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User's Mannual for THYDE-P1

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THYDE-P1 is a computer code applicable to LWR (light water reactor) plant dynamics in response to various disturbances. This work is the user's mannual of THYDE-P1 (version SV02L03). The input requirements, steady state adjustment, execution of runs and output specifications are described.

Keywords: LWR, THYDE-P1 Code, User's Mannual, Plant Dynamics, LOCA

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THYDE－P1 コードの使用手引書

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朝　日　義　郎

（1982年3月29日受理）

THYDE－P1は色々の外乱に対する軽水炉プラントの動特性に適用可能な計算コードである。この報告書はTHYDE－P1（SVO2LO3）の使用手引書である。インプット規約，定常設定，ジョブの実行，出力仕様について述べてある。

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1. Introduction

The purpose of this document is to provide the user's mannual of the computer code THYDE-P1[1] (version SV02L03). The THYDE-P1 code is applicable to analyses of LWR (light water coold reactor) plant behaviors in response to various disturbances, including the thermal hydraulic transient following a break of a primary coolant system pipe, generally referred to as a loss-of-coolant accident (LOCA). LOCA can be considered to be the most critical for testing the methods and models for plant dynamics, since thermal hydraulic conditions in the system drastically change during the transient. Therefore, THYDE-P1 has intensively been applied to LOCA analyses[2],[3],[4],[5],[6] to verify its methods and models. As a result it has been shown that THYDE-P1 is capable of through calculation of LOCA from its initiation to complete reflooding of the core by subcooled water.

THYDE-P1 has several characteristics which will briefly be described in the following. Readers can refer to the details of THYDE-P1 in Ref.(1) and the improvements in Refs.(2) to (6) that have been made since publication of Ref.(1).

(1) Complete Steady State Adjustment

First of all, THYDE-P1 carries out steady state adjustment, which is complete in the sense that the steady state obtained is a set of exact solutions of all the transient equations without time derivatives, not only for plant hydraulics, but also for all the other phenomena in THYDE-P1 simulation of a PWR plant.

(2) New Hydraulic Network Theory

A new representation of a control volume has made it possible to develop a new hydraulic network theory, which well matches our physical intuitions. The theory reduces the flow equations by three steps, each of which corresponds with topological features of the hydraulic network. The new theory does not depend on specific forms for the conservation equations, but is quite general.

(3) Non-linear Implicit Method

To solve the flow equations "exactly", an iterative method is applied based on the new network theory. Applicability of linear implicit method is questionable especially during refill and reflooding phases, since non-linearity of the flow equations predominates at low pressure.

(4) Independent Models for Pressurizer, Accumulator and SG Secondary System

THYDE-P has special provisions for modelling of pressurizer, accumulator, and SG secondary system. They are not regarded as part of flows, but as reservoirs with flows coming in or going out. In other words, in THYDE-P, they are not regarded as part of the network, but as its exterior. They will be coupled to the hydraulic network with appropriate boundary conditions.

(5) Non-Equilibrium Models

Non-linear implicit method requires continuity of the various coefficients involved in the flow equations. Physically this requirement is equivalent to taking into consideration non-equilibrium effects arising from various mode transitions. In THYDE-P1, all the non-equilibrium effects are accounted for by means of relaxiation equations.

(6) Automatic Time Step Width Control

THYDE-P1 determines the time step width automatically as the calculation proceeds. Non-linear implicit method, non-equilibrium models and steady state adjustment are all combined to materialize the automatic time step width control of THYDE-P1.

(7) Heat Transfer Correlations Package Applicable to Both Blowdown and Reflood

THYDE-P has a conventional heat transfer correlations package which is applicable to both blowdown and reflood. Therefore, those correlations whose theoretical background is not clear, for example, FLECHT correlations need not be used.

(8) Flow Model

(1) The drift flux model is adopted.
(2) The momentum flux is not neglected, but is exactly accounted for.
(3) Mass strictly conserves. This was made possible by the space-differencing scheme and the non-linear implicit method.
(4) Non-equilibrium models are incorporated.

This document is divided into serveral sections. Section 2 describes the inputs and noding requirements. Section 3 explains how to obtain an initial steady state of the primary loop as well as the secondary system of a steam generator. Section 4 describes the data flow in a series of THYDE-P1 jobs and shows an example of job control cards. Section 5 explains output listing as well as the plotter.

2. THYDE-P1 Inputs Requirements

In the following, requirements for noding, data deck organization, input data cards and problem restart are presented.

2.1 Noding

When we intend to use THYDE-P1, first of all we have to reticulate the plant by means of nodes and junctions according to the THYDE-P1 network theory(1). It is required that the network has at least one mixing junction except for the core heatup calculation mode and that a normal node without heat source (or sink) must be placed at both the top and bottom ends of the core. After so reticulating the plant, we have to number the nodes and junctions separately, strictly in numeric order in accordance with the following rules:

(a) Normal nodes (except linkage nodes) should be numbered in numeric order chain-wise from one mixing junction to another according to the direction of the steady state chain flow.

(b) Then linkage nodes should be numbered in numeric order chainwise from the corresponding mixing junction.

(c) Special nodes should be numbered after all the normal and linkage nodes.

(d) Among junctions, normal and guilotine break junctions should be numbered first. Then the mixing junctions should be numbered according to the direction of the steady state flow. After them, the injection junctions and finally the dead end junctions should be numbered.

(e) In the present version of THYDE-P1, it is required that either of the hot leg nodes adjacent to the upper plenum mixing junction must be numbered as one and that the upper plenum should be numbered first among the mixing junctions.

2.2 Data Deack Organization

A THYDE-P1 data deck, ending with the terminator card, could contain more than one problem each of which consists of a title card, data cards and the sub-terminator card. The terminator is a card whose first 4 columns are punched as BEND, while the subterminator is the identification card for dummy data block 99. A listing of the data cards is printed at the beginning and end of each THYDE-P1 problem.

A block identification card is placed for the top of each data block and is punched in the first 4 columns as BBXX, where XX indicates the data block number. If the block XX has more than one sub-block, a sub-block identification card must be placed at the top of each data sub-block and will be punched in the first 6 columns as SBXXYY where YY indicates the sub-block number starting with 01.

Since THYDE-P1 is still in a process of development, it contains a number of methods and models yet to be theoretically or empirically established. In the present version of THYDE-P1, the data related to these methods and models are collected at the end of the input data set without a block identification card.

2.3 Data Card Summary

In the following description of the data cards, the data block number is given along with a descriptive title of the data block and the number of the sub-blocks. Then, the order of the data (1,2,......), the format (I,R or A), the variable name and the input data description are given where applicable. The format of the field, integer, real or floating, or alphanumeric is indicated by I, R, or A, respectively. Table data for an independent variable should be given as follows. First, the number of points must be given. Then as many sets of the independent and dependent variables as the point number must be inputted.

Reading input cards is performed soley by the free-format input routime REAG[(2)], except for problem control data to be placed after the BEND card, which are inputted by list-directed READ.

2.3.1 Problem Title (No block numbers)

The problem title must be punched in columns 1 to 72 on an IMB card.

2.3.2 Problem Dimensions Data BB01

Number of subblocks = 1

1-I NMODEL	Calculation mode 1 = standard mode 2 = core heat up mode 3 = loop hydraulics At present, the standard mode only is available.
2-I LDMP	Restart file control 0 = no restart file used N = restart at restart number N using the file on FORTRAN Unit 3.
3-I NEDI	Number of minor edit variables desired $(0 \le NEDI \le 9)$
4-I NTC	Number of time step width controls $(1 \le NTC \le 20)$
5-I NTRP	Number of trip controls $(1 \le NTC \le 20)$
6-I NVOL	Number of normal and special nods $(1 \le NVOL < 100)$
7-I NJUNC	Number of junctions including break and injection junctions $(1 \le NJUNC \le 100)$
8-I NMIX	Number of mixing junctions $(1 \le NMIX \le 20)$
9-I NPINJ	Number of pumped injections $(1 \le NPINJ \le 10)$
10-I NPUMP	Number of pumps $(1 \le NPUMP \le 4)$
11-I NACCUM	Number of accumulators $(1 \le NACCUM \le 4)$
12-I NSG	Number of steam generators $(1 \le NSG \le 4)$
13-I NSGT	Maximum number of SG primary nodes per unit $(1 \le NSG \le 10)$
14-I NCORE	Number of axial fuel nodes $(3 \le NCORE \le 50)$

15-I NR	Number of radial fuel nodes $(0 < NR \leq 50)$
16-I NF	Number of radial pellet nodes. $(0 < NF \leq 50)$
17-I NTYPE	Core heater type, 0 = nuclear heating 1 = electric heating
18-I ICHNL	Core configuration 1 = one channel 2 = two channel For the two channel option, noding for the two channel is assumed identical.

2.3.3 Minor Edit Variable Data BB02

Data block BB02 is required if NED1 is greater than zero. This data block specifies the variables to be edited in the minor edits. NED1 specifications must be inputted. Each specification consists of an alphanumeric entry and an integer entry as shown below, in which

AAA ∿ BBB ; are variable symbols to be edited, and

XX ∿ YY ; (1) is set equal to the number if the variable refers to a node except core nodes, and

(2) is the primary node number for HT1 and HT2.

1 - A4	AAA XX
NEDI - A4	BBB YY

(b) Symbols of available minor edit variables

Symbol	Variable (with reference to normal node)
PRA	Pressure as point A
PRE	Pressure as point E
GLA	Mass velocity at point A
GLE	Mass velocity at point E
HLA	Specific enthalpy at point A
HLE	Specific enthalpy at point E
RHA	Density at point A
RHE	Density at point E
XLA	Quality at point A
XLE	Quality at point E
ALA	Void fraction at point A
ALE	Void fraction at point E
QQQ	Power density
TMP	Temperature

Symbol	Variable (with reference to injection)
JMI	Injection flow rate

Symbol	Variable (with reference to pump)
HDP	Pump head
AAA	Relative pump speed
BBB	Relative pump torque
WWW	Relative volumetric flow rate
PEY	Pump eye pressure
XEY	Pump eye quality
HEY	Pump eye specific enthalpy

Symbol	Variable (with reference to accumulator)
PAC	Nitrogen pressure
GAJ	Mass flow rate
HAC	Water specific enthalpy
VAG	Nitrogen volume
VAL	Water volume
XAC	Phase index

Symbol	Variable (with reference to SG secondary system)
PSG	Pressure
MUG	Feed water flow
MRG	Relief flow
MSG	Spray line flow
IVG	Phase index
HS1	Specific enthalpy of region I
HS2	Specific enthalpy of region II
MG1	Mass of region I
MG2	Mass of region II
HT1	Heat transfer coefficient of primary side
HT2	Heat transfer coefficient of secondary side

Symbol	Variable (with reference to pressurizer)
PPP	Pressure
GPR	Surge flow rate
MRP	Relief flow rate
MSP	Spray line flow
ISV	Phase index
HP1	Specific enthalpy of region I
HP2	Specific enthalpy of region II
MS1	Mass of region I
MS2	Mass of region II

