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	6.3 Sim	ulation a	and Pre	diction	of Cont	aminatio	) <b>n</b>
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				보고다 한 번째로 가지 나타를 보고하게 하는 것은
$\mathbf{\Omega}$				
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			ressions	

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#### 1. Introduction

The purpose of the MSF-2 is to estimate the quality of the product water in case when the oil contaminated seawater has been fed into the MSF Plant. It has been done through the investigation on the quantitative analysis of the evaporation phenomena of the volatile organic contaminants in the feed sea-water.

The quality of seawater in the Arabian Gulf has been surveyed and reported in 6.1.1. The volatility mechanisms of oil and bromoform, a kind of trihalomethane, has been investigated by preparative experiment and reported in 6.1.2.

The Henry's constant of bromoform in brine, which is the basic physical property necessary for the quantitative analysis of dilute solution, has been measured by the "Vapor/Liquid Equilibrium Experimental Apparatus". The results are reported in 6.2. The Henry's constant obtained in 6.2 showed good agreement with that of 6.1.2. Thus, the Henry's constant, as a function of temperature obtained by 6.2, has been used for the computer simulation.

The flow chart and the formula used for the computer simulation of the evaporation of the organic contaminants in brine are described in this section based on the evaporation mechanisms shown in 6.1 and 6.2.

As this simulation is of the first order estimation, this calculates the amount of evaporated oil and/or bromoform in the MSF test plant but does not include the calculation for the amount of oil and/or bromoform in the product water.

The oil carried-over from the brine can be estimated by the computer program shown in 6.3.2. However, not all of the carried-over oil goes into the product water. Certain amount of the oil will be exhausted out of the system from the ejector, but the unknown factors still remains for the quantitative estimation of the process.

#### 2. Precondition for the computer program

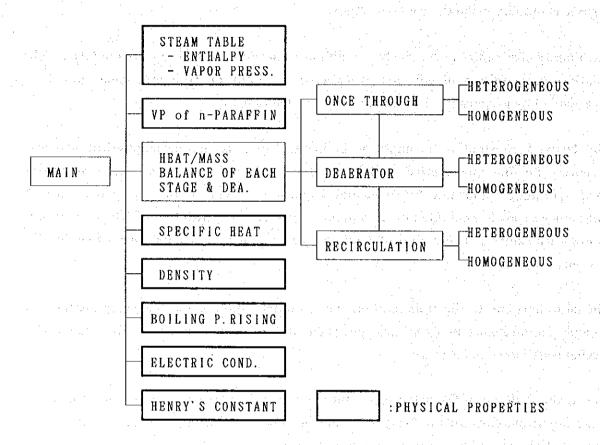
The precondition for the computer program should be the program which can run on the computer owned by SWCC. To satisfy this precondition, followings are taken into account.

HARD WARE : PC type IBM Compatible, 486 based machines operating

• SOFT WARE : FORTRAN Language

• HD Space : less than 200MB

## 3. Structure of the Program



# 4. How to Set Up Symbols for the Formulas

# 4.1 Fundamental rule for setting up the above mentioned symbols

I	II	Ш	IV

• <b>I</b> • •	F: Flow rate of brine, wate	r & contaminants	(kg/h)
	C:Concentration of the con	stituents	(kg/L)
	T:Temperature		(C)
55 3	P:Pressure		(Pa)
	S:Electric conductivity		(S/cm)
	X:Mole fraction		
П	B:Seawater, brine		
	W:Water		
	O:Aliphatic hydrocarbonic	& homogeneous contain	minants
M	E:Vapor generated by evap	poration & distillation	
	L:Liquid (Water, seawater	, brine)	
	M:Liquid (Contaminants t	o be dosed)	
	S:Solid that phase change	do not occures by heating	ng, etc.
IV	M:Make-up	D:Inlet of deaerator	
	T:Outlet of Last stage	G:Outlet of dea	erator
	C:Recirculation brine	1:#1 stage	4:#4 stage
	B:Blow brine	2:#2 stage	5:#5 stage
	O:Outlet of brine heater	3:#3 stage	6:#6 stage

# 4.2 Physical properties, etc. (The symbols are not treated the same as a fundamental rule)

D	:	Density	(kg/L)
H	:	Henry's constant	$\{mol/(L^{\bullet}Pa)\}$
ENT	:	Enthalpy	(kJ/kg)
CP	:	Specific heat	$\{kJ/(kg^{\bullet}C)\}$
MW, MO	:	Molecular weight of water & contaminants	
EC	:	Electric conductivity of the brine at 25 O C	(S/cm)
ONTD		Overall NETD	<b>(C)</b>
NTD	:	NETD based on the equipment structure	(C)
BPR		Boiling point rising	(C)
N		Number of carbons of paraffin (Aliphatic hydroca	rbon)

# 4.3 Symbols which are Added on the Top or the End of Four Figures

'A' added on the top : The assumed value & the value obtained by the

convergence caluculation

'B' added on the top : The final results obtained by assuming the A

'NE' added on the top : The value of #6 stage obtained by calculation

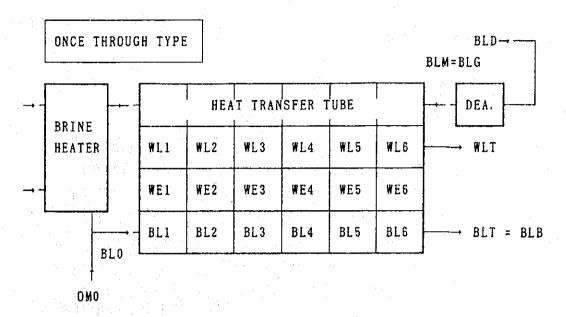
based on the once through type

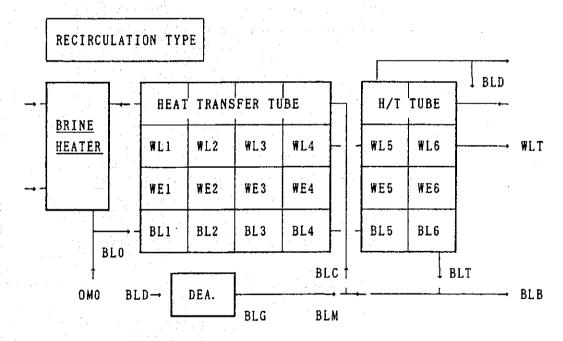
'BB' added on the top : The final results obtained by the 'NE'

'1...9, a...z' added on the end : Number of carbons in paraffin, where,

'a···z' indicate the number of carbons 10···35

## 4.4 Flow of MSF Test Plant and Symbols of II, III, IV Groups





#### HEAT RECOVERY SECTION HEAT REJECTION SECTION

(FUNDAMENTAL MASS BALANCE OF MSF PROCESSES)

 $FBLM = FBLB + FWLT + \alpha$ 

(FBLM)(CBLM) = (FBLB)(CBLB)

FBLB = FBLM(CBLM/CBLB) = FBLM - FWLT

Where,  $\alpha$  indicates the amount of non-condensible gasses.

#### 5. Flow Chart

#### 5.1 Heat & Mass Balance

## 5.1.1 Once Through/Recirculation Type

```
START
1-1 GIVEN CONDITION -1 (OPERATION CONDITION)
  -Brine Flow Rate ex BH
                                     FBL0:
                                            (KG/H)
  -Brine Temp. ex BH
                                     TBL0
                                                (C)
  -Steam Temp, in each stage
                                     TWE1-6
                                                (C)
1-2 GIVEN CONDITION -2 (ELECTRIC CONDUCTIVITY)
  -Brine E. Conductivity ex BH
                                    SBLO
                                            (S/CM)
  -E Conduct. in each stage
                                    SBL1-6 (S/CM)
                        \diamondsuit \leftarrow \text{S/R} \text{ (ELECRIC COND. -TDS)}
2 Brine TDS Conc. ex BH
                                    CBSO (KG/L)
  Brine TDS Conc. in each stage
                                    CBS1-6(KG/L)
                        3. Steam pressure in each stage
                                    PWE1-6
                                             (PA)
4. Assume ONETD for each stage
                                     AONTD
                                               (C)
5. Brine Temp. in each stage
                                     ATBL1-6
                                               (C)
6. B. T. Difference between stages \triangle ATBL1-5 (C)
                        \diamondsuit \leftarrow S/R (CP, ENT, D)
7. Eva. rate in each stage
                                    AFWE1-6(KG/H)
  Brine TDS Conc. in each stage
                                    ACBS1-6 (KG/L)
          ( KACBS-CBS | / | CBS D ≤ 0.01
                 YES
                           ←S/R (BPR)
8. NETD based on equipment structure
                                        NTD1-6(C)
9. Set following values for each stage
 · Steam pressure
                                    PWE1-6 (PA)
 · Brine temperature
                                  .. TBL1-6
                                               (C)
 · Evaporation rate of brine
                                 FWE1-6 (KG/H)

    TDS concentration of brine

                                    CBS1-6 (KG/L)

    NETD based on equip structure NTD1-6
```

(Go to calculation for carryover estimation)

#### 5.1.2 Deaerator

START 1-1 GIVEN CONDITION -1 (OPERATION CONDITION) -Make-up Flow Rate at dea.inlet FBLD (KG/H) -Make-up Temp, at dea, inlet (C) -Make-up Temp. at dea. outlet (C) TBLG 1-2 GIVEN CONDITION -2 (ELECTRIC CONDUCTIVITY) -Make-up E. Conduct. at dea.inlet SBLD (S/CM) 2. Make-up TDS conc. at dea.inlet CBSD (KG/L) S/R (BPR)  $\rightarrow \diamondsuit$   $\leftarrow S/R$  (STEAM TABLE) PWEG (PA) 3. Steam pressure at dea. inlet Difference between dea.  $in/out \triangle TBLG(C)$  $\diamondsuit \leftarrow S/R (CP, ENT, D)$ 7. Eva. rate at dea. FWEG (KG/H) 9. Set following values at Deaerator · Steam pressure PWEG (PA) · Evaporation rate in Deaerator FWEG (KG/H) · Make-up Flow Rate at dea.outlet FBLG (KG/H) · TDS concentration of make-up CBSg (KG/L)

