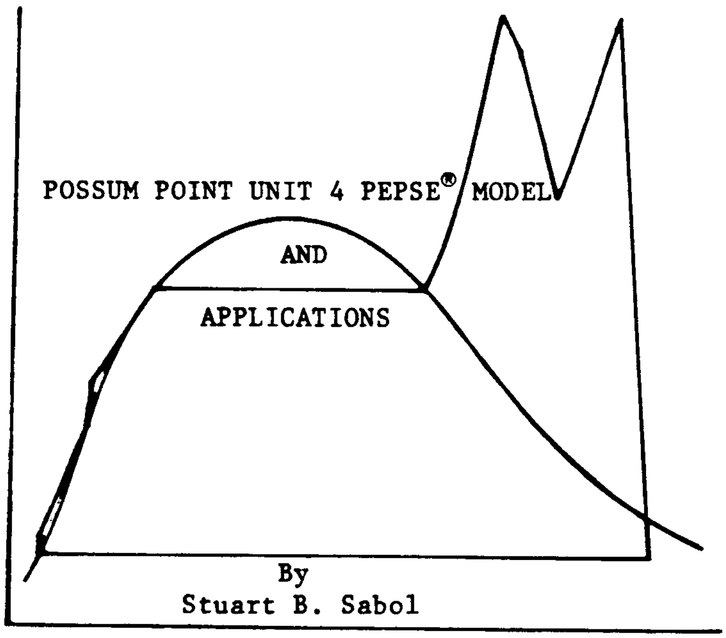

POSSUM POINT UNIT 4 PEPSE® MODEL AND APPLICATIONS

By
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POSSUM POINT UNIT 4 PEPSE MODEL AND APPLICATIONS

ABSTRACT

During 1983 Vepco's Performance Services Department was asked to develop a PEPSE® model for a medium sized coal fired generating unit in order to update the design heat rates for as-built conditions and to perform sensitivities to determine the optimum cycle arrangement for two incycle evaporators (one a submerged tube and one a flash evaporator). This paper discusses the development of design PEPSE® submodels for each type of evaporator which were incorporated into the plant unit model, suggestions for coding to allow better use of computer time with such submodels and the results of the sensitivity study.

Section 1

INTRODUCTION

One of Vepco's Performance Services Department goals during 1982 was to model the system's medium sized coal-fired stations (150 MW - 250 MW) with the PEPSE® code. These models were to serve to update the unit heat rates for as-built conditions, and current operating practices. Furthermore, the models were to be flexible enough to run sensitivity studies of off design operation or with unit improvements.

The first medium sized unit to be modeled, Possum Point Unit 4, had three plant components in the steam cycle which were not component models in the original PEPSE® code. They are: 1) Flash Evaporator; 2) Evaporator; 3) Boiler Feed Pump Turbine. In order to complete the model and perform sensitivity studies, design submodels of these components had to be constructed with existing PEPSE® components and operations, and then incorporated into the model for the unit. This paper is a discussion of the development of two of these components, the shell and tube or conventional evaporator, and the flash evaporator, and of suggestions for PEPSE® to allow such submodels to be incorporated into a unit model that would make better use of computer time. Included is a brief review of a sensitivity study used to determine the optimum cycle operation of the two types of evaporators.

