



INSTRUCTION MANUAL

SPD0008EIE

Design Instruction

CONTROL VALVE SIZING BY COMPUTER

REV. : 0

DATE : 2013.08.08

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1. General

This is the execution manual of the program (KFCV), which is based on fortran IV, for calculation of valve coefficient Cv. The sizing formula is referred to FCI & ISA.

References

- (1) Masoneilan handbook for control valve sizing
- (2) ISA handbook of control valve
- (3) ISA RP 39.1 – 39.4

2. Sizing

2.1 FCI

P1 : Upstream pressure, Absolute (KG/CM²ABS)

P2 : Downstream pressure, Absolute (KG/CM²ABS)

ΔP : P1 – P2

(1) Liquid

$$CvI' = 1.167 \times V \sqrt{\frac{G}{\Delta P}}$$

$$CvI = Fr \times CvI'$$

V = Flow rate (M³/HR)

G = Specific gravity (water = 1)

Fr = Viscosity correction factor

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(2) Gas & vapour

$$1) \text{ When } \Delta P < \frac{P_1}{2} \quad \text{CVG1} = \frac{268.6 \times Q}{273} \cdot \frac{\sqrt{G(273 + T_f)}}{287 \sqrt{\Delta P(P_1 + P_2)}}$$

$$2) \text{ When } \Delta P \geq \frac{P_1}{2} \quad \text{CVG2} = \frac{288.6 \times Q}{273} \cdot \frac{\sqrt{G(273 + T_f)}}{249 \times P_1}$$

Q : Flow rate (M³/HR) at 760mmHg, 0°C

G = $\frac{\text{M.W}}{28.9}$: Specific gravity (air = 1)

M.W : Molecular weight

T_f = Flowing temperature (°C)

(3) Steam

$$1) \text{ When } \Delta P < \frac{P_1}{2} \quad \text{CVS1} = \frac{W \times K}{13.67 \sqrt{\Delta P(P_1 + P_2)}}$$

$$2) \text{ When } \Delta P \geq \frac{P_1}{2} \quad \text{CVS2} = \frac{W \times K}{11.9 \times P_1}$$

W : Flow rate (Kg/HR)

K : 1 + 0.0013 x (Superheat, °C)

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(4) Flashing service(F%)

1) When $\Delta P < \frac{P1}{2}$

$$CVF1 = 1.167 \times \left(1 - \frac{F\%}{100}\right) \sqrt{\frac{G}{\Delta P}} + \frac{288.6V}{273} \cdot \frac{G \times F\% \sqrt{(MW/28.9)(273 + Tf)}}{28.7 (MW/22.414) \sqrt{\Delta P (P1 + P2)}}$$

2) When $\Delta P \geq \frac{P1}{2}$

$$CVF2 = 1.167 \times V \left(1 - \frac{F\%}{100}\right) \cdot \sqrt{\frac{G}{\Delta P}} + \frac{288.6V}{273} \cdot \frac{G \times F\% \sqrt{(MW/28.9)(273 + Tf)}}{24.9 \cdot (MW/22.414) \cdot P1}$$

V : Flow rate (M³/HR)

F% : Flashing percentage (weight %)

G : Specific gravity (Water= 1)

MW : Molecular weight

Tf : Temperature (°C)

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2.2 ISA Formula

(1) Liquid

1) Subcritical flow

$$CV = \frac{q}{N1 \cdot Fr \cdot Fp} \times \sqrt{\frac{G}{\Delta P}}$$

2) Laminar flow

$$CV = \frac{1}{FsFp} \times \left(\frac{q}{N10} \cdot \frac{\mu}{\Delta P} \right)^{\frac{2}{3}}$$

3) Critical flow

$$CV = \frac{q}{N1 \cdot F1p} \times \sqrt{\frac{G}{\Delta P}}$$

(2) Gas

$$CV = \frac{W}{N8 \cdot Fp \cdot Y \cdot P} \times \sqrt{\frac{T \cdot Z}{X \cdot (MW)}}$$

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(3) Steam

1) $X \geq X_{tp}$ (choked flow)

$$CV = \frac{W}{N_{11} \cdot F_p \cdot P_1 \cdot \sqrt{X_{tp}}}$$

2) $X < X_{tp}$

$$CV = \frac{W}{N_{12} \cdot F_p \cdot P \cdot \left(3 - \frac{X}{X_{tp}}\right) \cdot \sqrt{X}}$$

2.3 Variables

(1) $\Delta P_s = P_1 - P_{vc}$

(2) $P_{vc} = F_f \times P_v$

(3) $F_f = 0.96 - 0.28 \cdot \sqrt{\frac{P_v}{P_c}}$

(4) $F_{lp} = \left\{ \frac{1}{F_{l2}} + \frac{K_i}{N_2} \right\}^{-\frac{1}{2}} (Cd)^2$

(5) $F_s = \left(\frac{F_p \times F_d^{\frac{2}{3}}}{F_{lp}} \right) \times \left\{ \frac{(F_{lp} \times Cd)^2}{N_2} + 1 \right\}^{\frac{1}{6}}$

