0.00000	0.00000	0,71616	0,70000	0,54431	263,021	0,000	
CORE								
0,06797	0,00000	0.00000	1,28459	1,27246	0,53742	263,021	0,000	-0,000
0,20391	0,00000	0,00000	1,28459	1,27246	0,52363	263,021	0,000	-0,000
0,33985	0,00000	0,00000	1,41034	1,24817	10,26332	253,268	-0,000	8,796
0,47690	0,00081	0.02013	1,43834	1,24480	8,66087	254,856	8,321	42,921
0,61947	0,00244	0.05784	1,49490	1,24617	6,89448	256,608	14,318	58,781
0,76950	0,00487	0.10784	1,57760	1,26372	5,07980	258,408	19,865	69,158
0,92812	0,00803	0.16187	1,67723	1,30300	3,36692	260,104	21,434	64,762
1,09848	0,01119	0,20620	1,76721	1,35111	1,98306	261,471	20,393	53,996
1,27857	0,01423	0,24197	1,84443	1,40053	0,92838	262,507	17,775	41,630
1,46475	0,01684	0,26852	1,90336	1,44347	0,21836	263,199	13,884	29,143
1,65456	0,01896	0,28785	1,94087	1,47861	-0,08177	263,479	9,974	17,087
1,75000	0,01984	0,29539	1,95341	1,49330	-0,11225	263,500	8,113	12,273
RISER								
0,31600	0,02079	0,29621	1,42418	1,56162	-0,04622	263,399	0,694	
0,94800	0,02168	0,30331	1,41760	1,57809	-0,00830	263,290	0,126	
1,58000	0,02203	0,30611	1,41458	1,58476	-0,00334	263,215	0,051	

T = 8,5000-001	G = 8,0860+007	DP = 3,2764+003	SL = 2,6518+001	FW = 1,1668+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7251-001	VI = 1,2807+000	VC = 1,4448-001
VR = 3,0106-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7375+002
FS = 4,3606+002	FC = 1,2520+003	N = 3,2516+008	RC = 0,0000+000	RD = -5,7045-004
RT = 8,9346-004	RV = 4,6286-003	RE = 4,9516-003		

T = 9,0000-001	G = 8,3036+007	DP = 3,9993+003	SL = 2,6522+001	FW = 1,2198+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7296-001	VI = 1,2773+000	VC = 1,4453-001
VR = 2,9969-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7384+002
FS = 4,4145+002	FC = 1,2633+003	N = 3,2255+008	RC = 0,0000+000	RD = -6,9594-004
RT = 9,7405-004	RV = 4,5421-003	RE = 4,8202-003		

T = 9,5000-001	G = 8,5221+007	DP = 4,5570+003	SL = 2,6525+001	FW = 1,2729+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7339-001	VI = 1,2732+000	VC = 1,4460-001
VR = 2,9819-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7393+002
FS = 4,4656+002	FC = 1,2746+003	N = 3,2303+008	RC = 0,0000+000	RD = -8,1916-004
RT = 1,0556-003	RV = 4,4909-003	RE = 4,7274-003		

T = 1,0000+000	G = 8,7529+007	DP = 5,0846+003	SL = 2,6528+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,7384-001	VI = 1,2685+000	VC = 1,4467-001
VR = 2,9664-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7401+002
FS = 4,5152+002	FC = 1,2860+003	N = 3,2796+008	RC = 0,0000+000	RD = -9,4250-004
RT = 1,1378-003	RV = 4,4746-003	RE = 4,6700-003		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0.00000	0.66722	0,38538	0,09180	0,01814	263,064	-0,023	
DOWNCOMER1								
1,38000	0.00000	0.00000	0,38538	-0,20820	0,20481	263,024	0,000	
DOWNCOMER2								
1,95080	0.00000	0.00000	2,57386	0,56407	0,41542	263,022	0,000	
LOWER PLENUM								
1,53000	0.00000	0.00000	0,70717	0,70000	0,57958	263,021	0,000	
CORE								
0,06797	0.00000	0.00000	1,26846	1,27592	0,57265	263,021	0,000	-0,000
0,20391	0.00000	0.00000	1,26846	1,27592	0,55880	263,021	0,000	-0,000
0,33985	0.00000	0.00000	1,41761	1,24689	12,15698	251,409	-0,000	9,860
0,47690	0.00077	0.01911	1,44331	1,24381	10,43752	253,115	7,850	48,071
0,61947	0.00241	0.05727	1,49757	1,24552	8,47270	255,065	13,954	65,689
0,76950	0.00491	0.10872	1,57824	1,26432	6,41672	257,106	19,703	77,176
0,92812	0.00817	0.16411	1,67669	1,30571	4,47301	259,033	21,475	72,314
1,09849	0.01136	0.20869	1,76646	1,35492	2,91878	260,570	20,542	60,382
1,27857	0.01438	0.24367	1,84507	1,40345	1,72801	261,742	17,940	46,634
1,46475	0.01687	0.26890	1,90680	1,44385	0,87768	262,574	14,026	32,701
1,65456	0.01861	0.28493	1,94810	1,47194	0,32177	263,110	9,102	19,198
1,75000	0.01921	0.29015	1,96128	1,48154	0,14185	263,280	6,863	13,781
RISER								
0,31600	0.01972	0.28747	1,42789	1,54261	0,01008	263,377	-0,012	
0,94800	0.02100	0.29783	1,41359	1,56692	-0,00250	263,318	0,038	
1,58000	0.02173	0.30358	1,40507	1,58087	-0,00012	263,245	0,002	

T =	1,0500+000	C =	8,9940+007	DP =	5,5879+003	SL =	2,6531+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,7430-001	VI =	1,2646+000	VC =	1,4474-001
VR =	2,9513-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7408+002
FS =	4,5645+002	FC =	1,2977+003	N =	3,3574+008	RC =	0,0000+000	RD =	-1,0681-003
RT =	1,2164-003	RV =	4,4758-003	RE =	4,6241-003				

T =	1,1000+000	C =	9,2292+007	DP =	6,0752+003	SL =	2,6534+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,7479-001	VI =	1,2606+000	VC =	1,4485-001
VR =	2,9372-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7415+002
FS =	4,6139+002	FC =	1,3397+003	N =	3,4197+008	RC =	0,0000+000	RD =	-1,1964-003
RT =	1,2878-003	RV =	4,4780-003	RE =	4,5694-003				

T =	1,1500+000	C =	9,4582+007	DP =	6,5205+003	SL =	2,6536+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,7529-001	VI =	1,2566+000	VC =	1,4494-001
VR =	2,9240-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7423+002
FS =	4,6629+002	FC =	1,3229+003	N =	3,4696+008	RC =	0,0000+000	RD =	-1,3268-003
RT =	1,3514-003	RV =	4,4876-003	RE =	4,5123-003				

T =	1,2000+000	C =	9,6758+007	DP =	6,9487+003	SL =	2,6539+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,7583-001	VI =	1,2527+000	VC =	1,4506-001
VR =	2,9120-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7430+002
FS =	4,7115+002	FC =	1,3345+003	N =	3,4964+008	RC =	0,0000+000	RD =	-1,4585-003
RT =	1,4079-003	RV =	4,4923-003	RE =	4,4418-003				

T =	1.2000+000	C =	9.6758+007	DP =	6.9487+003	SL =	2.6539+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7583-001	VI =	1.2527+000	VC =	1.4506-001
VR =	2.9120-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7430+002
FS =	4.7113+002	FC =	1.3345+003	N =	3.4964+008	RC =	0.0000+000	RD =	-1.4585-003
WT =	1.4079-003	RV =	4.4923-003	RE =	4.4418-003				

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.66587	0.38058	0.08034	0.01869	263.087	-0.024	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.38058	-0.21966	0.22487	263.027	0.000	
DOWNCOMER2								
1.95380	0.00000	0.00000	2.54179	0.56236	0.43643	263.023	0.000	
LOWER PLENUM								
1.53001	0.00000	0.00000	0.69836	0.70000	0.60058	263.021	0.000	
CORE								
0.06797	0.00000	0.00000	1.25266	1.27941	0.59368	263.021	0.000	-0.000
0.20391	0.00000	0.00000	1.25266	1.27941	0.57986	263.021	0.000	-0.000
0.33985	0.00000	0.00000	1.40165	1.24971	12.69384	250.893	-0.000	10.670
0.47690	0.00076	0.01887	1.42849	1.24630	11.53399	252.039	8.016	53.214
0.61947	0.00234	0.05576	1.48303	1.24719	9.82347	253.735	13.869	72.565
0.76950	0.00480	0.10675	1.56325	1.26492	7.71293	255.831	19.557	85.144
0.92812	0.00810	0.16313	1.66156	1.30644	5.55133	257.976	21.482	79.823
1.09848	0.01141	0.20909	1.75131	1.35723	3.78298	259.727	20.750	66.743
1.27857	0.01454	0.24536	1.83002	1.40798	2.42932	261.062	18.234	51.633
1.46475	0.01713	0.27128	1.89188	1.44994	1.47366	261.999	14.230	36.269
1.65456	0.01888	0.28719	1.93341	1.47795	0.84541	262.608	9.085	21.327
1.75000	0.01945	0.29212	1.94672	1.48699	0.62219	262.821	6.758	15.319
RISER								
0.31600	0.01939	0.28455	1.42129	1.53773	0.23534	263.173	-0.282	
0.94800	0.02013	0.29070	1.41156	1.55218	0.00889	263.329	-0.011	
1.58000	0.02115	0.29890	1.40030	1.57158	-0.00328	263.271	0.049	

T =	1.2500+000	C =	9.8740+007	DP =	7.3505+003	SL =	2.6541+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7642-001	VI =	1.2488+000	VC =	1.4519-001
VR =	2.9012-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7437+002
FS =	4.7585+002	FC =	1.3472+003	N =	3.4865+008	RC =	0.0000+000	RD =	-1.5902-003
WT =	1.4576-003	RV =	4.4827-003	RE =	4.3502-003				

T =	1.2500+000	C =	9.8740+007	DP =	7.3505+003	SL =	2.6541+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7642-001	VI =	1.2488+000	VC =	1.4519-001
VR =	2.4012-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7437+002
FS =	4.7585+002	FC =	1.3472+003	N =	3.4865+008	RC =	0.0000+000	RD =	-1.5902-003
RT =	1.4576-003	RV =	4.4627-003	RF =	4.3502-003				

T =	1.3000+000	C =	1.0045+008	DP =	7.6991+003	SL =	2.6543+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7705-001	VI =	1.2452+000	VC =	1.4535-001
VR =	2.3913-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7443+002
FS =	4.8038+002	FC =	1.3598+003	N =	3.4284+008	RC =	0.0000+000	RD =	-1.7201-003
RT =	1.5009-003	RV =	4.4508-003	RF =	4.2317-003				

T =	1.3500+000	C =	1.0181+008	DP =	7.9776+003	SL =	2.6545+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7774-001	VI =	1.2420+000	VC =	1.4552-001
VR =	2.3824-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7449+002
FS =	4.8463+002	FC =	1.3722+003	N =	3.3122+008	RC =	0.0000+000	RD =	-1.8462-003
RT =	1.5383-003	RV =	4.3912-003	RF =	4.0832-003				

T =	1.4000+000	C =	1.0272+008	DP =	8.1650+003	SL =	2.6546+001	FW =	1.3259+002
FT =	1.4710+002	GR =	9.8100+000	WL =	7.7849-001	VI =	1.2393+000	VC =	1.4572-001
VR =	2.3740-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	0.0000+000	CA =	2.7454+002
FS =	4.8853+002	FC =	1.3842+003	N =	3.1177+008	RC =	0.0000+000	RD =	-1.9670-003
RT =	1.5701-003	RV =	4.3002-003	RF =	3.9033-003				

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.66410	0.37651	0,07040	0,01281	263.108	-0,016	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.37651	-0,22966	0,23744	263.031	0,000	
DOWNCOMER2								
1.95000	0.00000	0.00000	2.51460	0.56087	0,45280	263.024	0,000	
LOWER PLENUM								
1.53001	0.00000	0.00000	0.69089	0,70000	0,61427	263.022	0,000	
CORE								
0.06797	0.00000	0.00000	1.23926	1,28243	0,61240	263.022	0,000	-0.000
0.20391	0.00000	0.00000	1.23926	1,28243	0,59864	263.021	0.000	-0.000
0.33985	0.00000	0.00000	1.38821	1,25212	12,85631	250.750	-0,000	11.135
0.47690	0.00084	0.02985	1.41697	1,24657	11,73414	251,858	8,548	56,568
0.61947	0.00248	0.05879	1.47391	1,24991	10,18782	253,390	14,363	76,977
0.76950	0.00488	0.10815	1.55604	1,26704	8,31935	255,243	19,738	90,204
0.92812	0.00801	0.16181	1.65520	1,30571	6,31262	257,234	21,240	84,612
1.09848	0.01121	0.20669	1.74392	1,35449	4,55273	258,976	20,316	70,844
1.27357	0.01439	0.24380	1.81970	1,40632	3,10165	260,409	17,856	54,897
1.46475	0.01707	0.27071	1.87855	1,45013	2,03209	261,460	13,952	38,631
1.65456	0.01888	0.28709	1.91766	1,47923	1,32364	262,149	8,793	22,747
1.75000	0.01971	0.29415	1.92582	1,49323	1,07405	262,388	6,434	16,359
RISER								
0.31600	0.01936	0.28408	1.40505	1,53963	0,57174	262,855	-0,686	
0.94800	0.01962	0.28619	1.39815	1,54519	0,08730	263,268	-0,105	
1.58000	0.02045	0.29308	1.38901	1,56119	-0,00314	263,287	0,047	

T	=	1,4500+000	G	=	1,0398+008	DP	=	8,1360+003	SL	=	2,6546+001	FW	=	1,3259+002
FT	=	1,4710+002	GR	=	9,8100+000	WL	=	7,7926-001	VI	=	1,2357+000	VC	=	1,4584-001
VR	=	2,8663-001	V1	=	0,0000+000	V2	=	0,0000+000	H	=	0,0000+000	CA	=	2,7459+002
FS	=	4,9186+002	FC	=	1,3953+003	N	=	3,0717+008	RC	=	0,0000+000	RD	=	-2,0773-003
RT	=	1,5971-003	RV	=	4,2060-003	RE	=	3,7258-003						

T	=	1,5000+000	G	=	1,0477+008	DP	=	8,0134+003	SL	=	2,6545+001	FW	=	1,3259+002
FT	=	1,4710+002	GR	=	9,8100+000	WL	=	7,8008-001	VI	=	1,2328+000	VC	=	1,4603-001
VR	=	2,8586-001	V1	=	0,0000+000	V2	=	0,0000+000	H	=	0,0000+000	CA	=	2,7462+002
FS	=	4,948[illegible]+002	FC	=	1,4060+003	N	=	2,9495+008	RC	=	0,0000+000	RD	=	-2,1805-003
RT	=	1,6196-003	RV	=	4,0844-003	RE	=	3,5236-003						

T	=	1,5500+000	G	=	1,0537+008	DP	=	7,8955+003	SL	=	2,6544+001	FW	=	1,3259+002
FT	=	1,4710+002	GR	=	9,8100+000	WL	=	7,8093-001	VI	=	1,2302+000	VC	=	1,4627-001
VR	=	2,8506-001	V1	=	0,0000+000	V2	=	0,0000+000	H	=	0,0000+000	CA	=	2,7465+002
FS	=	4,9732+002	FC	=	1,4161+003	N	=	2,8080+008	RC	=	0,0000+000	RD	=	-2,2757-003
RT	=	1,6381-003	RV	=	3,9466-003	RE	=	3,3110-003						

T	=	1,6000+000	G	=	1,0571+008	DP	=	7,8250+003	SL	=	2,6544+001	FW	=	1,3259+002
FT	=	1,4710+002	GR	=	9,8100+000	WL	=	7,8178-001	VI	=	1,2278+000	VC	=	1,4654-001
VR	=	2,8422-001	V1	=	0,0000+000	V2	=	0,0000+000	H	=	0,0000+000	CA	=	2,7468+002
FS	=	4,9945+002	FC	=	1,4255+003	N	=	2,6759+008	RC	=	0,0000+000	RD	=	-2,3630-003
RT	=	1,6527-003	RV	=	3,8109-003	RF	=	3,1007-003						