Symbol	Variable (with reference to fuel)
QCR	Relative power
PG1	Gap pressure of rod 1
PG2	Gap pressure of rod 2
HC1	Heat transfer coefficient of rod 1
HC2	Heat transfer coefficient of rod 2
HG1	Gap conductivity of rod 1
HG2	Gap conductivity of rod 2
LI1	Thickness of zircaloy reacted at the clad inner surface of rod 1
LI2	Thickness of zircaloy reacted at the clad inner surface of rod 2
LO1	Thickness of zircaloy reacted at the clad outer surface of rod 1
LO2	Thickness of zircaloy reacted at the clad outer surface of rod 2
QM1	Metal-water heat production rate of rod 1
QM2	Metal-water heat production rate of rod 2
TS1	Fuel rod surface temperature of rod 1
TS2	Fuel rod surface temperature of rod 2
TC1	Fuel rod center temperature of rod 1
TC2	Fuel rod center temperature of rod 2

2.3.4 Time Step Width Control (TSWC) Sequence Data BB03

Number of subblocks = 1

The time step width is controlled by parameters e_1, e_2 and e_3 as follows. We define a relative increment R of quantity χ in the interval t (old) and t + Δt (new) as

$$R = \frac{|\chi^{new} - \chi^{old}|}{\dfrac{|\chi^{new}| + |\chi^{old}|}{2} + e_3}$$

where e_3 is an input value. If any R is greater than e_1, the time step width will be halved and the calculation is to be done over again. If all R's are less than e_1e_2, then the calculation proceeds to the next time step which will have twice as large a width as the last. If all R's are less than e_1e_2, then the calculation proceeds to the next time step which will have twice as large a width as the last. If all R's are less than e_1 and, moreover, any R is in between e_1 and e e_2, then the calculation proceeds to the next time step with the same widthe as the last. For TSWC of G, parameters e_1, e_2 and e_3 are inputs, whreas for TSWC of all the other variables only e_1 is a single input (EPSMX) with the fixed values e_2 = 0.2 and e_3 = 0.001.

The inputs 4 to 11 must be repeated NTC times.

1-R	E_1	e_1 for mass flux G
2-R	E_2	e_2 for mass flux G
3-R	E_3	e_3 for mass flux G
4-I	NMIN	Number of DTMAX's per minor edit $(1 \leq NMIN \leq 1000)$
5-I	NMAJ	Number of minor edits per major edit $(1 \leq NMAJ \leq 1000)$
6-I	NDMP	Number of major edits per restart file edit $(1 \leq NDMP \leq 100)$
7-I	NCHK	Option for time step width control 0 = time step width control (1 = No time stepwidth control) In the present version, only NCHK = 0 is available.

8-R	DTMAX	Maximum time step width (sec)
9-R	DTMIN	Minimum time step width (sec) (DTMIN < DTMAX)
10-R	TLAST	End of control by this set (data 4 to 11)
11-R	EPSMX	e_1 for the time step width control variables except G

2.3.5 Trip Control Data BB04

Number of subblocks = NTRP

If more than one trip control are inputted for the same IZ, then off-actions override on-actions.

1-I	IDTRP	Action to be taken (IDTRPS $\leq$ |NTRP|) ±1 = end of problem ±2 = locking of pump rotor ±3 = reactor scram ±4 = pumped injection ±5 = SG feed water stop ±6 = pressurizer heater off If IDTRP is positive, the corresponding trip is made in action. Otherwise, it is made out of action.
2-I	IZ	Location where action is to be taken. (0 $\leq$ IZ $\leq$ NVOL) (1) Node number for IDTRP = ±2 and ±5 (2) Injection number NOPINJ (see BB09) for IDTRP = ±4 (3) Heater Number (see BB14) for IDTRP = ±6 (4) 0 for IDTRIP = ±1 and ±3
3-I	IDSIG	Signal being compared to trigger the action ±1 = time ±2 = pressure (only for SG and PZR) ±3 = temperature (only for SG and PZR) If IDSIG is positive, the trip is actuated when the signal becomes greater than the value of SETPT. If IDSIG is negative, the trip is actuated when the signal becomes less htan the value of SETPT.

4-I	IX	Node number where signal IDSIG belongs ($0 \leq IX \leq NVOL$). IX must be set equal to 0 when IDSIG = 1.
5-R	SETPT	Setpoint for signal IDSIG, i.e., time (sec) for IDSIG = ±1, pressure (PASCAL) for IDSIG = ±2 and temperature (°C) for IDSIG = ±3.
6-R	DELAY	Delay time for initiation of action after reaching setpoint (sec)

2.3.6 Data for Steady State Adjustment of Loop Hydraulics BB05

1-I	IVOL	Node number In the present version, t is imperative to set IVOL = 1
2-R	G^A	G at point A of node IVOL (kg/m²/sec)
3-R	h^A	h at point A of node IVOL (kcal/kg).

2.3.7 Normal or Linkage Node Data BB06

Number of subblocks = NLOOP

1-I	NOV	Node number ($1 \leq NOV \leq NLOOP$)
2-I	ITYP	Node type 1 = duct 2 = core 3 = core bypass 4 = downcomer 5 = lower plenum 6 = upper head 7 = SG primary duct (U-tube) 8 = pump 9 = orifice 10 = SG secondary flow 11 = pressurizer 12 = accumulator 13 = linkage duct

3-I	IW1	From-junction number ($1 \leq IW1 \leq NJUNC$)
4-I	IW2	To-junction number ($1 \leq IW2 \leq NJUNC$)
5-I	IQ	Index for external heat 0 = without heat source or sink 1 = with heat source ro sink
6-R	INU	Number of parallel nodes ($1 \leq INU$)
7-R	P^A or K	Initial pressure (ata) for IVTYP ≠ 13 or loss coefficient for IVTYP = 13
8-R	Deffc.	Effective diameter (m) (= arbitrary seal number when ITYP = 2)
9-R	D_h	Hydraulic Diameters (m) D_h = Deffec when D_h = 0.0 is inputted.
10-R	L	Node length (m)
11-R	L_H	Node height with reference to point A. (m)
12-R	K_A^f	Junction loss coefficient at point A for forward flow
13-R	K_A^r	Junction loss coefficient at point A for reverse flow
14-R	K_E^f	Junction loss coefficient at point E for forward flow
15-R	K_A^r	Junction loss coefficient at point E for reverse flow

The built-in formula will be used to obtain the junction loss coefficient for a normal junction, if - 1.0 is inputted for either A or E point ajacent to the junction. No built-in formula is available for the junction loss coefficients around a mixing junction.

2.3.8 Junction Data BB07

1-I	JNO	Junction number ($1 \leq JNO \leq NJUNC$)

2-I	JTP	Junction type 1 = normal junction 2 = upper plenum 3 = downcomer top 4 = other mixing junction 5 = injection junction (accumulator) 6 = injection junction (pressurizer) 7 = injection jinction (pumped injection) 8 = dead end junction
3-I	V	Junction volume (m^3)

2.3.9 Mixing Junction Data BB08

Number of subblocks = NMIX

Data (3, 4, 5, 6) must correspond to data (7, 8, 9, 10), respectively.

1-I	NOMIX	Junction number ($1 \leq NOMIX \leq NJUNC$)
2-I	NOUT	Number of outgoing flows at steady state ($1 \leq NOUT \leq 4$)
3-I	JOUT1	To-node number (1) ($0 \leq JOUT1 \leq NVOL$)
4-I	JOUT2	To-node number (2) ($0 \leq JOUT2 \leq NOVL$)
5-I	JOUT3	To-node number (3) ($0 \leq JOUT3 \leq NOVL$)
6-I	JOUT4	To-node number (4) ($0 \leq JOUT4 \leq NOVL$)
7-R	OMAS1	Fraction of outgoing flow (1) at steady state ($0 \leq OMAS1 \leq 1.0$)
8-R	OMAS2	Fraction of outgoing flow (2) at steady state ($0 \leq OMAS2 \leq 1.0$)
9-R	OMAS3	Fraction of outgoing flow (3) at steady state
10-R	OMAS4	Fraction of outgoing flow (4) at steady state ($a \leq OMAS4 \leq 1.0$)

2.3.10 Pumped Injection Data BB09

Numbers of subblocks = NPINJ

1-I	NOPINJ	Number of pumped injection ($1 \leq NOPINJ \leq NPINJ$)
2-I	IJ	Number of injection junction ($1 \leq IJ \leq NJUNC$)
3-R	h^{INJ}	Specific enthalpy of injected water (kg/kg)
4-I	NPI	Number of points in m^{INJ} table
5-I	IFPT	m^{INJ} table option flag 1 = (t-m) table 2 = (p-m) table

6-R Feed NPI pairs of (t-m^{INJ}) for IFPT = 1 or (p-m^{INJ}) curve for IFPT = 2 with [t] = sec, [p] = ata and [m] = kg/sec

2.3.11 Pump Data BB10

1-I	NOVOL	Node number ($1 \leq NOVOL \leq NVOL$)
2-I	ITAP	Number of table group to be used ($1 \leq ITAP \leq NPUMP$) (See NPTB in BB11)
3-I	ID	Trip index 0 = locking of rotor 1 = pump coastdown
4-R	Ω_r	Rated pump speed (rpm)
5-R	W_r	Rated volumetric flow rate (m^3/sec)
6-R	Tr	Rated torque ($kgm^2/sec^2/rad$)
7-R	$L_{head\ r}$	Rated Head (m)
8-R	ρ_{fr}	Rated density (kg/m^3)
9-R	$\Omega(0)$	Initial pump speed (rpm)
10-R	I_m	Moment of inertia (kgm^2/rad^2)
11-R	k_1	Coefficient of angular momentum equation (See Eq.(2-3-51) in Ref.(1))
12-R	k_2	Coefficient of angular momentum equation (See Eq.(2-3-51) in Ref.(1))

13-R $\tau = \tau_a$ (decay constant for pump speed) when ID = 0
$= \tau_t$ (decay constant for electric torque) when ID = 1
= 0.01 (default)

2.3.12 Pump Characteristic Curves Data (BB11)

Number of subblocks = NPUMP

0-I	NPTB	Table group number ($1 \leq$ NPTB $\leq$ NPUMP)

The following 19 table inputs should be inputted according to THYDE-P table input specification. In the data from 9 to 16, $\Delta\tau$ and ΔH mean $\tau^{1\phi} - \tau^{2\phi}$ and $\tau^{1\phi} - \tau^{2\phi}$, respectively, with 1ϕ = single phase and 2ϕ = two pahse.