(6) $Y = 1 - \frac{X}{3F_k \times X_t} \leq \frac{2}{3}$

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$$(7) \quad F_k = \frac{K}{1.4}$$

$$(8) \quad X_{tp} = \frac{X_t}{F_{p2}} \cdot \left\{ \frac{X_t \times K_i}{N5} \cdot (Cd)^2 + 1 \right\}^{-1}$$

$$(9) \quad F_p = \left\{ \frac{\sum K}{N2} \cdot (Cd)^2 + 1 \right\}^{-\frac{1}{2}}$$

$$(10) \quad \sum K = K1 + K2 + K_{b1} - K_{b2}$$

$$(11) \quad K_{b1} = K_{b2} = 1 - \left(\frac{d}{D} \right)^4$$

$$(12) \quad K1 = 0.5 \times \left\{ 1 - \left(\frac{d}{D} \right)^2 \right\}^2$$

$$(13) \quad K2 = 1.0 \times \left\{ 1 - \left(\frac{d}{D} \right)^2 \right\}^2$$

$$(14) \quad K_i = K1 + K_{b1}$$

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2.4 Unit

N	Q	P	r	T	d.D	S
N1 : 0.865	M ³ /HR					
N2 : 890					mm	
N3 : 645					mm	
N5 : 1000					mm	
N6 : 27.3	Kg/HR	bar	Kg/m ³			
N8 : 94.8	Kg/HR	bar		°K		
N10 : 172.0	M ³ /HR	bar			mm	Centipoise
N11 : 30.4	Kg/HR	bar				
N12 : 15.2	Kg/HR	bar				

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2.5 Nomenclature

Cd : Relative capacity (at rated Cv) $Cd = N3 \cdot Cv \cdot d^2$

Cv : Valve coefficient

d : Valve port diameter

D : Pipe inside diameter

Fd : Experimentally determined factor relating valve Cv to an equivalent diameter for Reynolds number

Ff : Liquid critical pressure ratio factor, $Ff = Pvc/Pv$

Fk : Ratio of specific heats factor

FI : Pressure recovery factor. when the valve is not choked:

$$FI = (P1 - P2) / (P1 - Pvc)$$

Ffp : Combined pressure loss and piping geometry factors for valve/fitting assembly

Fp : Correction factor for piping around valve (e.g. reducers)
 $FpCv$ = Effective Cv for valve/fitting assembly

Fr : Correction factor for Reynolds number, where $Fr \cdot Cv$ = effective Cv

Fs : Laminar, or streamline, flow factor

G : Specific gravity of liquids at flowing temperature relative to water to water at 15°C

$\sum K$: Sum total of effective velocity head coefficients where
 $K(U^2/2g) = h$

Kb : Bernoulli coefficient = $1 - (d/D)^4$

Ki : Inlet velocity head coefficient, $K1 + Kb1$

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K1 : Resistance coefficient for Inlet fitting

K2 : Resistance coefficient for outlet fitting

k : Ratio of specific heats of a gas = C_p/C_v , dimensionless

M.W : Molecular weight

N : Numerical constant (see Section 2.4)

p : Absolute static pressure

Pc : Thermodynamic critical pressure

Pv : Vapor pressure of liquid at inlet

Q : Volume rate of flow

T : Absolute temperature

W : Weight rate of flow

X : Ratio of differential pressure to absolute inlet static pressure,
 $X = (p_1 - p_2)/p_1$