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,66216	0,37301	0,06169	-0,00274	263,119	0,043	
DOWNCOMER1								
1,38000	0,00000	0,00000	0,37301	-0,23831	0,22993	263,035	0,000	
DOWNCOMER2								
1,95080	0,00000	0,00000	2,49127	0,55957	0,44945	263,026	0,000	
LOWER PLENUM								
1,53000	0,00000	0,00000	0,68448	0,70000	0,61894	263,022	0,000	
CORE								
0,06797	0,00000	0,00000	1,22776	1,28507	0,61213	263,022	0,000	-0,000
0,20391	0,00000	0,00000	1,22776	1,28507	0,59848	263,022	0,000	-0,000
0,33985	0,00000	0,00000	1,37668	1,25423	12,94798	250,658	-0,000	11,364
0,47690	0,00088	0,02185	1,40644	1,25058	11,80797	251,784	8,835	58,275
0,61947	0,00261	0,06168	1,46453	1,25268	10,24438	253,333	14,727	79,164
0,76950	0,00515	0,11305	1,54750	1,27218	8,40187	255,161	20,109	92,673
0,92812	0,00839	0,16750	1,64669	1,31354	6,48526	257,061	21,437	86,965
1,09848	0,01154	0,21079	1,73546	1,36164	4,86297	258,666	20,188	72,893
1,27857	0,01450	0,24504	1,81193	1,40933	3,52578	259,985	17,437	56,562
1,46475	0,01699	0,27003	1,87034	1,44962	2,49815	260,994	13,407	39,855
1,65456	0,01873	0,28586	1,90714	1,47769	1,77124	261,701	8,271	23,516
1,75000	0,01930	0,29081	1,91789	1,48694	1,50241	261,961	5,940	16,924
RISER								
0,31600	0,01914	0,28207	1,39253	1,53776	0,92076	262,506	-1,101	
0,94800	0,01931	0,28330	1,38169	1,54225	0,22820	263,126	-0,273	
1,58000	0,01990	0,28824	1,37419	1,55379	0,00509	263,276	-0,006	

T = 1.6500+000	G = 1.0598+008	DP = 7.7441+003	SL = 2.6543+001	FW = 1.3259+002
FT = 1.4710+002	GR = 9.8100+000	WL = 7.8265-001	VI = 1.2254+000	VC = 1.4685-001
VR = 2.8334-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 0.0000+000	CA = 2.7470+002
FS = 5.0124+002	FC = 1.4343+003	N = 2.5453+008	RC = 0.0000+000	RD = -2.4431-003
RT = 1.6641-003	RV = 3.6737-003	RE = 2.8947-003		

T = 1.7000+000	G = 1.0617+008	DP = 7.5944+003	SL = 2.6543+001	FW = 1.3259+002
FT = 1.4710+002	GR = 9.8100+000	WL = 7.8353-001	VI = 1.2231+000	VC = 1.4719-001
VR = 2.8245-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 0.0000+000	CA = 2.7472+002
FS = 5.0272+002	FC = 1.4427+003	N = 2.4295+008	RC = 0.0000+000	RD = -2.5166-003
RT = 1.6727-003	RV = 3.5435-003	RE = 2.6995-003		

T = 1.7500+000	G = 1.0633+008	DP = 7.3753+003	SL = 2.6541+001	FW = 1.3259+002
FT = 1.4710+002	GR = 9.8100+000	WL = 7.8441-001	VI = 1.2209+000	VC = 1.4754-001
VR = 2.8154-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 0.0000+000	CA = 2.7473+002
FS = 5.0394+002	FC = 1.4505+003	N = 2.3301+008	RC = 0.0000+000	RD = -2.5844-003
RT = 1.6789-003	RV = 3.4220-003	RE = 2.5165-003		

T = 1.8000+000	G = 1.0646+008	DP = 7.0887+003	SL = 2.6540+001	FW = 1.3259+002
FT = 1.4710+002	GR = 9.8100+000	WL = 7.8529-001	VI = 1.2186+000	VC = 1.4789-001
VR = 2.8065-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 0.0000+000	CA = 2.7474+002
FS = 5.0496+002	FC = 1.4560+003	N = 2.2493+008	RC = 0.0000+000	RD = -2.6471-003
RT = 1.6832-003	RV = 3.3131-003	RE = 2.3492-003		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.66021	0.37024	0.05466	-0.00533	263.112	0.084	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.37024	-0.24534	0.21674	263.040	0.000	
DOWNCOMER2								
1.95080	0.00000	0.00000	2.47275	0.55851	0.43851	263.029	0.000	
LOWER PLENUM								
1.53000	0.00000	0.00000	0.67939	0.70000	0.61045	263.022	0.000	
CORE								
0.06797	0.00000	0.00000	1.21863	1.28721	0.60371	263.022	0.000	-0.000
0.20391	0.00000	0.00000	1.21863	1.28721	0.59019	263.022	0.000	-0.000
0.33985	0.00000	0.00000	1.36753	1.25594	13.02081	250.578	-0.000	11.415
0.47690	0.00090	0.02213	1.39732	1.25224	11.86539	251.719	8.859	58.730
0.61947	0.00265	0.06255	1.45533	1.25458	10.27591	253.294	14.759	79.673
0.76950	0.00525	0.11484	1.53807	1.27503	8.40169	255.153	20.180	93.196
0.92812	0.00858	0.17023	1.63678	1.31815	6.46606	257.073	21.560	87.484
1.09848	0.01181	0.21405	1.72495	1.36784	4.86606	258.655	20.279	73.391
1.27857	0.01480	0.24803	1.80087	1.41581	3.60220	259.901	17.375	57.010
1.46475	0.01720	0.27194	1.85912	1.45448	2.67625	260.808	13.144	40.230
1.65456	0.01877	0.28621	1.89614	1.47948	2.04144	261.424	7.865	23.771
1.75000	0.01924	0.29031	1.90707	1.48694	1.80568	261.650	5.500	17.120
RISER								
0.31600	0.01881	0.27924	1.38355	1.53369	1.24500	262.174	-1.484	
0.94800	0.01889	0.27960	1.36794	1.53729	0.41931	262.926	-0.500	
1.58000	0.01945	0.28424	1.35906	1.54839	0.05159	263.221	-0.062	

T = 1,8500+000	C = 1,0664+008	DP = 6,7316+003	SL = 2,6538+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,8618-001	VI = 1,2163+000	VC = 1,4823-001
VR = 2,7978-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7475+002
FS = 5,0577+002	FC = 1,4651+003	N = 2,1984+008	RC = 0,0000+000	RD = -2,7053-003
RT = 1,6863-003	RV = 3,2175-003	RE = 2,1984-003		

T = 1,9000+000	C = 1,0663+008	DP = 6,3388+003	SL = 2,6535+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,8707-001	VI = 1,2143+000	VC = 1,4855-001
VR = 2,7896-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7475+002
FS = 5,0646+002	FC = 1,4720+003	N = 2,1130+008	RC = 0,0000+000	RD = -2,7601-003
RT = 1,6883-003	RV = 3,1317-003	RE = 2,0599-003		

T = 1,9500+000	C = 1,0659+008	DP = 5,8891+003	SL = 2,6533+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,8798-001	VI = 1,2124+000	VC = 1,4885-001
VR = 2,7819-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7475+002
FS = 5,0704+002	FC = 1,4786+003	N = 2,0331+008	RC = 0,0000+000	RD = -2,8117-003
RT = 1,6897-003	RV = 3,0573-003	RE = 1,9353-003		

T = 2,0000+000	C = 1,0665+008	DP = 5,3650+003	SL = 2,6530+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 7,8889-001	VI = 1,2103+000	VC = 1,4912-001
VR = 2,7750-001	V1 = 0,0000+000	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7475+002
FS = 5,0750+002	FC = 1,4849+003	N = 1,9901+008	RC = 0,0000+000	RD = -2,8602-003
RT = 1,6908-003	RV = 2,9947-003	RE = 1,8253-003		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.65819	0.36770	0.04814	-0.00661	263.092	0.104	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.36770	-0.25186	0.19206	263.043	0.000	
DOWNCOMER2								
1.95080	0.00000	0.00000	2.45580	0.55754	0.41482	263.032	0.000	
LOWER PLENUM								
1.53000	0.00000	0.00000	0.67473	0.70000	0.58930	263.023	0.000	
CORE								
0.06797	0.00000	0.00000	1.21028	1.28919	0.58263	263.023	0.000	-0.000
0.20391	0.00000	0.00000	1.21028	1.28919	0.56926	263.022	0.000	-0.000
0.33985	0.00000	0.00000	1.35915	1.25751	13.07621	250.502	-0.000	11.423
0.47690	0.00090	0.02219	1.38880	1.25379	11.91015	251.654	8.829	58.867
0.61947	0.00267	0.06280	1.44655	1.25615	10.30398	253.246	14.716	79.770
0.76950	0.00528	0.11544	1.52893	1.27690	8.40734	255.127	20.147	93.250
0.92812	0.00866	0.17136	1.62722	1.32080	6.44560	257.073	21.586	87.558
1.09848	0.01197	0.21583	1.71499	1.37178	4.82360	258.678	20.374	73.503
1.27857	0.01504	0.25041	1.79051	1.42121	3.55546	259.928	17.496	57.149
1.46475	0.01750	0.27463	1.84842	1.46087	2.65603	260.808	13.214	40.370
1.65456	0.01907	0.28874	1.88538	1.48577	2.08039	261.365	7.822	23.884
1.75000	0.01951	0.29257	1.89643	1.49270	1.88271	261.553	5.395	17.212
RISER								
0.31600	0.01877	0.27890	1.37673	1.53425	1.44498	261.954	-1.721	
0.94800	0.01843	0.27559	1.36062	1.53066	0.61948	262.705	-0.734	
1.58000	0.01895	0.27994	1.34948	1.54148	0.13176	263.119	-0.157	

T =	2,2000+000	Q =	1,0678+008	DP =	2,7506+003	SL =	2,6515+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,9285-001	VI =	1,2027+000	VC =	1,4991-001
VR =	2,7552-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7474+002
FS =	5,0871+002	FC =	1,5085+003	N =	1,8640+008	RC =	0,0000+000	RD =	-3,0321-003
RT =	1,6954-003	RV =	2,8219-003	RE =	1,4851-003				

T =	2,4000+000	Q =	1,0663+008	DP =	-5,8408+002	SL =	2,6496+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	7,9752-001	VI =	1,1966+000	VC =	1,5042-001
VR =	2,7478-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7472+002
FS =	5,0930+002	FC =	1,5301+003	N =	1,7277+008	RC =	0,0000+000	RD =	-3,1788-003
RT =	1,7026-003	RV =	2,7127-003	RE =	1,2364-003				

T =	2,6000+000	Q =	1,0681+008	DP =	-4,5104+003	SL =	2,6474+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	8,0298-001	VI =	1,1913+000	VC =	1,5075-001
VR =	2,7496-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7468+002
FS =	5,0953+002	FC =	1,5500+003	N =	1,7162+008	RC =	0,0000+000	RD =	-3,3064-003
RT =	1,7121-003	RV =	2,6423-003	RE =	1,0481-003				

T =	2,8000+000	Q =	1,0649+008	DP =	-8,7284+003	SL =	2,6450+001	FW =	1,3259+002
FT =	1,4710+002	GR =	9,8100+000	WL =	8,0906-001	VI =	1,1880+000	VC =	1,5102-001
VR =	2,7570-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	0,0000+000	CA =	2,7463+002
FS =	5,0961+002	FC =	1,5689+003	N =	1,5997+008	RC =	0,0000+000	RD =	-3,4205-003
RT =	1,7228-003	RV =	2,5820-003	RE =	8,8427-004				

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.64825	0.36094	0.03031	-0.00661	262.914	0.105	
DOWNCOMER1								
1.38000	0.00000	0.00000	0.36094	-0.26969	0.02217	263.037	0.000	
DOWNCOMER2								
1.95080	0.00000	0.00000	2.41065	0.55487	0.23384	263.038	0.000	
LOWER PLENUM								
1.53000	0.00000	0.00000	0.66233	0.70000	0.41262	263.027	0.000	
CORE								
0.06797	0.00000	0.00000	1.18803	1.29461	0.40609	263.027	0.000	-0.001
0.20391	0.00000	0.00000	1.18803	1.29461	0.39306	263.026	0.000	-0.001
0.33985	0.00000	0.00000	1.33684	1.26181	13.11557	250.290	-0.000	11.426
0.47690	0.00091	0.02233	1.36622	1.25798	11.94481	251.447	8.742	58.869
0.61947	0.00268	0.06312	1.42333	1.26025	10.32261	253.055	14.549	79.521
0.76950	0.00532	0.11606	1.50480	1.28108	8.39986	254.962	19.939	92.797
0.92812	0.00874	0.17250	1.60219	1.32558	6.40396	256.942	21.469	87.201
1.09848	0.01212	0.21779	1.68954	1.37792	4.74170	258.588	20.415	73.340
1.27857	0.01532	0.25341	1.76491	1.42950	3.43192	259.879	17.704	57.167
1.46475	0.01794	0.27881	1.82279	1.47185	2.49757	260.795	13.539	40.506
1.65456	0.01968	0.29408	1.85973	1.49955	1.90452	261.369	8.174	24.056
1.75000	0.02020	0.29845	1.87077	1.50775	1.70826	261.556	5.726	17.373
RISER								
0.31600	0.01945	0.28480	1.35818	1.54969	1.41719	261.809	-1.700	
0.94800	0.01827	0.27445	1.34586	1.53123	0.92698	262.224	-1.096	
1.58000	0.01767	0.26909	1.33867	1.52214	0.47347	262.602	-0.556	

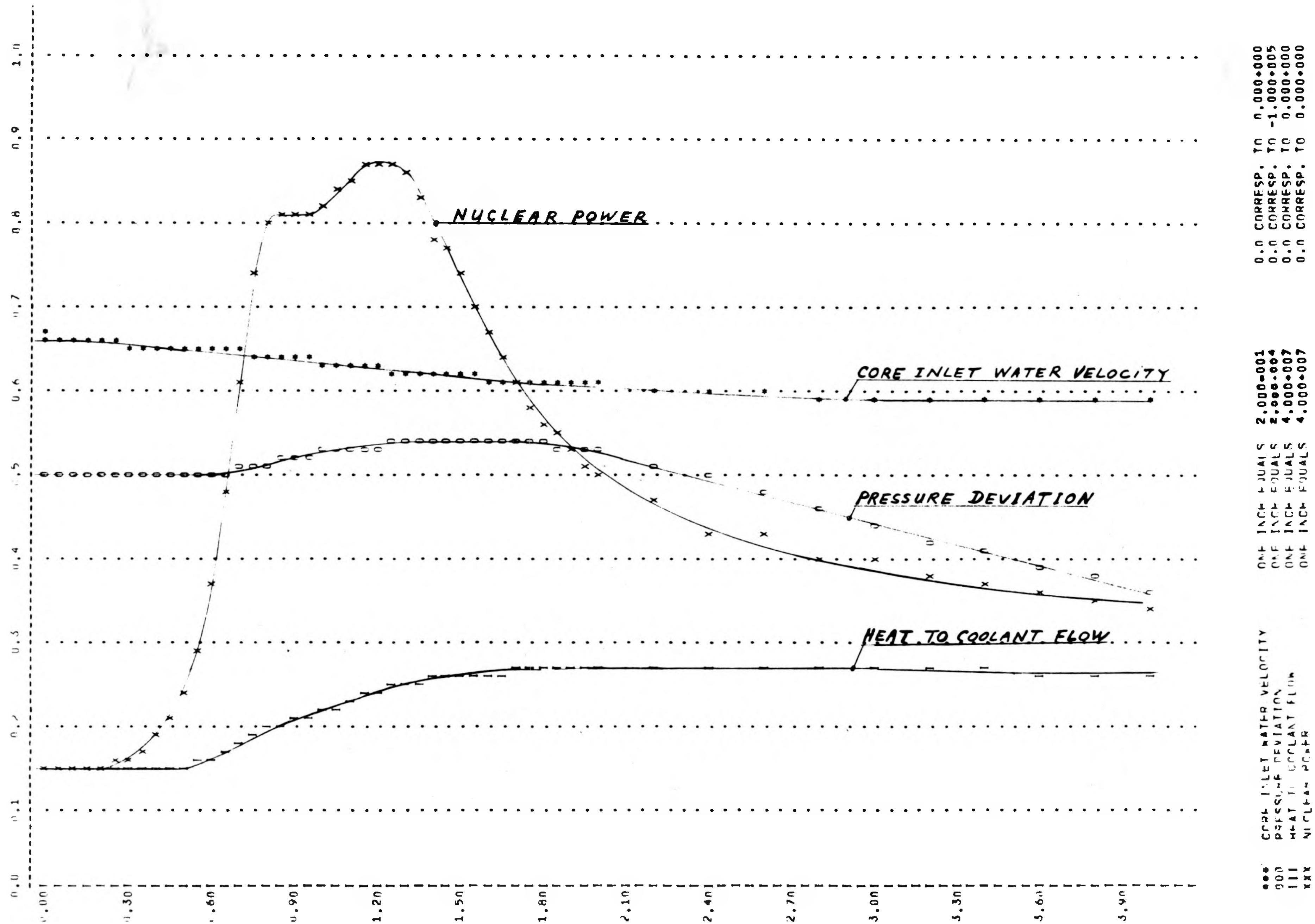
T = 3,0000+000	G = 1,0660+008	DP = -1,2826+004	SL = 2,6426+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 8,1569-001	VI = 1,1862+000	VC = 1,5117-001
VR = 2,7662-001	V1 = 2,2665-004	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7459+002
FS = 5,0954+002	FC = 1,5867+003	N = 1,6086+008	RC = 0,0000+000	RD = -3,5222-003
RT = 1,7334-003	RV = 2,5520-003	RE = 7,6325-004		