1	IP1	Number of points
	w/a-H	Head-discharge curve for positive speed
2	IP2	Number of points
	w/a-H	Head-discharge curve for negative speed
3	IP3	Number of points
	a/w-H	Head-speed curve for positive flow.
4	IP4	Number of points
	a/w	Head-speed curve for negative flow
5	IP5	Number of points
	w/a-T	Torgue-discharge curve for positive speed
6	IP6	Number of points
	w/a-T	Torque-discharge curve for negative speed
7	IP7	Number of points
	a/w-T	Torque-speed curve for positive flow
8	IP8	Number of points
	a/w-T	Torque-speed cuver for negative flow
9	IP9	Number of points
	w/a-ΔH	ΔH-discharge curve for positive speed
10	IP10	Number of points
	w/a-ΔH	ΔH-discharge curve for negative speed

11	IP11	Number of points
	a/w-ΔH	ΔH-speed curve for positive flow
12	IP12	Number of points
	a/w-ΔH	ΔH-speed curve for negative flow
13	IP13	Number of points
	w/a-ΔT	ΔT-discharge curve for positive flow
14	IP14	Number of points
	w/a-ΔT	ΔT-discharge curve for negative flow
15	IP15	Number of points
	a/w-ΔT	ΔT-speed curve for positive flow
16	IP16	Number of points
	a/w-ΔT	ΔT-speed curve for negative flow
17	IP17	Number of points
	$\alpha-M_H$	Head multiplier
18	IP18	Number of points
	$\alpha-M_T$	Torque multiplier
19	IP191	Number of points for a
	IP192	Number of points for w
		NPSHr table (Feed as follows).

w_1, NPSH(w_1, a_1), NPSH(w_1, a_2) --------- NPSH(w_1, a_{IP181})
w_2, NPSH(w_2, a_1), NPSH(w_2, a_2) --------- NPSH(w_2, a_{IP191})

w_{IP192}, NPSH(w_{IP192}, a_1), NPSH(w_{IP192}, a_2),---, NPSH(w_{IP182}, a_{IP191})

2.3.13 Accumulator Data BB12
Number of sub-blocks = NACCUM

1-I	NOV	Node number (1 ≤ NOV ≤ NVOL)
2-I	IJUNC	Injection junction number (1 ≤ IJUNC ≤ NJUNC)
3-R	$V_L(0)$	Initial water volume (m^3)
4-R	$V_G(0)$	Nitrogen gas volume (m^3)
5-R	$h_L(0)$	Initial specificenthalpy of water (kcal/kg)

6-R	$P_G(0)$	Initial pressure (ata)
7-R	C_{ACD}	$h_{ACD}(0)/h_{fs}(P_G(0))$ (-) $(0.0 \le C_{ACD} \le 1.0)$
8-R	V_{ACD}	Duct volume from accumulator to check valve (m^3)

2.3.14 Break Point Data BB13

In case of guilotine break, the data 4 to 6 are associated with the from-node of the break junction, while the data 7 to 9 with the other. In case of dead-end break, the latter must be set to be zero.

1-I	NBBEAK	Break junction number (1 ≤ NBREAK ≤ NJUNC)
2-R	TBRK	Break time (sec) (0 < TBRK)
3-R	τ	Decay constant of pressure at break junction (sec) $(0 < \tau)$
4-R	C_2	See Eq.(2-1-35) of Ref.(1)
5-R	C_D	Discharge coefficient for critical flow
6-R	C_{eff}	Discharge coefficient for inertial flow
7-R	C_2	(See above.)
8-R	C_D	(See above.)
9-R	C_{eff}	(See above.)
10 (Table)		
	IP	Number of points
	time-Pref	Time (sec) versus container pressure (ata)

2.3.15 Pressurizer Data BB14

In the present version, the relief valve is not implemented so that data 11 to 13 are dummy.

1-I	NOV	Node number (1 ≤ NOV ≤ NVOL)
2-1	IJ	Injection junction number (1 ≤ IJ ≤ NJUNC)

3-I	NSP	Node number whose pressure P_{NSP} actuates spray when $P_{NSP} < P_{ZR}$. ($1 \leq NSP \leq NVOL$)
4-R	A_T	Pressurizer Cross-section (m^2)
5-R	H_T	Pressurizer height (m)
6-R	Z_{WO}	Initial water level (m) (Initial region II height) ($0 \leq Z_{WO} \leq H_T$)
7-R	α_{IO}	Initial void fraction of region I.
8-R	ℓ_{in}	Stand pipe length (m)
9-R	V_D	Warm duct volume (m^3)
10-R	h_{IIO}	Initial specific enthalpy of region II. (kcal/kg)
11-R	P_{set}	Relief valve setpoint (ata)
12-R	A_{re}	Relief line cross-section (m^2)
13-R	A_{sp}	Spray line cross-section (m^2)
14-R	C_{a_1}	$m_{sp} = C_{a_1}(P_{PZR} - P_{NSP})^2 + C_{a_2}(P_{PZR} - P_{NSP})$
15-R	C_{a_2}	m_{sp}: spray flow rate (kg/sec)
16-R	L_1	Length of heater 1 (m)
17-R	L_2	Length of heater 2 (m)
18-R	L_3	Length of heater 3 (m)
19-R	b_1	See Fig. 3-2-2 of Ref. (1)
20-R	b_2	
21-R	b_3	
22-R	τ_{SUB}	Heater time constant when coolant is subcooled. (sec)
23-R	τ_{sat}	Heater time constant when coolant is saturated. (sec).
24-R	τ_{sup}	Heater time constant when coolant is superheated steam. (sec).
25 (Table)		
	IP	Number of points

(time, G_1, G_2 G_3) Time (sec) versus relative power inputs to heaters 1, 2 and 3.

2.3.16 Steam Generator Data BB15

1-I	NOV	Node number $(1 \leq NOV \leq NVOL)$
2-I	NTUBE	Number of U-tubes $(1 \leq NTUBE \leq 2000)$
3-I	NSGS	Number of inlet node of primary flow
4-I	NSGE	Number of outlet node of primary flow
5-I	NSGN	Number of SG primary nodes
6-I	NREF	Number of relief valves in turbine steam supply flow
7-R	A_T	SG vessel cross-section (m^2)
8-R	H_T	SG vessel height (m)
9-R	$A_{s-\ell}$	Cross-section of turbine steam supply flow (m^2)
10-R	τ_{is}	Time constant of isolation valve of the secondary flow. (see IDTRP = ±5 in BB04)
11-R	ℓ_{pu}	U-tube pitch (m)
12-R	R_{SGin}	U-tube inner radius (m) $(= D_{eff}/2)$
13-R	ℓ_{TSG}	Wetted perimeter of SG vessel (m)
14-R	Z_{WO}	Initial region II level (m)
15-R	h_{SUO}	Initial specific enthalpy of feedwater (kg/kcal)
16-R	M_{SUO}	Initial feedwater flow rate (kg/sec)
17-R	β	Coefficient to decide the initial specific enthalpy of region II such that $h_{II} = \beta h_{fs} + (1 - \beta) h_{su}$ $(0.0 \leq \beta \leq 1.0)$
18-R	α_{IO}	Initial void fraction $(0.0 \leq \alpha_{IO} \leq 1.0)$
19-R	P_o	Initial pressure (ata)
20-R	C_2	Recirculation fraction $(0 < C_2 < 1.0)$
21-R	h_{DOWN}	Downcomer height (m)
22-R	$\phi_{SG}(1, 0)$	Initial heat flux of node NSGS (negative, kcal/m²/sec)
	⁓	
	$\phi_{SG}(NSGS, 0)$	Initial heat flux of node NSGE (negative, kcal/m²/sec)

23-R (Repeat the following set NREF times)

A_{re}	Relief line cross-section (m^2)
P_{set}	Relief valve setpoint (ata)
C_2	See Eq.(2-1-27) of Fef.(1)
C_D	Discharge coefficient for critical flow (-)
C_{eff}	Discharge coefficient for inertial flow (-)

24 (Table input for SG secondary flow up to container isolation)

IP	Number of points of t
(t, R_{msu}, R_{hsu}, R_G)	R_{msu}: Relative feedwater flow rate (-)
	R_{hsu}: Relative feedwater specific enthalpy (-)
	R_G : dummy

2.3.17(a) Core Data BB16
(1channel, nuclear heating option)

1-I	NRODS	Number of fuel rods (1 ≤ NRODS ≤ 50,000)
2-I	NCL	Number of most upstream core node (1 ≤ NCL ≤ NVOL)
3-I	NCH	Number of most downstream core node (1 ≤ NCH ≤ NVOL)
4-I	IEM	Option for calculation mode 0 = Best estimate model 1 = Evaluation model
5-I	ICHFOP(1)	CHF correlation index for flow condition 1 = Biasi's correlation 2 = GE correlation 3 = RELAP type correlation (interpolation of B&W2, Barnett and modified Barnett)
6-I	ICHFOP(2)	CHF correlation index for pool condition 1 = Interpolation by G between CHF of ICHFOP(1) at G = G_{min} and 67.9 kcal/m²/sec. 2 = Modified Zuber's correlation

7-I	IHTROP(1)	Index for heat transfer correlation for nuclear boiling 1 = Jens - Lottes 2 = Thom
8-I	IHTROP(2)	Index for heat transfer correlation for film boiling at pool condition 1 = Berenson 2 = Bromley and Pomerantz 3 = Modified Bromley
9-R	T_o	Reactors operating time up to the present (hour)
10-R	r_{NR}	Fuel rod outer radius at hot steady state (m)
11-R	$r_{NR}-r_{cl}^{in}$	Clad thickness at hot steady state (m)
12-R	r_{NF}	Pellet radius at hot steady state (m)
13-R	ℓ_p	Fuel rod pitch at hot steady state (m)
14-R	BLMINI	Minimum blockage (m)
15-R	ℓ	Neutron lifetime (sec)
16-R	(λ_1, β_1) ~ (λ_6, β_6)	λ_i = Decay constant of delayed neutron precursor of i-th group (1/sec) β_i = Delayed neutron fraction of i-th group (-)
17-R	τ	Time constant of power decay after neutron density becomes sufficiently small. (1/sec)
18-R	C_R	Conversion ratio (-)
19-R	λ_1	Decay constant of U^{239} (1/sec)
20-R	λ_2	Decay constant of N_p^{239} (1/sec)
30-R	Σ_a/Σ_f	See Eqs.(3-1-5) and (3-1-6) of Ref.(1)
31-R	h_r	Heat of zirconium-water reaction (kcal/kg)
32-R	$(\phi_0, \ell_1^{out}, \ell_2^{out}, \ell_1^{in}, \ell_2^{in})_I$	

~ from upstream to downstream nodes

$(\phi_0, \ell_1^{out}, \ell_2^{out}, \ell_1^{in}, \ell_2^{in})_{NCORE}$

ϕ_0 ; initial heat flux (kcal/m²/sec)

ℓ_1^{out} ; initial thickness of zircaloy reacted for rod 1 outer surface (m)

ℓ_2^{out} ; initial thickness of zircaloy reacted for rod 2 outer surface (m)

ℓ_1^{in} ; initial thickness of zircaloy reacted for rod 1 inner surface (m)

ℓ_2^{in} ; initial thickness of zircaloy reacted for rod 2 inner surface (m)

2.3.17(b) Core Data BB16
(2channel, nuclear heating option)
Number of sub-blocks = 2