Xt : Terminal or ultimate value of X, used to establish expansion factor, Y

Xtp : Value of Xt for valve/fitting assembly

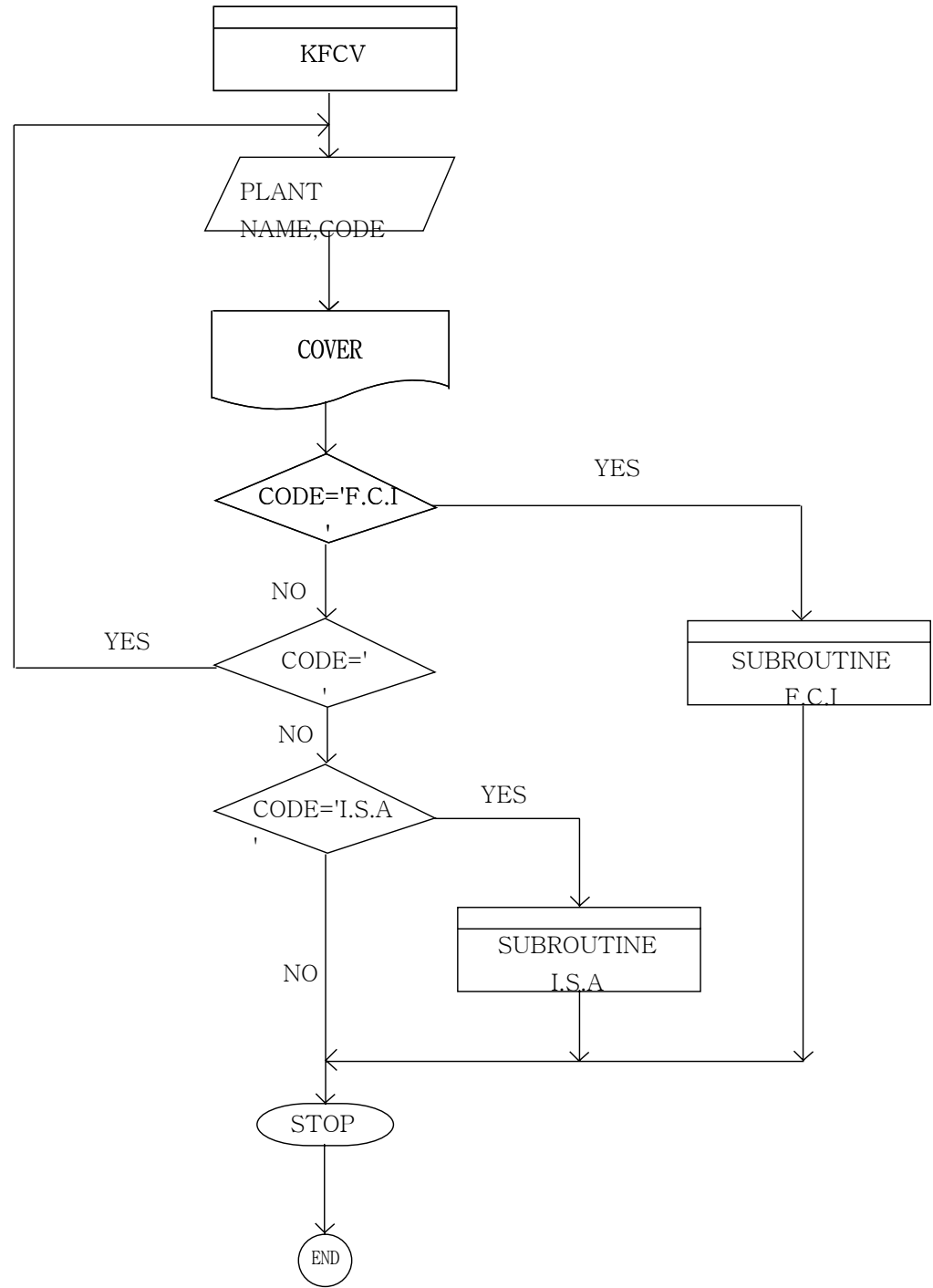
Y : Expansion factor. ratio of flow coefficient for a gas to that for a liquid
at the same Reynolds number (includes radial as well as Longitudinal expansion
effects)

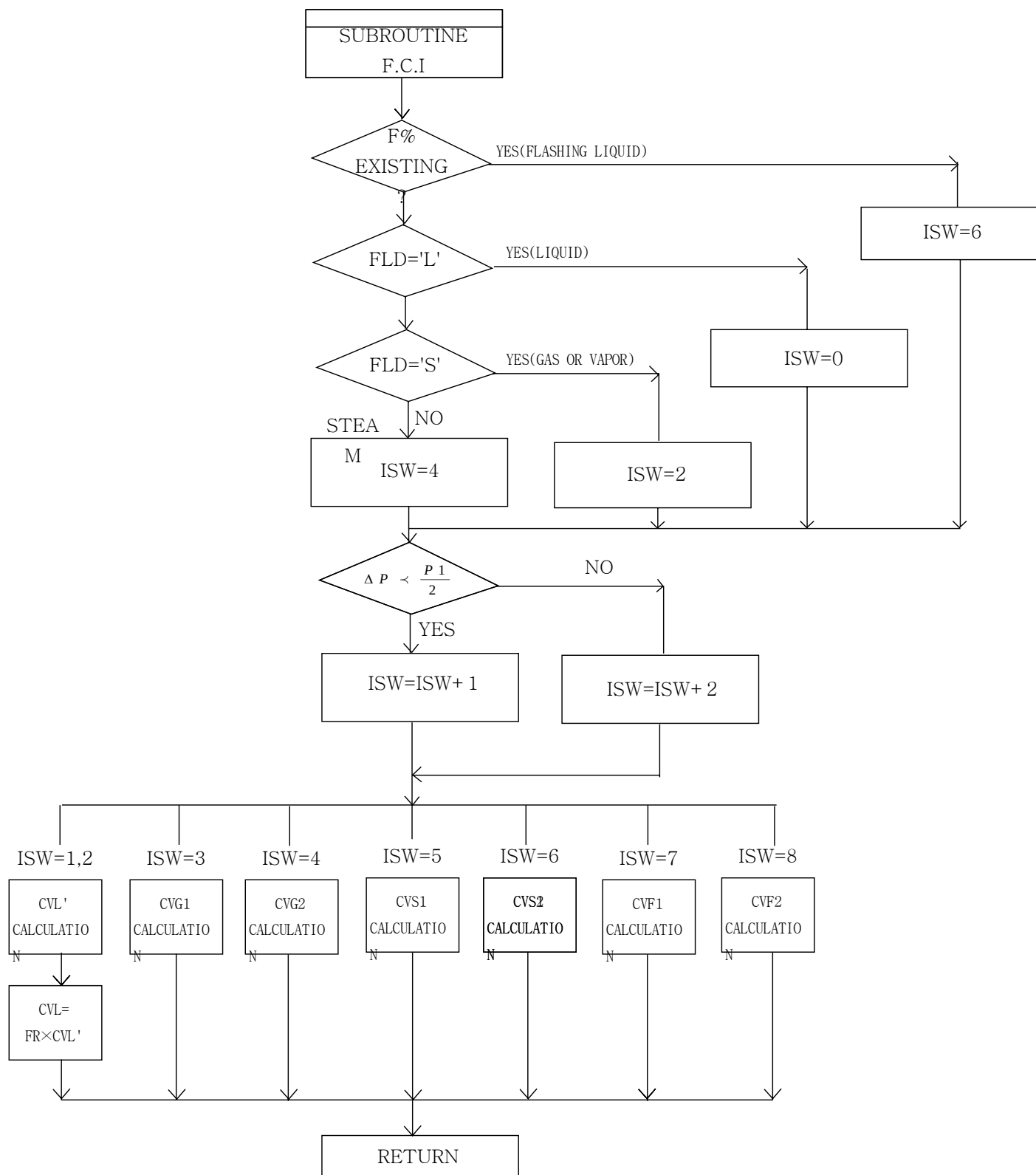
Z : Compressibility factor (refer to Nelson-Obert compressibility charts)