## 5.2 Carryover Estimation of Contaminants

## 5.2.1 Once Through Type

```
START
                    1-1. GIVEN CONDITION -1
              · Once through type.
                                                   : 1
              · In case of hetero-contaminants
              · In case of homo-contaminant
                    1-2. GIVEN CONDITION -2
     · Brine flow rate
                                                 FBLM=FBLO(KG/H)
     · Make-up concentration of contaminants COMM=COMO(KG/L)
     · Constituent ratio in the crude oil
                                                             (%)
     · Conc. of constituents in the crude oil COMM=COMO(KG/L)
                            \diamondsuit \rightarrow \mathsf{Calculation} for CHBr<sub>3</sub> (OPTION 2)
         (OPTION 1)
Calculation for crude oil \diamondsuit \leftarrow S/R (Vapor pressure of n-Paraffin)
    2. The below mentioned physical properties
     · Molecular weight of paraffin
                                                         MO
                                                              (-)
     · Vapor Pressure of paraffin
                                                             (PA)
                            3-1-1 n-Paraffin Flow Rate ex BH
                                                   FOM0
                                                           (KG/H)
          Mole Fraction of Consutituents
                                                   XOM11-z
                                                              (-)
           Vaporization rate of paraffin in #1 FOE11-z(KG/H)
    3-1-2 Find constituents finishing vaporization in #1
                            \Diamond \rightarrow (Exclude the constituents finishing
                                 vaporization in #1 stage)
    3-2-1 n-Paraffin Flow Rate at #1 outlet
                                                   FOM1
          Mole Fraction of Constituents
                                                   XOM21-z
          Vaporizationn rate of paraffin in #2 FOE21-z(KG/H)
    3-2-2 Find constituents finishing vaporization in #2
                            \diamondsuit \rightarrow (Exclude the constituents finishing)
                                 vaporization in #2 stage)
         Repeat the same calculation until the #6 stage
     4. Vaporization rate of paraffin in #1-#6
                                                    FOE1-6(KG/H)
                               \leftarrow S/R (H1 to H6, MO)
```

2. The below mentioned	physical propert	ies	
· Molecular weight		M O	(-)
· HENRY's constant		Н (	MOL/L PA)
	→ HEAT & MASS B	ALANCE	
3-1 Bromoform Flow Rat	e ex BH	FOM	0 (KG/H)
Vaporization rate	of Bromoform in	#1 F0E	1 (KG/H)
3-2 Bromoform Flow Rat	e at #1 outlet	FOM	0 (KG/H)
Vaporization rate	of Bromoform in	#2 F0E	2 (KG/H)
Repeat the same ca	lculation until	the #6 s	tage
4. Vaporization rate of HEAT & MASS BALANCE→		-#6 FOE1	-6 (KG/H)
5. Carryover concentrat ‡6 stage outlet This value is cal	ion in the each		
values:     Brine evaporation r     Vaporization rate o			-6 (KG/H)
and bromoform in ea			-6 (KG/H)

#### 5.2.2 Recirculation Type

```
START
              1-1. GIVEN CONDITION -1
        · Recirculation Type
        · In case of hetero-cntaminants
                                            : 1
        · In case of homo-cntaminant
                1-2. GIVEN CONDITION -2
 · Make-up flow rate
                                             FBLM
                                                     (KG/H)
 · Recirculation brine flow rate
                                             FBLC
                                                     (KG/H)
· Make-up concentration of contaminants COMM
                                                     (KG/L)
 · Constituent ratio in the crude oil
                                                      (%)
 · Conc. of constituent in the crude oil COMM
                                                     (KG/L)
                      ♦ ← HEAT & MASS BALANCE
                  2. MASS BALANCE
 · Product water flow rate
                                             FWLT
                                                     (KG/H)
 · Blow brine flow rate
                                            FBLB
                                                     (KG/H)
                      \Diamond \rightarrow \text{Calculation for CHBr}_3 (OPTION 2)
   (OPTION 1)
HEAT & MASS BALANCE \rightarrow \diamondsuit \leftarrow S/R (Vapor pressure of n-Paraffin)
       3. The below mentioned physical properties
 · Molecular weight of paraffin
                                                       (MD)
 · Vapor pressure of paraffin
                                                       (PA)
4. Constituent calculated by method of once through
  type in #6 stage
                                              NEFOMC(KG/H)
5-1-1 n-Paraffin Flow Rate ex BH
                                            FOMO(KG/H) | #1 st.
     Mole Fraction of constituents
                                            XOM11-z(-)
     Vaporization rate of paraffin in #1 FOE11-z(KG/H)
        Find constituents finishing vaporization in $1
                      \diamond \rightarrow (Exclude the constituents finish-
                           ing vaporization in #1 stage)
5-2-1 n-Paraffin Flow Rate at #2 inlet FOM1(KG/H) | #2 st.
    Mole Fraction of constituents
                                           XOM21-z(-)
    Vaporization rate of paraffin in #2 FOE21-z(KG/H)
```

```
Find constituents finishing vaporization in #2
                    ♦ → (Exclude the constituents finish-
                         ing vaporization in #2 stage)
   Repeat the same calculation until #6 stage
6. n-Paraffin concentration at #6 outlet
                                             COMT (KG/L)
7. n-Paraffin Flow Rate in blow brine
                                             FOMB(KG/H)
8, n-Paraffin Flow Rate in Recir. brine
                                           BBFOMC(KG/H)
     | NEFONC-BBFONC | / | NEFONC | ≤ 0.01 -

    ← HEAT & MASS BALANCE

            YES
9. n-Paraffin vaporized Rate in each stage FOE1-6(KG/H)
                      \leftarrow S/R (H1 to H6, M0)
      3. The below mentioned physical properties
                                                     (-)
· Molecular weight
                                           H (MOL/L PA)
· HENRY's constant
4. Constituents calculated by method of once through
                                           NEFOMC(KG/H)
 type in $6 stage
                                       FOMO(KG/H) #1 st.
5-1 Bromoform Flow Rate ex BH
    CARRYOVER Constant at #1 stage
                                           R1 (-) L
   Vaporization rate of Bromoform in #1 FOE1(KG/H)
                                       FOM1 (KG/H)
5-2, Bromoform Flow Rate at #2 inlet
                                           R2 (-) L
    CARRYOVER Constant at #2 stage
    Vaporization rate of Bromoform in #2
                                           FOE2(KG/H)
   Repeat the same calculation until #6 stage
6. Bromoform concentration at #6 outlet
                                             COMT(KG/L)
7. Bromoform Flow Rate in blow brine
                                             FOMB(KG/H)
                                           BBFOMC(KG/H)
8. Bromoform Flow Rate in Recir. brine
     | NEFONC-BBFOMC | / | NEFOND | ≤ 0.01 -
```

## 9. Bromoform vaporization Rate in each stage FOE1-6(KG/H)

## HEAT & MASS BALANCE → ♦

10. Carryover concentration in the each stage(\$1-\$6) & \$46\$ stage outlet

This value is calculated from the below mentioned values:

- · Brine evaporation rate in each stage FWE1-6 (KG/H)
- Vaporization rate of the both paraffin and bromoform in each stage.
   FOE1-6 (KG/H)

#### 5.2.3 Deaerator

```
START
                  1-1. GIVEN CONDITION -1
             · Deaerator
             • In case of hetero-contaminants : 1
             · In case of homo-contaminant
                  1-2. GIVEN CONDITION -2
                                                    FBLD(KG/H)
    · Brine flow rate
    · Make-up concentration of contaminants
                                                    COMD(KG/L)
    · Constituent ratio in the crude oil
                                                    COMP (%)
                                                    COMD(KG/L)
     · Conc. of constituents in the crude oil
                         \Diamond \rightarrow Calculation for CHBr<sub>3</sub> (OPTION 2)
        (OPTION 1)
Calculation for crude oil \diamondsuit \leftarrow S/R (Vapor pressure of n-Paraffin)
    2. The below mentioned physical properties
                                                            (-)
    · Molecular weight of paraffin
                                                      MO
                                                      POED (PA)
     · Vapor Pressure of paraffin

    ← HEAT & MASS BALANCE

    3-1-1 n-Paraffin Flow Rate at dea.inlet
                                                 FOMD
                                                         (KG/H)
          Mole Fraction of Consutituents
                                                 XOMD1-z
                                                            (-)
          Vaporization rate of paraffin in dea. FOED1-z(KG/H)
    3-1-2 Find constituents finishing vaporization in dea.
                           \diamond \rightarrow (Exclude the constituents finishing
                                vaporization in dea.)
    3-2-1 n-Paraffin Flow Rate at dea outlet
                                                   FOMG (KG/H)
          Mole Fraction of Constituents
                                                   XOMG1-z (-)
                           2. The below mentioned physical properties
                                                  МO
                                                            (-)
      · Molecular weight
      · HENRY's constant
                                                  H (MOL/L PA)
                           3-1 Bromoform Flow Rate at dea. inlet
                                                         (KG/H)
         Vaporization rate of Bromoform in dea. FOED
                                                        (KG/H)
     HEAT & MASS BALANCE→♦
```

5. Concentration of the both paraffin and bromoform in the dearator outlet : COMM1-Z

This value is calculated from the below mentioned values:

- · Brine evaporation rate in deaerator FWEG (KG/H)
- · Vaporization rate of the both paraffin
  - and bromoform in deaerator FOEG1-z(KG/H)