T = 3,2000+000	G = 1,0623+008	DP = -1,6037+004	SL = 2,6408+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 8,2345-001	VI = 1,1856+000	VC = 1,5122-001
VR = 2,7745-001	V1 = 1,5201-003	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7456+002
FS = 5,0946+002	FC = 1,6037+003	N = 1,5035+008	RC = 0,0000+000	RD = -3,6159-003
RT = 1,7429-003	RV = 2,5422-003	RE = 6,6919-004		

T = 3,4000+000	G = 1,0611+008	DP = -1,8940+004	SL = 2,6391+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 8,3167-001	VI = 1,1842+000	VC = 1,5124-001
VR = 2,7802-001	V1 = 3,3668-003	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7452+002
FS = 5,0934+002	FC = 1,6200+003	N = 1,4683+008	RC = 0,0000+000	RD = -3,7019-003
RT = 1,7510-003	RV = 2,5326-003	RE = 5,8169-004		

T = 3,6000+000	G = 1,0598+008	DP = -2,1700+004	SL = 2,6376+001	FW = 1,3259+002
FT = 1,4710+002	GR = 9,8100+000	WL = 8,4000-001	VI = 1,1826+000	VC = 1,5130-001
VR = 2,7835-001	V1 = 5,4513-003	V2 = 0,0000+000	H = 0,0000+000	CA = 2,7449+002
FS = 5,0917+002	FC = 1,6357+003	N = 1,4370+008	RC = 0,0000+000	RD = -3,7808-003
RT = 1,7577-003	RV = 2,5115-003	RE = 4,8841-004		

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,63511	0,34476	-0,01521	-0,00097	262,745	0,016	
DOWNCOMER1								
1,38000	0,00000	0,00545	0,36179	-0,26415	-0,04626	262,943	0,271	
DOWNCOMER2								
1,95080	0,00000	0,00000	2,39967	0,55421	0,10289	263,009	0,000	
LOWER PLENUM								
1,53000	0,00000	0,00000	0,65931	0,70000	0,25304	263,027	0,000	
CORE								
0,06797	0,00000	0,00000	1,18262	1,29595	0,24589	263,028	0,000	-0,001
0,20391	0,00000	0,00000	1,18262	1,29595	0,23183	263,028	0,000	-0,001
0,33985	0,00000	0,00000	1,33142	1,26288	13,00993	250,236	-0,000	11,389
0,47690	0,00091	0,02254	1,36094	1,25900	11,84902	251,384	8,749	58,636
0,61947	0,00269	0,06345	1,41795	1,26133	10,24104	252,977	14,496	79,068
0,76950	0,00532	0,11638	1,49909	1,28223	8,33602	254,867	19,819	92,161
0,92812	0,00873	0,17274	1,59595	1,32672	6,35823	256,829	21,334	86,639
1,09848	0,01211	0,21802	1,68289	1,37910	4,70956	258,461	20,305	72,961
1,27857	0,01531	0,25371	1,75793	1,43082	3,40830	259,744	17,630	56,950
1,46475	0,01795	0,27923	1,81557	1,47347	2,47744	260,656	13,514	40,426
1,65456	0,01971	0,29471	1,85229	1,50162	1,88383	261,231	8,192	24,062
1,75000	0,02024	0,29919	1,86320	1,51010	1,68610	261,419	5,758	17,398
RISER								
0,31600	0,01958	0,28623	1,35184	1,55385	1,38154	261,685	-1,660	
0,94800	0,01860	0,27766	1,33770	1,53919	0,89927	262,091	-1,068	
1,58000	0,01794	0,27184	1,32980	1,52923	0,54106	262,372	-0,637	


NUCLEAR POWER
CORE INLET WATER VELOCITY
PRESSURE DEVIATION
HEAT TO COOLANT FLOW
••• CORE INLET WATER VELOCITY
000 PRESSURE DEVIATION
III HEAT TO COOLANT FLOW
XXX NUCLEAR POWER
ONE INCH EQUALS 2.000+001
ONE INCH EQUALS 2.000+004
ONE INCH EQUALS 4.000+007
ONE INCH EQUALS 4.000+007
0.0 CORRESP. TO 0.000+000
0.0 CORRESP. TO -1.000+005
0.0 CORRESP. TO 0.000+000
0.0 CORRESP. TO 0.000+000

APPENDIX D

Sample problems, Listing

Part 2

Test CALINE - RAMONA I. Approach to hydrodynamic loop instability.

INPUT DATA SAMPLE PROBLEM NO. 2 P. BAKSTAD

```
                                                                                  1         2
TEXT
     TEST CALINE - RAMONA I .JANUARY 1968.
GEØMETRICAL DATA
2.173  E-54.906   E-41.0       2.826  E-52.826  E-52.826  E-5
2.912     0.452     1.0       0.2       0.2       0.14
5.26   E-30.025     100.0     2.73   E-4
0.0       0.0       0.0       0.0       0.0
        30         5         1         1         2
9.81      0.1       1.652  E-2
TWØ-PHASE FLØW
         0
         1
      2000
         2
1.2       3.4       2.0       0.0
         0
0.85      5.0    E+64.0    E+70.184     0.2
INTEGRATØR
0.1       0.002     0.01
NØMINAL ØPERATING CØNDITIØNS
         1         0         0         0         0         1
0.95   E+433.6      78.5   E+50.8
HEAD FØRCED CIRCULATION
```

2 2

```
1.5       E+40.0      0.0
HEAT TØ CØØLANT FLØW DISTURBANCE
0.0       100.0     10.0    E-210.0      0.0       1.0
TRANSFER FUNCTIØNS
  7  3
         5
0.1       10.0      2.8       2.9       3.0
0.05      4.0
ØUTPUT INFØRMATIØN
         5         1
         1         3         7
0.0       0.0       0.0
2.0       1.0       2.0     E+4
0.1
         2         2         1         1
0.1       2.0       0.1       8.0
FINISH
```

GEOMETRICAL DATA

FLOW AREA OF			LENGTH (HEIGHT) OF		
CORE	=	2.17300-005	CORE	=	2.91200+000
RISER	=	1.90600-004	RISER	=	4.25000-001
UPPER PLENUM	=	1.00000+000	UPPER PLENUM	=	1.00000+000
DOWNCOMER 1	=	2.82600-005	DOWNCOMER 1	=	2.00000-001
DOWNCOMER 2	=	2.82600-005	DOWNCOMER 2	=	2.00000-001
LOWER PLENUM	=	2.82600-005	LOWER PLENUM	=	1.40000-001

PRESSURE DIFFERENCE IN LOCAL VELOCITY HEADS		
CORE INLET	=	0.00000+000
RISER OUTLET	=	0.00000+000
DOWNCOMER INLET	=	0.00000+000
DOWNCOMER 1-2	=	0.00000+000
DOWNCOMER 2-LOW.PL.	=	0.00000+000

NUMBER OF SUBSECTIONS IN		
CORE	=	30
RISER	=	5
DOWNCOMER 1	=	1
DOWNCOMER 2	=	1
SUBSECTION WHERE FEEDWATER IS RETURNED	=	2

HYDRAULIC DIAMETER OF		
CORE	=	5.26000-003
RISER	=	2.50000-002
DOWNCOMER 1	=	1.00000+002
DOWNCOMER 2	=	2.73000-004

GRAVITY ACCELERATION (NOMINAL)	=	9.81000+000
WATER LEVEL (NOMINAL)	=	1.00000-001
HEATED PERIMETER (TOTAL)	=	1.65200-002

TWO-PHASE FLOW DATA

IMOD = 0	LIGHT WATER MODERATOR				
IMULT= 1	BECKERS CORRELATION				
	COEFFICIENT	2.00000+003			
ISLIP= 2	ROLSTERGS SLIP FORMULA				
	COEFFICIENTS	1.20000+000	3.40000+000	2.00000+000	0.00000+000
ICU = 0	NEGLECT CARRY-UNDER				
COEFFICIENTS FOR EVAPORATION RATE		8.50000-001	5.00000+006	4.00000+007	
COEFFICIENTS IN SINGLE PHASE FRICTION FACTOR		1.84000-001	2.00000-001		

INTEGRATION SPECIFICATION
****

LOCAL RELATIVE ACCURACY	=	1,00000-001
MINIMUM INTEGRATION STEP	=	2,00000-003
INITIAL GUESS --- --	=	1,00000-002

NOMINAL OPERATING CONDITIONS
****

ITEMP =	1	SUBCOOLING IN DEGREES GIVEN
IPRES =	0	CONSTANT DRUM PRESSURE
IPLOC =	0	THERMAL VARIABLES NOT SPATIALLY DEPENDENT
ISTEP =	0	CONSTANT SPATIAL STEP IN CORE
IFLOW =	0	CORE INLET VEL. FROM MOM. BALANCE
ISTEADY=	1	INTEGRATE LOOP-CASE TO ACHIEVE STEADY STATE AND RESET TIME TO ZERO

NOMINAL POWER	9,50000+003
NOMINAL SUBCOOLING IN DEGREES	3,36000+001
NOMINAL PRESSURE	7,85000+006
CORE INLET VELOCITY (DLESS)	8,00000-001

HEAD FORCED CIRCULATION
****

COEFFICIENTS FOR FORCED CIRCULATION HEAD	1,50000+004	0,00000+000	0,00000+000

HEAT TO COOLANT FLOW DISTURBANCE
****

DISTURBANCE STARTS AT	=	0,00000+000
RAMP (RELATIVE VALUES)	=	1,00000+002
RAMP MAX. --- --	=	1,00000-001
TIME INTERVAL	=	1,00000+001
AMPLITUDE (REL.) OF SINUS	=	0,00000+000
PERIOD OF OSCILLATION	=	1,00000+000

OUTPUT INFORMATION
****

ITAB = 5 LARGE OUTPUT EVERY ITAB STEP SMALL OUTPUT
IPLOT = 1 PLOTTING

OUTPUT FOR EACH 2. SECTION IN CORE
-- - -- 2. -- - RISER
-- - -- 1. -- - DOWNCOMER1
-- - -- 1. -- - DOWNCOMER2

THE TIME BETWEEN OUTPRINT IS 1.000-001 FOR TIME LESS THAN 2.0000+000 AND
1.000-001 FOR TIME GR. THAN 2.0000+000 AND LESS THAN 8.0000+000 (SEC)

THERMAL VARIABLES CALCULATED FROM RATIONAL
APPROXIMATIONS WITHIN THE PROGRAM
****

		VALUE AT NOMINAL PRESS.	PRESSURE DERIV. ALONG SAT. CURVE
SATURATION TEMPERATURE	(DEGR. C)	2.93629+002	8.86217-006
DENSITY OF WATER	(KG/MMM)	7.25194+002	-1.74192-005
-- - STEAM	(KG/MMM)	4.16012+001	6.06870-006
HEAT OF VAPORIZATION	(WATT.SEC/KG)	1.45079+006	-6.32381-002
SPESIFIC HEAT OF WATER	(WATT.SEC/KG.DEGR C)	5.47048+003	1.75713-004
VISCOSITY - --	(KG/M.SEC)	9.22108-005	-3.02707-012
THERMAL COND. - --	(WATT/M.DEGR C)	5.53414-001	-1.52563-008

STANDARD VOIFLO OUTPUT (REF.KR-85)
****

GENERAL INPUT DATA.

2.1730-005	4.9060-004	2.8260-005	2.9120+000	4.2500-001	1.0000-001	4.0000-001
3.4370+000	1.6520-002	5.2600-003	2.5000-002	5.4600-004	7.8500+006	9.8100+000
4.1601+001	7.2519+002	1.4508+006	5.4705+003	0.0000+000	1.5000+004	0.0000+000
0.0000+000	0.0000+000	0.0000+000	0.0000+000	0.0000+000	0.0000+000	0.0000+000
-0.0000+000	-0.0000+000	1.0000+000	0.0000+000	0.0000+000	0.0000+000	0.0000+000
4.4293-002	1.2000+000	3.4000+000	2.0000+000	2.0000+003	2.3000-002	1.8400-001
1.3000+000	5.5341-001	9.2211-005	0.0000+000	0.0000+000		

NUMBER OF POINTS IN CORE AND RISER.

31 6

INPUT POWER DISTRIBUTION,UNNORMALIZED.

1.0000+000 1.0000+000

QTOT= 9.5000+003	VI = 8.8636-001	SUB = 2.7025-001	TI = 3.3600+001
TSCB= 1.4192+001	TD = 4.8682+000	TT = 4.8682+000	ZSCB= 4.5456-001
ZD = 6.7295-001	ZT = 6.7295-001	ML = 7.8697-001	ZB = 8.7467-001

POSITION	QUALITY	VOID FRACTION	WATER VELOCITY	SLIP RATIO	PRESSURE
0.0000+000	0.0000+000	0.0000+000	8.8636-001	1.2000+000	3.4851+004
1.9413-001	0.0000+000	0.0000+000	8.8636-001	1.2000+000	3.3233+004
3.8827-001	0.0000+000	0.0000+000	8.8636-001	1.2000+000	3.1615+004
5.8240-001	0.0000+000	0.0000+000	8.8636-001	1.2000+000	2.9998+004
7.7653-001	7.2508-003	9.2887-002	9.7004-001	1.2434+000	2.8342+004
9.7067-001	2.9574-002	2.4819-001	1.1441+000	1.6092+000	2.6680+004
1.1648+000	6.0828-002	3.4367-001	1.2683+000	2.1562+000	2.4969+004
1.3589+000	9.2082-002	4.0596-001	1.3547+000	2.5871+000	2.3118+004
1.5531+000	1.2334-001	4.5686-001	1.4306+000	2.9156+000	2.1095+004
1.7472+000	1.5459-001	5.0138-001	1.5028+000	3.1700+000	1.8890+004
1.9413+000	1.8584-001	5.4134-001	1.5733+000	3.3714+000	1.6498+004
2.1355+000	2.1710-001	5.7765-001	1.6430+000	3.5343+000	1.3917+004
2.3296+000	2.4835-001	6.1090-001	1.7123+000	3.6684+000	1.1143+004
2.5237+000	2.7961-001	6.4152-001	1.7812+000	3.7807+000	8.1752+003
2.7179+000	3.1086-001	6.6982-001	1.8500+000	3.8761+000	5.0114+003
2.9120+000	3.4211-001	6.9608-001	1.9187+000	3.9580+000	1.6499+003
0.0000+000	3.4211-001	6.9608-001	8.4983-002	3.9580+000	1.7549+003
1.7000-001	3.4211-001	6.9608-001	8.4983-002	3.9580+000	1.3377+003
3.4000-001	3.4211-001	6.9608-001	8.4983-002	3.9580+000	9.2050+002
4.2500-001	3.4211-001	6.9608-001	8.4983-002	3.9580+000	7.1189+002

MEAN VOID IN CORE= 3.6120-001

PI = 0.0000+000   PS1 =-0.0000+000   PS2 =-0.0000+000   PCR = 1.0504+002
PRO = 0.0000+000   PDI = 0.0000+000   PDB = 3.4851+004

NOMENCLATURE			UNIT
T	=	TIME	SEC
Q	=	HEAT TO COOLANT FLOW	WATT
DP	=	SYSTEM PRESSURE REL. TO NOMINAL	N/MM
SL	=	STEAM LOAD	KG/SEC
FW	=	FEEDWATER FLOW	KG/SEC
FT	=	FEEDWATER TEMPERATURE	DEGR. C
GR	=	GRAVITY ACCELERATION	M/SECSEC
WL	=	WATER LEVEL IN UPPER PLENUM	M
VI	=	CORE INLET VELOCITY	M/SEC
VC	=	AVERAGE VOID IN CORE	NONE
VR	=	-- - - RISER	--
V1	=	-- - - DOWNCOMER1	--
V2	=	-- - - DOWNCOMER2	--
H	=	PUMP HEAD	N/MM
CA	=	MAX. CANNING SURFACE TEMP.	DEGR. C