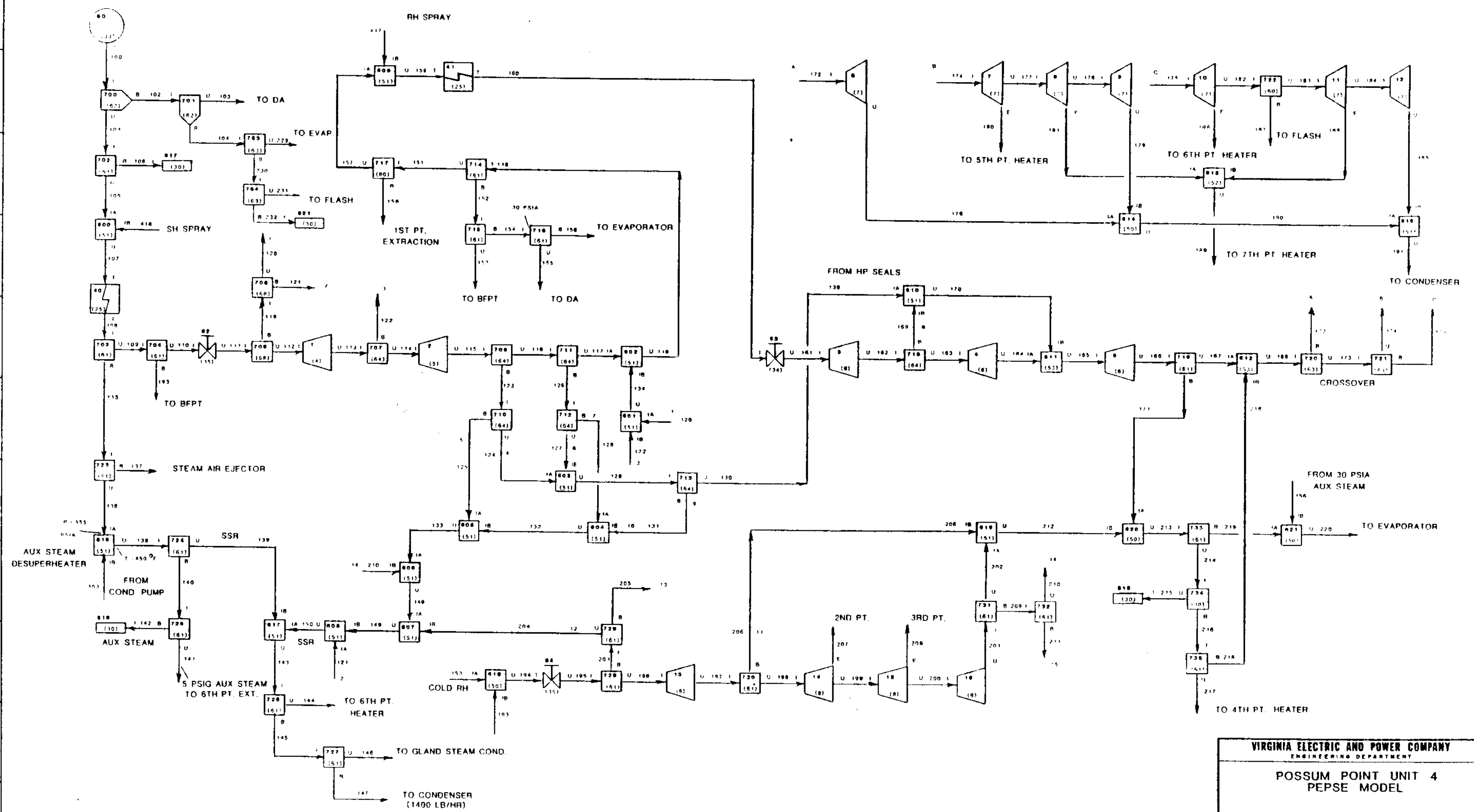
The Possum Point Unit 4 power plant, shown schematically in Figure 1.1, has a 235 MW General Electric tandem compound single reheat turbine with a triple flow low pressure turbine section. The initial steam conditions are 1000°F, 2400 psig throttle, and 1000°F reheat. There is a double extracting boiler feed pump turbine (BFPT) which receives steam from the high pressure (HP) turbine exhaust or from the main steam line or both. The BFPT exhaust into the fourth point extraction line. There are two types of evaporators and seven stages of feedwater heating. The flash evaporator demands steam from the sixth point extraction line and discharges distillate to the distilled water tank. The shell and tube evaporator demands steam from the fourth extraction point and its distillate is pumped ahead in the cycle. There is a single pressure two pass condenser. The unit went into commercial operation in 1962.

The original heat balance (Figure 1.1) shows that the flash evaporator distillate was circulated through the distilled water tank to the shell and tube evaporator where it was redistilled before entering the cycle. The reason for this mode of operation and, for the shell and tube evaporator, was that the flash evaporator was the first in cycle flash evaporator used on a utility unit. As such, the designers were unsure if the distillate quality would be high enough for continuous operation. Therefore, the original cycle design called for two evaporators to ensure the required water quality regardless of which evaporator first distilled the water. Since the start-up of the unit, the shell and tube evaporator has been needed only for emergency situations since the quality of distillate from the flash evaporator was at or above design. Furthermore, since this operation has been so consistent, the new PEPSE® design heat balance was to be run without the shell and tube evaporator in service.