The formulas adopted for Calculation/Estimation

# The formulas adopted for Heat/Mass Balance Calculation PWE1~PEW6 (Steam Pressure in each stage) (PA) Eash value read corresponds to from TWE1 to TWE6 of the STEAM TABLE (2) ONTD1~ONTD6 (Overall NETD for each stage) **(C)** AONTD = ATBL - TWE = $0 \sim +5.0$ **(C)** TBL1~TBL6 (Brine Temp. in each stage) **(C)** ATBL1-6 = TWE1-6 + AONTD1-6 $\triangle$ ATBL (Temperature difference of brine between this stage and the preceding stage) **(C)** $\triangle$ ATBL1 = TBL0 - ATBL1 $\triangle$ ATBL2 = ATBL1 - ATBL2 $\triangle$ ATBL3 = ATBL2 - ATBL3 $\triangle$ ATBL4 = ATBL3 - ATBL4 $\triangle$ ATBL5 = ATBL4 - ATBL5 $\triangle$ ATBL6 = ATBL5 - ATBL6 **AFWE** (Evaporation flow rate in each stage) $(KG/H)(KJ/KG \cdot C)(C)/(KJ/KG) = (KG/H)$ $AFWE1 = (FBL0)(CP1)(\triangle ATBL1/ENT1)$ $AFWE2 = (AFBL1)(CP2)(\triangle ATBL2/ENT2)$ $AFWE3 = (AFBL2)(CP3)(\triangle ATBL3/ENT3)$ $AFWE4 = (AFBL3)(CP4)(\triangle ATBL4/ENT4)$ $AFWE5 = (AFBL4)(CP5)(\triangle ATBL5/ENT5)$ $AFWE6 = (AFBL5)(CP6)(\triangle ATBL6/ENT6)$ AFWLT = AFWE1+AFWE2+AFWE3+AFWE4+AFWE5+AFWE6 (Flow rate of produced water) AFBL (Brine flow rate in each stage) (KG/H)

AFBL1 = FBLO - AFWE1

AFBL2 = AFBL1 - AFWE2

AFBL3 = AFBL2 - AFWE3

AFBL4 = AFBL3 - AFWE4

AFBL5 = AFBL4 - AFWE5

AFBL6 = AFBL5 - AFWE6

AFBLT = AFBL6 (Brine flow rate in the last stage)

## (7) CBS (Concentration of TDS in each stage)

(KG/L)(KG/H)(H/KG)(KG/L)(L/KG)=(KG/L)

ACBS1 = CBS0(FBL0/AFBL1)(DB1/DB0)

ACBS2 = ACBS1(AFBL1/AFBL2)(DB2/DB1)

ACBS3 = ASBS2(AFBL2/AFBL3)(DB3/DB2)

ACBS4 = ACBS3(AFBL3/AFBL4)(DB4/DB3)

ACBS5 = ACBS4(AFBL4/AFBL5)(DB5/DB4)

ACBS6 = ACBS5(AFBL5/AFBL6)(DB6/DB5)

ACBST = ACBS6 (TDS Concentration in the last stage)

## (8) CONVERGENCE CALCULATION

The difference between TWE and TBL during the normal operation is due to three reasons: the first is the temperature distribution of both phases (gaseous and liquid at the stage), the second is BPR and the third is the diversion from the equilibrium based on the equipment structure.

Generally speaking, this diversion is defined by the name of ONETD (Symbol:ONTD) and its value is obtained by convergence calculation.

- a) Caluculate values of ACBS1 $\sim$ ACBS6, assume ONTD = 0 at stage #1.
- b) Compare the results of (1) with proceeding data from CBS1 to CBS6.
- c) Try the convergence calculation going down the ratio of the difference between ACBS and CBS within 1 %.
- d) Obtain the values of TBL1~TBL6 from the convergent ONTD.

#### (9) **NETD**

Divide ONTD into the parts: BPR and that based on the equipment structure.

NTD1-6 = ONTD1-6 - BPR1-6

 $BPR1-6 = f(CBS.TBL) \cdots S/R$ 

#### 6.2 The Formulas added for Carryover Estimation

## 6.2.1 Heterogeneous, Once Through Type

```
(1)
   XOM (Mole fraction of paraffin consisted of 35 kinds <1-9, A-Z>)
    XOM11-z
      XOM11=(COM01/MO1)/\{(COM01/MO1)+\cdots+(COM0z/MOz)\}
      XOM1a=(COM0a/MOa)/\{(COM01/MO1)+\cdots+(COM0z/MOz)\}
       XOM1z=(COM0z/MOz)/\{(COM01/MO1)+\cdots+(COM0z/MOz)\}
    XOM21-z
       XOM21 = (COM11/MO1)/\{(COM11/MO1) + \cdots + (COM1z/MOz)\}
       XOM2a = (COM1a/MOa)/\{(COM11/MO1) + \cdots + (COM1z/MOz)\}
       XOM2z = (COM1z/MOz)/\{(COM11/MO1) + \cdots + (COM1z/MOz)\}
     XOM31-z
       XOM31=(COM21/MO1)/\{(COM21/MO1)+\cdots+(COM2z/MOz)\}
       XOM3a = (COM2a/MOa)/\{(COM21/MO1) + \cdots + (COM2z/MOz)\}
       XOM3z = (COM2z/MOz)/\{(COM21/MO1) + \cdots + (COM2z/MOz)\}
     XOM41-z
       XOM41=(COM31/MO1)/\{(COM31/MO1)+\cdots+(COM3z/MOz)\}
       XOM4a = (COM3a/MOa)/\{(COM31/MO1) + \cdots + (COM3z/MOz)\}
       XOM4z=(COM3z/MOz)/\{(COM31/MO1)+\cdots+(COM3z/MOz)\}
     XOM5-z
       XOM51=(COM41/MO1)/\{(COM41/MO1)+\cdots+(COM4z/MOz)\}
       XOM5a=(COM4a/MOa)/\{(COM41/MO1)+\cdots+(COM4z/MOz)\}
       XOM5z=(COM4z/MOz)/\{(COM41/MO1)+\cdots+(COM4z/MOz)\}
     XOM6-z
       XOM61=(COM51/MO1)/\{(COM51/MO1)+\cdots+(COM5z/MOz)\}
       XOM6a=(COM5a/MOa)/\{(COM51/MO1)+\cdots+(COM5z/MOz)\}
       XOM6z=(COM5z/MOz)/\{(COM51/MO1)+\cdots+(COM5z/MOz)\}
   FOE, FOM (Evaporation/Flow rate of paraffin in each stage)
                                                                      (KG/H)
       FOE11-z = (XOM11-z)(R11-z)(FWE1), FOM11-z = FOM01-z - F0E11-z
       FOE21-z = (XOM21-z)(R21-z)(FWE2), FOM21-z = FOM11-z - F0E21-z
       FOE31-z = (XOM31-z)(R31-z)(FWE3), FOM31-z = FOM21-z - F0E31-z
       FOE41-z = (XOM41-z)(R41-z)(FWE4), FOM41-z = FOM31-z - F0E41-z
```

FOE51-z = (XOM51-z)(R51-z)(FWE5), FOM51-z = FOM41-z - F0E51-z

```
FOE61-z = (XOM61-z)(R61-z)(FWE6), FOM61-z = FOM51-z - F0E61-z
```

(3) COM (Paraffin concentration in the brine at each stage)

(The symbols '1' through 'z' were omitted.)

 $(KG/L)\{(KG/H)(KG/L)(L/KG)-(KG/H)\}/(KG/H)=(KG/L)$ 

COM1=DB1(FBL0 · COM0/DB0 - FOE1)/FBL1

COM2=DB2(FBL1 · COM1/DB1 - FOE2)/FBL2

COM3=DB3(FBL2 · COM2/DB2 - FOE3)/FBL3

COM4=DB4(FBL3 · COM3/DB3 - FOE4)/FBL4

COM5=DB5(FBL4 · COM4/DB4 - FOE5)/FBL5

COM6=DB6(FBL5 · COM5/DB5 - FOE6)/FBL6

(4) COE (Paraffin concentration in the product water at each stage)

(The symbols '1' through 'z' for 'COE' & 'FOE' were omitted.)

(KG/H)/(KG/H)(KG/L)=(KG/L)

COE1=(FOE1/FWE1)(DW1)

COE2={(FOE1+FOE2)/FWE1+FWE2)} DW2

COE3={(FOE1+FOE2+FOE3)/(FWE1+·····+FWE3)} DW3

COE4={(FOE1+FOE2+FOE3+FOE4)/(FWE1+·····+FWE4)} DW4

COE5={(FOE1+FOE2+FOE3+FOE4+FOE5)/(FWE1+······FWE5)} DW5

COE6={(FOE1+FOE22+FOE3+FOE44+FOE5+FOE6)/(FWE1+·····+FWE6)} DW6

(5) R (CARRYOVER'S CONSTANTS)

R11-z = (M01-z/MW)(POE11-z/PWE1)

R21-z = (M01-z/MW)(POE21-z/PWE2)

R31-z = (M01-z/MW)(POE31-z/PWE3)

R41-z = (M01-z/MW)(POE41-z/PWE4)

R51-z = (M01-z/MW)(POE51-z/PWE5)

R61-z = (M01-z/MW)(POE61-z/PWE6)

MW = 18.02

MO1-z = 14.027N + 2.016

PWE: STEAM TABLE

POE11-z: Be calculated by using ANTOINE'S equation.

POE21-z: Be calculated by using ANTOINE'S equation.

POE31-z: Be calculated by using ANTOINE'S equation.

POE41-z: Be calculated by using ANTOINE'S equation.

POE51-z: Be calculated by using ANTOINE'S equation. POE61-z: Be calculated by using ANTOINE'S equation.

### 6.2.2 Homogeneous, Once Through Type

(1) FOE, FOM: Be the same equation in case of 'HETEROGENEOUS'. However, the symbols '1' through 'z' were not necessary.