STEADY STA... BASED ON , VCIFLO
****

T	=	0,0000+000	G =	9,5000+003	DP =	0,0000+000	SL =	2,5599-004	FW =	4,7785-003
FT	=	1,6590+002	GR =	9,8100+000	WL =	1,0000-001	VI =	1,4681+000	VC =	3,4971-001
VR	=	6,9608-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9833+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90003	0.89568	0.60924	-0.00000	293,629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	1.12885	0.38995	33.60000	260.029	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	1.12885	-4,16314	33,60000	260,029	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	1.12885	0,70000	33,60000	260,029	0.000	
CORE								
0,09707	0,00000	0,00000	1,46808	1,20000	31,73562	261,893	0,000	19,748
0,29120	0.00000	0,00000	1,46808	1,20000	24,27812	269,351	0,000	19,748
0,48533	0.00000	0.00000	1,46808	1,20000	16,82062	276,808	0,000	19,748
0,67947	0,00023	0,00329	1,45992	1,20004	9,36311	284,266	-3,273	19,748
0,87360	0,01015	0,12488	1,40363	1,25303	1,90561	291,723	-1,846	19,748
1,06773	0,03088	0,27578	1,28537	1,45859	-0,00000	293,629	0,000	19,748
1,26187	0,05035	0,36026	1,17620	1,64128	-0,00000	293,629	0,000	19,748
1,45600	0,06926	0,41917	1,08520	1,79740	-0,00000	293,629	0,000	19,748
1,65013	0,08951	0,46832	1,00350	1,94568	-0,00000	293,629	0,000	19,748
1,84427	0,11158	0,51162	0,92956	2,08997	-0,00000	293,629	0,000	19,748
2,03840	0,13555	0,55062	0,86304	2,23083	-0,00000	293,629	0,000	19,748
2,23253	0,16135	0,58614	0,80356	2,36811	-0,00000	293,629	0,000	19,748
2,42667	0,18888	0,61871	0,75061	2,50154	-0,00000	293,629	0,000	19,748
2,62080	0,21797	0,64873	0,70356	2,63090	-0,00000	293,629	0,000	19,748
2,81493	0,24848	0,67651	0,66177	2,75605	-0,00000	293,629	0,000	19,748
2,91200	0,26421	0,68963	0,64265	2,81703	-0,00000	293,629	0,000	19,748
RISER								
0,08500	0,27225	0,69608	0,02806	2,84738	0,00000	293,629	0,000	
0,25500	0,27225	0,69608	0,02806	2,84738	0,00000	293,629	0,000	
0,42500	0,27225	0,69608	0,02806	2,84738	0,00000	293,629	0,000	

DYNAMIC CALCULATION STARTS

T = 0.0000+000	G = 9.5000+003	DP = 0.0000+000	SL = 4.7455-003	FW = 4.7785-003
FT = 1.9277+002	GR = 9.8100+000	WL = 1.0001-001	VI = 9.0941-001	VC = 3.6453-001
VR = 7.3784-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9833+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./F+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90002	0.46611	0.24910	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.69928	0.19948	33.58336	260.045	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.69928	-7.15061	33.59642	260.032	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.69928	0.70000	33.59899	260.030	0.000	
CORE								
0.09707	0.00000	0.00000	0.90941	1.20000	29.56483	264.064	0.000	19.748
0.29120	0.00000	0.00000	0.90941	1.20000	21.48819	272.141	0.000	19.748
0.48533	0.00000	0.00000	0.90941	1.20000	13.40824	280.221	0.000	19.748
0.67947	0.00000	0.00000	0.90941	1.20000	5.32722	288.302	-0.000	19.748
0.87360	0.00250	0.03503	0.94003	1.20417	-2.09593	295.725	16.977	19.748
1.06773	0.02151	0.21941	1.13987	1.36367	-5.24079	298.870	79.197	19.748
1.26187	0.05090	0.36222	1.35318	1.64608	-5.70549	299.334	103.607	19.748
1.45600	0.08231	0.45210	1.52296	1.89494	-5.62805	299.257	106.992	19.748
1.65013	0.11368	0.51533	1.66269	2.10292	-5.55976	299.189	106.278	19.748
1.84427	0.14478	0.56399	1.78329	2.28149	-5.57005	299.199	105.378	19.748
2.03840	0.17570	0.60370	1.89092	2.43912	-5.64141	299.270	104.812	19.748
2.23253	0.20652	0.63738	1.98905	2.58125	-5.75298	299.382	104.502	19.748
2.42667	0.23742	0.66681	2.07936	2.71178	-5.89000	299.519	104.301	19.748
2.62080	0.26912	0.69359	2.16043	2.83564	-6.03250	299.661	103.855	19.748
2.81493	0.30266	0.71896	2.23141	2.95747	-6.25050	299.879	104.271	19.748
2.91200	0.32260	0.73286	2.23687	3.02609	-5.18261	298.811	84.796	19.748
RISER								
0.08500	0.32926	0.73733	0.10314	3.04843	-0.40624	294.035	6.603	
0.25500	0.33017	0.73794	0.10317	3.05146	-0.00106	293.630	0.017	
0.42500	0.33023	0.73798	0.10316	3.05168	-0.00000	293.629	0.000	

T	=	1.0000-001	C	=	1.0450+004	DP	=	0.0000+000	SL	=	5.0650-003	FW	=	4.7785-003
FT	=	1.9726+002	GR	=	9.8100+000	WL	=	1.0001-001	VI	=	8.6987-001	VC	=	3.6593-001
VR	=	7.3793-001	V1	=	0.0000+000	V2	=	0.0000+000	H	=	1.5000+004	CA	=	2.9845+002
T	=	2.0000-001	C	=	1.0450+004	DP	=	0.0000+000	SL	=	5.1969-003	FW	=	4.7785-003
FT	=	1.9891+002	GR	=	9.8100+000	WL	=	1.0001-001	VI	=	8.5475-001	VC	=	3.6965-001
VR	=	7.3804-001	V1	=	0.0000+000	V2	=	0.0000+000	H	=	1.5000+004	CA	=	2.9845+002
T	=	3.0000-001	C	=	1.0450+004	DP	=	0.0000+000	SL	=	5.2615-003	FW	=	4.7785-003
FT	=	2.0007+002	GR	=	9.8100+000	WL	=	1.0001-001	VI	=	8.4425-001	VC	=	3.7402-001
VR	=	7.3821-001	V1	=	0.0000+000	V2	=	0.0000+000	H	=	1.5000+004	CA	=	2.9845+002
T	=	4.0000-001	C	=	1.0450+004	DP	=	0.0000+000	SL	=	5.3110-003	FW	=	4.7785-003
FT	=	2.0180+002	GR	=	9.8100+000	WL	=	1.0002-001	VI	=	8.2863-001	VC	=	3.7888-001
VR	=	7.3845-001	V1	=	0.0000+000	V2	=	0.0000+000	H	=	1.5000+004	CA	=	2.9845+002
T	=	5.0000-001	C	=	1.0450+004	DP	=	0.0000+000	SL	=	5.3576-003	FW	=	4.7785-003
FT	=	2.0425+002	GR	=	9.8100+000	WL	=	1.0002-001	VI	=	8.0657-001	VC	=	3.8429-001
VR	=	7.3878-001	V1	=	0.0000+000	V2	=	0.0000+000	H	=	1.5000+004	CA	=	2.9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90002	0.38703	0.09567	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.62019	0.13566	33.69740	259.931	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.62019	-8.15165	33.65194	259.977	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.62019	0.70000	33.62989	259.999	0.000	
CORE								
0.09707	0.00000	0.00000	0.80657	1.20000	28.75205	264.877	0.000	21.723
0.29120	0.00000	0.00000	0.80657	1.20000	19.40987	274.219	0.000	21.723
0.48533	0.00000	0.00000	0.80657	1.20000	10.66754	282.961	0.000	21.723
0.67947	0.00000	0.00000	0.80657	1.20000	2.36193	291.267	-0.000	21.723
0.87360	0.00662	0.08662	0.90680	1.22551	-4.14762	297.776	43.181	21.723
1.06773	0.03176	0.28043	1.16825	1.46738	-6.09675	299.726	101.623	21.723
1.26187	0.06398	0.40429	1.39803	1.75573	-6.25021	299.879	116.630	21.723
1.45600	0.09679	0.48357	1.58189	1.99505	-6.15691	299.786	117.681	21.723
1.65013	0.12900	0.54063	1.73653	2.19375	-6.12338	299.752	116.609	21.723
1.84427	0.16056	0.58513	1.87252	2.36408	-6.16835	299.797	115.705	21.723
2.03840	0.19158	0.62167	1.99578	2.51400	-6.26860	299.897	115.169	21.723
2.23253	0.22214	0.65273	2.10968	2.64858	-6.40478	300.034	114.887	21.723
2.42667	0.25235	0.67980	2.21620	2.77125	-6.56528	300.194	114.751	21.723
2.62080	0.28235	0.70392	2.31629	2.88472	-6.74250	300.371	114.666	21.723
2.81493	0.31289	0.72619	2.40799	2.99302	-6.91486	300.544	114.218	21.723
2.91200	0.32432	0.73403	2.46785	3.03190	-7.11074	300.740	116.146	21.723
RISER								
0.08500	0.33438	0.74072	0.11230	3.06544	-0.37766	294.006	6.107	
0.25500	0.33063	0.73824	0.11321	3.05299	-0.00115	293.630	0.019	
0.42500	0.33023	0.73797	0.11328	3.05165	-0.00000	293.629	0.000	

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T  =  6.0000-001     C  =  1.0450+004     DP =  0.0000+000     SL =  5.4055-003     FW =  4.7785-003
FT =  2.0725+002     GR =  9.8100+000     WL =  1.0002-001     VI =  7.7950-001     VC =  3.9034-001
VR =  7.3924-001     V1 =  0.0000+000     V2 =  0.0000+000     H  =  1.5000+004     CA =  2.9845+002

T  =  7.0000-001     C  =  1.0450+004     DP =  0.0000+000     SL =  5.4548-003     FW =  4.7785-003
FT =  2.1034+002     GR =  9.8100+000     WL =  1.0002-001     VI =  7.5169-001     VC =  3.9712-001
VR =  7.3983-001     V1 =  0.0000+000     V2 =  0.0000+000     H  =  1.5000+004     CA =  2.9845+002

T  =  8.0000-001     C  =  1.0450+004     DP =  0.0000+000     SL =  5.5048-003     FW =  4.7785-003
FT =  2.1304+002     GR =  9.8100+000     WL =  1.0002-001     VI =  7.2735-001     VC =  4.0456-001
VR =  7.4055-001     V1 =  0.0000+000     V2 =  0.0000+000     H  =  1.5000+004     CA =  2.9845+002

T  =  9.0000-001     C  =  1.0450+004     DP =  0.0000+000     SL =  5.5610-003     FW =  4.7785-003
FT =  2.1547+002     GR =  9.8100+000     WL =  1.0002-001     VI =  7.0541-001     VC =  4.1259-001
VR =  7.4142-001     V1 =  0.0000+000     V2 =  0.0000+000     H  =  1.5000+004     CA =  2.9845+002

T  =  1.0000+000     C  =  1.0450+004     DP =  0.0000+000     SL =  5.6126-003     FW =  4.7785-003
FT =  2.1693+002     GR =  9.8100+000     WL =  1.0002-001     VI =  6.9222-001     VC =  4.2099-001
VR =  7.4244-001     V1 =  0.0000+000     V2 =  0.0000+000     H  =  1.5000+004     CA =  2.9845+002
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POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90002	0.29910	-0.17017	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.53227	0.04244	33.75943	259.869	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.53227	-9.61386	33.72281	259.906	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.53227	0.70000	33.69061	259.938	0.000	
CORE								
0,09707	0.00000	0.00000	0.69222	1.20000	28.02069	265.608	0.000	21.723
0.29120	0.00000	0.00000	0.69222	1.20000	17.31901	276.310	0.000	21.723
0.48533	0.00000	0.00000	0.69222	1.20000	7.37999	286.249	0.000	21.723
0.67947	0.00123	0.01761	0.71580	1.20105	-1.63536	295.265	11.873	21.723
0.87360	0.02112	0.21672	0.94210	1.35968	-5.71332	299.342	85.895	21.723
1.06773	0.05491	0.37602	1.19526	1.68074	-6.24931	299.878	114.634	21.723
1.26187	0.09010	0.46958	1.39602	1.94973	-6.17583	299.805	117.837	21.723
1.45600	0.12414	0.53290	1.56304	2.16555	-6.12618	299.755	116.840	21.723
1.65013	0.15693	0.58044	1.70935	2.34550	-6.16078	299.790	115.807	21.723
1.84427	0.18874	0.61856	1.84174	2.50089	-6.25645	299.885	115.184	21.723
2.03840	0.21980	0.65050	1.96379	2.63869	-6.39096	300.020	114.860	21.723
2.23253	0.25033	0.67810	2.07760	2.76336	-6.55120	300.180	114.709	21.723
2.42667	0.28049	0.70250	2.18446	2.87790	-6.73033	300.359	114.658	21.723
2.62080	0.31039	0.72445	2.28528	2.98440	-6.92491	300.554	114.662	21.723
2.81493	0.34018	0.74449	2.38062	3.08450	-7.13147	300.760	114.664	21.723
2.91200	0.35476	0.75373	2.42759	3.13157	-7.25348	300.882	114.922	21.723
RISER								
0.08500	0.35010	0.75081	0.11261	3.11665	-0.36863	293.997	5.868	
0.25500	0.33386	0.74037	0.11560	3.06370	-0,00109	293.630	0.018	
0.42500	0.33062	0.73824	0.11617	3.05298	-0.00000	293.629	0.000	

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T  =  1,1000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,6573-003    FW =  4,7785-003
FT =  2,1720+002    GR =  9,8100+000    WL =  1,0002-001    VI =  6,8980-001    VC =  4,2935-001
VR =  7,4363-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  1,2000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,6920-003    FW =  4,7785-003
FT =  2,1637+002    GR =  9,8100+000    WL =  1,0002-001    VI =  6,9725-001    VC =  4,3722-001
VR =  7,4501-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  1,3000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,7154-003    FW =  4,7785-003
FT =  2,1468+002    GR =  9,8100+000    WL =  1,0002-001    VI =  7,1251-001    VC =  4,4421-001
VR =  7,4653-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  1,4000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,7277-003    FW =  4,7785-003
FT =  2,1235+002    GR =  9,8100+000    WL =  1,0002-001    VI =  7,3352-001    VC =  4,5004-001
VR =  7,4836-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  1,5000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,7292-003    FW =  4,7785-003
FT =  2,0959+002    GR =  9,8100+000    WL =  1,0002-001    VI =  7,5841-001    VC =  4,5451-001
VR =  7,5033-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002
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POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.34999	-0.00001	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.58316	0.09982	33.54325	260.086	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.58316	-8.71377	33.65967	259.969	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.58316	0.70000	33.69615	259.933	0.000	
CORE								
0.09707	0.00000	0.00000	0.75841	1.20000	28.17727	265.452	0.000	21.723
0.29120	0.00000	0.00000	0.75841	1.20000	16.83322	276.796	0.000	21.723
0.48533	0.00000	0.00000	0.75841	1.20000	5.67116	287.958	0.000	21.723
0.67947	0.00578	0.07670	0.82010	1.22000	-3.43820	297.067	34.340	21.723
0.87360	0.03613	0.30202	1.06295	1.51012	-5.95445	299.583	101.988	21.723
1.06773	0.07474	0.43361	1.26909	1.83925	-6.16067	299.789	116.453	21.723
1.26187	0.11342	0.51487	1.43324	2.10131	-6.11798	299.747	116.952	21.723
1.45600	0.15090	0.57243	1.57346	2.31409	-6.14782	299.777	115.947	21.723
1.65013	0.18715	0.61680	1.69928	2.49352	-6.25281	299.882	115.249	21.723
1.84427	0.22230	0.65288	1.81551	2.64925	-6.40548	300.034	114.885	21.723
2.03840	0.25646	0.68326	1.92473	2.78726	-6.58751	300.216	114.718	21.723
2.23253	0.28973	0.70950	2.02848	2.91152	-6.78914	300.418	114.660	21.723
2.42667	0.32221	0.73260	2.12774	3.02476	-7.00539	300.634	114.664	21.723
2.62080	0.35395	0.75322	2.22325	3.12897	-7.23375	300.863	114.704	21.723
2.81493	0.38499	0.77185	2.31556	3.22555	-7.47293	301.102	114.769	21.723
2.91200	0.40026	0.78052	2.36066	3.27134	-7.59677	301.226	114.814	21.723
RISER								
0.08500	0.37882	0.76826	0.11142	3.20674	-0.34856	293.977	5.388	
0.25500	0.34358	0.74667	0.11731	3.09557	-0.00096	293.630	0.015	
0.42500	0.33287	0.73972	0.11920	3.06043	-0.00000	293.629	0.000	

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T  =  1.6000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.7201-003    FW =  4.7785-003
FT =  2.0658+002    GR =  9.8100+000    WL =  1.0002-001    VI =  7.8563-001    VC =  4.5752-001
VR =  7.5247-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002