Another change made to the original steam cycle design was to route the boiler blowdown from the blowdown flash tank to the shell and tube evaporator or to waste, rather than to the flash evaporator. As part of the study to find the optimum steam cycle arrangement, the cost of the blowdown to waste would also be determined.

One unique feature of this unit, from a modeling standpoint, is that the BFPT exhaust and the intermediate pressure (IP) turbine both supply steam through a common line to both the fourth point heater and the shell and tube evaporator. With this geometry, the BFPT exhaust flow can occasionally be a greater flow than that which can be condensed in both the feedwater heater and evaporator. This can occur at low loads when auxiliary steam is supplied to the evaporator for distillation. When the BFPT exhaust flow is greater than the 4th point extraction steam demand, the exhaust flows to the low pressure (LP) turbine through the fourth point extraction line. Special geometry in the PEPSE® model was used to accommodate this situation, and operations had to be written to determine in which direction the steam in the fourth point extraction line was to flow.

Figure 2.9



VIRGINIA ELECTRIC AND POWER COMPANY
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POSSUM POINT UNIT 4
PEPSE MODEL

	NAME	DATE	PROJECT NO	SHEET NO
DRAWN				1 of 2
CHECKED			SCALE	
INSPECTED				
CORRECT			REVISIONS	
APPROVED				

DRAWING REFERENCE	TITLE / NUMBER	ELECTRICAL	ELECTRICAL	STEEL ASSEMBLY	STEEL DETAILS	FOUNDATIONS	CONDUIT & GROUNDS	LOCATION PLAN	LOT PLAN	TOPOGRAPHY		WORK ORDER	BILL OF MATERIAL

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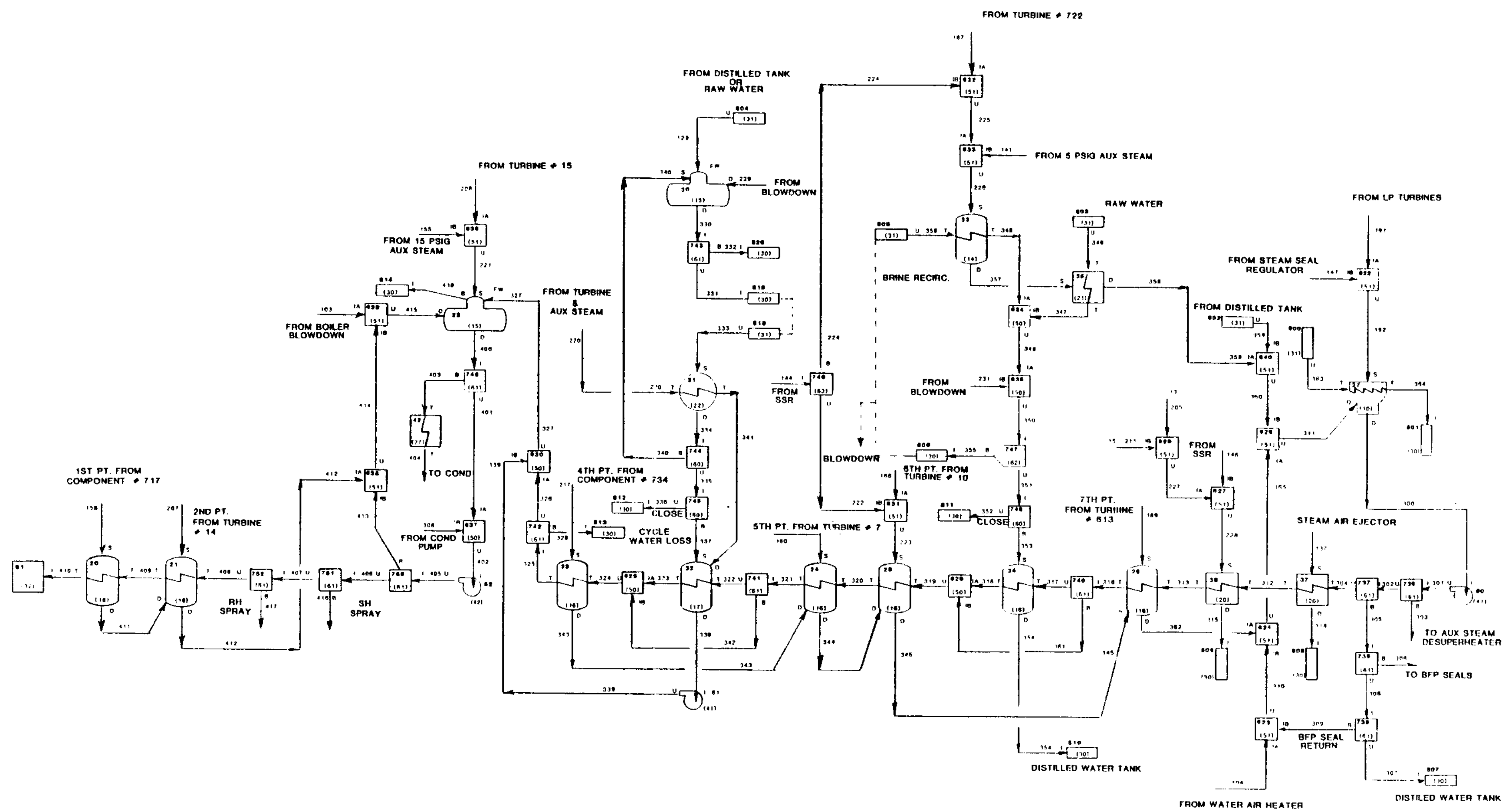
NO 97566120