0-I	ICHNL	Channel index 1 = average channel 2 = hot channel

1-I ~ 32-R } identical with 1-channel, nuclear heating option

2.3.27(c) Core Data BB16
(1channel, electric heating option)

Feed Max $FCOMP_i$ sets for each of input tables 16, 17 and 18.
$1 \leq i \leq NR$

1-I	NRODS	Number of heater rods (1 ≤ NRODS ≤ 50,000)
2-I	NCL	Number of most upstream core node (1 ≤ NCL ≤ NVOL)
3-I	NCH	Number of most downstream core node (1 ≤ NCH ≤ NVOL)
4-I		dummy
5-I	ICHFOP(1)	CHF correlation index for flow condition (see 17(a))
6-I	ICHFOP(2)	CHF correlation index for pool condition (see 17(a))

7-I	IHTROP(1)	Index for heat transfer correlation for nucleate boiling (see 17(a))
8-I	IHTROP(2)	Index for het transfer correlation for film boiling (see 17(a))
9-R	r_{NR}	Heater rod outer radius at hot steady state (m)
11-R	PLCNST	C_T in Eq.(3-3-29) in Ref.(1)
12-R	ϕ_1 ∫ ϕ_{NCORE} (from upstream to downstream nodes)	Initial heat flux (kcal/m²/sec)
13-I	$FCOMP_1$ ∫ $FCOMP_{NR}$ (from center to outer modes)	Component flag ($1 \leq FCOMP_i \leq 4$)
14-R	q_i ∫ q_{NR}	Relative powers (-)

15 (Table)

IPPW	Number of points
(t, q_t)	t : time (sec)
	q_t: heater power $q_t(0) = 1$

16 (Table)

IPDS	Number of points
(T, ρ)	T : temperature [°C]
	ρ : density [kg/m³]

17 (Table)

IDCP	Number of points
(T, C_p)	T : temperature [°C]
	C_p: specific heat [kcal/kg/°C]

18 (Table)

IPKT	Number of points for temperature
IPKD	Number of points for another density attribute such as degree of packing

Feed thermal conductivity table as follows,
where $[\rho]$ = kg/m³, [T] = °C and [k] = kcal/m/s/°C.

$\rho_1(T_1)$, $\rho_2(T_1)$, $\rho_3(T_1)$ --------- $\rho_{IPKD}(T_1)$
$\rho_1(T_2)$, $\rho_2(T_2)$, $\rho_3(T_2)$ --------- $\rho_{IPKD}(T_2)$
⋮
$\rho_1(T_{IPKT})$, $\rho_2(T_{IPKT})$, $\rho_3(T_{IPKT})$, ----- $\rho_{IPKD}(T_{IPKT})$

Next feed thermal conductivity corresponding to the matrix shown above

K_{11} K_{12} ----------------- $k_{1,\ IPKD}$
K_{21} K_{22} ----------------- $k_{2,\ IPKD}$
⋮
$K_{IPKT,1}$ $K_{IPKT,2}$ ------------- $k_{IPKT,\ IPKD}$

2.3.18 Reactivity Data BB17

1-(Table)		Void fraction vs. void coefficient
	IP1	Number of points
	(α, γ_α)	α : void fraction
		γ_α: void coefficient ($)
2-(Table)		Temperature vs. temperature coefficient
	IP2	Number of points
	(T, γ_T)	T : temperature (°C)
		γ_T: temperature coefficient ($/°C)
3-(Table)		Time vs. external reactivity
	IP3	Number of points
	(t, R_{ex})	t : time (sec)
		R_{ex}: External reactivity ($)

2.3.19 Metal-water reaction Data BB18

1-R	Δh_{reac}	Heat of metal-water reaction (kcal/kg)
2-R	k_1	Coefficient of Eq.(3-1-7) in Ref.(1), (m^2/sec)
3-R	k_2	Coefficient of Eq.(3-1-7) in Ref.(1), (°K)

2.3.20 Fuel Gap Data BB19

1-R	N	Mols of gas in pin
2-R	P_{gc}	Contact pressure (ata)
3-R	V_{pe}	Plenum gas volume (m^3)
4-R	V_{opr}	Open porosity volume (m^3)
5-R	V_{cr}	Chip and roughness volume (m^3)
6-R	$V_{cd}(0)$	Steady state clad volume (m^3)
7-R	C_T	Constant in Eq.(3-3-29) in Ref.(1) (°C)
8-R	ε_{NF}	Fuel pellet emissivity (-)
9-R	ε_{cl}	Fuel clad emissivity (-)
10-R	FRASM	Mean free path (m)
11-R	η_{He}	Mol fraction of H_e (-)
12-R	η_{He}	Mol fraction of X_e (-)
13-R	η_{Kr}	Mol fraction of K_r (-)
14-R	η_{air}	Mol fractin of air (-)
15-R	ηN_2	Mol fraction of N_2 (-)
16-R	η_{H_2}	Mol fractin of H_2 (-)
17-R	η_{H_2O}	Mol fraction of H_2O (-)

2.3.21 Clad Brust Description Data BB21

1-I	N_i	Number of non-burst digonal rods in 3 × 3 matrix
2-I	M_i	Number of non-burst off-diagonal rods in 3 × 3 matrix
3-R	A	Coefficients of Eq.(4-1-11) of Ref.(1)
4-R	B	
5-R	C	
6-R	D	
7-R	E	

8-R	A_0	Coefficients of Eq.(4-1-14) of Ref.(1)
9-R	A_1	
10-R	A_2	
11-R	A_3	
12-R	A_4	
13-R	A	Coefficients of Eq.(4-1-13) of Ref.(1)
14-R	B	
15-R	S_{burst}	Threshold strain for burst (-) ($0.0 < S_{burst} < 1.0$)

2.3.22 Miscellaneous Data BB22

1-R	Z_{DMAX}	dummy (set 0.0)
2-R	γ_{H_2O}	Isentropic exponent of H_2O (-)
3-R	γ_{N2}	Isentropic exponent of nitrogen (-)
4-R		dummy (set 0.0)

2.3.23 Problem Control Data (no block ID)

These data should be placed after the BEND card.

1(1)-I	ICLASS	CPU time parameter ($0 \leq ICLASS \leq 8$)
2(1)-I	LSEC	CPU time (sec)
2(2)-I	NCLL	Dumping index of flow network iteration 0 = no dumping -1 = start dumping at time step NCSTEP
2(3)-I	NCSTEP	Time step number when dumping of flow network iteration starts.
2(4)-I	NXDMP	Number of groups of array dumping
2(5)-I	IDPSTP	Time step number when calculation is to be stopped.
2(6)-R	DMPTM	Physical time when calculation is to be stopped.
3(1)-R	TSTOP(1)	Time to cut pressurizer off network (sec)
3(2)-R	TSTOP(2)	Time after which rewet is allowed in core. (sec)

3(3)-R	TSTOP(3)	Time to delete momentum flux terms. (sec)
3(4)-R	TSTOP(4)	Time after which FLECHT correlations are used. (sec)
3(5)-R	TSTOP(5)	Time when forms of mass equation shits. (sec)
3(6)-R	TSTOP(6)	Time after which smoothing of density near saturation is implemented and density relaxation is considered. (sec)
4(1)-I	NOCK	Number of nodes without time step width control for G. If there is not such a node, 0 should be inputted. ($0 \leq$ NOCK ≤ 50)
4(2)-I	NOCKND	Node numbers without time step width control for G. Feed them on one line.
5(1)-I	NTAUD	Number of nodes whose τ_D^N are to be changed for time $\geq$ TSTOP(6).
5(2)-R	DTAUD	Default value for τ_D^N (sec)

5(3)-(I, R)

(Feed ITAUD and ATAUD as follows. The time constant T_D of density relaxation of node ITAUD will be changed to ATAUD (sec).)

$ITAUD_1$	$ITAUD_2$	-----	$ITAUD_{10}$
$ATAUD_1$	$ATAUD_2$	-----	$ATAUD_{10}$
$ITAUD_{11}$	$ITAUD_{12}$	-----	$ITAUD_{20}$
$ATAUD_{11}$	$ATAUD_{12}$	-----	$ATAUD_{20}$

6(1)-I	NTAUDJ	Number of mixing junctions whose τ_D^J are to be changed for time $\geq$ TSTOP(6).
6(2)-I	DTAUDJ	Default value for τ_D^J. (sec)

6(3)-(I, R)

(Feed ITAUDJ and ATAUDJ in the same way as for 5(3). The time constant of density relaxation of junction ITAUDJ will be changed to ATAUDJ (sec).)

7(1) (Feed when NXDMP $\neq$ 0)

2.4 Input for Restarting

An old restart data file to be used must be mounted on FORTRAN Unit 3 and a blank file must be mounted on Unit 2. A new plot file will be generated on Unit 50.

THYDE-P is used with the following input definitions.

Probelm Dimension Data BB01

LDMP = a positive integer

NEDI ; can be changed.

NTC ; can be changed.

NTRP ; must be equal to be the value at the previous run.

The others muse be set euqāl to the values at the previous run.

Minor Edit Variable Data BB02

The quantities being edited on the new run need not have any relation to those of the original run. The same rules apply as for the original problem.

Time Step Control Sequence Data BB03

TLAST ; must be greater than the time at which the present run satrts. The same rules as for the original problem apply to the rest of the variables.

Trip Control Data BB04

Data block BB04 must not be changed only with the following exception. For the sub-block corresponding to IDTRP = 1, the value for SETPT must be greater than that of the previous run.

The other data block need not be inputted except the terminator card, the dump card and problem control data cards.

3. Steady State Adjustment

3.1 Primary Loop

Based on the input values such as pressure p_A of each node of the primary loop and mass flux G_A and specific enthalpy h_A of node 1 at the steady state, THYDE-P1 obtains G_A, G_E, h_A, h_E and k throughout the network by solving the steady state equation. Often, however, the loss coefficient k turns out to be unrealistic or negative. In the following, a recipie for steady state adjustment to yield realistic loss coefficients will be shown.

In THYDE-P1 the loss coefficients are obtained as follows depending on node-(normal junction)-node coupling or node-mixing junction coupling.