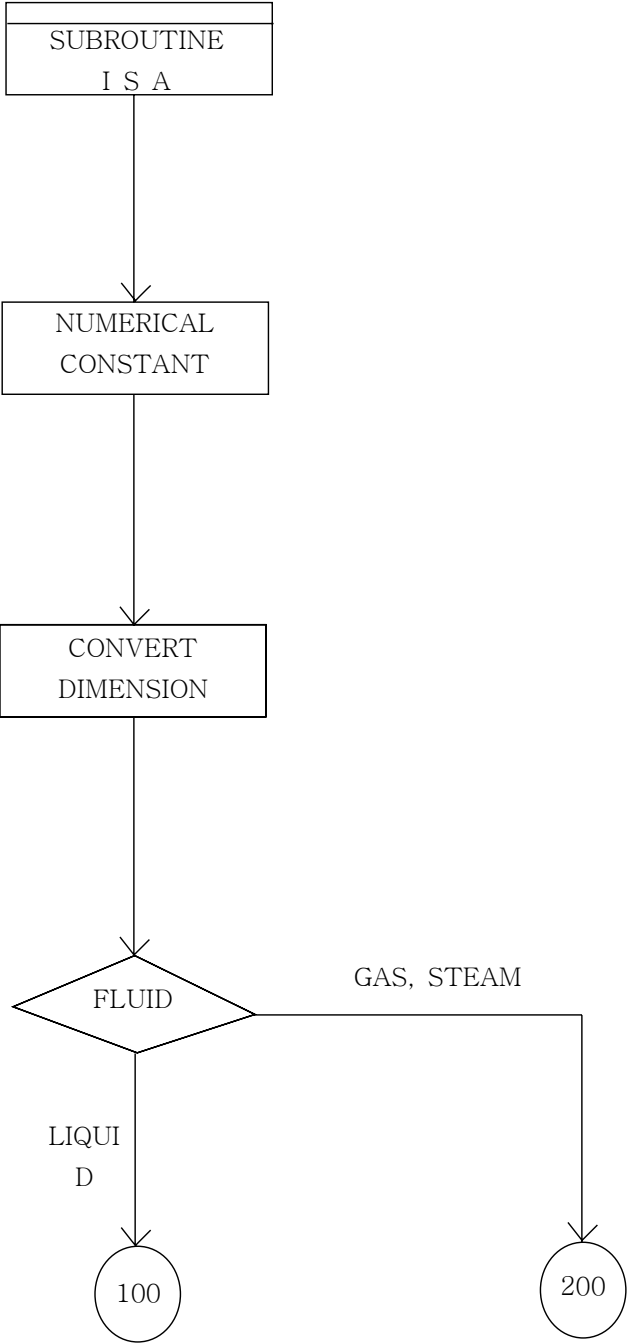
$\mu(\mu)$: Viscosity, centipoise

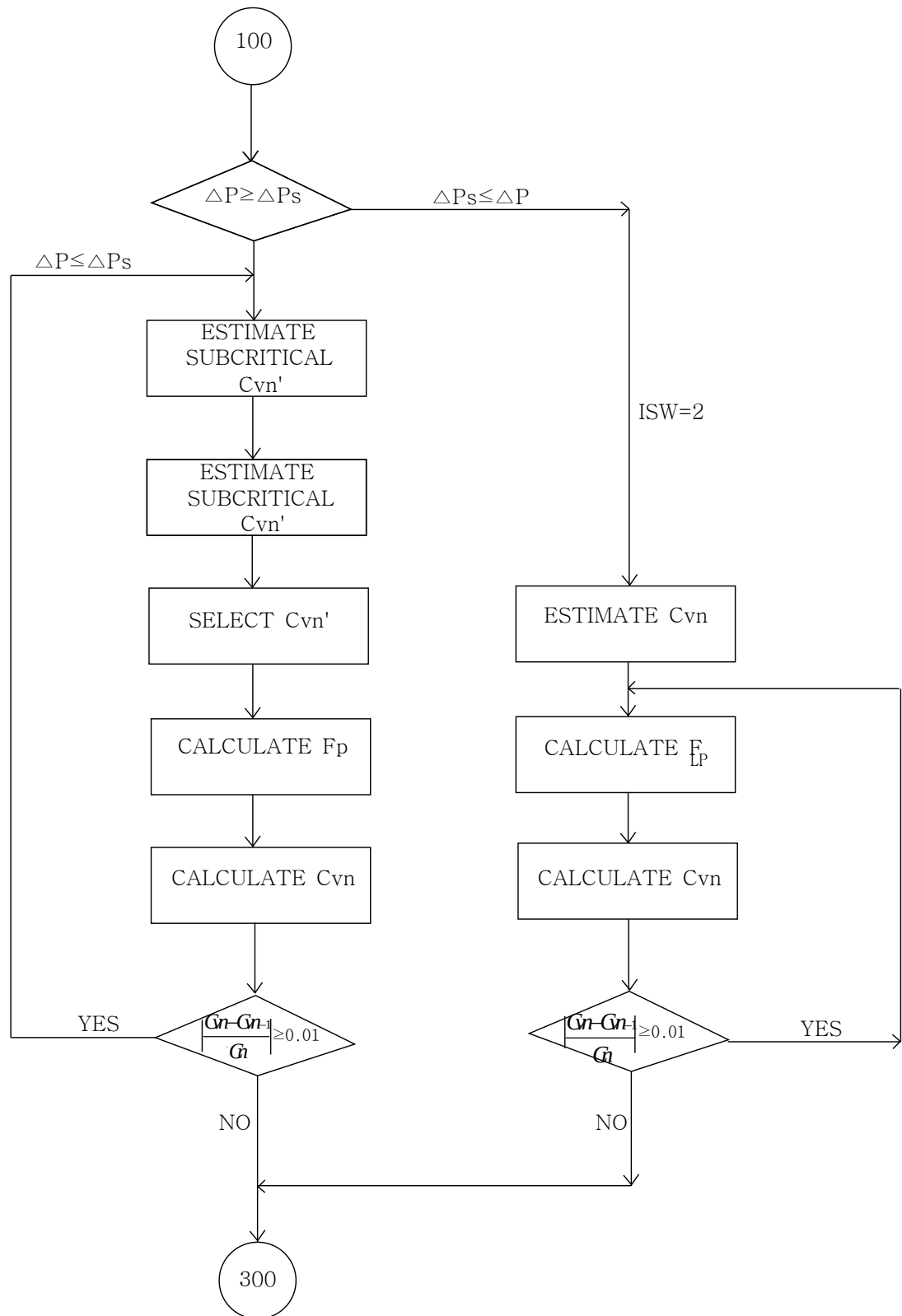
3. Configuration of program

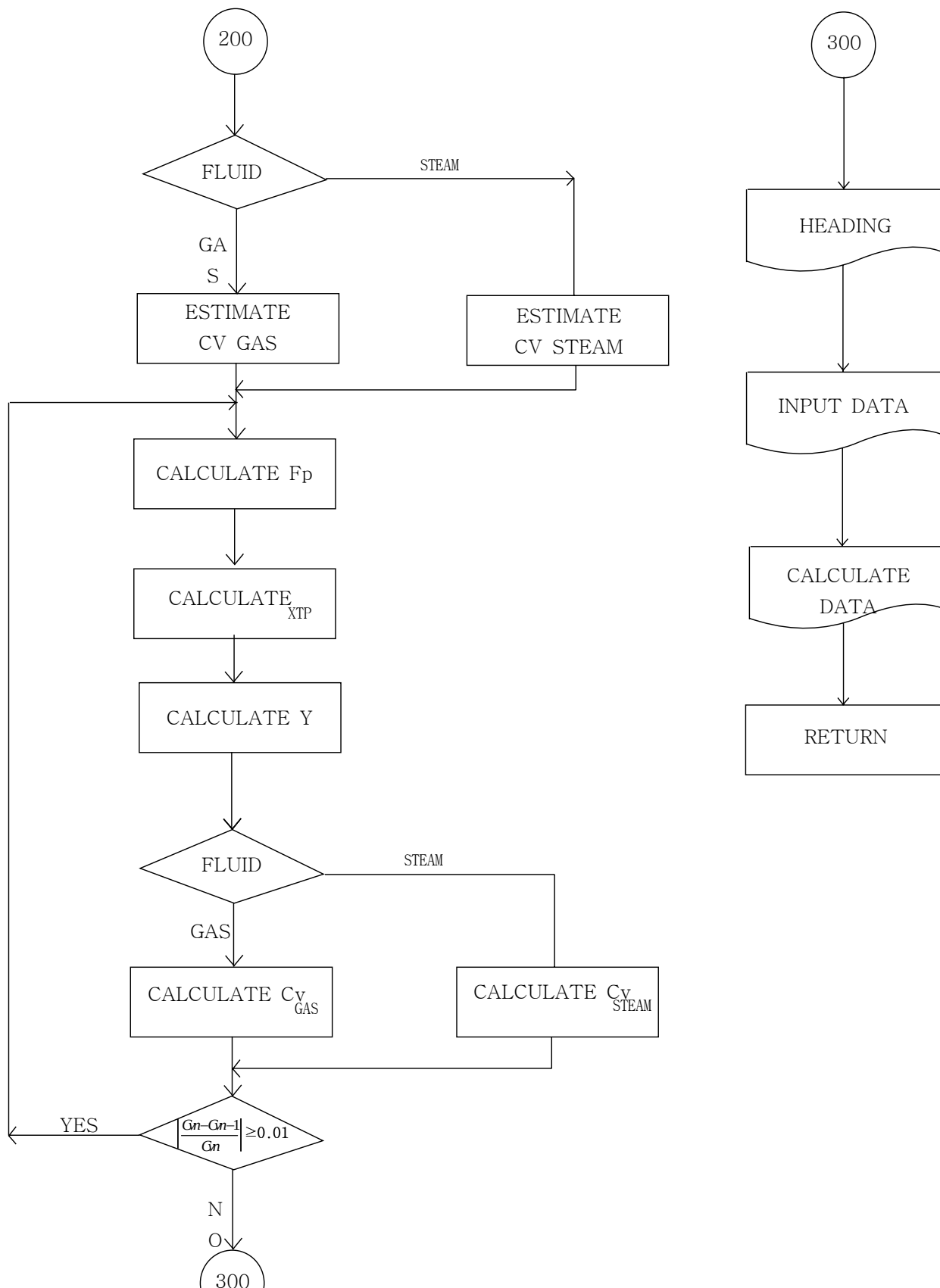
3.1 Flow Chart











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3.2 Program Coding

(1) FCI formula

No.	Column No.	Parameter	Unit	Description
1	1 - 8	Ajobno	-	Job No.
2	9 - 28	Aname	-	Job Name
3	29 - 48	Cust	-	Customer Name
4	49 - 51	Code	-	FCI or ISA
5	1 - 12	Tango	-	Tag No.
6	13	FLD	-	Fluid Type
7	14 - 18	P1	Kg/Cm ² G	Inlet Pressure
8	19 - 23	DP	Kg/Cm ²	Differential Pressure
9	24 - 28	T	°C	Operating Temperature
10	29 - 34	TS	°C	Superheat Degree
11	35 - 42	F(1)	*	Minimum Flow Rate
12	43 - 50	F(2)	*	Normal Flow Rate
13	51 - 58	F(3)	*	Maximum Flow Rate
14	59 - 63	G	-	Specific Gravity (H ₂ O = 1)
15	64 - 68	RMW	-	Molecular Weight
16	69 - 73	U	C.P.S	Viscosity
17	74 - 79	FPER	-	Weight % of Flashing Protion
18	80	After	-	Skip