Figure 2.10



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POSSUM POINT UNIT 4
PEPSE MODEL

SHEET NO. 2 OF 2

NO. 9756120

Section 2

DEVELOPMENT OF SUBMODELS

FLASH EVAPORATOR

The principle of operation of the flash evaporator is to heat water under pressure, then suddenly lower the pressure to allow a small fraction of the heated water to flash into steam. This steam is then condensed and pumped into the cycle or to a storage tank. As seen in Figure 2.1, a flash evaporator can be divided into five working subsystems: 1) the brine heater, 2) the brine recirculation, 3) the flash chamber, 4) the make-up heater, and 5) the flash evaporator condenser. The brine heater demands steam from a turbine extraction to heat the brine to a TTD (Terminal Temperature Difference) usually of about 5°F. The drains from the heater cascade through the make-up heater to the condenser. The raw make-up from the make-up heater and the brine mix, and then flow into the flash chamber. Within the flash chamber, drying screens insure a high thermodynamic quality in the distillate leaving the chamber. The flash evaporator condenser (FEC) then condenses the vapor with condensate before it is returned to the cycle. The concentrated brine less blowdown, which is determined by the amount of dissolved solids in the brine, is then pumped back to the brine heater. Usually the dissolved solids concentration of the brine is three to five times that of the raw makeup.

In the solution of the thermodynamic conditions inside the flash evaporator, there are three variables which the user may not know before a PEPSE® run. These are: 1) the flash chamber pressure; 2) the make-up flow and; 3) the blowdown flow. This is because the flash chamber pressure can change as a result of condensate system changes and once affected, will alter the amount of distillate flow from the flash evaporator. For example, a feedwater heater in the cycle before to the FEC is often constructed with a condensate bypass that is used to lower the condensate temperature to the FEC, and therefore, increase the distillate flow. The FEC also has a condensate bypass which is used to decrease the distillate flow from the flash evaporator.

The design heat balance from the PEPSE® model for Possum Point 4, unlike the original heat balance, was to be slightly more conservative and operated without any bypasses. This would insure that a heat rate was calculated for the case when operating precautions are taken to ensure that enough distilled water is on hand so that the highest unit availability can be maintained.

The reason each of the bypasses mentioned above affects distillate flow, can be explained with the heater effectiveness equation (9-32) found in the PEPSE® Manual Volume II. From this equation it can be deduced that the greater the condensate flow at the lower the temperature, the greater the mass flow of steam to the condenser at a given inlet pressure. Since the flow is determined by flashing to a specified pressure, both it and pressure can be solved for with the equations for heater effectiveness. Therefore, a PEPSE® control can be used to change the flash chamber pressure until the flow to the FEC and its ability to condense the flow are exactly matched.