T  =  1.7000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.7005-003    FW =  4.7785-003
FT =  2.0344+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.1398-001    VC =  4.5898-001
VR =  7.5476-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002

T  =  1.8000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.6708-003    FW =  4.7785-003
FT =  2.0030+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.4230-001    VC =  4.5888-001
VR =  7.5719-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002

T  =  1.9000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.6321-003    FW =  4.7785-003
FT =  1.9729+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.6947-001    VC =  4.5726-001
VR =  7.5971-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002

T  =  2.0000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5864-003    FW =  4.7785-003
FT =  1.9453+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.9435-001    VC =  4.5421-001
VR =  7.6230-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002
```

POSITION (M)	QUALITY	VOID FRACTION	AT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0.00000	0.90001	0,45453	0,22997	0.00000	293,629	0,000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.68769	0,19105	33,43629	260,192	0,000	
DOWNCOMER2								
0,20000	0.00000	0.00000	0,68769	-7,28285	33,50644	260,122	0,000	
LOWER PLENUM								
0,14000	0.00000	0.00000	0,68769	0,70000	33,56381	260,065	0,000	
CORE								
0,09707	0.00000	0.00000	0.89435	1,20000	28,92058	264,708	0,000	21,723
0,29120	0.00000	0.00000	0,89435	1,20000	19,07741	274,551	0,000	21,723
0,48533	0.00000	0.00000	0,89435	1,20000	8,50763	285,121	0,000	21,723
0,67947	0.00295	0.04100	0.91666	1,20571	-1,62946	295,258	13,657	21,723
0,87360	0.02876	0.26424	1.11711	1,43739	-5,53128	299,160	90,117	21,723
1.06773	0.06720	0.41348	1.30988	1.78129	-6,08719	299,716	114.109	21,723
1,26187	0.10807	0.50527	1.45836	2,06801	-6,09805	299,727	116,632	21,723
1,45600	0.14915	0.57004	1,58063	2,30481	-6,14269	299,771	115,957	21,723
1,65013	0.19007	0.62002	1,68745	2,50705	-6,27015	299,899	115,325	21,723
1,84427	0.23068	0.66071	1,78454	2,68422	-6,45654	300,085	114,992	21,723
2,03840	0.27082	0.69494	1,87521	2,84201	-6,68144	300,310	114,848	21,723
2,23253	0,31030	0,72438	1,96154	2,98407	-6,93302	300,562	114,807	21,723
2,42667	0,34894	0,75008	2,04488	3,11293	-7,20473	300,834	114,825	21,723
2,62080	0,38662	0,77279	2,12616	3,23049	-7,49280	301,122	114,879	21,723
2,81493	0.42323	0,79303	2,20599	3,33827	-7,79503	301,424	114,958	21,723
2,91200	0.44111	0.80237	2,24549	3,38889	-7,95129	301,580	115,009	21,723
RISER								
0,08500	0.41569	0.78900	0.10589	3,31657	-0,32606	293,955	4,848	
0,25500	0.36180	0,75807	0.11391	3,15386	-0,00074	293,630	0,012	
0,42500	0.33926	0.74390	0.11768	3,08149	-0,00000	293,629	0,000	

T =	2.1000+000	G =	1.0450+004	DP =	0.0000+000	SL =	5.5362-003	FW =	4.7785-003
FT =	1.9214+002	GR =	9.8100+000	WL =	1.0002-001	VI =	9.1591-001	VC =	4.4992-001
VR =	7.6491-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

T =	2.2000+000	G =	1.0450+004	DP =	0.0000+000	SL =	5.4845-003	FW =	4.7785-003
FT =	1.9021+002	GR =	9.8100+000	WL =	1.0002-001	VI =	9.3330-001	VC =	4.4460-001
VR =	7.6750-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

T =	2.3000+000	G =	1.0450+004	DP =	0.0000+000	SL =	5.4398-003	FW =	4.7785-003
FT =	1.8915+002	GR =	9.8100+000	WL =	1.0002-001	VI =	9.4287-001	VC =	4.3858-001
VR =	7.7004-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

T =	2.4000+000	G =	1.0450+004	DP =	0.0000+000	SL =	5.4004-003	FW =	4.7785-003
FT =	1.8877+002	GR =	9.8100+000	WL =	1.0002-001	VI =	9.4617-001	VC =	4.3225-001
VR =	7.7247-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

T =	2.5000+000	G =	1.0450+004	DP =	0.0000+000	SL =	5.3653-003	FW =	4.7785-003
FT =	1.8890+002	GR =	9.8100+000	WL =	1.0002-001	VI =	9.4517-001	VC =	4.2592-001
VR =	7.7475-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.49360	0.29093	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.72677	0.21842	33.54032	260.088	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.72677	-6.85365	33.49690	260.132	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.72677	0.70000	33.49089	260.138	0.000	
CORE								
0.09707	0.00000	0.00000	0.94517	1.20000	29.21148	264.417	0.000	21.723
0.29120	0.00000	0.00000	0.94517	1.20000	20.53387	273.095	0.000	21.723
0.48533	0.00000	0.00000	0.94517	1.20000	11.48835	282.140	0.000	21.723
0.67947	0.00002	0.00029	0.94499	1.20000	1.89564	291.733	-0.056	21.723
0.87360	0.01322	0.15419	1.06762	1.28084	-4.47879	298.108	58.349	21.723
1.06773	0.04535	0.34154	1.28448	1.59662	-5.97228	299.601	106.586	21.723
1.26187	0.08349	0.45483	1.45403	1.90337	-6.10196	299.731	116.080	21.723
1.45600	0.12318	0.53136	1.58625	2.15996	-6.10226	299.731	116.415	21.723
1.65013	0.16368	0.58909	1.69550	2.37988	-6.18052	299.809	115.716	21.723
1.84427	0.20492	0.63574	1.78986	2.57418	-6.33656	299.965	115.247	21.723
2.03840	0.24683	0.67509	1.87394	2.74955	-6.54907	300.178	115.026	21.723
2.23253	0.28935	0.70921	1.95057	2.91013	-6.80395	300.433	114.952	21.723
2.42667	0.33231	0.73935	2.02164	3.05859	-7.09403	300.723	114.961	21.723
2.62080	0.37555	0.76633	2.08859	3.19670	-7.41600	301.045	115.018	21.723
2.81493	0.41884	0.79069	2.15253	3.32565	-7.76850	301.397	115.109	21.723
2.91200	0.44042	0.80201	2.18367	3.38696	-7.95605	301.585	115.164	21.723
RISER								
0.08500	0.44155	0.80259	0.09969	3.39013	-0.32445	293.953	4.691	
0.25500	0.38570	0.77226	0.10709	3.22770	-0.00059	293.629	0.009	
0.42500	0.35100	0.75138	0.11236	3.11954	-0.00000	293.629	0.000	

T = 2.6000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3364-003	FW = 4.7785-003
FT = 1.8947+002	GR = 9.8100+000	WL = 1.0002-001	VI = 9.3999-001	VC = 4.1985-001
VR = 7.7686-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002
T = 2.7000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3154-003	FW = 4.7785-003
FT = 1.9049+002	GR = 9.8100+000	WL = 1.0002-001	VI = 9.3083-001	VC = 4.1432-001
VR = 7.7876-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002
T = 2.8000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3033-003	FW = 4.7785-003
FT = 1.9189+002	GR = 9.8100+000	WL = 1.0002-001	VI = 9.1812-001	VC = 4.0958-001
VR = 7.8041-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002
T = 2.9000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3007-003	FW = 4.7785-003
FT = 1.9362+002	GR = 9.8100+000	WL = 1.0002-001	VI = 9.0259-001	VC = 4.0584-001
VR = 7.8181-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002
T = 3.0000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3069-003	FW = 4.7785-003
FT = 1.9555+002	GR = 9.8100+000	WL = 1.0002-001	VI = 8.8515-001	VC = 4.0323-001
VR = 7.8293-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./F+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.97001	0.44745	0.21780	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	1.00000	0.00000	0.68062	0.18576	33.66436	259.964	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.68062	-7.36580	33.59688	260.032	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.68062	0.70000	33.55842	260.070	0.000	
CORE								
0.09707	0.00000	0.00000	0.88515	1.20000	29.06098	264.568	0.000	21.723
0.29120	0.00000	0.00000	0.88515	1.20000	20.26134	273.367	0.000	21.723
0.48533	0.00000	0.00000	0.88515	1.20000	11.58729	282.041	0.000	21.723
0,67947	0.00000	0.00000	0,88515	1,20000	2,84994	290,779	-0,000	21,723
0,87360	0.00838	0.19302	0.97874	1.23609	-3,99229	297,621	44,272	21,723
1,06773	0,03575	0,31021	1,21732	1,50642	-5,95443	299,583	101,769	21,723
1,26137	0,07060	0,42281	1,41867	1,80781	-6,15246	299,781	115,811	21,723
1,45600	0,10674	0,50282	1,57716	2,05962	-6,11182	299,741	116,901	21,723
1,65013	0,14314	0,56167	1,70813	2,27262	-6,13173	299,761	116,095	21,723
1,84427	0,17989	0,60858	1,82066	2,45925	-6,23118	299,860	115,440	21,723
2,03840	0,21717	0,64796	1,91971	2,62748	-6,39018	300,019	115,093	21,723
2,23253	0,25520	0,68221	2,00809	2,78239	-6,59338	300,222	114,949	21,723
2,42667	0,29415	0,71278	2,08755	2,92737	-6,83326	300,462	114,923	21,723
2,62080	0,33416	0,74059	2,15924	3,06479	-7,10756	300,736	114,966	21,723
2,81493	0,37543	0,76626	2,22407	3,19631	-7,41722	301,046	115,052	21,723
2,91200	0,39652	0,77843	2,25416	3,26024	-7,58615	301,215	115,107	21,723
RISER								
0,08500	0,43656	0,80003	0,09837	3,37614	-0,35225	293,981	5,120	
0,25500	0,40803	0,78483	0,10205	3,29423	-0,00059	293,629	0,009	
0,42500	0,36706	0,76126	0,10776	3,17036	-0,00000	293,629	0,000	

T = 3.1000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3211-003	FW = 4.7785-003
FT = 1.9759+002	GR = 9.8100+000	WL = 1.0002-001	VI = 8.6675-001	VC = 4.0182-001
VR = 7.8380-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

T = 3.2000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3418-003	FW = 4.7785-003
FT = 1.9964+002	GR = 9.8100+000	WL = 1.0002-001	VI = 8.4820-001	VC = 4.0157-001
VR = 7.8444-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

T = 3.3000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3675-003	FW = 4.7785-003
FT = 2.0163+002	GR = 9.8100+000	WL = 1.0002-001	VI = 8.3029-001	VC = 4.0242-001
VR = 7.8487-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

T = 3.4000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.3966-003	FW = 4.7785-003
FT = 2.0346+002	GR = 9.8100+000	WL = 1.0002-001	VI = 8.1379-001	VC = 4.0425-001
VR = 7.8513-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

T = 3.5000+000	C = 1.0450+004	DP = 0.0000+000	SL = 5.4274-003	FW = 4.7785-003
FT = 2.0504+002	GR = 9.8100+000	WL = 1.0003-001	VI = 7.9950-001	VC = 4.0692-001
VR = 7.8525-001	V1 = 0.0000+000	V2 = 0.0000+000	H = 1.5000+004	CA = 2.9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./F*4 (WATT/MM)
UPPER PLENUM								
0,00000	0.00000	0,90001	0,38159	0,08279	0,00000	293,629	0.000	
DOWNCOMER1								
0,20000	0.00000	0.00000	0,61476	0,13067	33,70971	259,919	0,000	
DOWNCOMER2								
0,20000	0,00000	0,00000	0,61476	-8,22991	33,67554	259,953	0,000	
LOWER PLENUM								
0,14000	0.00000	0.00000	0,61476	0,70000	33,64511	259,984	0,000	
CORE								
0,09767	0.00000	0.00000	0,79950	1,20000	28,68237	264,946	0,000	21,723
0,29120	0.00000	0.00000	0,79950	1,20000	19,08690	274,542	0,000	21,723
0,48533	0,00000	0,00000	0,79950	1,20000	9,88528	283,744	0,000	21,723
0,67947	0,00000	0,00000	0,79950	1,20000	0,96964	292,659	-0,000	21,723
0,87360	0,01205	0,14337	0,94644	1,26988	-4,82122	298,450	60,941	21,723
1,06773	0,04202	0,32810	1,19992	1,56600	-6,13158	299,760	108,039	21,723
1,26187	0,07670	0,43855	1,40614	1,85392	-6,18224	299,811	117,060	21,723
1,45600	0,11152	0,51151	1,57219	2,08957	-6,12211	299,751	117,059	21,723
1,65013	0,14590	0,56555	1,71283	2,28750	-6,13838	299,767	116,066	21,723
1,84427	0,18000	0,60871	1,83639	2,45980	-6,22833	299,857	115,378	21,723
2,03840	0,21403	0,64488	1,94748	2,61396	-6,36947	299,998	115,012	21,723
2,23253	0,24814	0,67622	2,04878	2,75472	-6,54645	300,175	114,848	21,723
2,42667	0,28249	0,70403	2,14194	2,88522	-6,75120	300,380	114,799	21,723
2,62080	0,31718	0,72916	2,22806	3,00771	-6,98028	300,609	114,817	21,723
2,81493	0,35235	0,75223	2,30791	3,12387	-7,23301	300,862	114,879	21,723
2,91200	0,37015	0,76312	2,34566	3,17998	-7,36855	300,997	114,922	21,723
RISER								
0,08500	0,41119	0,78656	0,10221	3,30349	-0,37098	294,000	5,542	
0,25500	0,42008	0,79136	0,10126	3,32925	-0,00071	293,629	0,011	
0,42500	0,38472	0,77169	0,10597	3,22472	-0,00000	293,629	0,000	

T =	3,6000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,4582-003	FW =	4,7785-003
FT =	2,0630+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7.8815-001	VC =	4,1025-001
VR =	7,8526-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	3,7000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,4886-003	FW =	4,7785-003
FT =	2,0722+002	GR =	9,8100+000	WL =	1.0003-001	VI =	7,7982-001	VC =	4,1403-001
VR =	7,8520-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	3,8000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,5211-003	FW =	4,7785-003
FT =	2,0807+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,7218-001	VC =	4,1814-001
VR =	7,8511-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	3,9000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,5498-003	FW =	4,7785-003
FT =	2,0852+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,6813-001	VC =	4,2240-001
VR =	7,8500-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	4,0000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,5738-003	FW =	4,7785-003
FT =	2,0855+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,6783-001	VC =	4,2662-001
VR =	7,8492-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.35724	0.02026	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.59041	0.10719	33.65675	259.972	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.59041	-8.59827	33.67926	259.950	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.59041	0.70000	33.67933	259.949	0.000	
CORE								
0.09707	0.00000	0.00000	0.76783	1.20000	28.43524	265.194	0.000	21.723
0.29120	0.00000	0.00000	0.76783	1.20000	18.11024	275.519	0.000	21.723
0.48533	0.00000	0.00000	0.76783	1.20000	8.11516	285.514	0.000	21.723
0.67947	0.00108	0.01546	0.78479	1.20081	-1.23321	294.862	8.820	21.723
0.87360	0.02099	0.21575	0.99586	1.35827	-5.57398	299.203	83.645	21.723
1.06773	0.05521	0.37701	1.23553	1.68326	-6.20198	299.831	113.843	21.723
1.26187	0.09154	0.47268	1.42355	1.95964	-6.15386	299.783	117.473	21.723
1.45600	0.12734	0.53802	1.57807	2.18418	-6.12082	299.750	116.625	21.723
1.65013	0.16238	0.58745	1.71208	2.37331	-6.17423	299.803	115.689	21.723
1.84427	0.19679	0.62727	1.83255	2.53780	-6.29133	299.920	115.139	21.723
2.03840	0.23067	0.66070	1.94334	2.68419	-6.44933	300.078	114.864	21.723
2.23253	0.26413	0.68957	2.04667	2.81672	-6.63487	300.264	114.746	21.723
2.42667	0.29724	0.71504	2.14388	2.93835	-6.84113	300.470	114.718	21.723
2.62080	0.33010	0.73789	2.23585	3.05123	-7.06499	300.694	114.742	21.723
2.81493	0.36279	0.75867	2.32315	3.15700	-7.30541	300.934	114.801	21.723
2.91200	0.37910	0.76842	2.36520	3.20761	-7.43206	301.061	114.843	21.723
BISER								
0.08500	0.39793	0.77922	0.10604	3.26444	-0.36559	293.994	5.539	
0.25500	0.41858	0.79055	0.10348	3.32491	-0.00081	293.630	0.012	
0.42500	0.39983	0.78028	0.10597	3.27006	-0.00000	293.629	0.000	

T =	4,1000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,5919-003	FW =	4,7785-003
FT =	2,0816+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,7133-001	VC =	4,3059-001
VR =	7,8487-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

T =	4,2000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,6036-003	FW =	4,7785-003
FT =	2,0738+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,7841-001	VC =	4,3414-001
VR =	7,8488-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

T =	4,3000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,6089-003	FW =	4,7785-003
FT =	2,0626+002	GR =	9,8100+000	WL =	1,0003-001	VI =	7,8854-001	VC =	4,3713-001
VR =	7,8495-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

T =	4,4000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,6080-003	FW =	4,7785-003
FT =	2,0486+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,0110-001	VC =	4,3944-001
VR =	7,8508-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

T =	4,5000+000	G =	1,0450+004	DP =	0,0000+000	SL =	5,6011-003	FW =	4,7785-003
FT =	2,0328+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,1541-001	VC =	4,4098-001
VR =	7,8529-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./F+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.39383	0.11128	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.62699	0.14178	33.54960	260.079	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.62699	-8.05567	33.61176	260.017	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.62699	0.70000	33.64272	259.986	0.000	
CORE								
0,09707	0.00000	0.00000	0.81541	1.20000	28.60422	265.025	0.000	21.723
0.29120	0.00000	0.00000	0.81541	1.20000	18.31601	275.313	0.000	21.723
0,48533	0.00000	0.00000	0,81541	1.20000	7.93846	285.690	0.000	21.723
0,67947	0.00230	0.03228	0.83983	1,20354	-1.70807	295.337	13.612	21.723
0,87360	0.02611	0.24889	1.05400	1,41061	-5.60804	299.237	89.230	21.723
1,06773	0.06261	0.40026	1.27022	1.74470	-6.14221	299.771	114.368	21.723
1.26187	0.10089	0.49171	1.43947	2,02206	-6.11965	299.748	117.032	21.723
1.45600	0.13869	0.55526	1.58004	2.24827	-6.12635	299.755	116.227	21.723
1.65013	0.17578	0.60380	1.70330	2.43955	-6.21451	299.843	115.453	21.723
1.84427	0.21222	0.64310	1.81519	2.60617	-6.36072	299.990	115.021	21.723
2.03840	0.24807	0.67616	1.91897	2.75444	-6.54429	300.173	114.817	21.723
2.23253	0.28338	0.70471	2.01654	2.88848	-6.75351	300.382	114.742	21.723
2.42667	0.31819	0.72986	2.10908	3.01115	-6.98248	300.611	114.740	21.723
2.62080	0.35256	0.75236	2.19739	3.12455	-7.22845	300.857	114.781	21.723
2.81493	0.38653	0.77274	2.28204	3.23023	-7.49038	301.119	114.852	21.723
2.91200	0.40338	0.78226	2.32314	3.28056	-7.62739	301.256	114.897	21.723
RISER								
0.08500	0.40491	0.78311	0.10634	3.28507	-0.35041	293.979	5.270	
0.25500	0.41158	0.78677	0.10562	3.30461	-0.00079	293.630	0.012	
0.42500	0.40852	0.78509	0.10603	3.29566	-0.00000	293.629	0.000	

T =	4,6000+000	G =	1,0450+004	DP =	0.0000+000	SL =	5,5886-003	FW =	4,7785-003
FT =	2,0158+002	GR =	9,8100+000	WL =	1.0003-001	VI =	8,3070-001	VC =	4,4170-001
VR =	7,8557-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1.5000+004	CA =	2,9845+002
T =	4,7000+000	G =	1,0450+004	DP =	0.0000+000	SL =	5,5710-003	FW =	4,7785-003