(2) COM: Be the same equation in case of 'HETEROGENEOUS'. However, the symbols '1' through 'z' were not necessary.

(3) COE : Be the same equation in case of HETEROGENEOUS'. However, the symbols '1' through 'z' were not necessary.

(4) R (CARRYOVER'S CONSTANTS)

R1=(MO/MW)(POE1/PWE1)

R2=(MO/MW)(POE2/PWE2)

R3=(MO/MW)(POE3/PWE3)

R4=(MO/MW)(POE4/PWE4)

R5=(MO/MW)(POE5/PWE5)

R6=(MO/MW)(POE6/PWE6)

MW=18.02 (Molecular weight of  $H_2O$ )

MO=252.718 (Molecular weight of CHBr<sub>3</sub>)

**PWE:STEAM TABLE** 

 $POE1=1000 \cdot COM0/(H1 \cdot MO) \qquad (KG/L)/\{(KG/MOL)(MOL/L)(1/PA)\}=(PA)$ 

POE2=1000 · COM1/(H2 · MO)

POE3=1000 · COM2/(H3 · MO)

POE4=1000 · COM3/(H4 · MO)

POE5=1000 • COM4/(H5 • MO)

POE6=1000 · COM5/(H6 · MO)

## 6.2.3 Heterogeneous, Recirculation Type

(1) MASS BALANCE

FBLB = FBLM - FWLT = FBLM(CBLM/CBLB)

FWLT (value obtained by 5 in 5.1)

(2) R (CARRYOVER's constant)

 $R11-z = (MO1-z)(POE11-z)/{(MW)(PWE1)}$ 

R21-z = (MO1-z)(POE21-z)/((MW)(PWE2))

 $R31-z = (MO1-z)(POE31-z)/{(MW)(PWE3)}$ 

 $R41-z = (MO1-z)(POE41-z)/{(MW)(PWE4)}$ 

 $R51-z = (MO1-z)(POE51-z)/{(MW)(PWE5)}$ 

 $R61-z = (MO1-z)(POE61-z)/{(MW)(PWE6)}$ 

MO = 14.027N + 2.016, MW = 18.02

POE: Be calculated by using ANTOINE'S equation

**PWE: STEAM TABLE** 

(3) FOMM (Dosing rate of paraffin)

(KG/L)(KG/H)(L/KG)=(KG/H)

FOMM1-z = (COMM1-z)(FBLM)(1/DBT)

(4) NEFOMC (Constituent flow rate calculated by method of once through type in #6 stage)

MAX.NEFOMC1-z = (COMM1-z)(1/DBT)(FBLM) (KG/L)(L/KG)(KG/H)=(KG/H) MIN. NEFOMC1-z = 0

- (5) Mass balance in each stage
- (5)-1 #1 stage
- (5)-1-1 FOM0 (n-Paraffin flow rate ex brine heater)

(KG/H)

MAX. : FOM01-z = (FOMM1-z) + (NEFOMC1-z)

MTN. : FOM01-z = (F0MM1-z)

(5)-1-2 XOM11-z (Mole fraction of constituents at #1 stage)

 $XOM11 = (COM01/MO1)/\{(COM01/MO1)+\cdots+(COM0z/MOz)\}$ 

 $XOM1a = (COM0a/MOa)/\{(COM01/MO1)+\cdots + (COM0z/MOz)\}$ 

 $XOM1z = (COM0z/MOz)/\{(COM01/MO1)+\cdots+(COM0z/MOz)\}$ 

(5)-1-3 FOE1, FOM1 (Vaporization rate of paraffin at #1 stage)

(KG/H)

FOE11 = (XOM11)(R11)(FWE1)

FOM11 = FOM01 - F0E11

FOE1a = (XOM1a)(R1a)(FWE1)

FOM1a = FOM0a - F0E1a

FOE1z = (XOM1z)(R1z)(FWE1)

FOM1z = FOM0z - F0E1z

(5)-1-4  $\triangle$ FOM1 (Exclude the constituents finishing vaporization at #1 stage)

 $\triangle$ FOM11 = FOM01 - FOM11

 $\triangle$ FOM1a = FOM0a - FOM1a

 $\triangle$ FOM1z = FOM0z - FOM1z

No calculation for the below #2 stage is carred out about each paraffin which is  $\triangle FOM1 \ge FOM0$ .

(5)-2 #2 stage

If calculation results for praffin until N = 9 are FOM1 $\geq$ FOM0, each formula are as follows:

(5)-2-1 FOM1 (n-Paraffin flow rate at #2 inlet)

(KG/H)

The value is the same as FOM1a-z obtained by 5-1-3.

(5)-2-2 XOM2a-z (Mole fraction of constituents at #2 stage)

 $XOM2a = (COM1a/MOa)/\{(COM1a/MOa) +$ 

+ · · · · · + (COM1z/MOz)}

 $XOM2i = (COM1i/MOi)/\{(COM1a/MOa) + \cdots + (COM1z/MOz)\}$ 

 $XOM2z = (COM1z/MOz)/\{(COM1a/MOa) + \cdots + (COM1z/MOz)\}$ 

(5)-2-3 FOE2, (Vaporization rate of paraffin at #2 stage)

(KG/H)

FOE2a = (XOM2a)(R2a)(FWE2)

FOM2a = FOM1a - F0E2a

FOE2i = (XOM2i)(R2i)(FWE2)

FOM2i = FOM1i - F0E2i

FOE2z = (XOM2z)(R2z)(FWE2)

FOM2z = FOM1z - F0E2z

(5)-2-4  $\triangle$ FOM2 (Exclude the constituents finishing vaporization at #2 stage)

 $\triangle$ FOM2a = FOM1a - FOM2a

 $\triangle$ FOM2i = FOM1i - FOM2i

 $\triangle$ FOM2z = FOM1z - FOM2z

No calculation for the below #2 stage are carried out about each paraffin which is △FOM2≥FOM1.

Repeat the same calclation until #6 stage

(6) COMT (n-Paraffin concentration at #6 stage) (KG/L)(KG/H)/(KG/H) = (KG/L)Calculation for #6 stage outlet is carried out about each paraffin (N = i - z) which is excepted on N = 1 - h changing into  $\triangle AFOM6 \ge AFOM5$ .

COMTi = (DBT)(FOM6i)/(FBL0 - FWET)

COMTk = (DBT)(FOM6k)/(FBL0 - FWET)

COMTz = (DBT)(FOM6z)/(FBL0 - FWET)

 $COMT = (COMTi) + \cdots + (COMTz)$ 

(7) FOMB (n-Paraffin flow rate in blow brine)

(KG/L)(KG/H)/(KG/L)=(KG/H)

FOMBi = (COMTi)(FBLB)/(DBT)

FOMBk = (COMTk)(FBLB)/(DBT)

FOMBz = (COMTz)(FBLB)/(DBT)

 $FOMB = (COMTi) + \cdots + (FOMTz)$ 

(8) BBFOMC (n-Paraffin flow rate in recirculation brine)

BBFOMCi = (FOM6i) - (FOMBi)

BBFOMCk = (FOM6k) - (FOMBk)

BBFOMCz = (FOM6z) - (FOMBz)

 $BBFOMC = (FOM6i) + \cdots + (FOMCz)$ 

(9) FOMCi-z (Convergence calculation)

| NEFOMCi-BBFOMCi | / | NEFOMCi | ≤0.01

| NEFOMCk-BBFOMCk | / | NEFOMCk | ≤0.01

 $| NEFOMCz - BBFOMCz | / | NEFOMCz | \leq 0.01$ 

However, it is necessary to be satisfied the formulas calculating the below shown values.

XOM11-z

XOM21-z

XOM31-z

XOM41-z

## XOM51-z XOM61-z

(10) COE1-6 (Concentration on the assumption that all of paraffin carring over is dissolved in the evaporated water.)

(KG/H)(KG/L)/(KG/H)=(KG/L)

COE1 = (FOE1/FWE1)(DW1)

 $COE2 = \{(FOE1+FOE2)/(FWE1+FWE2)\} DW2$ 

 $COE3 = \{(FOE1+FOE2+FOE3)/(FWE1+\cdots+FWE3)\} DW3$ 

 $COE4 = \{(FOE1+FOE2+FOE3+FOE4)/(FWE1+\cdots\cdot FWE4)\} DW4$ 

 $COE5 = \{(FOE1+FOE2+FOE3+FOE4+FOE5)/(FWE1+\cdots\cdots+FWE5)\} DW5$ 

 $COE6 = \{(FOE1+FOE22+FOE3+FOE44+FOE5+FOE6)/(FWE1+\cdots+FWE6)\} DW6$ 

= COET (n-Paraffin concentration in the product water)

### 6.2.4 Homogeneous, Recirculation Type

(1) MASS BALANCE

FBLB = FBLM - FWLT = FBLM(CBLM/CBLB)

FWLT (value obtained by 5 in 5.1)

- (2) R (CARRYOVER'S constant)
- $(2)-1 R1 = (MO)(POE1)/{(MW)(PWE1)}$

 $R2 = (MO)(POE2)/\{(MW)(PWE2)\}$ 

 $R3 = (MO)(POE3)/{(MW)(PWE3)}$ 

 $R4 = (MO)(POE4)/\{(MW)(PWE4)\}$ 

 $R5 = (MO)(POE5)/\{(MW)(PWE5)\}$ 

 $R6 = (MO)(POE6)/\{(MW)(PWE6)\}$ 

- (2)-2 MO as CHBr<sub>3</sub> = 252.718, MW as  $H_2O = 18.02$
- (2)-3 POE1-6 (Vapor pressure of bromoform)

(PA)