3.1.1 Node-Node Coupling

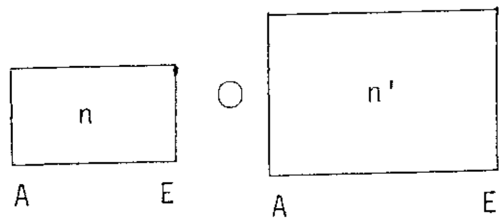

Fig.3.1 Node-Node Coupling

Suppose that junction friction factor k_J at E-point of node n has been inputted (see above). Then, equation f_3 for node n and f_2 for node n' gives

$$p_n^E + (\kappa - \frac{k_J}{2}) \frac{G_n^2}{\rho_n^E} = p_{n'}^A + \frac{G_{n'}^2}{2\rho_{n'}^A} \qquad (3\text{-}1)$$

and f_4 for node n gives

$$p_n^A + \frac{G_n^2}{\rho_n^A} - p_n^E - \frac{G_n^2}{\rho_n^E} - \frac{1}{2}(k_n + \frac{f_n L_n}{D_n}) \frac{G_n^2}{\rho_n} - \rho_n g L_{Hn} = 0 \qquad (3\text{-}2)$$

Eliminating p_n^E from Eqs.(3-1) and (3-2) and solving the redulting equation for k_n, we obtain

$$k_n = \frac{2\rho_n}{G_n^2} [p_n^A - p_{n'}^A + G_n^2 \{ \frac{1}{\rho_n^A} + \frac{1}{\rho_n^E} (\kappa - \frac{k_J}{2} - 1) - \rho_n g L_{Hn}] - \frac{f_n L_n}{D_n} \quad (3\text{-}3)$$

3.1.2 Node-Mixing Junction Coupling

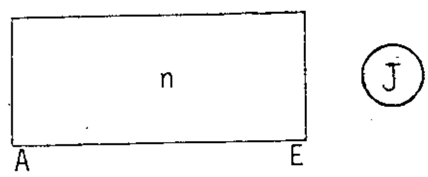

Fig.3.2 Node-Mixing Junction Coupling

Suppose that junction friction factor k_J at E-point of node n has been inputted (see above). Then equation f_3 for node n gives

$$p_n^E + (\kappa - \frac{k_J}{2}) \frac{G_n^2}{\rho_n^E} = p_J^+ \quad . \quad (3\text{-}4)$$

Eliminating p_n^E from Eqs.(3-2) and (3-4) and solving the resulting equation for k_n, we obtain

$$k_n = \frac{2\rho_n}{G_n^2} [p_n^A - p_J^+ + G_n^2 \{ \frac{1}{\rho_n^A} + \frac{1}{\rho_n^E} (\kappa - \frac{k_J}{2} - 1) - \rho_n g L_{Hn}] - \frac{f_n L_n}{D_n} \quad . \quad (3\text{-}5)$$

We note that mixing junction pressure p_J^+ is given[(1)] by

$$p_J^+ = \frac{1}{n_{out}} \sum_{i=1}^{n_{out}} (p_i^A + \kappa \frac{G_i^2}{\rho_i^A}) \quad .$$

3.1.3 Determination of p_n^A

We tramsform Eqs.(3-3) and (3-5) as follows, respectively,

$$p_{n'}^{A} = p_n^{A} + x_1 k_m + x_2 \tag{3-6}$$

and

$$p_J^{+} = p_n^{A} + x_1 k_m + x_3$$

where it should be noted that x_1 and x_2 are insensitive to p or k. Therefore, the values k_1 and k_2 of each node will be printed out as a guide to select new pressure distribution to yield realistic loss coefficients.

3.2 Secondary System of SG

The input data for SG are shown in 2.4.16 (BB15), i.e., (1) dimensions, (2) water level, (3) specific enthalpy of feed water, (4) flow rate of feed water, (5) coefficient β, (6) void fraction in region I, (7) internal pressure and (8) heat fluxes of primary nodes. Since dtata (1), (3), (4) and (7) are given as measured values, the rest may be changed so that realistic steady state will be materialized. It is the nodes crossing the water level that are difficult to obtain a steady state. The reason is that such a node has a constraint

$$f = \gamma - \frac{(T_{ws} - T_{wp})^{II}}{(T_{ws} - T_{wp})^{I}} = 0$$

where $\gamma = \phi_{II}^{o}/\phi_{I}^{o}$ (see Fig.3.3)

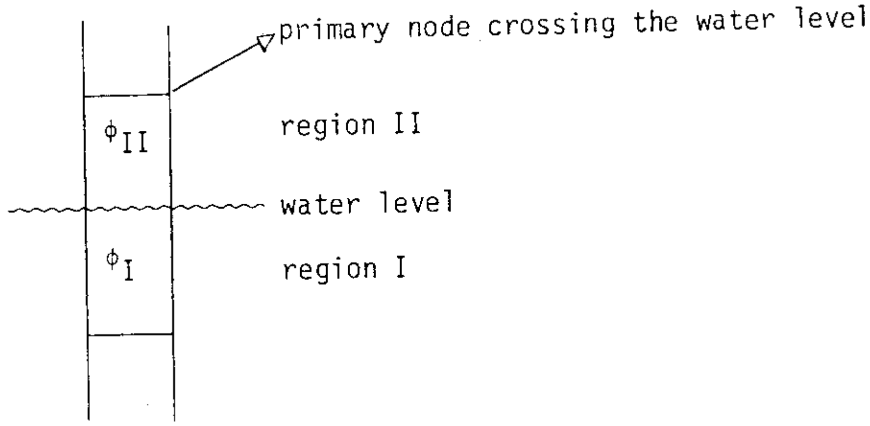

Fig.3.3

It is data (2) and (8) among data (2), (5), (6) and (8) that most influence convergence of SG secondary system. Therefore, by changing data (2) and (8), a steady state can hopefully be obtained.

4. Execution of Run

The following data sets are required to perform a THYDE-P calculation. The relationship among these data sets are shown in Fig.4-1.

input data sets

- FT01F001 : steam table
- FT03F001 : restart data
- FT12F001 : input data

output data sets

- FT02F001 : data for next restart
- FT06F001 : data for ordinary output
- FT08F001 : data for compiled output
- FT09F001 : data for debugging output
- FT10F001 : data for restart at the latest major edit in case of abnormal ending
- FT20F001 : data for output of input data
- FT50F001 : data for plotter

When a THYDE-P calculation is started from an initial state, all the data described in subsection 2.4 are required with LDMP = 0 in BB01 and with a dummy data set FT03F001. When a THYDE-P calculation is restarted from a restart dump point in a previous run, all the data in subsection 2.4 is not required. Input data requirements for restart are described in subsection 2.5.

Restart dump fequency can be controlled by NDMP in BB03. In addition, restart dump is made also by data 1(1), 2(1), 2(5) and 2(6) in problem Control Data block. These restart dump is made on FORTRAN Unit 2 in case of normal ending. To back up the cases when the run stops abnormally, the restart data at the latest major edit is storted in FORTRAN Unit 10 with LDMP = 1.

Control cards for execution is computer system dependent so that they will not be discussed in detail. Tables 4.1, 4.2 and 4.3 show examples of control cards.

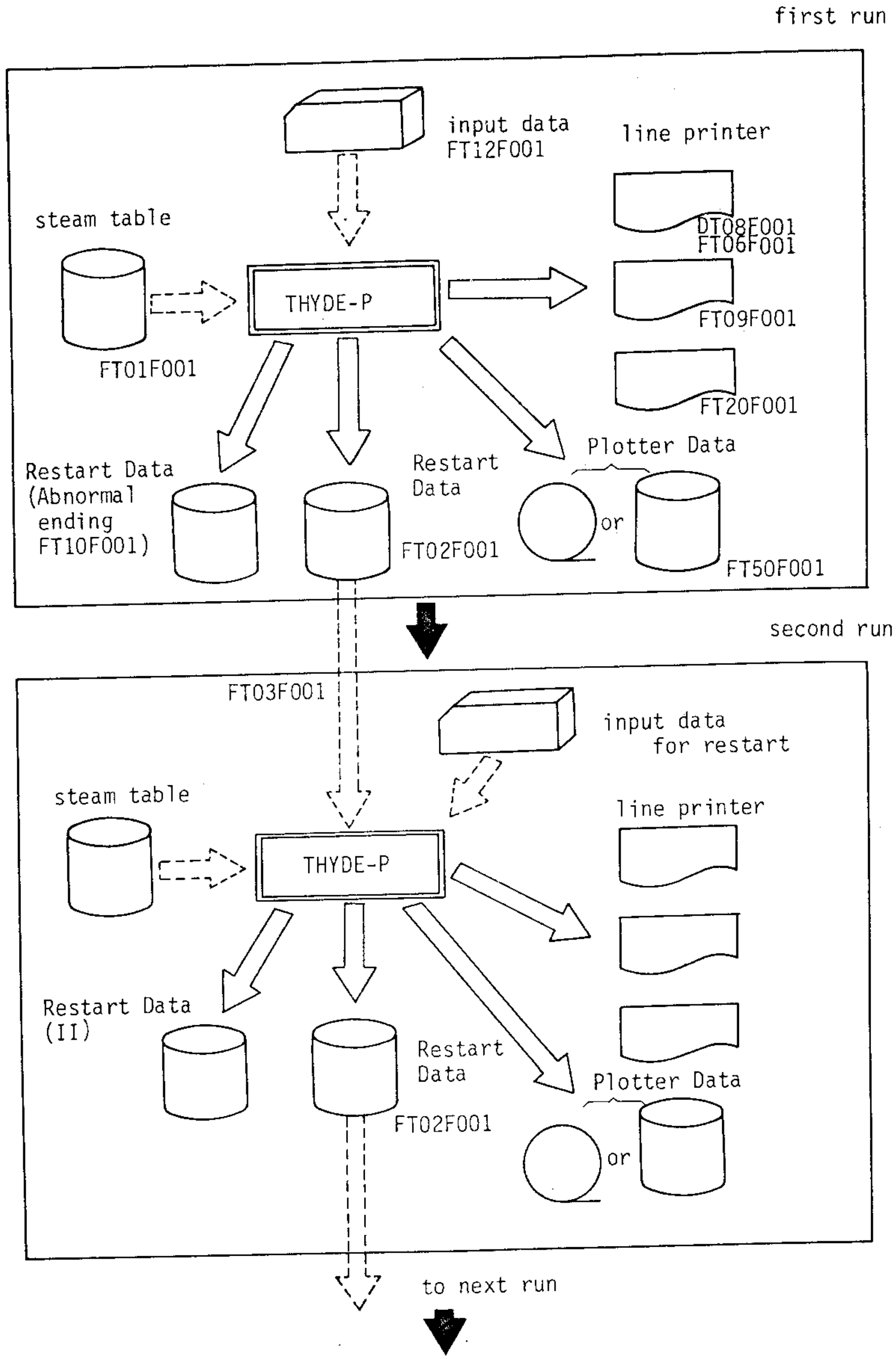

Fig. 4.1 Data Flow of THYDE-P1 Runs

```
//JCLG  JOB
//        EXEC  JCLG
//SYSIN  DD   DATA,DLM='**'
//        JUSER CARD
 T.7C.3P.OW.4I.4
 OPTP MSGLEVEL=(1,1),NOTIFY=J2937,MSGCLASS=I
//FORT   EXEC FORTHE,SO='J2937.THYDEP',A='ELM(*),NOPRINT,ALC,BYNAME'.
//         SYSOUT=I,B='NOMAP'
//LKED   EXEC LKED,SYSOUT=I
//THYDEP EXEC GO,SYSOUT=I
//*
//SYSPRINT DD DUMMY
//SYSIN DD DUMMY
//*               *** STEAM TABLE DATA ***
//  EXPAND DISKTO,DDN=FT01F001,DSN='J2937.ALMST2',Q='.DATA'
//*               *** STEAM TABLE DATA ***
//  EXPAND OISKTO,DDN=FT02F001,DSN='J2937.F01',Q='.DATA'
//FT03F001 DD DUMMY
//*               *** PRINT OUT DATASET***
//FT08F001 DD SYSOUT=I,DC3=(RECFM=FBA,LRECL=144,BLKSIZE=3168)

//FT09F001 DD DUMMY
//FT10F001 DD DUMMY
//*               *** INPUT DATA ***
//  EXAPND DISKTO,DDN=FT12F001,DSN='J2937.RUNDATA',Q='.DATA(TESTOO)'
//*               *** INPUT DATA PRINT OUT DATASET ***
//FT20F001 DD SYSOUT=I,DC8=(RECFM=FSA,LRECL=144,BLKSIZE=3168)
//*               *** PLOTTER OUT PUT DATASET ***
//  EXPAND DISKTO,DDN=FT50F001,DSN='J2937.PL01',Q='.DATA'
**
//
```