FT =	1,9987+002	GR =	9,8100+000	WL =	1.0003-001	VI =	8,4613-001	VC =	4,4156-001
VR =	7,8592-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1,5000+004	CA =	2,9845+002
T =	4,8000+000	G =	1,0450+004	DP =	0.0000+000	SL =	5,5492-003	FW =	4,7785-003
FT =	1,9824+002	GR =	9,8100+000	WL =	1.0003-001	VI =	8,6090-001	VC =	4,4058-001
VR =	7,8634-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1,5000+004	CA =	2,9845+002
T =	4,9000+000	G =	1,0450+004	DP =	0.0000+000	SL =	5,5244-003	FW =	4,7785-003
FT =	1,9675+002	GR =	9,8100+000	WL =	1.0003-001	VI =	8,7429-001	VC =	4,3883-001
VR =	7,8681-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1,5000+004	CA =	2,9845+002
T =	5,0000+000	G =	1,0450+004	DP =	0.0000+000	SL =	5,4976-003	FW =	4,7785-003
FT =	1,9549+002	GR =	9,8100+000	WL =	1.0003-001	VI =	8,8572-001	VC =	4,3641-001
VR =	7,8733-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1,5000+004	CA =	2,9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,90001	0,44789	0,21855	0,00000	293,629	-0,000	
DOWNCOMER1								
0,20000	0,00000	0,00000	0,68105	0,18609	33,51387	260,115	0,000	
DOWNCOMER2								
0,20000	0,00000	0,00000	0,68105	-7,36066	33,53998	260,089	0,000	
LOWER PLENUM								
0,14000	0,00000	0,00000	0,68105	0,70000	33,56599	260,063	0,000	
CORE								
0,09707	0,00000	0,00000	0,88572	1,20000	28,94663	264,682	0,000	21,723
0,29120	0,00000	0,00000	0,88572	1,20000	19,44801	274,181	0,000	21,723
0,48533	0,00000	0,00000	0,88572	1,20000	9,58724	284,042	0,000	21,723
0,67947	0,00073	0,01057	0,88892	1,20038	-0,33481	293,964	2,313	21,723
0,87360	0,02063	0,21328	1,06776	1,35466	-5,22841	298,857	78,083	21,723
1,06773	0,05602	0,37967	1,28180	1,69010	-6,08377	299,713	111,874	21,723
1,26187	0,09480	0,47951	1,44749	1,98175	-6,10927	299,738	116,724	21,723
1,45600	0,13394	0,54821	1,58174	2,22182	-6,11681	299,746	116,274	21,723
1,65013	0,17300	0,60050	1,69697	2,42605	-6,20735	299,836	115,533	21,723
1,84427	0,21196	0,64284	1,79983	2,60503	-6,36378	299,993	115,100	21,723
2,03840	0,25078	0,67847	1,89410	2,76512	-6,56463	300,193	114,899	21,723
2,23253	0,28940	0,70925	1,98209	2,91033	-6,79698	300,426	114,829	21,723
2,42667	0,32774	0,73632	2,06533	3,04335	-7,05397	300,683	114,832	21,723
2,62080	0,36569	0,76044	2,14492	3,16610	-7,33212	300,961	114,878	21,723
2,81493	0,40319	0,78216	2,22164	3,28002	-7,62973	301,259	114,955	21,723
2,91200	0,42175	0,79225	2,25912	3,33403	-7,78571	301,415	115,003	21,723
RISER								
0,08500	0,42066	0,79167	0,10358	3,33091	-0,33775	293,967	4,995	
0,25500	0,40932	0,78553	0,10522	3,29801	-0,00070	293,629	0,010	
0,42500	0,41088	0,78639	0,10501	3,30258	-0,00000	293,629	0,000	

T =	5,1000+000	C =	1,0450+004	DP =	0,0000+000	SL =	5,4711-003	FW =	4,7785-003
FT =	1,9451+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,9448-001	VC =	4,3345-001
VR =	7,8787-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	5,2000+000	C =	1,0450+004	DP =	0,0000+000	SL =	5,4493-003	FW =	4,7785-003
FT =	1,9408+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,9836-001	VC =	4,3017-001
VR =	7,8841-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	5,3000+000	C =	1,0450+004	DP =	0,0000+000	SL =	5,4291-003	FW =	4,7785-003
FT =	1,9396+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,9952-001	VC =	4,2678-001
VR =	7,8893-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	5,4000+000	C =	1,0450+004	DP =	0,0000+000	SL =	5,4116-003	FW =	4,7785-003
FT =	1,9410+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,9819-001	VC =	4,2343-001
VR =	7,8942-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002
T =	5,5000+000	C =	1,0450+004	DP =	0,0000+000	SL =	5,3976-003	FW =	4,7785-003
FT =	1,9451+002	GR =	9,8100+000	WL =	1,0003-001	VI =	8,9454-001	VC =	4,2028-001
VR =	7,8984-001	V1 =	0,0000+000	V2 =	0,0000+000	H =	1,5000+004	CA =	2,9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.45467	0.23021	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.68784	0.19116	33.58321	260.046	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.68784	-7.28119	33.55244	260.076	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.68784	0.70000	33.54378	260.085	0.000	
CORE								
0.09707	0.00000	0.00000	0.89454	1.20000	29.03776	264.591	0.000	21.723
0.29120	0.00000	0.00000	0.89454	1.20000	20.00829	273.620	0.000	21.723
0.48533	0.00000	0.00000	0.89454	1.20000	10.83807	282.791	0.000	21.723
0.67947	0.00000	0.00003	0.89452	1.20000	1.41184	292.217	-0.005	21.723
0.87360	0.01334	0.15527	1.03069	1.28196	-4.67628	298.305	61.099	21.723
1.06773	0.04507	0.34041	1.26004	1.59399	-6.04179	299.671	107.716	21.723
1.26187	0.08203	0.45143	1.44145	1.89289	-6.12943	299.758	116.503	21.723
1.45600	0.11990	0.52594	1.58516	2.14049	-6.10725	299.736	116.607	21.723
1.65013	0.15805	0.58189	1.70535	2.35124	-6.16420	299.793	115.797	21.723
1.84427	0.19653	0.62700	1.80992	2.53664	-6.29683	299.926	115.262	21.723
2.03840	0.23541	0.66502	1.90340	2.70363	-6.48310	300.112	115.001	21.723
2.23253	0.27469	0.69800	1.98856	2.85647	-6.70846	300.337	114.902	21.723
2.42667	0.31432	0.72719	2.06728	2.99791	-6.96538	300.594	114.893	21.723
2.62080	0.35423	0.75340	2.14090	3.12987	-7.25052	300.879	114.937	21.723
2.81493	0.39434	0.77720	2.21040	3.25373	-7.56285	301.192	115.017	21.723
2.91200	0.41445	0.78832	2.24385	3.31295	-7.72924	301.358	115.067	21.723
RISER								
0.08500	0.42964	0.79642	0.10088	3.35658	-0.34095	293.970	4.993	
0.25500	0.41372	0.78793	0.10304	3.31083	-0.00064	293.629	0.010	
0.42500	0.41099	0.78645	0.10340	3.30289	-0.00000	293.629	0.000	

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.39182	0.10673	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.62499	0.13999	33.65270	259.976	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.62499	-8.08377	33.64441	259.984	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.62499	0.70000	33.63190	259.997	0.000	
CORE								
0.09707	0.00000	0.00000	0.81280	1.20000	28.69607	264.933	0.000	21.723
0.29120	0.00000	0.00000	0.81280	1.20000	18.98153	274.647	0.000	21.723
0.48533	0.00000	0.00000	0.81280	1.20000	9.48993	284.139	0.000	21.723
0.67947	0.00000	0.00000	0.81280	1.20000	0.19246	293.436	-0.000	21.723
0.87360	0.01534	0.17261	0.98215	1.30131	-5.11781	298.747	69.912	21.723
1.06773	0.04755	0.34996	1.22591	1.61639	-6.14593	299.775	110.499	21.723
1.26187	0.08346	0.45476	1.41939	1.90315	-6.15832	299.787	117.150	21.723
1.45600	0.11934	0.52500	1.57609	2.13714	-6.11598	299.745	116.788	21.723
1.65013	0.15475	0.57757	1.70993	2.33419	-6.15552	299.784	115.850	21.723
1.84427	0.18983	0.61976	1.82853	2.50593	-6.26499	299.894	115.250	21.723
2.03840	0.22473	0.65517	1.93606	2.65946	-6.42176	300.051	114.945	21.723
2.23253	0.25957	0.68584	2.03498	2.79928	-6.61150	300.240	114.815	21.723
2.42667	0.29444	0.71299	2.12683	2.92841	-6.82684	300.456	114.783	21.723
2.62080	0.32943	0.73744	2.21268	3.04901	-7.06452	300.693	114.811	21.723
2.81493	0.36460	0.75977	2.29324	3.16266	-7.32368	300.952	114.875	21.723
2.91200	0.38227	0.77027	2.33172	3.21728	-7.46146	301.090	114.918	21.723
RISER								
0.08500	0.40933	0.78554	0.10342	3.29806	-0.36252	293.991	5.426	
0.25500	0.42103	0.79187	0.10209	3.33198	-0.00073	293.630	0.011	
0.42500	0.41515	0.78870	0.10284	3.31498	-0.00000	293.629	0.000	

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.42235	0.17130	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	1.00000	0.65552	0.16607	33.64712	259.982	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.65552	-7.67470	33.61043	260.018	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.65552	0.70000	33.58767	260.041	0.000	
CORE								
0,09707	0,00000	0.00000	0,85250	1,20000	28,89505	264,734	0,000	21,723
0,29120	0,00000	0,00000	0,85250	1,20000	19,65907	273,970	0,000	21,723
0,48533	0,00000	0,00000	0,85250	1,20000	10,55087	283,078	0,000	21,723
0,67947	0,00000	0,00000	0,85250	1,20000	1,46165	292,167	-0,000	21,723
0,87360	0,01188	0,14185	0,98635	1,26841	-4,63267	298,261	58,300	21,723
1,06773	0,04225	0,32904	1,22775	1,56812	-6,06446	299,693	106,957	21,723
1,26187	0,07790	0,44152	1,42281	1,86281	-6,15324	299,782	116,623	21,723
1,45600	0,11414	0,51613	1,57848	2,10573	-6,11223	299,741	116,830	21,723
1,65013	0,15030	0,57161	1,70940	2,31090	-6,14573	299,775	115,945	21,723
1,84427	0,18646	0,61603	1,82382	2,49027	-6,25394	299,883	115,327	21,723
2,03840	0,22277	0,65333	1,92628	2,65125	-6,41497	300,044	115,010	21,723
2,23253	0,25937	0,68568	2,01944	2,79852	-6,61392	300,243	114,877	21,723
2,42667	0,29635	0,71439	2,10496	2,93519	-6,84317	300,472	114,849	21,723
2,62080	0,33379	0,74033	2,18397	3,06349	-7,09972	300,729	114,884	21,723
2,81493	0,37176	0,76409	2,25726	3,18504	-7,38330	301,012	114,958	21,723
2,91200	0,39099	0,77530	2,29196	3,24369	-7,53560	301,164	115,007	21,723
RISER								
0,08500	0,42227	0,79253	0,10110	3,33554	-0,35634	293,985	5,261	
0,25500	0,41965	0,79112	0,10159	3,32798	-0,00067	293,629	0,010	
0,42500	0,41232	0,78717	0,10253	3,30676	-0,00000	293,629	0,000	

T = 6.1000+000 C = 1.0450+004 DP = 0.0000+000 SL = 5.4075-003 FW = 4.7785-003
FT = 2.0026+002 CR = 9.8100+000 WL = 1.0002-001 VI = 8.4265-001 VC = 4.1175-001
VR = 7.9051-001 V1 = 0.0000+000 V2 = 0.0000+000 H = 1.5000+004 CA = 2.9845+002

T = 6.2000+000 C = 1.0450+004 DP = 0.0000+000 SL = 5.4217-003 FW = 4.7785-003
FT = 2.0129+002 CR = 9.8100+000 WL = 1.0002-001 VI = 8.3337-001 VC = 4.1240-001
VR = 7.9032-001 V1 = 0.0000+000 V2 = 0.0000+000 H = 1.5000+004 CA = 2.9845+002

T = 6.3000+000 C = 1.0450+004 DP = 0.0000+000 SL = 5.4376-003 FW = 4.7785-003
FT = 2.0221+002 CR = 9.8100+000 WL = 1.0002-001 VI = 8.2507-001 VC = 4.1354-001
VR = 7.9007-001 V1 = 0.0000+000 V2 = 0.0000+000 H = 1.5000+004 CA = 2.9845+002

T = 6.4000+000 C = 1.0450+004 DP = 0.0000+000 SL = 5.4542-003 FW = 4.7785-003
FT = 2.0296+002 CR = 9.8100+000 WL = 1.0002-001 VI = 8.1811-001 VC = 4.1509-001
VR = 7.8979-001 V1 = 0.0000+000 V2 = 0.0000+000 H = 1.5000+004 CA = 2.9845+002

T = 6.5000+000 C = 1.0450+004 DP = 0.0000+000 SL = 5.4707-003 FW = 4.7785-003
FT = 2.0357+002 CR = 9.8100+000 WL = 1.0002-001 VI = 8.1280-001 VC = 4.1695-001
VR = 7.8946-001 V1 = 0.0000+000 V2 = 0.0000+000 H = 1.5000+004 CA = 2.9845+002

T =	5.6000+000	C =	1.0450+004	DP =	0.0000+000	SL =	5.3878-003	FW =	4.7785-003
FT =	1.9515+002	GR =	9.8100+000	WL =	1.0003-001	VI =	8.8875-001	VC =	4.1747-001
VR =	7.9019-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002
T =	5.7000+000	C =	1.0450+004	DP =	0.0000+000	SL =	5.3828-003	FW =	4.7785-003
FT =	1.9599+002	GR =	9.8100+000	WL =	1.0003-001	VI =	8.8117-001	VC =	4.1512-001
VR =	7.9045-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002
T =	5.8000+000	C =	1.0450+004	DP =	0.0000+000	SL =	5.3827-003	FW =	4.7785-003
FT =	1.9698+002	GR =	9.8100+000	WL =	1.0002-001	VI =	8.7225-001	VC =	4.1334-001
VR =	7.9061-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002
T =	5.9000+000	C =	1.0450+004	DP =	0.0000+000	SL =	5.3872-003	FW =	4.7785-003
FT =	1.9806+002	GR =	9.8100+000	WL =	1.0002-001	VI =	8.6252-001	VC =	4.1219-001
VR =	7.9067-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002
T =	6.0000+000	C =	1.0450+004	DP =	0.0000+000	SL =	5.3957-003	FW =	4.7785-003
FT =	1.9917+002	GR =	9.8100+000	WL =	1.0002-001	VI =	8.5250-001	VC =	4.1166-001
VR =	7.9063-001	V1 =	0.0000+000	V2 =	0.0000+000	H =	1.5000+004	CA =	2.9845+002

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0,00000	0,00000	0,90001	0,41149	0,14944	0,00000	293,629	-0,000	
DOWNCOMER1								
0,20000	0,00000	0,00000	0,64466	0,15708	33,56357	260,065	0,000	
DOWNCOMER2								
0,20000	0,00000	0,00000	0,64466	-7,81574	33,59361	260,035	0,000	
LOWER PLENUM								
0,14000	0,00000	0,00000	0,64466	0,70000	33,61093	260,018	0,000	
CORE								
0,09707	0,00000	0,00000	0,83838	1,20000	28,74813	264,881	0,000	21,723
0,29120	0,00000	0,00000	0,83838	1,20000	18,89186	274,737	0,000	21,723
0,48533	0,00000	0,00000	0,83838	1,20000	8,93335	284,695	0,000	21,723
0,67947	0,00096	0,01376	0,84801	1,20064	-0,76977	294,399	5,441	21,723
0,87360	0,02121	0,21733	1,04139	1,36058	-5,38617	299,015	81,072	21,723
1,06773	0,05630	0,38061	1,26470	1,69255	-6,13144	299,760	112,821	21,723
1,26187	0,09415	0,47816	1,43875	1,97735	-6,12586	299,755	117,023	21,723
1,45600	0,13189	0,54510	1,58105	2,21026	-6,11821	299,747	116,391	21,723
1,65013	0,16921	0,59593	1,70405	2,40744	-6,19436	299,823	115,575	21,723
1,84427	0,20615	0,63700	1,81437	2,57962	-6,33461	299,963	115,100	21,723
2,03840	0,24276	0,67155	1,91568	2,73332	-6,51713	300,146	114,874	21,723
2,23253	0,27907	0,70140	2,01016	2,87269	-6,72907	300,358	114,788	21,723
2,42667	0,31510	0,72772	2,09922	3,00058	-6,96383	300,593	114,780	21,723
2,62080	0,35085	0,75128	2,18380	3,11906	-7,21836	300,847	114,820	21,723
2,81493	0,38635	0,77263	2,26456	3,22967	-7,49155	301,120	114,892	21,723
2,91200	0,40401	0,78261	2,30366	3,28242	-7,63516	301,264	114,937	21,723
RISER								
0,08500	0,41114	0,78653	0,10469	3,30334	-0,34909	293,978	5,215	
0,25500	0,41297	0,78752	0,10462	3,30866	-0,00075	293,630	0,011	
0,42500	0,41746	0,78995	0,10403	3,32167	-0,00000	293,629	0,000	

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90001	0.38699	0.09559	0.00000	293.629	-0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.62016	0.13563	33.61446	260.014	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.62016	-8.15215	33.63417	259.995	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.62016	0.70000	33.63954	259.989	0.000	
CORE								
0.09707	0.00000	0.00000	0.80652	1.20000	28.62237	265.006	0.000	21.723
0.29120	0.00000	0.00000	0.80652	1.20000	18.61686	275.012	0.000	21.723
0.48533	0.00000	0.00000	0.80652	1.20000	8.72647	284.902	0.000	21.723
0.67947	0.00075	0.01082	0.81693	1.20040	-0.79997	294.429	5.537	21.723
0.87360	0.02001	0.20886	1.01438	1.34832	-5.43749	299.066	80.497	21.723
1.06773	0.05429	0.37393	1.24835	1.67540	-6.17086	299.800	113.030	21.723
1.26187	0.09116	0.47186	1.43143	1.95703	-6.14489	299.774	117.288	21.723
1.45600	0.12776	0.53868	1.58108	2.18661	-6.11867	299.747	116.568	21.723
1.65013	0.16383	0.58926	1.71015	2.38059	-6.17864	299.807	115.670	21.723
1.84427	0.19947	0.63011	1.82555	2.54991	-6.30435	299.933	115.143	21.723
2.03840	0.23480	0.66446	1.93113	2.70114	-6.47316	300.102	114.885	21.723
2.23253	0.26986	0.69418	2.02925	2.83842	-6.67160	300.300	114.779	21.723
2.42667	0.30469	0.72041	2.12139	2.96457	-6.89267	300.521	114.760	21.723
2.62080	0.33930	0.74392	2.20857	3.08162	-7.13311	300.762	114.791	21.723
2.81493	0.37375	0.76526	2.29148	3.19114	-7.39174	301.021	114.856	21.723
2.91200	0.39092	0.77525	2.33149	3.24346	-7.52789	301.157	114.898	21.723
RISER								
0.08500	0.40538	0.78337	0.10505	3.28645	-0.35731	293.986	5.371	
0.25500	0.41718	0.78980	0.10368	3.32088	-0.00077	293.630	0.011	
0.42500	0.41743	0.78993	0.10365	3.32158	-0.00000	293.629	0.000	

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T  =  7.1000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5451-003    FW =  4.7785-003
FT =  2.0382+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.1056-001    VC =  4.2953-001
VR =  7.8797-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002


T  =  7.2000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5469-003    FW =  4.7785-003
FT =  2.0320+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.1608-001    VC =  4.3102-001
VR =  7.8786-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002


T  =  7.3000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5455-003    FW =  4.7785-003
FT =  2.0246+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.2278-001    VC =  4.3214-001
VR =  7.8780-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002


T  =  7.4000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5409-003    FW =  4.7785-003
FT =  2.0162+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.3035-001    VC =  4.3286-001
VR =  7.8780-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002


T  =  7.5000+000    G  =  1.0450+004    DP =  0.0000+000    SL =  5.5335-003    FW =  4.7785-003
FT =  2.0073+002    GR =  9.8100+000    WL =  1.0002-001    VI =  8.3838-001    VC =  4.3313-001
VR =  7.8785-001    V1 =  0.0000+000    V2 =  0.0000+000    H  =  1.5000+004    CA =  2.9845+002
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T  =  6,6000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,4874-003    FW =  4,7785-003
FT =  2,0402+002    GR =  9,8100+000    WL =  1,0002-001    VI =  8,0874-001    VC =  4,1902-001
VR =  7,8917-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  6,7000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,5044-003    FW =  4,7785-003
FT =  2,0440+002    GR =  9,8100+000    WL =  1,0002-001    VI =  8,0532-001    VC =  4,2123-001
VR =  7,8886-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  6,8000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,5192-003    FW =  4,7785-003
FT =  2,0457+002    GR =  9,8100+000    WL =  1,0002-001    VI =  8,0380-001    VC =  4,2348-001
VR =  7,8858-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  6,9000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,5311-003    FW =  4,7785-003
FT =  2,0452+002    GR =  9,8100+000    WL =  1,0002-001    VI =  8,0421-001    VC =  4,2568-001
VR =  7,8833-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002

T  =  7,0000+000    C  =  1,0450+004    DP =  0,0000+000    SL =  5,5398-003    FW =  4,7785-003
FT =  2,0426+002    GR =  9,8100+000    WL =  1,0002-001    VI =  8,0652-001    VC =  4,2773-001
VR =  7,8812-001    V1 =  0,0000+000    V2 =  0,0000+000    H  =  1,5000+004    CA =  2,9845+002
```