 $POE1 = 1000 \cdot COM0/\{(H1)(MO)\}$ 

 $POE2 = 1000 \cdot COM1/\{(H2)(MO)\}$ 

 $POE3 = 1000 \cdot COM2/\{(H3)(MO)\}$ 

 $POE4 = 1000 \cdot COM3/\{(H4)(MO)\}$ 

 $POE5 = 1000 \cdot COM4/\{(H5)(MO)\}$ 

 $POE6 = 1000 \cdot COM5/\{(H6)(MO)\}$ 

(3) FOMM (Dosing rate of bromoform)

(KG/L)(KG/H)(L/KG)=(KG/H)

FOMM = (COMM)(FBLM)(1/DBT)

(4) NEFOMC (Constituent flow rate calculated by method of once through type in #6 stage)

MAX. NEFOMC1-z = (COMM1-z)(1/DBT)(FBLM)

(KG/L)(L/KG)(KG/H)=(KG/H)

MIN. NEFOMC1-z=0

(5) Mass balance in each stage

(5)-1. #1 stage (5)-1-1 FOM0 (Bromoform flow rate ex BH) (KG/H) MAX. : FOM0 = (FOMM) + (FOMC)MIN. : FOM0 = (FOMM)(5)-1-2 **FOE1** (Vaporization rate of bromoform at #1 stage) (KG/H) FOM1 = FOM0 - FOE1 FOE1 = (R1)(FWE1) $R1 = (MO)(POE1)/\{(MW)(PWE1)\}$ POE1 =  $1000 \cdot \text{COM0}/\{(\text{H1})(\text{MO})\}$ OM0 = (AFOM0)(1/FBL1)(DB1)(5)-1-3 COM1 (Bromoform concentration at #1) (KG/H)(H/KG)(KG/L)=(KG/L)ACOM1 = (AFOM1)(1/FBL1)(DB1)(5)-2 #2 stage (5)-2-1 FOM1 (The value is the same as FOM1 obtained by 5-1-2) (KG/H) (5)-2-2 FOE2 (Vaporization rate of bromoform at #2 stage) (KG/H) FOM2 = FOM1 - FOE2 FOE2 = (R2)(FWE2) $R2 = (MO)(POE2)/\{(MW)(PWE2)\}$  $POE2 = 1000 \cdot COM1/\{(H2)(MO)\}$ COM1 = (FOM1)(1/FBL2)(DB2)(5)-2-3 COM2 (Bromoform concentration at #2) (KG/H)(H/KG)(KG/L)=(KG/L)COM2 = (FOM2)(1/FBL2)(DB2)Repeat the same calclation until #6 stage

(6) COMT (Bromoform concentration at #6)

COMT = (DBT)(AFOM6)/(FBL0 - FWET)

(KG/L)(KG/H)/(KG/H)=(KG/L)

- (7) FOMB (Bromoform Flow rate in blow brine) (KG/L)(KG/H)/KG/L)=(KG/H)
  FOMB = (COMT)(FBLB)/(DBT)
- (8) BBFOMC (Bromoform Flow rate in recirculation brine)
  BBFOMC = (FOM6)-(FOMB)
- (9) FOMC (Convergence calculation)

  | NEFOMC-BBFOMC | / | NEFOMC | ≤ 0.01
- (10) COE1-6 (Concentration on the assumption that bromoform carrying over is dissolved in the evaporated water.)

enditional Library

(KG/H)(KG/L)/(KG/H)=(KG/L)

- COE1 = (FOE1/FWE1)(DW1)
- $COE2 = \{(FOE1+FOE2)/(FWE1+FWE2)\} DW2$
- $COE3 = \{(FOE1+FOE2+FOE3)/(FWE1+\dots+FWE3)\} DW3$
- COE4 = {(FOE1+FOE2+FOE3+FOE4)/(FWE1+.....FWE4)} DW4
- $COE5 = \{(FOE1+FOE2+FOE3+FOE4+FOE5)/(FWE1+\cdots+FWE5)\} DW5$
- $COE6 = \{(FOE1+FOE22+FOE3+FOE44+FOE5+FOE6)/(FWE1+\cdots+FWE6)\}DW6$ 
  - = COET (Bromoform concentration in the product water)

#### 6.2.5 Deaerator

#### 6.2.5.1 HETEROGENEOUS

(1) XOM (Mole fraction of paraffin consisted of 35 kinds <1-9.A-Z>)

XOMG1-z

 $XOMG1 = (COMD1/MO1)/\{(COMD1/MO1)+\cdots+(COMDz/MOz)\}$ 

 $XOMGa = (COMDa/MOa)/\{(COMD1/MO1) + \cdots + (COMDz/MOz)\}$ 

 $XOMGz = (COM0z/MOz)/\{(COMD1/MO1)+\cdots + (COMDz/MOz)\}$ 

(2) FOE, FOM (Evaporatin/Flow rate of paraffin in deaerator)

(KG/H)

FOEG1-z = (XOMG1-z)(RG1-z)(FWEG), FOMG1-z = FOMD1-z - FOEG1-z

(3) COM (Paraffin concentration in the brine at deaerator)

(The symbols '1' through 'z' were omitted.)

 $(KG/L)\{(KG/H)(KG/L)(L/KG)-(KG/H)\}/(KG/H)=(KG/L)$ 

COMG=DB1(FBLD · COMD/DB0 - FOEG)/FBLG

(4) COE (Paraffin concentration in the ejector drain at dearetor)

(The symbols '1' through 'z' for 'COE' & 'FOE' were omitted.)

(KG/H)/(KG/H)(KG/L)=(KG/L)

COEG = (FOEG/FWEG)(DW1)

(5) R (CARRYOVER'S CONSTANTS)

RG1-z = (MO1-z/MW)(POEG1-z/PWEG)

MW = 18.02

MO1-z = 14.027N + 2.016

**PWE: STEAM TABLE** 

POEG1-z: Be calculated by using ANTIOINE'S equation.

#### 6.2.5.2 HOMOGENEOUS

(1) FOE, FOM: Be the same equation in case of 'HETEROGENEOUS'. However, the symbols '1' through 'z' were not necessary.

<b>(2)</b>	: Be the same equation in case of 'HETEROGENEOUS'. However,	
	the symbols '1' through 'z' were not necessary.	
(3)	COE: Be the same equation in case of 'HETEROGENEOUS'. However,	,
	the symbols '1' through 'z' were not necessary.	
(4)	R (CARRYOVER'S CONSTANTS)	
	RG=(MO/MW)(POEG/PWEG)	
	MW=18.02 (Molecular weight of H <sub>2</sub> O)	
	MO=252.718 (Molecular weight of CHBr <sub>3</sub> )	
	PWE:STEAM TABLE	(4)
	POEG=1000 · COMD/(HG · MO) (KG/L)/{(KG/MOL)(MOL/L)(1/PA)}=(PA	<b>)</b>
2.5.3	3 HEAT/MASS BALANCE	
_,		
1)	PWEG (Steam Pressure in deaerator)	a
~,	The value corresponds to TWEG of the steam table.	<b>.</b>
	The value corresponds to a visit of the security and the	
(2)	BPRG (Boiling point rising of feed seawater) (C	45
( <b></b> )	BPRG is calculated from the TDS concentration of the feed seawater.	<i>.</i> )
	DI NO IS CARCULATED TO THE TOTAL CONTENT OF THE SECURITY OF TH	
3).	TWEG (Steam temp. in deaerator) (C	1)
<i></i>	See the value of TR201 indicated on P/I diagram	<i>.</i> )
	See the value of 1 K201 mulcated on 1/1 diagram	
(A)	ATRIC (Tomporature difference of bring between inlet and suited town	
(4)	△TBLG (Temperature difference of brine between inlet and outlet temp.	
	in deaerator) (C	<i>)</i>
	TBLG = TWEG + BPRG	
	$\triangle$ TBLG = TBLD - TBLG	
(5)	FWEG (Evaporation flow rate in deaerator)	٠.
	$(KG/H)(KJ/KG \cdot C)/(C)/(KJ/KG) = (KG/KG)$	H)
	$FWEG = (FBLG)(CPG)(\triangle TBLG/ENTG)$	
	FWLT = FWEG (Condensate flow rate by the ejector condenser)	
	and the control of th	

# 7 Physical Properties

The physical properties used for the calculation are mainly derived from the RESEARCH AND DEVELOPMENT PROGRESS REPORT No.214 (Sep. 1966), OSW, "The Oakridge National Laboratory Conceptional Design of a 250-MGD Desalination Plant". They are shown in 6.3.2.

6.3.2 Simulation for Behaviors of Oil Contaminants	

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#### 1. Introduction

The purpose of the MSF-2 is to estimate the quality of the product water in case when the oil contaminated seawater has been fed into the MSF Plant. It has been done through the investigation on the quantitative analysis of the evaporation phenomena of the volatile organic contaminants in the feed seawater.

The Henry's constant of bromoform in brine, which is the basic physical property necessary for the quantitative analysis of the dilute solution, has been measured by the "Vapor/Liquid Equilibrium Experimental Apparatus". The results are reported in 6.2. The Henry's constant obtained in 6.2 showed good agreement with that of 6.1.2. Thus, the Henry's constant, as a function of temperature obtained by 6.2, has been used for the computer simulation.

The flow chart and the formula used for the computer simulation of the evaporation of the organic contaminants in brine are described in 6.3.1 based on the evaporation mechanisms shown in 6.1 and 6.2. In this section the details of the computer programs are described.

#### 2. Structure of the program

The basic structure has been already shown in 6.3.1. The structure comprise of subroutines shown in Figs.1 to 4. The variables used and the dimensions of them are shown in Table 1 with its meanings. The physical properties and the chemical constants are shown in Table 2 as the function of parameters.

The input and output form of the program are shown in Figs.5 and 6.

- Input processing
- Deaerator calculation
- · Heat and mass balance calculation
- Carryover calculation
- Output processing

Each part is made up of a number of subordinate subroutines.