Table 4.1 Control Cards for Compile of Source THYDE-P1, Linkage and Execution Starting form a Steady State

```
//JCLG    JOB
//        EXEC   JCLG
//SYSIN    DD    DATA,DLM='***'
//        JUSER  CARD
 T.7C.3P.OW.4I.4
 OPTP MSGLEVEL=(1,1),NOTIFY=J2937,MSGCLASS=I
//*
//THYDEP EXEC LMGO,LM='J2937,SV01L16',SYSOUT=I
//*
//SYSPRINT DD DUMMY
//SYSIN DD DUMMY
//*              *** STEAM TABLE DATA ***
//  EXPAND DISKTO,DDN=FT01F001.DSN='J2937.ALMST2',Q='.DATA'
//*               *** RESTART DUMP OATASET ***
//  EXPAND DISKTO,DDN=FT01F001,DSN='J2937.F01',Q='.DATA'
//FT03F001 DD DUMMY
//*              *** PRINT OUT DATASET ***
//FT08F001 DD SYSOUT=I,DCB=(RECFM=FBA,LRECL=144,BLKSIZE=3168)
//FT09F001 DD DYMMY
//FT10F001 DD DYMMY
//*              *** INPUT DATA ***

//  EXPAND DISKTO,DDN=FT12F001,DSN='J2937.RUNDATA',Q='.DATA(TEST00)'
//*              *** INPUT DATA PRINT OUT DATASET ***
//FT20F001 DD SYSOUT=I,DCB=(RECFM=FBA,LRECL=144,BLKSIZE=3168)
//*              *** PLOUTTER OUT PUT DATASET ***
//  EXPAND DISKTO,DDN=FT50F001,DSN='J2937.PL01', Q = '.DATA'
**
//
```

Table 4.2 Control Cards for Execution Starting for a Steady State by Load Module SV01L16

```
//JCLG.  JOB
//        EXEC  JCLG
//SYSIN   DD   DATA,DLM='***'
//        JUSER CARD
 T.7C.3P.OW.4I.4
 OPTP MSGLEVEL=(1,1),NOTIFY=J2937,MSGCLASS=I
//*
//THYDEP EXCE LMGO,LM='J2927.SV01L16',SYSOUT=I
//*
//SYSPRINT DD DUMMY
//SYSIN DD DUMMY
//*             *** STEAM TABLE DATA ***
//  EXPAND DISKTO,DDN=FT01F001,DSN='J2937.ALMST2',Q='.DATA'
//*             *** RESTART DATASET ***
//  EXPAND DISKTO,DDN=FT02F001,DSN='J2937.F02',Q='.DATA'
//*             *** PRINT OUT DATASET ***
//  EXPAND DSIKTO,DDN=FT03F001,DSN='J2937.F01',Q='.DATA'
//*             *** PRINT OUT DATASET ***
//FT08F001 DD SYSOUT=I,DCB=(RECFM=FBA,LRECL=144,BLKSIZE=3168)
//FT09F001 DD DUMMY
//FT10F001 DD DUMMY

//*             *** INPUT DATA ***
//  EXPAND DISKTO,DDN=FT12F001,DSN='J2937.RUNDATA',Q='.DATA(RTEST00)'
//*             *** INPUT DATA PRINT OUT DATASET ***
//FT20F001 DD SYSOUT=I,DCB=(RECFM=FBA,LRECL=144,BLKSIZE=3168)
//*             *** PLOTTER OUT PUT DATASET ***
//  EXPAND DISKTO,DDN=FT50F001,DSN='J2937.PL02',Q='.DATA'
**
//
```

Table 4.3 Control Cards for Restarted Excecution by Load Module SV01L16
(Required memory is about 1.2 M bytes)

5. Output

5.1 Output Listing

The format of the output listing of THYDE-P is shown in Fig.5.1.

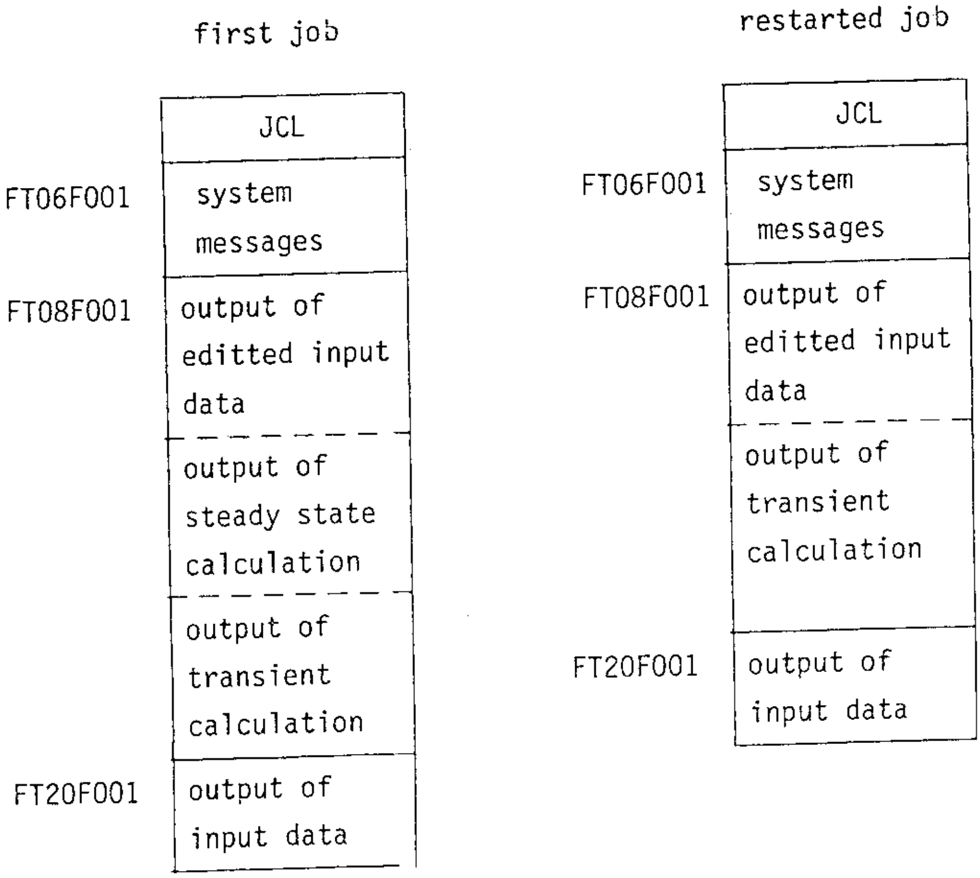

Fig.5.1 Format of Output Listing

```
****ERROR     0     3 2000 TRSGC     AT    2    1.000D-4    RETURN CODE ERROR
****ERROR     1     3 3355 SGHTRC    AT    2    1.000D-4    ABNORMAL RETURN AT ( CALL PHASE)
```

- 3 2000 / 3 3355: numbers set in THYDE-P program
- TRSGC / SGHTRC: name of module where error occured
- 2: time step
- 1.000D-4: time step width
- RETURN CODE ERROR / ABNORMAL RETURN AT (CALL PHASE): error description

Fig.5.2 Error message

```
****MESSAGE   0     1 6320* TRENT    AT    1    4.000D-3    NEED FOR TIME STEP CONTROL
```

- 1 6320*: numbers set in THYDE-P program
- TRENT: module where need for TSWC occurred
- 1: time step
- 4.000D-3: time step width

Fig.5.3 Nessage of time step width control (TSWC)

Fig.5.2 shows an example of error message. Fig.5.3 shows the message which will be printed out when need for time step width control occurs (see BB03). When the module where this need occurred is TRPG, the number AYYY indicated by* in Fig.5.3 has the following meaning.

A= 3 TSWC due to pressure change at node YYY
   4 TSWC due to mass flux change at node YYY
   5 TSWC due to low pressure ($\leq$ 1 atm) (Refer to TRPG for YYY)

5.2 THYDE-P1 Plotting System

The THYDE-P plotting system can show on a cathod-ray tube or com film the results of THYDE-P by compling the data sets generated in a series of THYDE-P jobs. The data for the THYDE-P plotting system are stored in a data set defined by F50F001 with the same frequency as for minor edit during execution of a THYDE-P job. Fig.5.4 shows relationship between execution of THYDE-P jobs and generation of plot data.

Fig.5.5 shows relationship between the plotting system and the required input data sets. In the following, each of the data sets will be explained.

5.2.1 Plot Control Data (to be inputted by FORTRAN Unit 10)

1-A	KTITLE	Title to be printed on top of each figure
2-A	FEND	Number of plot data sets (1 $\leq$ FEND)
3-I	IXTIN	Flag for editting plot data sets 0 = When time spans of two data sets overlap, the data set for the earlier period overrides the other. 1 = For each data set, the data in the period specified by additional inputs as indicated next are used.