The PEPSE® submodel for the flash evaporator is shown in Figure 2.2. All the five subsystems are modeled exactly as they appear in Figure 2.1 except for the brine recirculation and no raw water coil through the evaporator condenser. Because of the PEPSE codes solution method, the brine recirculation loop had to be broken. The thermodynamic conditions entering the brine heater are solved for with an operation which sets the temperature entering the heater equal to the temperature leaving the flash chamber. The brine heater is a type 14 condensing feedwater as is the FEC. The make-up heater is an external drain cooler (type 20) and the flash chamber is a moisture separator (type 62). The pressure in the flash chamber is specified with a stream, (type 5) entering the "I" port of the type 62 moisture separator.

In order to operate the control which specifies the flash chamber pressure, the FEC (component number 34) references demand splitter number 748, which has a closed stream from its "U" port. The mass flow imbalance created by PEPSE® between iterations is then calculated with an operation (see Equation 2.1). The result of this operation is the goal variable for a control with the pressure in stream 350 entering the moisture separator as the control variable. Normally, 0.5 is the goal value since a goal of 0.0 will never converge and result in an abnormal termination for the run. The control is shown in Equation 2.2 This control should have an interval of 3, to allow convergence between PEPSE® guesses, and use control limiters.

881370 WW, 354, SUB, WW, 353, OPVB, 140 (2.1)

840200 PPSTRU, 350, 0.5, 50., 1.0, OPVB, 140 (2.2)

Make-up and blowdown are determined from simultaneous solutions of two conservation of mass equations. One is a conservation of steam and water and the other is a conservation of dissolved solids. From Figure 2.2 the conservation of steam and water is:

WW,346 + WW,230 = WW,355 - WW,356 + WW,354; (2.3)