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T  = 7.6000+000   G  = 1.0450+004   DP = 0.0000+000   SL = 5.5235-003   FW = 4.7785-003
FT = 1.9984+002   GR = 9.8100+000   WL = 1.0002-001   VI = 8.4645-001   VC = 4.3295-001
VR = 7.8794-001   V1 = 0.0000+000   V2 = 0.0000+000   H  = 1.5000+004   CA = 2.9845+002

T  = 7.7000+000   G  = 1.0450+004   DP = 0.0000+000   SL = 5.5115-003   FW = 4.7785-003
FT = 1.9899+002   GR = 9.8100+000   WL = 1.0002-001   VI = 8.5413-001   VC = 4.3234-001
VR = 7.8809-001   V1 = 0.0000+000   V2 = 0.0000+000   H  = 1.5000+004   CA = 2.9845+002

T  = 7.8000+000   G  = 1.0450+004   DP = 0.0000+000   SL = 5.4981-003   FW = 4.7785-003
FT = 1.9822+002   GR = 9.8100+000   WL = 1.0002-001   VI = 8.6104-001   VC = 4.3132-001
VR = 7.8827-001   V1 = 0.0000+000   V2 = 0.0000+000   H  = 1.5000+004   CA = 2.9845+002

T  = 7.9000+000   G  = 1.0450+004   DP = 0.0000+000   SL = 5.4840-003   FW = 4.7785-003
FT = 1.9757+002   GR = 9.8100+000   WL = 1.0002-001   VI = 8.6689-001   VC = 4.2997-001
VR = 7.8848-001   V1 = 0.0000+000   V2 = 0.0000+000   H  = 1.5000+004   CA = 2.9845+002