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Notes

- 1) No1~4: Data for cover heading
- 2) No.5 : Special characters may be used.
- 3) No.6 :

Fluid	Input Data
Liquid	L
Gas, Vapor	G
Steam	S

- 4) No.7,8,9 :

Fluid	Unit
Liquid	M ³ /HR
Gas, Vapor	NM ³ /HR
Steam	KG/HR

- 5) No.17: Key in weight(%) of flashing and 0.0 for non-flashing.

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(2) ISA formula

No.	Column수	변 수	단 위	내 용
1	1 - 12	Tagno	-	Tag Number
2	13	FLD	-	Fluid
3	14 - 18	P1	Kg/Cm ² G	Upstream Pressure
4	19 - 23	ΔP1	Kg/Cm ²	Differential Pressure
5	24 - 28	T1	℃	Operating Temperature
6	29 - 36	Q	*	Flow Rate
7	37 - 41	G M.W	*	Liq. Steam : Specific Gravity(H ₂ O = 1) Gas : Molecular Weight
8	42 - 46	U	C.P.S	Viscosity
9	47 - 51	D	mm	Pipe Dia.
10	52 - 56	d	mm	Valve Dia.
11	57 - 61	K	-	Specific Heat Ratio
12	62 - 66	FL	-	Pressure Recovery Factor
13	67 - 71	Xt PC	- -	Terminal Valve Of (P ₁ - P ₂)/P ₁ Thermodynamic Critical Pressure
14	72 - 76	Z Pv	- -	Compressibility Factor Vapor Pressure of Liquid
15	77 - 80	Fd	-	Valve Type Modifier

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Notes

1) No2:

Fluid	Key in
Liquid	1
Gas, vapor	2
Steam	3

2) No6:

Fluid	Unit
Liquid	M ³ /HR
Gas, vapor	NM ³ /HR
Steam	KG/HR

3) No7: Specific gravity for liquid & steam and molecular weight for gas.

4) No15:

Valve Type	Fd
Single Ported Globe Valve V-Notch Ball Valve	1.0
Double Ported Globe Valve Butterfly Valve Two - Parallel Flow Paths Valve	0.7

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4. Using the program

```

DES server 500 Terminal Server V1.0 - LAT V5.1
Please type HELP if you need assistance

Enter username > SE0JH
Local > C V6420

```

4.1 Computer Log-in

- (1) Turning on the computer terminal, above screen displays.
- (2) In case of Personal Computer, VAX emulator program shall be applied.
- (3) Press "ENTER", and then "Local>" will display.
- (4) Key in "C V6420", next screen displays.