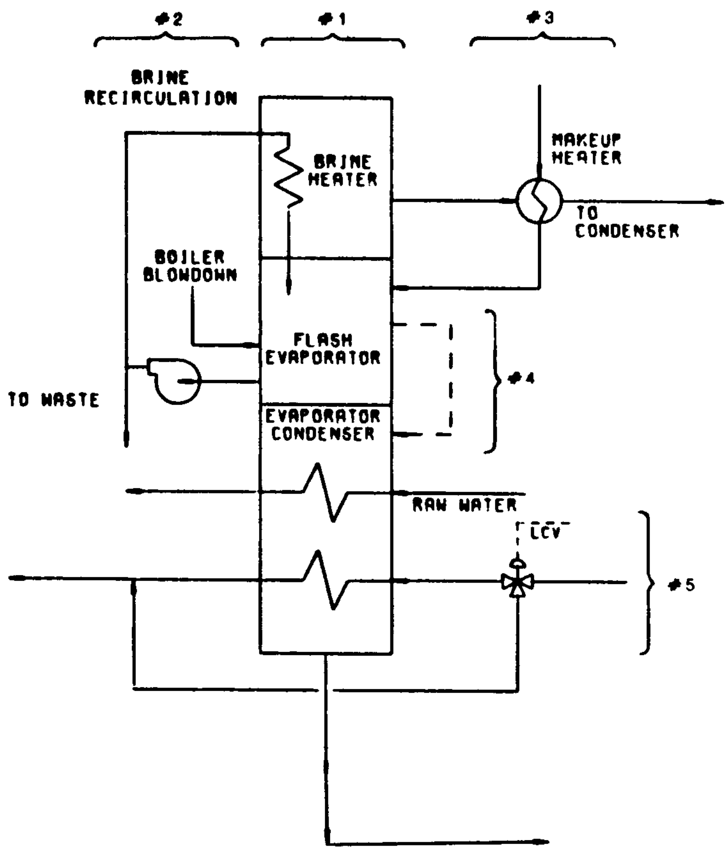


Figure 2.1 Flash Evaporator

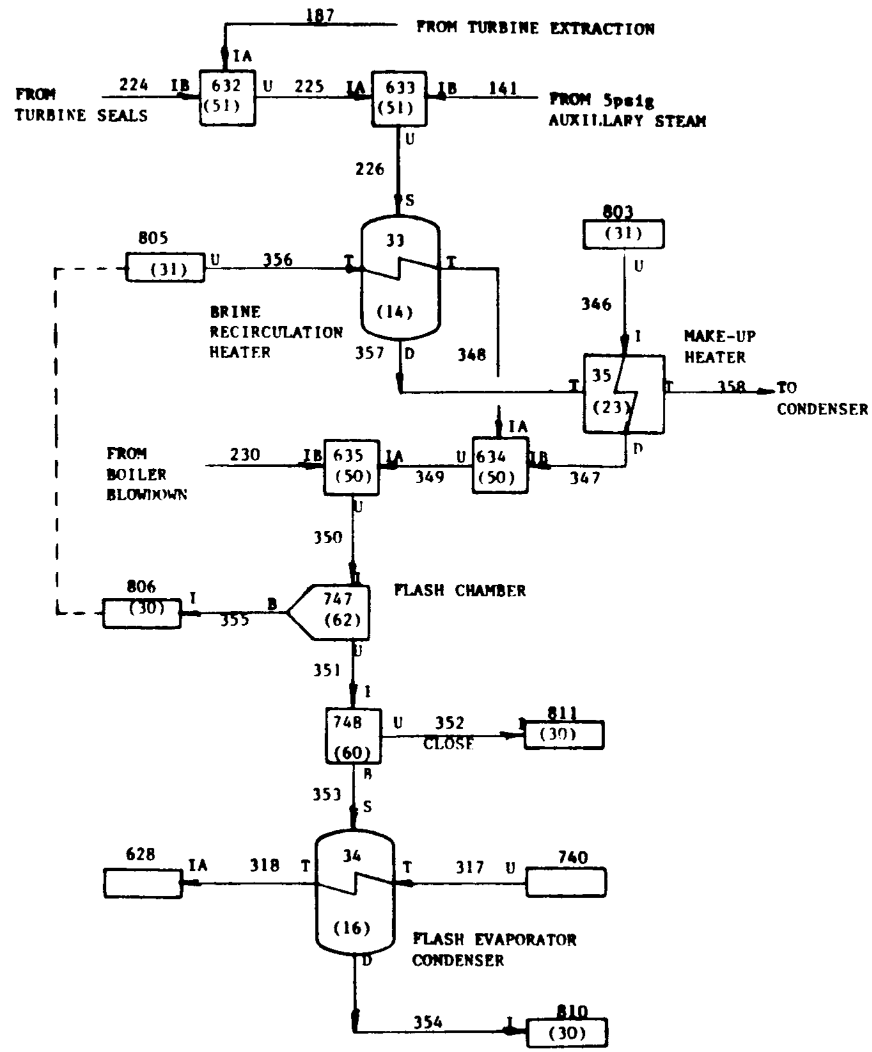


Figure 2.2 Flash Evaporator Submodel

The conservation of dissolved solids is:

$$WW,346 \times PPM_{MU} + WW,230 \times PPM_{BBD} = (WW,355 - WW,356) \times PPM_{FEBD} \quad (2.4)$$

Where: PPM ≡ Parts Per Million
MU ≡ Raw Makeup
BBD ≡ Boiler Blowdown
FEBD ≡ Flash Evaporator Blowdown
WW ≡ Flow in steam (lb/hr)

In order to check the flash evaporator submodel for an accurate prediction of nature, a two part sensitivity study was conducted. For this study, the steam supply pressure, and enthalpy were fixed values; and condensate temperatures, and flows were changed independently. The results of the temperature study, which simulated a bypass of the previous heater, is shown in Figure 2.3. Notice that as condensate temperature decreases, distillate flow increases by approximately 248 lb/hr°F.

The results of the flow variations which simulate less bypass around the FEC are shown in Figure 2.4. Here distillate flow increases by about 9 lb per 1000 lb of condensate. Since these two studies reflect actual plant results and duplicate the original predictions, the PEPSE® submodel was accepted as an accurate model.