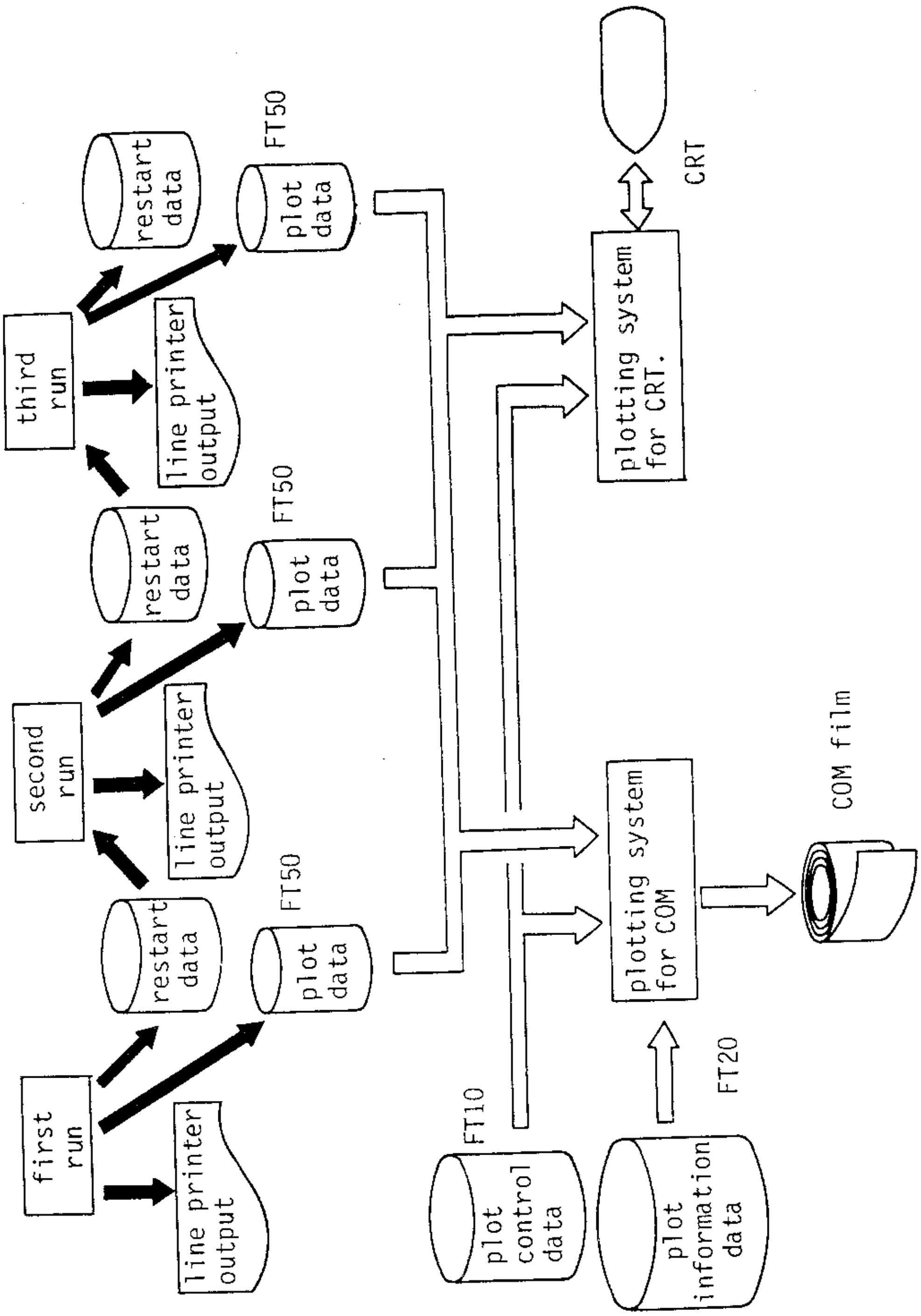

Fig.5.4 Relationship between THYDE-P Execution and Plot Data

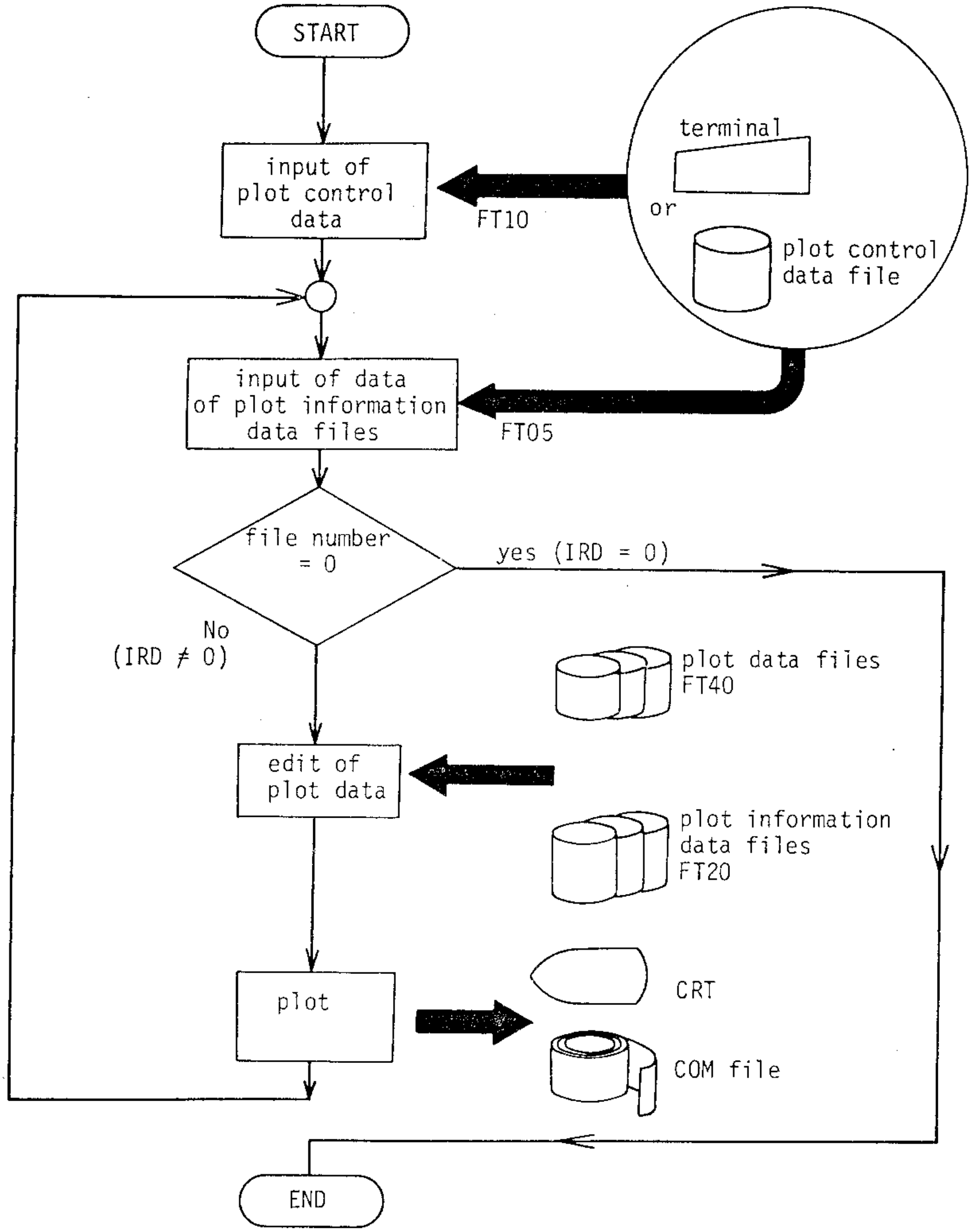

Fig.5.5 Flow Chart of Plotting System

3a - (R, P)	(TIMI, TIM2)	FEND pairs should be inputted. For each data set, the data in the period (TIMI, TIM2) are used.
4-R	TIMES	The smallest time of the abscissa (sec)
5-R	TIMEE	The largest time of the abscissa (sec)
I-R	IFLAG5	Flag for setting origin and scale (Inputting IFLAG5 is not required for COM film outputting.) 0 = use default values (see Appendix) (origin of abscissa = 0 for TYPE = 1 origin of oridinate = 0 for TYPE = 1 scale = 0.8) 1 = origin of abscissa, origin of ordinate and scale should be inputted in order.

5.2.2 Data of Plot Information Date Sets (to the inputted by FORTRAN Unit 5)

1-(I, I) (TRD, IOPTS)

IRD : Number of file unit which contains plot information data (20 ≤ IRD)

IOPTS: Flag to classify plot information file
0 = use index to select the valuables to be plotted.
1 = mannual setting

5.2.3 Plot Information Data (to be inputted by FORTRAN Unit 20, 21, 22 etc.)

The data show what is to be plotted among the variables contained in the plot data sets. In the following, only the case when IOPTS = 0 will be described. In this case, only the same kinds of variables can be plotted. Fgi.5.6 show examples of plot information data.

1-I	IPLNO	Number of curves to be plotted in the figure (1 ≤ IPLNO ≤ 20)

2 - I	IAXTY	Flag to give the minimum and maximum values of to oridnate 0 = use default values for each variable (see Appendix) 1 = give YM1 and YM2 (see next)
2a - (R, R)	(YM1, YM2)	Give when IAXTP = 1 YM1 : Maximum value YM2 : Minimum value
3 - A	Title	Title of figure
4 - A	ITAX	Give within a single line IPLNO variables to be plotted with a blank between each pair. The variables must be represented by the symbols with an index as shown in 5.2.6.

```
0005  4  0
0010  PRESSURE BESIDE INJECTION-1
0020  PRE-37 PRA-37 PRA-22 PRE-21
0030  4  0
0040  FLOW BESIDE INJECTION-1
0050  GLE-37 GLA-37 GLA-22 GLE-21
0060  4  0
0070  ENTHALPY BESIDE INJECTION-1
0080  HLE-37 HLA-37 HLA-22 HLE-21
0090  4  0
0100  QUALITY BESIDE INJECTION-1
0110  XLE-37 ELA-37 XLA-22 XLE-21
0120  0  0
```

Fig.5.6 (a) Example of Plot information Data
Numbers 4 and 0 in line 5 show that IPLNO and IAXTY are 4 and 0, respectively. Numbers 0 and 0 in line 120 indicate END of DATA.

```
00010  2  0
00020  SG PRESSURE
00030  PSG-01  PSG-02
00040  2  0
00050  SG FEED WATER FLOW
00060  MUG-01  MUG-02
00070  3  0
00080  HTR AT SG-1 2NDARY SIDE
00090  HT2-11 HT-2-12 HT2-13
00100  3  0
00110  HTR AT SG-1 PRIMARY SIDE
00120  HT1-11 HT1-12 HT1-13
00130  3  1
00131  5.0E4
00140  HEAT FLOW FROM SG-1
00150  QQQ-05 QQQ-06 QQQ-07
00160  0  0
```

Fig.5.6 (b) Example of Plot Information Data
Number 1 in line 130 shows that the maximum and minimum values of the ordinate are to be given. Line 131 shows that they are 5×10^4 and -5×10^4, respectively.

5.2.4 Output to Cathod Ray Tube (T4014 or T4006)

Graphic display output of THYDE-P results can be made by source file TXPLOT. FORT. In the following, the method to use command procedure TXPLOT (see Table 5.1) will be described.