#### 3. Variables

#### Variables are made up primarily of 6 groups:

- Heat and mass balance calculation
  - Designate calculation options
  - Carryover calculation
  - and Store log data affect of the meaning the first properties and the engine
  - Iteration in heat and mass balance calculation
    - Deacrator calculation

#### 4. Physical Properties and Chemical Constants

Physical properties and chemical constants used in the program:

• Function of temperature : Henry's constant

Saturated steam pressure,

Latent heat of vaporization

Hall to Albertal materials

• Function of TDC concentration : Electric conductivity

Boiling point elevation of brine

• Function of TDC conc. and temp. : Specific heat of brine

Brine density

• Function of temp. and carbon-number-dependent 3 constants

: Saturated n-paraffin pressure

Function of molecular weight : Carryover constant

Table 1 Variables using in the program

BLOCK NAME VARIABLE NAME UNIT PHYSICAL IDENTITY  SYMBOL  FBL K8/H BRINE FLOW  TWL 'C DISTILATE TEMPERATURE  TWE 'C STEAM TEMPERATURE  SBL S/cm BRINE ELECTRIC CONDUCTIVITY  CBS K8/K8 BRINE DISCONCENTRATION  PWE PA SATURATED STEAM PRESSURE  NTD 'C NON-EQUILIBRIUM TEMPERATURE  FWE K8/H STEAM FLOW  ONTD 'C NOTD BOILING POINT ELEVATION BY TOS IN BRINE  FWL K8/H DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  COARRY MO 8/MOI MOLECULAR WEIGHT  POE PA CONTAMINANT SATURATED PRESSURE  FOM K8/H CONTAMINANT FLOW INTO EACH STAGE  K8/H CONTAMINANT FLOW INTO EACH STAGE  COM K8/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM K8/L TOTAL CONTAMINANT CONCENTRATION  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  COE K8/L CONTAMINANT FLOW IN DISTILATE IN EACH STAGE  SUMMOB K8/L TOTAL CONTAMINANT FLOW IN DISTILATE IN EACH STAGE  COM K8/L TOTAL CONTAMINANT FLOW IN SUMMYE  COSS K8/K8 TOS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE FLOW  COMO K8/H CONTAMINANT FLOW IN SUMMYE  COSS K8/K8 TOS CONCENTRATION IN MAKEUP BRINE  FBLB K8/H BLOW BRINE FLOW  COMO K8/L CONTAMINANT FLOW IN SUMMYE  COMO K8/H CONTAMINANT FLOW IN SUMMYE  COMO K8/H CONTAMINANT FLOW IN SUMMYE  COMO K8/H CONTAMINANT FLOW IN MECIRCULATION BRINE  FBLB K8/H BLOW BRINE FLOW  COMO K8/H CONTAMINANT FLOW IN MECIRCULATION BRINE  FBLB K8/H FOOM CAPTER ONE MORE RECIRCULATION BRINE		Tabl	<u> </u>	Tables using in the program
TWL C DISTILATE TEMPERATURE  TWE 'C STEAM TEMPERATURE  SSL S/cm BRINE ELECTRIC CONDUCTIVITY  CBS Kg/kg BRINE TDS CONCENTRATION  PWE Pa SATURATED STEAM PRESSURE  NTD C NON-EQUILIBRIUM TEMPERATURE  TBL 'C BRINE TEMPERATURE  FPE Kg/H STEAM FLOW  ONTD 'C NTD + BOILING POINT ELEVATION BY TDS IN BRINE  FPU Kg/H DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEAIR - DEARRATOR IDENTIFIER  FOM Kg/H CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  GOMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FELLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  BROME Kg/L BROMOFORM TOTAL CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOME Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H FOMC AFTER ONE MORE RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		<del></del>	UNIT	
TWE C STEAM TEMPERATURE  SBL S/cm BRINE ELECTRIC CONDUCTIVITY  CBS kg/kg BRINE TDS CONCENTRATION  PWE PA SATURATED STEAM PRESSURE  NTD C NON-EQUILIBRIUM TEMPERATURE  TBL C BRINE TEMPERATURE  FWE Kg/H STEAM FLOW  ONTD C NTD + BOILING POINT ELEVATION BY TDS IN BRINE  FWL Kg/H DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CARRY MO g/moi Molecular wilght  POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT PLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT PLOW INTO EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  FELLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  COE Kg/L BROMOFORM TOTAL CONCENTRATION  SUMPOE Kg/L TOTAL CONTAMINANT CONCENTRATION  COE Kg/L CONTAMINANT FLOW IN SUMPWE  CWILT Kg/H CONTAMINANT FLOW IN SUMPWE  CESM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TELM C MAKEUP BRINE TEMPERATURE  FELLB Kg/H BLOW BRINE TEMPERATURE  FELLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  TELM C MAKEUP BRINE TEMPERATURE  FELLB Kg/H LOW BRINE TEMPERATURE  FELLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  TELM C MAKEUP BRINE TEMPERATURE  FELLB Kg/H LOW BRINE TEMPERATURE  FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION BRINE	SYMBOL	FBL		
SEL S/cm BRINE ELECTRIC CONDUCTIVITY  CES		TWL		DISTILATE TEMPERATURE
CBS		TWE	C	STEAM TEMPERATURE
PWE PA SATURATED STEAM PRESSURE  NTD 'C NON-EQUILIBRIUM TEMPERATURE  TBL 'C BRINE TEMPERATURE  FWE Kg/R STEAM FLOW  ONTD 'C NTD + BOILING POINT ELEVATION BY TDS IN BRINE  FWL Kg/R TOTAL DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CONTAM - DEARRATOR IDENTIFIER  CARRY MO g/mol MOLECULAR WEIGHT  POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/R CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  FELM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L TOTAL CONTAMINANT CONCENTRATION  FELM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT CONCENTRATION  BROME Kg/L TOTAL CONTAMINANT CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EYAPORATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EYAPORATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L CONTAMINANT FLOW IN SUMFWE  COM Kg/K CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TELM 'C CMAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  POMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		SBL	S/cm	BRINE ELECTRIC CONDUCTIVITY
NTD C NON-EQUILIBRIUM TEMPERATURE  TBL C BRINE TEMPERATURE  FWE Kg/H STEAM FLOW  ONTD C NTD + BOILING POINT BLEVATION BY TDS IN BRINE  FWL Kg/H DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEATR - DEABRATOR IDENTIFIER  CARRY MO g/mol MOLECULAR WEIGHT  POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION  COE Kg/L TOTAL CONTAMINANT EVAPORATION IN DISTILATE IN EACH STAGE  SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION  CUB Kg/L TOTAL CONTAMINANT EVAPORATION  COE Kg/L CONTAMINANT CONCENTRATION  COE Kg/L TOTAL CONTAMINANT EVAPORATION  COE Kg/L CONTAMINANT FLOW IN NUMFWE  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/K BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN RECIRCULATION BRINE  POMC Kg/H FOMC AFTER ONE MORE RECIRCULATION BRINE		CBS	kg/kg	BRINE TDS CONCENTRATION
TBL C BRINE TEMPERATURE  FWE Kg/H STEAM FLOW  ONTD 'C NTD + BOILING POINT ELEVATION BY TDS IN BRINE  FWL Kg/H DISTILATE FLOW  FWLT Kg/H TOTAL DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  CONTAM - DEABRATOR IDENTIFIER  CARRY MO g/mol Molecular Weight  POE Pa CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION  SUMMYE Kg/L TOTAL CONTAMINANT EVAPORATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMMYE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMMYE Kg/L CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H GONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE		PWE	Pa	SATURATED STEAM PRESSURE
FWE Kg/H STEAM FLOW ONTD 'C NTD + BOILING POINT ELEVATION BY TDS IN BRINE FWL Kg/H DISTILATE FLOW FWLT Kg/H TOTAL DISTILATE FLOW OPTION  TYPE - CALCULATION TYPE IDENTIFIER CONTAM - CONTAMINANT TYPE IDENTIFIER DEAIR - DEABRATOR IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  CARRY MO g/mol Molecular Weight POE Pa CONTAMINANT SATURATED PRESSURE FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION COMM Kg/L TOTAL CONTAMINANT CONCENTRATION FELM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM BROME Kg/L BROMOFORM TOTAL CONCENTRATION COE Kg/L CONTAMINANT CONCENTRATION SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION TOTAL CONTAMINANT EVAPORATION SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION TOTAL CONTAMINANT EVAPORATION TOTAL CONTAMINANT EVAPORATION TOTAL CONTAMINANT EVAPORATION TOTAL CONTAMINANT FLOW IN SUMPWE  CESM Kg/H CONTAMINANT FLOW IN SUMPWE  TELM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE		NTD	C	NON-EQUILIBRIUM TEMPERATURE
ONTD 'C NTD + BOILING POINT ELEVATION BY TDS IN BRINE  FWL Kg/H DISTILATE FLOW  FWLT Kg/H TOTAL DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEATR - DEABRATOR DENTIFIER  CARRY MO g/mol Molecular Weight  POE Pa CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FELM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL CONTAMINANT EVAPORATION  COE Kg/L CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL CONTAMINANT EVAPORATION  TELM CONTAMINANT FLOW IN SUMFWE  CESM Kg/H CONTAMINANT FLOW IN SUMFWE  TELM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE	i agressian t	TBL	С	BRINE TEMPERATURE
FWL Kg/H DISTILATE FLOW FWLT Kg/H TOTAL DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  MO g/mol MOLECULAR WEIGHT  POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION  SUMPWE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMPWE Kg/L TOTAL CONTAMINANT EVAPORATION  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN SUMFWE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		FWE	Kg/H	STEAM FLOW
PWLT Kg/H TOTAL DISTILATE FLOW  OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  OF PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMPOE Kg/L TOTAL CONTAMINANT EVAPORATION  COE Kg/L CONTAMINANT FLOW IN SUMPWE  CWLT Kg/H CONTAMINANT FLOW IN SUMPWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT FLOW  COMO Kg/L CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE		ONTD	· c	NTD + BOILING POINT ELEVATION BY TDS IN BRINE
OPTION TYPE - CALCULATION TYPE IDENTIFIER  CONTAM - CONTAMINANT TYPE IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  OF POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION  COE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL CONTAMINANT EVAPORATION  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION	e e errole	FWL The serve of the sec	Kg/H	DISTILATE FLOW
CONTAM - CONTAMINANT TYPE IDENTIFIER  DEAIR - DEABRATOR IDENTIFIER  ROM		FWLT	Kg/H	TOTAL DISTILATE FLOW
DEAIR — DEABRATOR IDENTIFIER  CARRY MO	OPTION	TYPE		CALCULATION TYPE IDENTIFIER
CARRY  MO  g/mol  MOLECULAR WEIGHT  POE  Pa  CONTAMINANT SATURATED PRESSURE  FOM  Kg/H  CONTAMINANT FLOW INTO EACH STAGE  XOM  MOLAR RATIO  FOE  Kg/H  CONTAMINANT EVAPORATION IN EACH STAGE  COM  Kg/L  INDIVIDUAL CONTAMINANT CONCENTRATION  COMM  Kg/L  TOTAL CONTAMINANT CONCENTRATION  FBLM  COMP  INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME  Kg/L  BROMOFORM TOTAL CONCENTRATION  COE  Kg/L  CONTAMINANT CONCENTRATION  COE  Kg/L  TOTAL CONTAMINANT EVAPORATION  SUMFWE  Kg/L  TOTAL CONTAMINANT EVAPORATION  SUMFWE  Kg/L  CONTAMINANT FLOW IN SUMFWE  CBSM  Kg/Kg  TDS CONCENTRATION IN MAKEUP BRINE  TBLM  C  MAKEUP BRINE TEMPERATURE  FBLB  Kg/H  BLOW BRINE TEMPERATURE  FOMC  Kg/L  CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC  Kg/H  CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC  Kg/H  FOMC  FOMC		CONTAM	-	CONTAMINANT TYPE IDENTIFIER
POE PA CONTAMINANT SATURATED PRESSURE  FOM Kg/H CONTAMINANT FLOW INTO EACH STAGE  XOM - MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL CONTAMINANT EVAPORATION  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT PLOW IN MAKEUP BRINE  FOMC Kg/L CONTAMINANT PLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		DEATR	<u> </u>	DEAERATOR IDENTIFIER
FOM Kg/H CONTAMINANT PLOW INTO EACH STAGE  XOM — MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP — INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE TEMPERATURE  FBLB Kg/H CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION	CARRY	мо	g/mol	MOLECULAR WEIGHT
XOM — MOLAR RATIO  FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP — INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION	:	POE	Pa	CONTAMINANT SATURATED PRESSURE
FOE Kg/H CONTAMINANT EVAPORATION IN EACH STAGE  COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		FOM	Kg/H	CONTAMINANT FLOW INTO EACH STAGE
COM Kg/L INDIVIDUAL CONTAMINANT CONCENTRATION  COMM Kg/L TOTAL CONTAMINANT CONCENTRATION  FBLM Kg/H MAKEUP BRINE FLOW  COMP - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		XOM	-	MOLAR RATIO
COMM  Kg/L  TOTAL CONTAMINANT CONCENTRATION  FBLM  Kg/H  MAKEUP BRINE FLOW  COMP  INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME  Kg/L  BROMOFORM TOTAL CONCENTRATION  COE  Kg/L  CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE  Kg/L  TOTAL CONTAMINANT EVAPORATION  SUMFWE  Kg/L  TOTAL DISTILATE FLOW  CWLT  Kg/H  CONTAMINANT FLOW IN SUMFWE  CBSM  Kg/Kg  TDS CONCENTRATION IN MAKEUP BRINE  TBLM  C MAKEUP BRINE TEMPERATURE  FBLB  Kg/H  COMO  Kg/L  CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC  Kg/H  CONTAMINANT FLOW IN RECIRCULATION BRINE  FOMC  Kg/H  FOMC  Kg/H  FOMC AFTER ONE MORE RECIRCULATION		FOE	Kg/H	CONTAMINANT EVAPORATION IN EACH STAGE
FBLM  Kg/H  MAKEUP BRINE FLOW  COMP  INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME  Kg/L  BROMOFORM TOTAL CONCENTRATION  COE  Kg/L  CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE  Kg/L  TOTAL CONTAMINANT EVAPORATION  SUMFWE  Kg/L  CWLT  Kg/H  CONTAMINANT FLOW IN SUMFWE  CBSM  Kg/Kg  TDS CONCENTRATION IN MAKEUP BRINE  TBLM  C MAKEUP BRINE TEMPERATURE  FBLB  Kg/H  BLOW BRINE FLOW  COMO  Kg/L  CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC  Kg/H  CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC  Kg/H  FOMC AFTER ONE MORE RECIRCULATION		COM	Kg/L	INDIVIDUAL CONTAMINANT CONCENTRATION
COMP  - INDIVIDUAL CONTAMINANT COMPOSITION OF COMM  BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		COMM	Kg/L	TOTAL CONTAMINANT CONCENTRATION
BROME Kg/L BROMOFORM TOTAL CONCENTRATION  COE Kg/L CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		FBLM	Kg/H	MAKEUP BRINE FLOW
COE  Kg/L  CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE  SUMFOE  Kg/L  TOTAL CONTAMINANT EVAPORATION  SUMFWE  Kg/L  CWLT  Kg/H  CONTAMINANT FLOW IN SUMFWE  CBSM  Kg/Kg  TDS CONCENTRATION IN MAKEUP BRINE  TBLM  C  MAKEUP BRINE TEMPERATURE  FBLB  Kg/H  BLOW BRINE FLOW  COMO  Kg/L  CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC  Kg/H  CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC  Kg/H  CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC  Kg/H  FOMC AFTER ONE MORE RECIRCULATION		COMP		INDIVIDUAL CONTAMINANT COMPOSITION OF COMM
SUMFOE Kg/L TOTAL CONTAMINANT EVAPORATION  SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		BROME	Kg/L	BROMOFORM TOTAL CONCENTRATION
SUMFWE Kg/L TOTAL DISTILATE FLOW  CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		COE	Kg/L	CONTAMINANT CONCENTRATION IN DISTILATE IN EACH STAGE
CWLT Kg/H CONTAMINANT FLOW IN SUMFWE  CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM 'C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		SUMFOE	Kg/L	TOTAL CONTAMINANT EVAPORATION
CBSM Kg/Kg TDS CONCENTRATION IN MAKEUP BRINE  TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		SUMFWE	Kg/L	TOTAL DISTILATE PLOW
TBLM C MAKEUP BRINE TEMPERATURE  FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		CWLT	Kg/H	CONTAMINANT FLOW IN SUMFWE
FBLB Kg/H BLOW BRINE FLOW  COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE  FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		CBSM	Kg/Kg	TDS CONCENTRATION IN MAKEUP BRINE
COMO Kg/L CONTAMINANT CONCENTRATION IN MAKEUP BRINE FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION	1	TBLM	. c	MAKEUP BRINE TEMPERATURE
FOMC Kg/H CONTAMINANT FLOW IN RECIRCULATION BRINE  N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION		FBLB	Kg/H	BLOW BRINE FLOW
N_FOMC Kg/H FOMC AFTER ONE MORE RECIRCULATION	.*	COMO	Kg/L	CONTAMINANT CONCENTRATION IN MAKEUP BRINE
		FOMC	Kg/H	CONTAMINANT FLOW IN RECIRCULATION BRINE
		N_FOMC	Kg/H	FOMC AFTER ONE MORE RECIRCULATION
LOG RUNNUMBER - TEST NUMBER	LOG	RUNNUMBER	_	TEST NUMBER
DATE - TEST DATE		DATE	-	TEST DATE
OPERATOR - OPERATOR NAME		OPERATOR	_	OPERATOR NAME
MAXTEMP C MAXIMUM BRINE TEMPERATURE		MAXTEMP	c	MAXIMUM BRINE TEMPERATURE