(C:Connect, V6420: Vax system name)

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S A M S U N G E N G I N E E R I N G

Username: SECL03

Password:

Welcome to VAX/VMS version V5.2 on node V6420

Last interactive login on Friday, 21-DEC-1990 16:05

Last non-interactive login on Saturday, 10-NOV-1990 10:36

(5) Key in department code and password, password does not display.

(6) Key in of username & password is able to attempt up to 3times.

If failed, the screen go back to "Local". then try step(4) again.

(7) If username & password is right, the next screen displays.

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사 번 (ID No) : 1179

성 명 (Name) : 서정훈

부 서 (Dept) : 전 기 계 장 부

PASSWORD :

Password termination : After 58 days.

(8) Key in ID No & password.

(9) If failed, the screen returns to "Local>" message. Then try step(4) again.

1;1f MENU00

SAMSUNG ENGINEERING

1. (설 계) M / H 관 리

2. (견 적) E N G ' G

3. (기 술) 전 기

4. (기 술) 계 장

5. (기 술) 설 계 공 정

6. (일 반) O A 업 무

7. (일 반) M I S 업 무

8. (전 산) 명 령 어

1. ANNUBA TUBE의 delta P 계산

2. CONTROL VALVE SIZING

3. RUPTURE DISK SIZING

4. ORIFICE CALCULATION

5. SAFETY VALVE SIZING

6. THERMO WELL STRESS CALCULATION

LOG OUT(F20)

(10) Select "6" on the left menu and press "ENTER".

Then select "2" on the right menu.

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4.2 Control valve data menu

```

*****
*                                     *
*   CONTROL VALVE SIZING   *
*                                     *
*****

Options available :    1. DATA INPUT
                      2. DATA INQUIRY
                      3. RUN
                      4. OUTPUT INQUIRY

                      9. FINISH

Please key in the number of the option required :

```

- (1) Select "1" for data key in.
- (2) Select "2" for data inqiiry.
- (3) Select "3" in order to run the program.
- (4) Select "4" for output inquiry.
- (5) Select "9" for ending of program run, then return to previous screen.

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4.3 Data input

KFCVIN	01/03/91
FILE NAME: K7018ACV.DAT	CONTROL VALVE SIZING
JOB NO : K-7018	
JOB NAME : DCNA PLANT	CUST : KOREA EXPLOSIVES
	CODE : FCI
1.FUNC : I (I,R,Q,D,S)	2.REC NO : 1

TAG NO	: FV-101
KIND OF FLUID	: L (L:LIQ. G:GAS/VAPOR S:STEAM)
INLET PRESSURE	: 5. Kg/Cm ² G
DIFFERENTIAL PRESSURE	: 2. Kg/Cm ²
OPERATING TEMPERATURE	: 30. °C
SUPERHEAT DEGREE	: °C
MINIMUM FLOW RATE	: (LIQUID : M ³ /HR)
NORMAL FLOW RATE	: 120. (GAS/VAPOR : NM ³ /HR)
MAXIMUM FLOW RATE	: 300. (STEAM : KG/HR)
SPECIFIC GRAVITY	: 1. (H ₂ O = 1)
MOLECULAR WEIGHT	:
VISCOSITY	: 1. C.P.S
WEIGHT % OF	:
FLASHING PORTION	: 0.0 If not FLASHING, Enter 0.0
SKIP	: If Error Data , Enter "D"
-----COMMAND ? -----(1 , 2 , S:STOP)-----	
Record Writed	

(1) Key in file name,Job No & Name.

(2) User will be able to key in filename upto 6 characters except ____CV.DAT

(3) Function

- I:Input
- R:Revise
- Q:Query
- D>Delete
- S:Stop

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4.4 Data inquiry

KFCVIQ01/03/91

FILE NAME : K7018ACV.DAT

CONTROL VALVE SIZING INQUIRE

JOB NO : K-7018

JOB NAME : DCNA PLANT

CUST : KOREA EXPLOSIVES

CODE :

1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

FV 101

L

5.

2.

30.

120.

300.

1.

1.

0.0

-----COMMAND ?-----

(B:BACK N:NEXT S:STOP)-----

- (1) Select "2" on Control Valve data menu and then key in the file name.
- (2) The partial or total display of key-in data can be done with command "B" or "N".

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4.5 Program Run

- 2. DATA INQUIRY
- 3. RUN
- 4. OUTPUT INQUIRY

9. FINISH

Please key in the number of the option required : 3

Data File Name (예 : K3495SSV.DAT) : K7018ACV.DAT

Output file ----- K7018ACV.OUT

- RUNNING -

%DCL-I-SUPERSEDE, previous value of SYS\$INPUT has been superseded
FORTRAN STOP

1:LINE PRINT 2:LASER PRINT 3:NO PRINT

Please enter your selection (1-3)? :

- (1) Select "3" on control valve data menu for program run.
- (2) Key in data file name.
- (3) Output file name is as the screen.
- (4) When run is completed with no interruption, the message "Fortran Stop" displays.
- (5) If any error, the message "Float by Zero" displays. Recheck inputted data.
- (6) After completing the run, select print type on print menu.