Before TXOLOT is actuated, plot data sets FT40F001, F41F001, ···· and plot information data sets FT20F001, FT21F001, ···· have to be allocated. When TXPLOT is actuated, FT05F001, and F10F001 are automatically allocated to the graphic display terminal. The former is to be used to give the data of the plot information data sets, while the latter to give the plot control data.

```
PROC 0
CONTROL NOMSG FLUSH
WRITE **** ENTER THYDEP PLOTTING SY6TEM (& SYSDATE & SYSTIME) ****
DELETE TEMP.OBJ
FREE F(FT10F001)
FREE F(FT06F001)
FREE F(FT05F001)
FREE AT(TY)
LIB 'SYS9.PTS.LOAD'
ATTR TY BLKSIZE(144) RECFM(U A)
FERR AT (F10)
ATTR F10 BLKSIZE(80) LRECL(80) RECFM(F)
ALLOC DA(*) F(FT10F001) USING(F10)
ALLOC DA(*) F(FT85F001)
ALLOC DA(*) F(FT06F001) USING(TY)
ALLOC DA(*) F(FT05F001)
ALLOC DA(TEMP.OBJ) F(SYSLIN) NEW
FORTHE TXPLOT.FORT TERM NOPRINT OBJ(TEMP.OBJ) ELM(*) BYNAME
WRITE **** END OF FORTAN COND CODE=&LASTCC ****
WRITE **** ENTER LOADGO PROCESS ****
LOADGO (TEMP.OBJ) LIB('SYS9.PTS.LOAD') FORTLIB NOLIBDD SIZE(512K)

DELETE TEMP.OBJ
FREE F(FT10F001)
 WRITE **** END OF PLOTTING SYSTEM (& SYSDATE & SYSTIME) ****
 EXIT
```

Table 5.1 Commad Procedure TXPLOT

In this command procedure, FT05F001, FT06F001 and FT10 are allocated for the terminal.

5 2 5 Output to COM

Com output of THYDE-Presults can be made by source file CMPLOT. FORT. In Table 5.2, an example of JCL for COM output is shown. The underlined part is characteristic of com output.

```
//JCLG  JOB
//        EXEX  JCLG
//SYSIN  DD   DATA.DLM='**'
// JUSER
   T.4C.3P.0W.4I.4
   C35
 OPTP MSGCLASS=I,MSGLEVEL=(1 , 1),NOTIFY=J9722
//FORTHE EXEC FORTHE,SO='J9722.CMPLOT',SYSOUT=I,
//         A='ELM(*),NOPRINT,BYNAME,ALC,TERM,FLAG(E)'
//LKED    EXEC LKED,SYSOUT=I,GRLIB=COM
//GO      EXEC GO
//    EXPAND  DISKTO,DDN=FT05F001,DSN='J9722.PLDATA',Q='.DATA(ONTL02)',
//        DCB='DSORG=PO'
//FT06F001  DD SYSOUT=I
//    EXPAND   GCOM35
//    EXPAND  DISKTO,DDN=FT10F001,DSN='J9722.PLDATA',Q='.DATA(ONTL01)',
//        DCB='DSORG=PO'
//    EXPAND  DISKTO,DDN=FT20F001,DSN='J9722.PLDATA',Q='.DATA(CORE01)',
//        DCB='DSORG=PO'
//    EXPAND  DISKTO,DDN=FT21F001,DSN='J9722.PLDATA',Q='.DATA(CORE02)',
//        DCB='DSORG=PO'

//    EXPAND  DISKTO,DDN=FT04F001,DSN='J9722,PL01'.DATA'
//    EXPAND  DISKTO,DDN=FT41F001,DSN='J9722,PL02'.DATA'
**
//
```

Table 5.2 Example of JCL for COM output

6. Condluding Remarks

In this document, information required for users of TEYDE-P1 (version SV02L03) has been described. This work has been done as part of the procedure required for public release of the THYDE-P1 code. With publication of this work, THYDE-P1 (version SV02L03) along with its plotter will become available for public use.

References

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(2) Y. Asahi and M. Hirano, 'Verification Study of LOCA Analysis Code THYDE-P (Sample Calculation Run 10)', JAERI-M8560, 1979.

(3) T. Shimizu and Y. Asahi, 'A Through Calculation of 1, 100 MWe RWR Large Break LOCA by THYDE-P (Sample Calculation Run 20)', JAERI-M9819, 1981

(4) M. Hirano and Y. Asahi, 'Through Analysis of LOFT L2-2 by THYDE-P Code', JAERI-M9535, 1981.

(5) M. Hirano, 'Through Analysis of LOFT L2-3 by THYDE-P Code (Sample Calculation Run 40)', JAERI-M9765, 1981

(6) M. Hirano, T. Shimizu and Y. Asahi, 'Analysis of LOFT L3-1 by THYDE-P', to be published

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Appendix Symbol·Table for Plotter Output

The symbols of plotter output has the following format

XXX - YY

where XXX and YY stand for variable and index, respectively. In the following, not only the symbols but also their unit or title along the abscissa, the default values for YM1 and YM2 (see 5.2.3) and the type of the oridnate (1 = linear and 2 = logarithmic) will be shown.

***** NORMAL NODE DATA ******

variable	UNIT	RANGE(MAX/MIN)		TYPE
1 PRA	PRESSURE (PASCAL)	2.000E+07	0.0	1
2 PRE	PRESSURE (PASCAL)	2.000E+07	0.0	1
3 PRV	PRESSURE (PASCAL)	2.000E+07	0.0	1
4 GLA	FLOW (KG/SEC/M**2)	1.000E+05	-1.000E+05	1
5 GLE	FLOW (KG/SEC/M**2)	1.000E+05	-1.000E+05	1
6 GLV	FLOW (KG/SEC/M**2)	1.000E+05	-1.000E+05	1
7 HLA	ENTHALPY (KCAL/KG)	1.500E+03	0.0	1
8 HLE	ENTHALPY (KCAL/KG)	1.500E+03	0.0	1
9 HLV	ENTHALPY (KCAL/KG)	1.500E+03	0.0	1
10 RHA	DENSITY (KG/M**3)	1.000E+03	0.0	1
11 RHE	DENSITY (KG/M**3)	1.000E+03	0.0	1
12 RHV	DENSITY (KG/M**3)	1.000E+03	0.0	1
13 XLA	QUALITY	2.000E+00	-1.000E+00	1
14 XLE	QUALITY	2.000E+00	-1.000E+00	1
15 XLV	QUALITY	2.000E+00	-1.000E+00	1
16 ALA	VOID FRACTION	1.200E+00	-8.000E-01	1
17 ALE	VOID FRACTION	1.200E+00	-8.000E-01	1
18 ALV	VOID FRACTION	1.200E+00	-8.000E-01	1
19 QQQ	Q (KCAL/SEC/M**3)	1.000E+05	-1.000E+05	1
20 TMP	BULK TEMP (DEG)	1.500E+03	0.0	1

XXA : quantity at point A

XXE : quantity at point E

XXV : quantity at average point

***** PUMP DATA *****

variable	UNIT	RANGE(MAX/MIN)		TYPE
21 HDP	PUMP HEAD (M)	2.000E+02	0.0	1
22 AAA	PUMP SPEED	1.000E+01	-1.000E+01	1
23 BBB	PUMP TORQUE	1.000E+01	-1.000E+01	1
24 WWW	PUMP FLOW	1.000E+01	-1.000E+01	

The variables 22 to 24 are relative values with respect to the stuady state values

***** ACCUMLATOR DATA *****

variable	UNIT	RANGE(MAX/MIN)		TYPE
25 PAC	PRESSURE (PASCAL)	2.000E+07	0.0	1
26 GAJ	FLOW (G/SEC)	5.000E+04	5.000E+04	1
27 HAC	ENTHALPY (KCAL/KG)	1.000E+03	0.0	1
28 VAG	GAS VOLUME (M**3)	2.000E+02	0.0	1
29 MAL	LIQUID MASW (KG)	2.000E+02	0.0	1

***** STEAM GENERATOR DATA *****

variable	UNIT	RANGE(MAX/MIN)		TYPE
30 PSG	PRESSURE (PASCAL)	2.000E+07	0.0	1
31 MUG	FLOW (KG/SEC)	1.000E+04	0.0	1
32 MRG	FLOW (KG/SEC)	1.000E+04	0.0	1
33 WLS	WATER LEVEL (M)	3.000E+01	0.0	1
34 HS1	ENTHALPY (KCAL/KG)	1.000E+03	0.0	1
35 HS2	ENTHALPY (KCAL/KG)	1.000E+03	0.0	1
36 HG1	MASS (KG)	1.000E+05	0.0	1
37 MG2	MASS (KG)	1.000E+05	0.0	1
38 HT1	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
39 HT2	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
40 TW1	WALL TEMP (DEG)	5.000E+02	0.0	1
41 TW2	WALL TEMP (DEG)	5.000E+02	0.0	1

For variables 30 to 37, XX1 and XX2 refer to Regions I and II, respectively. For variables 38 to 41, XX1 and XX2 refer to the primary and secondary sides, respectively. For variables 38 to 41, HT1-24, for example, means

HT1 : heat transfer coefficient at the primary side

and

24 : the fourth node from the inlet of the second SG

***** PRESSURIZER DATA *****

variable	UNIT	RANGE(MAX/MIN)		TYPE
42 PPP	PRESSURE (PASCAL)	2.000E+07	0.0	1
43 GPR	FLOW (KG/SEC)	5.000E+04	-5.000E+04	1
44 WLP	WATER LEVEL (M)	3.000E+01	0.0	1
45 MSP	FLOW (KG/SEC)	1.000E+04	0.0	1
46 HP1	ENTHALPY (KCAL/KG)	1.000E+03	0.0	1
47 HP2	ENTHALPY (KCAL/KG)	1.000E+03	0.0	1
48 MS1	MASS (KG)	1.000E+05	0.0	1
49 MS2	MASS (KG)	1.000E+05	0.0	1

Variables XX1 and XX2 refer to Regions I and II, respectively.

***** CORE AND FUEL DATA *****

variable	UNIT	RANGE(MAX/MIN)		TYPE
50 QCR	RELATIVE POWER	2.000E+00	1.000E-03	2
51 PG1	PRESSURE (PASCAL)	2.000E+07	0.0	1
52 PG2	PRESSURE (PASCAL)	2.000E+07	0.0	1
53 HE1	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
54 HE2	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
55 HC1	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
56 HC2	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
57 HG1	(KCAL/SEC/M**2/DEG)	1.000E+02	1.000E-03	2
58 HG2	(KCAL/SEC/M**2/DGE)	1.000E+02	1.000E-03	2
59 LI1	ZR-REACTED IN (M)	1.000E-04	0.0	1
60 LI2	ZR-REACTED IN (M)	1.000E-04	0.0	1
61 LO1	ZR-REACTED OUT (M)	1.000E-04	0.0	1
62 LO2	ZR-REACTED OUT (M)	1.000E-04	0.0	1
63 QM1	Q-MW (KCAL/M**3)	1.000E+06	0.0	1
64 QM2	Q-MW (KCAL/M**3)	1.000E+06	0.0	1
65 TS1	TEMP (DEG)	2.000E+03	0.0	1
66 TS2	TEMP (DEG)	2.000E+03	0.0	1
67 TC1	TEMP (DEG)	2.000E+03	0.0	1
68 TC2	TEMP (DEG)	2.000E+03	0.0	1
69 STR	PLASTIC H-S (KG/M**2)	1.000E+03	0.0	1
70 HST	HOOP STRAIN	1.000E+00	0.0	1
71 BTE	BURST TEMP (DEG)	2.000E+03	0.0	1

Variables XX1 and XX2 refer to non-burst and burst rods, respectively. Heat transfer coefficients HC and HE refer to values obtained from correlations and values obtained by smoothing HC, respectively.