T  = 8.0000+000   G  = 1.0450+004   DP = 0.0000+000   SL = 5.4710-003   FW = 4.7785-003
FT = 1.9713+002   GR = 9.8100+000   WL = 1.0002-001   VI = 8.7084-001   VC = 4.2835-001
VR = 7.8871-001   V1 = 0.0000+000   V2 = 0.0000+000   H  = 1.5000+004   CA = 2.9845+002
```
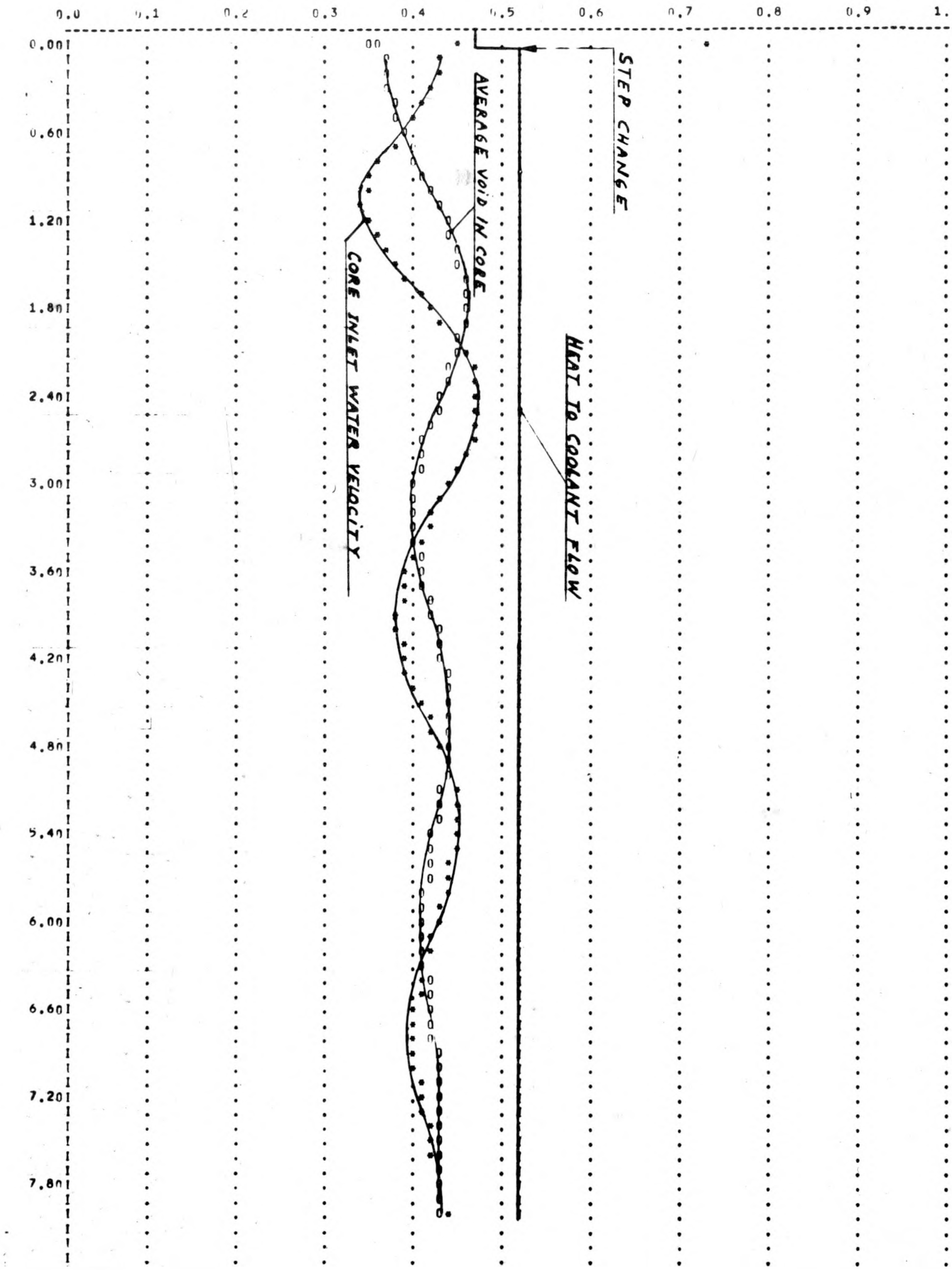

POSITION (M)	QUALITY	VOID FRACTION	WAT. VEL. (M/SEC)	SLIP RATIO	SUBCOOLING (DEGR. C)	WAT. TEMP (DEGR. C)	EVAP. RATE (KG/SECMMM)	HEAT FL./E+4 (WATT/MM)
UPPER PLENUM								
0.00000	0.00000	0.90002	0.43645	0.19808	0.00000	293.629	0.000	
DOWNCOMER1								
0.20000	0.00000	0.00000	0.66962	0.17731	33.55930	260.069	0.000	
DOWNCOMER2								
0.20000	0.00000	0.00000	0.66962	-7.49834	33.56477	260.064	0.000	
LOWER PLENUM								
0.14000	0.00000	0.00000	0.66962	0.70000	33.57467	260.054	0.000	
CORE								
0.09707	0.00000	0.00000	0.87084	1.20000	28.91234	264.716	0.000	21.723
0.29120	0.00000	0.00000	0.87084	1.20000	19.46930	274.159	0.000	21.723
0.48533	0.00000	0.00000	0.87084	1.20000	9.84470	283.784	0.000	21.723
0.67947	0.00012	0.00168	0.87051	1.20001	0.09553	293.533	-0.017	21.723
0.87360	0.01765	0.19123	1.04051	1.32434	-5.13455	298.763	73.243	21.723
1.06773	0.05169	0.36499	1.26549	1.65295	-6.10084	299.730	111.022	21.723
1.26187	0.08947	0.46823	1.44057	1.94542	-6.12528	299.754	116.846	21.723
1.45600	0.12759	0.53842	1.58172	2.18563	-6.11280	299.742	116.462	21.723
1.65013	0.16559	0.59147	1.70215	2.38943	-6.18426	299.813	115.650	21.723
1.84427	0.20350	0.63429	1.80898	2.56789	-6.32476	299.954	115.159	21.723
2.03840	0.24136	0.67032	1.90616	2.72772	-6.51207	300.141	114.924	21.723
2.23253	0.27919	0.70149	1.99610	2.87312	-6.73264	300.361	114.836	21.723
2.42667	0.31695	0.72900	2.08037	3.00692	-6.97947	300.608	114.830	21.723
2.62080	0.35461	0.75364	2.16008	3.13109	-7.24926	300.878	114.873	21.723
2.81493	0.39213	0.77594	2.23604	3.24710	-7.54074	301.170	114.948	21.723
2.91200	0.41082	0.78635	2.27282	3.30240	-7.69457	301.323	114.995	21.723
RISER								
0.08500	0.41953	0.79106	0.10303	3.32766	-0.34399	293.973	5.093	
0.25500	0.41244	0.78723	0.10411	3.30710	-0.00070	293.629	0.010	
0.42500	0.41584	0.78908	0.10367	3.31699	-0.00000	293.629	0.000	



***	CORE INLET WATER VELOCITY	ONE INCH EQUALS [illegible]	0.0 CORRESP. TO 0.000+000
000	AVERAGE VOID IN CORE	ONE INCH EQUALS [illegible]	0.0 CORRESP. TO 0.000+000
III	HEAT TO COOLANT FLOW	ONE INCH EQUALS [illegible]	0.0 CORRESP. TO 0.000+000

TRANSFER FUNCTION(S)
****

LAMBDA = 2.35447-001   OMEGA0 = 2.18570+000

TRANSFER FUNCTION(S)

LAMBDA = 2.35447-001

OMEGAO = 2.18570+000

AVERAGE VOID IN CORE

HEAT TO COOLANT FLOW

FREQUENCY (RAD/SEC)	GAIN (DB)	PHASE (DEGR.)
0.00000+000	4.2658	0.000
1.00000-001	4.2950	-1.308
1.25000-001	4.3113	-1.644
1.60000-001	4.3398	-2.125
2.00000-001	4.3804	-2.692
2.50000-001	4.4424	-3.432
3.20000-001	4.5484	-4.535
4.00000-001	4.6937	-5.904
5.00000-001	4.9053	-7.784
6.30000-001	5.2203	-10.492
8.00000-001	5.6874	-14.407
1.00000+000	6.3211	-19.361
1.25000+000	7.3340	-25.847
1.60000+000	9.6660	-37.123
2.00000+000	14.5600	-70.609
2.50000+000	9.3395	-165.692
3.20000+000	-5.2315	-174.434
4.00000+000	-15.0869	-81.601
5.00000+000	-7.3478	-77.245
6.30000+000	-4.3832	-66.722
8.00000+000	-3.3593	-64.389
1.00000+001	-2.9445	-56.774
2.80000+000	2.4492	-179.105
2.90000+000	0.4160	-179.838
3.00000+000	-1.5288	-179.319

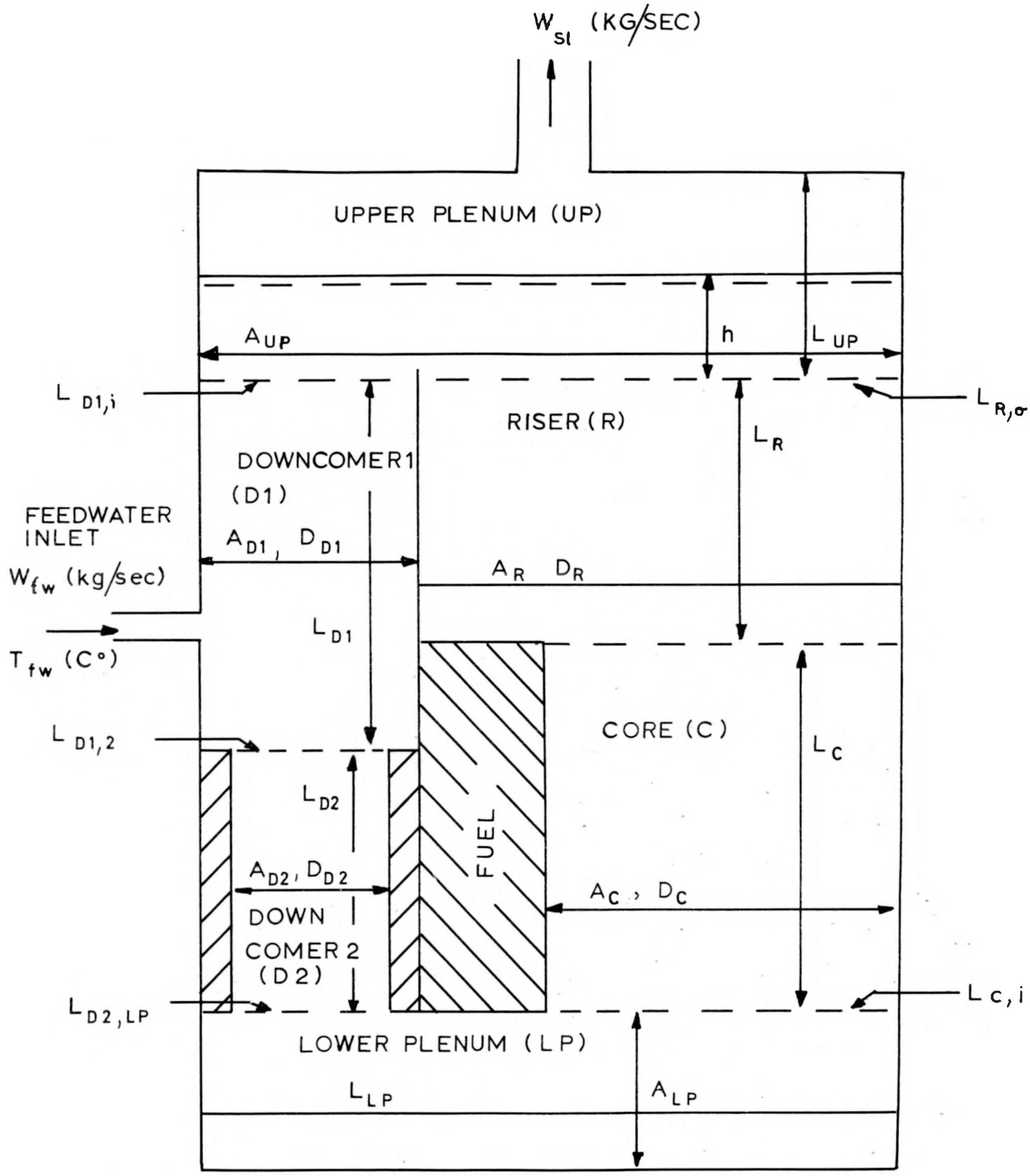


FIGURE 1

SKETCH OF GEOMETRY USED

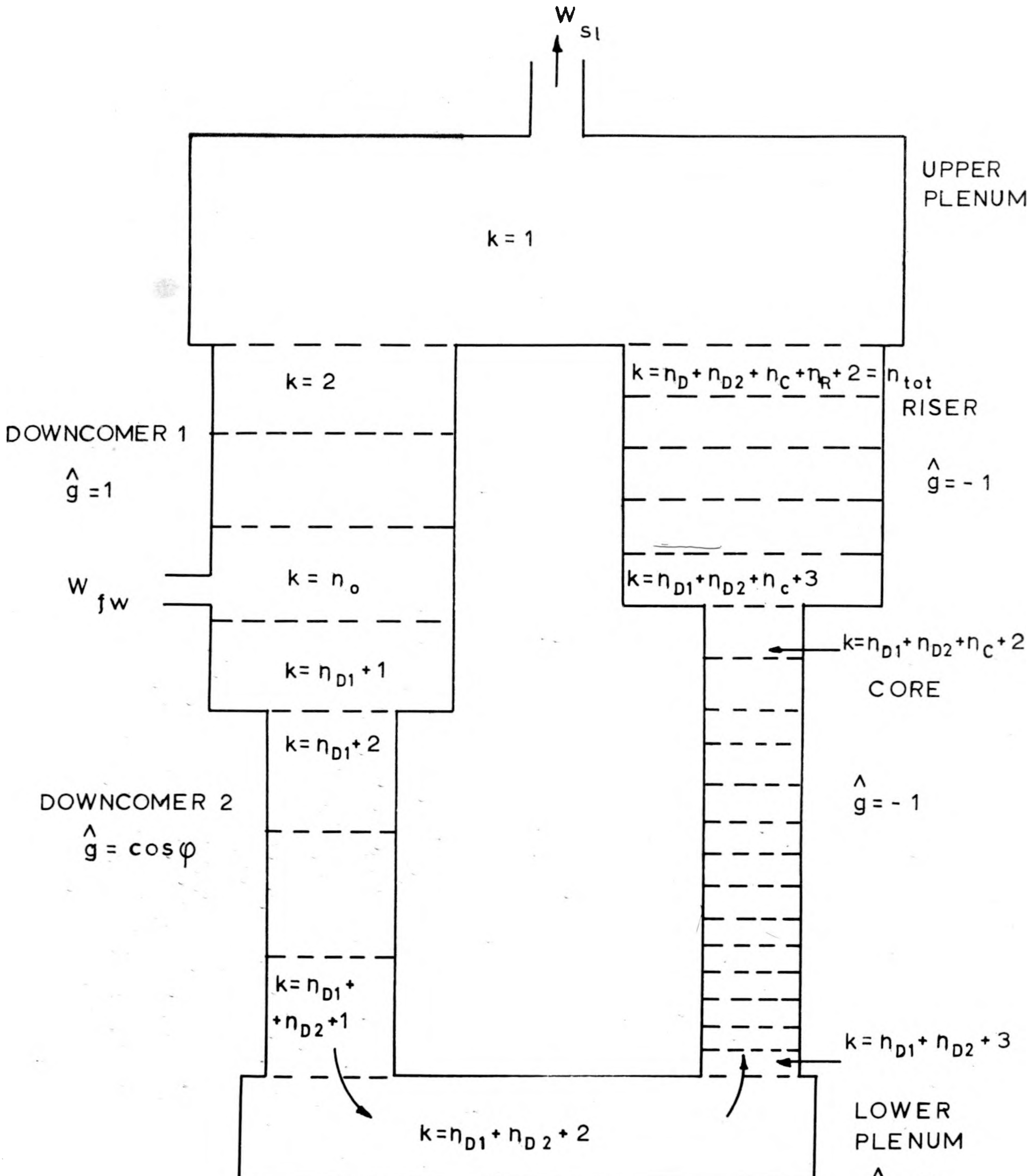


FIGURE 2

DIVISION OF THE HYDRAULIC LOOP INTO SUBSECTIONS.

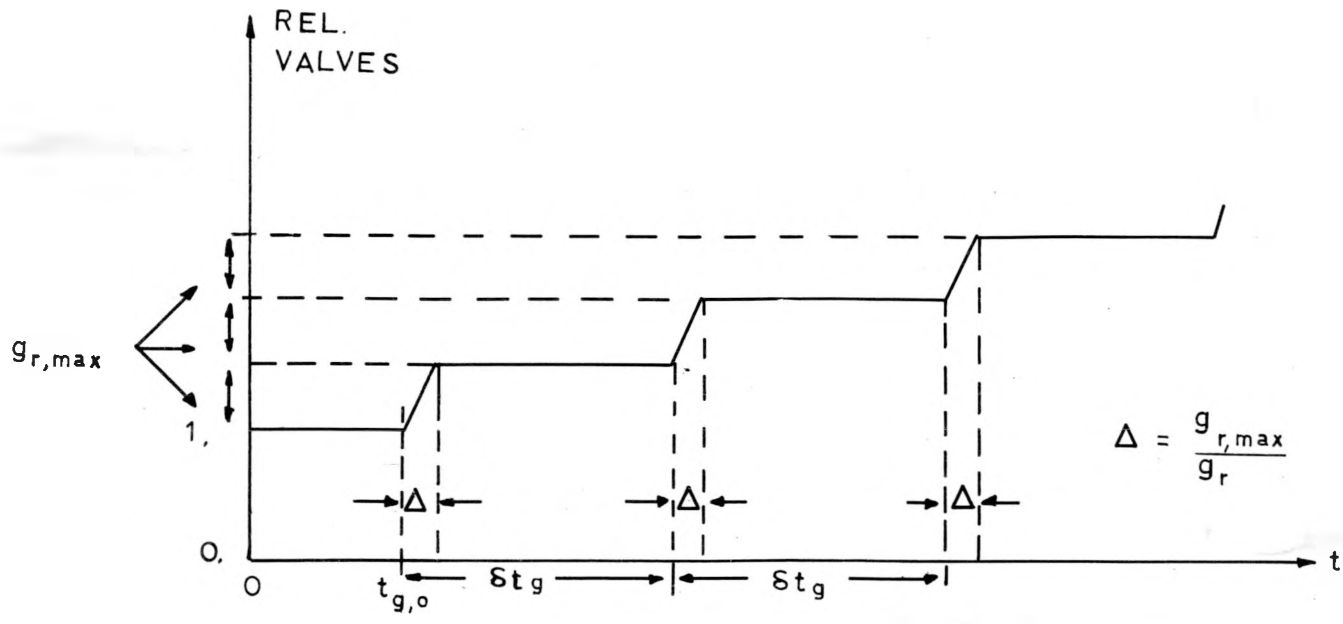
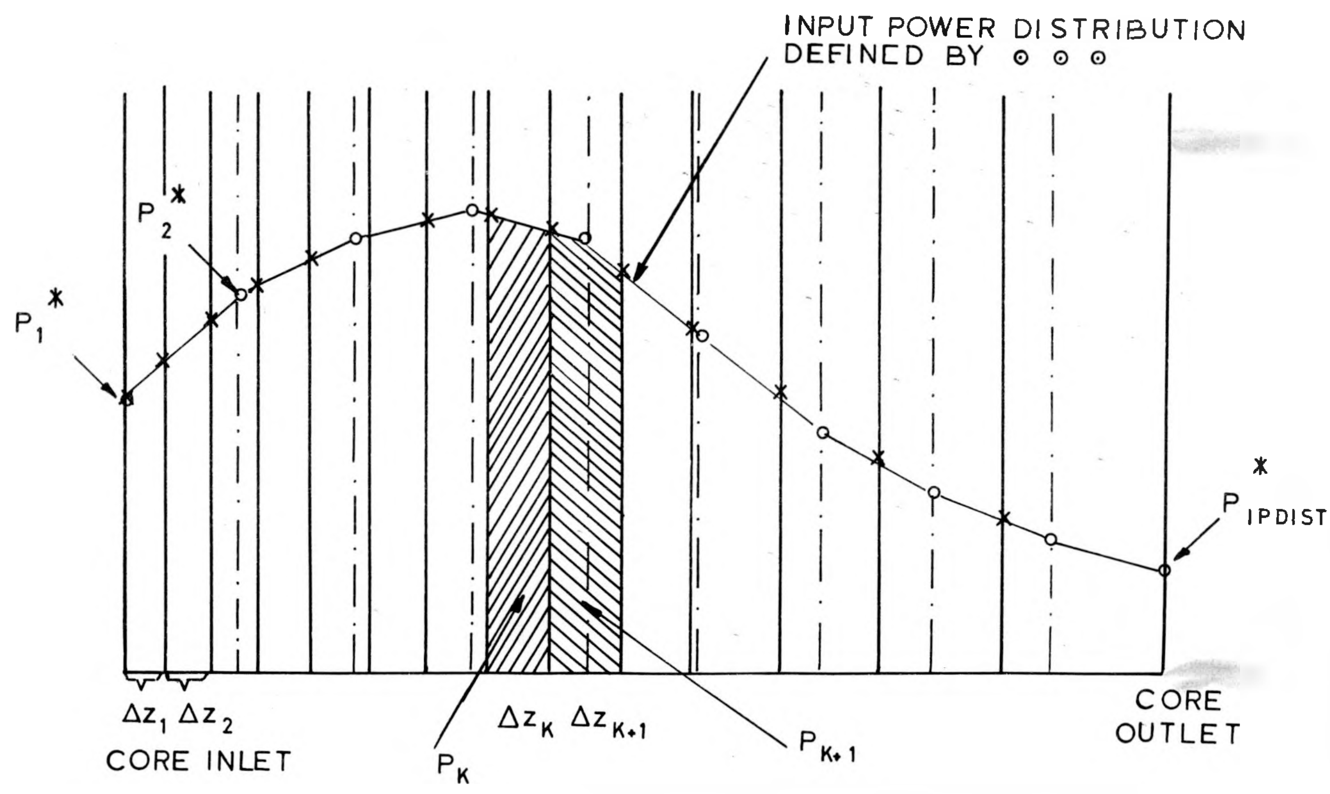


FIGURE 3

DISTURBANCE AS A SEQUENCE OF RAMPS, EXAMPLE "GRAVITY" DISTURBANCE ".



P_K EQUAL AREA UNDER THE CURVE

$\sum P_K = 1$, NORMALIZATION

FIGURE 4

THE CALCULATION OF THE (NORMALIZED) POWER DISTRIBUTION.