## (Cont.)

BLOCK NAME	VARIABLE NAME	UNIT	PHYSICAL IDENTITY
A	AONTD	c	ASSUMED ONTO IN HEAT/MASS BALANCE CALCULATION
	ATBL	. c	ASSUMED TBL IN HEAT/MASS BALANCE CALCULATION
*	DIFTBL	. c	BRINE TEMPERATURE DIFFERENCE IN SUCCESIVE STAGES
	AFBL	Kg/H	ASSUMED FBL IN HEAT/MASS BALANCE CALCULATION
	AFWE	Kg/H	ASSUMED FWE IN HEAT/MASS BALANCE CALCULATION
	ACBS	Kg/Kg	ASSUMED CBS IN HEAT/MASS BALANCE CALCULATION
GASNGO	GASNGO	• 1	LOGICAL VARIABLE TO TALLY COMPLETE EVAPORATION OF OIL
HFACTOR	HFACTOR	-	ARBITRARY INPUT VALUE TO DIVIDE HENRY'S CONSTANT
DEAER	TWEG	· c	DEAERATOR STEAM TEMPERATURE
	PWEG	Pa	DEAERATOR SATURATED STEAM PRESSURE
	DIFTBLC	· c	DEAERATOR INLET/OUTLET BRINE TEMPERATURE DIFFERENCE
	TBLD	· c	DEAERATOR OUTLET TEMPERATURE
4.	FWEG	Kg/H	DEAERATOR STEAM FLOW
	POED	Pa	DEAERATOR CONTAMINANT SATURATED PRESSURE
	FOMD	Kg/H	DEAERATOR INLET CONTAMINANT FLOW
	XOMD	-	CONTAMINANT MOLAR RATIO IN DEAERATOR
	RG		CARRYOVER COEFFICIENT IN DEAERATOR
	FOED	Kg/H	DEAERATOR CONTAMINANT EVAPORATION
	FOMG	Kg/H	DEAERATOR OUTLET CONTAMINANT FLOW
	FBLD	Kg/H	DEAERATOR INLET BRINE FLOW
	COEG	Kg/L	CONTAMINANT CONCENTRATION IN STEAM IN DEAERATOR
	COMD	Kg/L	DEAERATOR OUTLET CONTAMINANT CONCENTRATION
	FBLG	Kg/H	DEAERATOR OUTLET BRINE FLOW