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4.6 Output inquiry

```

*****
*                                     *
*   CONTROL VALVE SIZING           *
*                                     *
*****

Options available :      1. DATA INPUT
                        2. DATA INQUIRY
                        3. RUN
                        4. OUTPUT INQUIRY

                        9. FINISH

Please key in the number of the option required : 4

# Out File Name (예 : K3495SSV.OUT): : K7018ACV.OUT

```

- (1) Select "4" on control valve data menu.
- (2) Key in Output File Name and then press "ENTER".
- (3) "CTRL+S" for screen stop, "CTRL+Q" for release of "CTRL+S".
- (4) If any error, the program stops.

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4.7 Computer log out

```

SECL03      logged out at 21-DEC-1990 16:19:00.72
Accounting information:
Buffered I/O count:      2180      Peak working set size:      929
Direct I/O count:       586      Peak page file size:      3340
Page faults:            3129      Mounted volumes:           0
Charged CPU time:       0 00:00:13.44      Elapsed time:           0 00:09:04.40
Local -011- Session 1 disconnected from    V6420

```

Local>

(1) Select " 9" on control valve data menu, then previous screen displays.

(2) For Log-out, Key in "F20" in Vax terminal and "Shift+F10" in Personal computer.

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5. History

Rev. No.	Date of Rev.	Rev. page	Basis of revision
0	JUN. 20, 2013	Whole pages	- Establish environmental design criteria in accordance with SECL standard manual - Department : Environmental Engineering Dept. - Written by : Y.J.Yoon - Checked by : S.K.Kang - Approved by : Y.Y.Koo

Appendix 1 : Calculation Result Sample

APPENDIX I

SPD0008 EIE

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SAMSUNG ENGINEERING COMPANY LTD.

TAG-NO	FLUID	P1	PRESSURE DP	TEMPERATURE T	TEMPERATURE TS	MIN	FLOW RATE NOR	MAX	S.G	M.F	U	FS	MIN	CV	MAX
LV-9201	L	1.40	0.18	18.00	0.00	0.00	500.00	600.00	1.000	0.00	1.000	0.00	0.00	137532	1650.39
LV-9222	L	1.50	0.50	18.00	0.00	0.00	85.00	100.00	1.000	0.00	1.000	0.00	0.00	140.28	165.04
LV-9241	L	1.50	1.00	18.00	0.00	0.00	8.00	10.00	1.000	0.00	1.000	0.00	0.00	9.34	11.67
LV-9281	L	1.30	0.50	18.00	0.00	0.00	1.00	1.20	1.000	0.00	1.000	0.00	0.00	1.65	1.98
LV-9282	L	2.00	0.50	50.00	0.00	0.00	1.20	1.50	1.000	0.00	1.000	0.00	0.00	1.98	2.48
LV-9581	L	1.40	0.50	18.00	0.00	0.00	5.00	7.50	1.000	0.00	1.000	0.00	0.00	8.25	12.33
TV-9001	L	2.60	0.50	15.00	0.00	0.00	58.00	70.00	0.910	0.00	0.980	0.00	0.00	91.31	110.21
TV-9002	L	2.30	0.50	15.00	0.00	0.00	6.00	7.20	0.910	0.00	0.940	0.00	0.00	9.45	11.34
TV-9281	S	3.50	0.50	170.00	0.00	0.00	140.00	170.00	0.000	18.00	0.014	0.00	0.00	4.97	6.03
TV-9301	S	3.50	0.50	170.00	0.00	0.00	35.00	130.00	0.000	18.00	0.014	0.00	0.00	1.24	4.61
TV-9303	S	14.50	8.00	199.00	0.00	0.00	15000.00	25000.00	0.000	18.00	0.015	0.00	0.00	31.32	135.54
TV-9004A/B	G	5.00	4.30	30.00	0.00	0.00	90.00	0.00	0.000	28.00	0.020	0.00	0.00	1.09	0.00
TV-9005A/B	G	0.70	0.30	30.00	0.00	0.00	70.00	0.00	0.000	28.00	0.020	0.00	0.00	4.68	0.00
TV-8501	G	5.00	0.50	18.00	0.00	0.00	0.00	600.00	0.000	28.00	0.018	0.00	0.00	0.00	15.48
TV-9001	L	8.20	0.50	30.00	0.00	0.00	110.00	130.00	0.800	0.00	0.810	0.00	0.00	162.38	191.90
TV-9002	L	8.70	0.50	10.00	0.00	0.00	105.00	130.00	0.910	0.00	0.980	0.00	0.00	165.31	204.67
TV-9003	L	7.50	0.50	10.00	0.00	0.00	120.00	144.00	0.650	0.00	0.170	0.00	0.00	159.67	191.60
PCV-9003	L	10.00	0.50	10.00	0.00	0.00	120.00	140.00	0.640	0.00	0.170	0.00	0.00	158.44	184.84

FLUID L: LIQUID(M3/H) S: STEAM(M3/H) G: GAS(M3/H) V: VAPOR(M3/H)