Table 2. Physical Properties and Chemical Constants using in the Program

NAME	HENRY'S CONSTANT[mol/1.Pa](Y)
ARGUMENT	TEMPERATURE['C](X)
EQUATION	Y=10 (0. 24-0. 024x) /133. 3224

NAME	TDS CONCENTRATION[g/kg](Y)
ARGUMENT	BRINE ELECTRIC CONDUCTIVITY[S/cm](X)
EQUATION	Y=709.79993X-2.615515

NAME	SATURATED STEAM TEMPERATURE[Pa](Y)
ARGUMENT	TEMPERATURE['C](X)
EQUATION	Y=0.006895E6[2.1786818-0.70443622E-1(32+9X/5) +0.93941286E-3(32+9X/5) <sup>2</sup> -0.53958083E-5(32+9X/5) <sup>3</sup> +0.18139197E-7(32+9X/5) <sup>4</sup> ]

NAME	LATENT HEAT of VAPORIZATION [J/Kg](Y)
ARGUMENT	TEMPERATURE['C](X)
EQUATION	Y=1.055*2.205[1093.8-0.5703(32+9X/5)
	+1.2819E-4(32+9X/5) <sup>2</sup> -0.8824E-6(32+9X/5) <sup>3</sup> ]

NAME	SPECIFIC HEAT of BRINE[J/Kg·C](Z)
ARGUMENT	TEMPERATURE['C](X) BRINE TDS CONCENTRATION[Kg/Kg](,Y)
EQUATION	Z=1.055*2.205*9/5*[1.005773 -0.13280442E-3(32+9X/5) -1.5344907Y +0.39090715E-2(32+9X/5)Y +0.65092605E-6(32+9X/5) <sup>2</sup> +2.4955446Y <sup>2</sup> -0.11156771E-1(32+9X/5) <sup>2</sup> -0.88941836E-5(32+9X/5) <sup>2</sup> Y +0.3598702E-4(32+9X/5) <sup>2</sup> Y <sup>2</sup> ]

# (Continued)

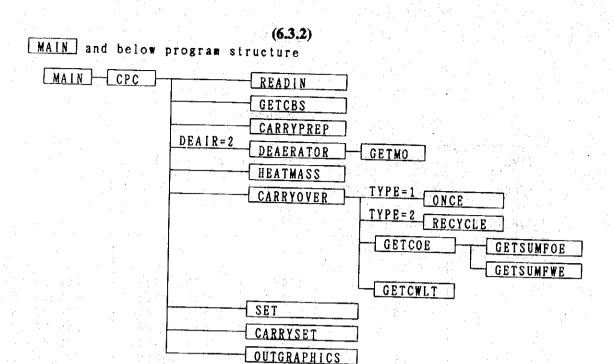
NAME	BRINE DENSITY[Kg/1](Z)
ARGUMENT	TEMPERATURE['C](X) BRINE TDS CONCENTRATION[Kg/Kg](Y)
EQUATION	$Z = \begin{bmatrix} 62.717753 - 0.32152986E - 2(32 + 9 \times / 5) \\ + 0.44315006E2Y \\ - 0.11647394E - 1 \times Y \\ - 0.48932777E - 4(32 + 9 \times / 5)^{2} \\ + 0.16449945E2Y^{2} \\ + 0.13761984E - 1(32 + 9 \times / 5)Y^{2} \\ + 0.34231326E - 5(32 + 9 \times / 5)^{2}Y \\ - 0.92275301E - 4(32 + 9 \times / 5)^{2}Y^{2} \Big]/62.43$

NAME	BRINE BOILING POINT ELEVATION[ C](Z)				
ARGUMENT	TEMPERATURE[°C](X) BRINE TDS CONCENTRATION[Kg/Kg](Y)				
EQUATION	$ \begin{array}{c} Z = 5/9 \left[ 0.\ 1014380E - 1 + 0.\ 1021815E2Y + 8.\ 809554Y^2 \\ - 0.\ 6386588E - 4 \left( 32 + 9X/5 \right) \\ + 0.\ 6118005E - 1 \left( 32 + 9X/5 \right)Y \\ + 0.\ 2386759E - 6 \left( 32 + 9X/5 \right)^2 \\ + 0.\ 2214495E - 4 \left( 32 + 9X/5 \right)^2Y \\ + 0.\ 1714722 \left( 32 + 9X/5 \right)Y^2 \\ + 0.\ 7173776E2Y^3 \\ + 0.\ 1170617E - 9 \left( 32 + 9X/5 \right)^3Y \\ + 0.\ 1042795E - 6 \left( 32 + 9X/5 \right)^3Y \\ + 0.\ 3620461 \left( 32 + 9X/5 \right)^3Y^2 \\ - 0.\ 5218751E - 6 \left( 32 + 9X/5 \right)^3Y^2 \end{array} $				

NAME	CARRYOVER CONSTANT[-](R)
ARGUMENT	CONTAMINANT MOLECULAR WEIGHT[g/mol] (X)SATURATED CONTAMINANT PRESSURE[Pa] (Y)SATURATED STEAM PRESSURE[Pa] (Z)
EQUATION	R = (X/18.02)(Y/2)

# (Continued)

NAME	n-PARRAFIN SATURATED PRESSURE[Pa](Y)					
ARGUMENT	TEMPERATURE['C](X)					
EQUATION	Y=133.322*10 (A-B/(X+C))					
CONSTANT	CARBON #	A	В	С		
	1	6.61184	389.93000	266.00000		
•	2	6.80266	656.40000	256.00000		
	3	6.82973	813.20000	248.00000		
•	4	6.83029	945.90000	240.00000		
	5 6	6.85221	1064.63000	232.00000		
		6.87776	1171.53000	224.36600		
	7	6.90240	1268.11500	216.90000		
	8	6.92377	1355.12600	209.51700		
	9 .	6.93513	1428.81100	201.61900		
	10	6.95367	1501.25800	194.48000		
	11	6.97674	1572.47700	188.02200		
	1 2	6.98059	1625.92800	180.31100		
•	1 3	7.00339	1669.09300	174.28300		
	14	7.01245	1739.62300	167.53400		
	15	7.02445	1789.65800	161.29100		
	16	7.03044	1831.31700	154.52800		
	17	7.04237	1880.60000	150.02000		
	18	7.04823	1920.60000	144.53000		
	19	7.05710	1961.60000	139.60000		
	20	7.06640	1994.00000	133.20000		
	21	7.07380	2026.00000	128.20000		
	2 2	7.07950	2052.00000	123.00000		
	2 3	7.08570	2078.00000	119.00000		
	24	7.09240	2104.00000	114.00000		
•	2.5	7.09910	2132.00000	109.00000		
•	26	7.10610	2158.00000	106.00000		
	27	7.11300	2184.00000	102.00000		
*	28	7.11950	2218.00000	98.00000		
	29	7.12690 7.13280	2240.00000 2264.00000	94.00000 91.00000		



DEAIR=2:WITH DEAERATOR

TYPE=1:ONCE THROUGH 2:RECIRCULATION

Fig. 1 MAIN and below Program Structure

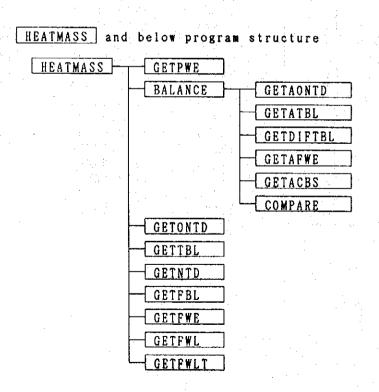


Fig. 2 HEATMASS and below Program Structure

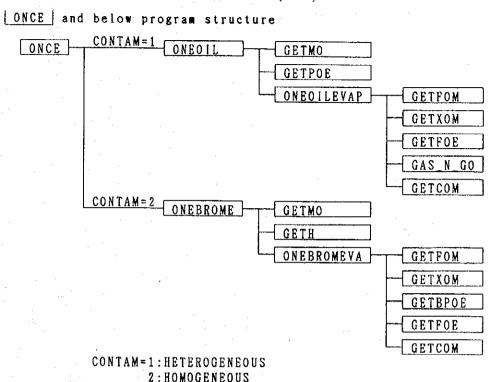


Fig. 3 ONCE and below Program Structure

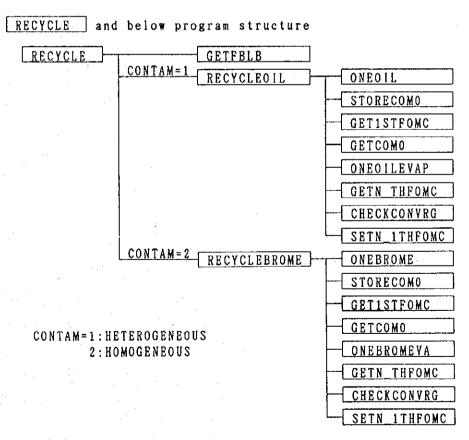


Fig. 4 RECYCLE and below Program Structure