SHELL AND TUBE EVAPORATOR

A shell and tube evaporator is similar to a fire tube boiler in that hot fluid passes through tubes which are surrounded by boiling water and the entire apparatus is contained inside one shell. A shell and tube evaporator, shown skematically in Figure 2.5, can be divided into five subsystems similar to those of the flash evaporator. They are: 1) the evaporator preheater; 2) the evaporator, 3) the evaporator condenser 4) the make-up heater and; 5) the evaporator control valve. (Because the Possum Point Unit 4 evaporator was originally designed to accept hot water from the flash evaporator there was no need to include a make-up heater.) Extraction steam is supplied to the evaporator coil through the control valve. The steam condenses to saturation and then goes to the evaporator condenser. Make-up water is supplied to the preheater where it is heated to saturation by vapor from the evaporator. The make-up and condensed steam then fall into the evaporator shell, they are distilled, and go to either the preheater or the evaporator condenser. The majority of the distillate, about 87%, goes to the evaporator condenser and into the cycle. Notice that a loop is made from the evaporator shell to the preheater and back to the evaporator, by a portion of the distillate.

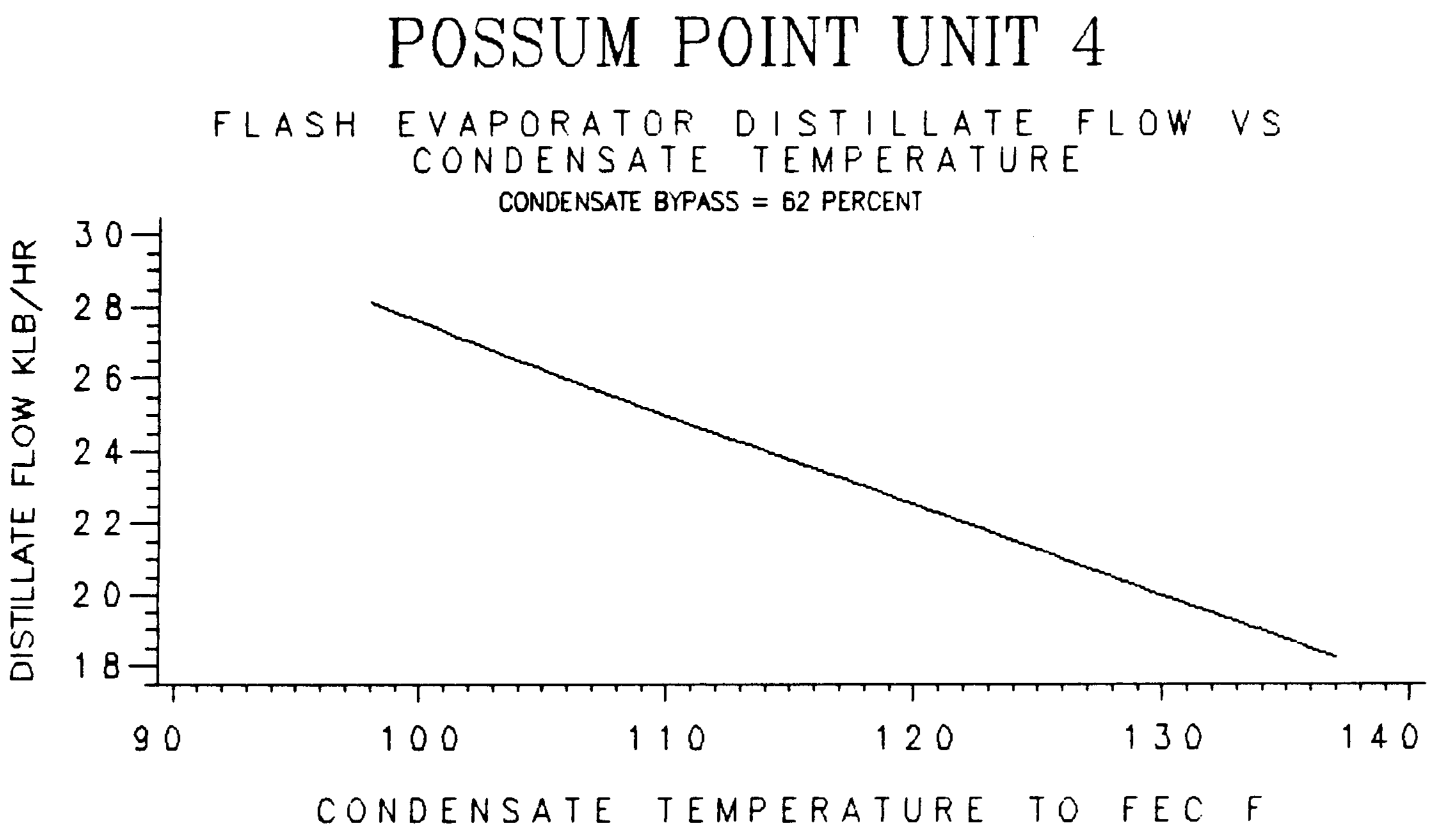


Figure 2.3 Distillate Flow vs. Condensate Temperature

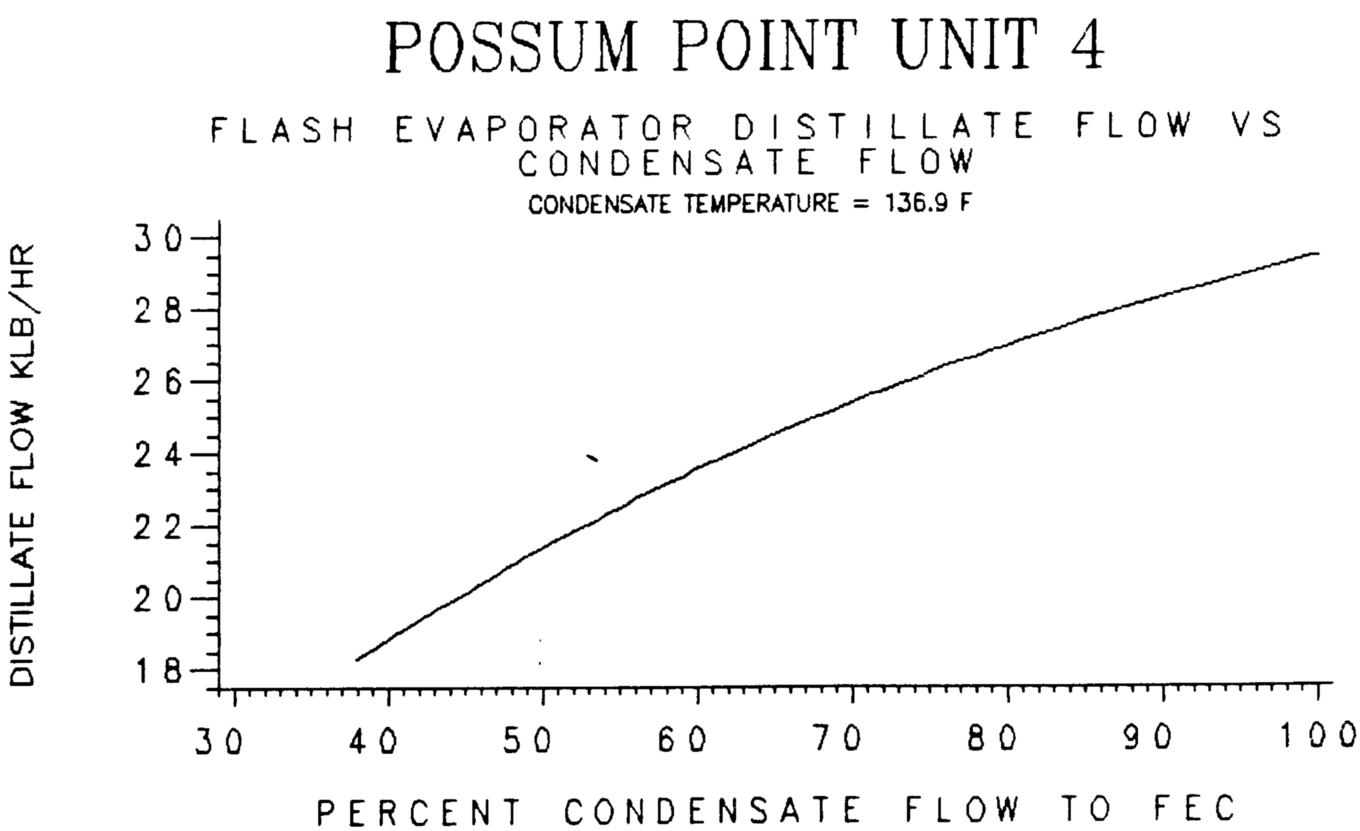


Figure 2.4 Distillate Flow vs. Condensate Flow

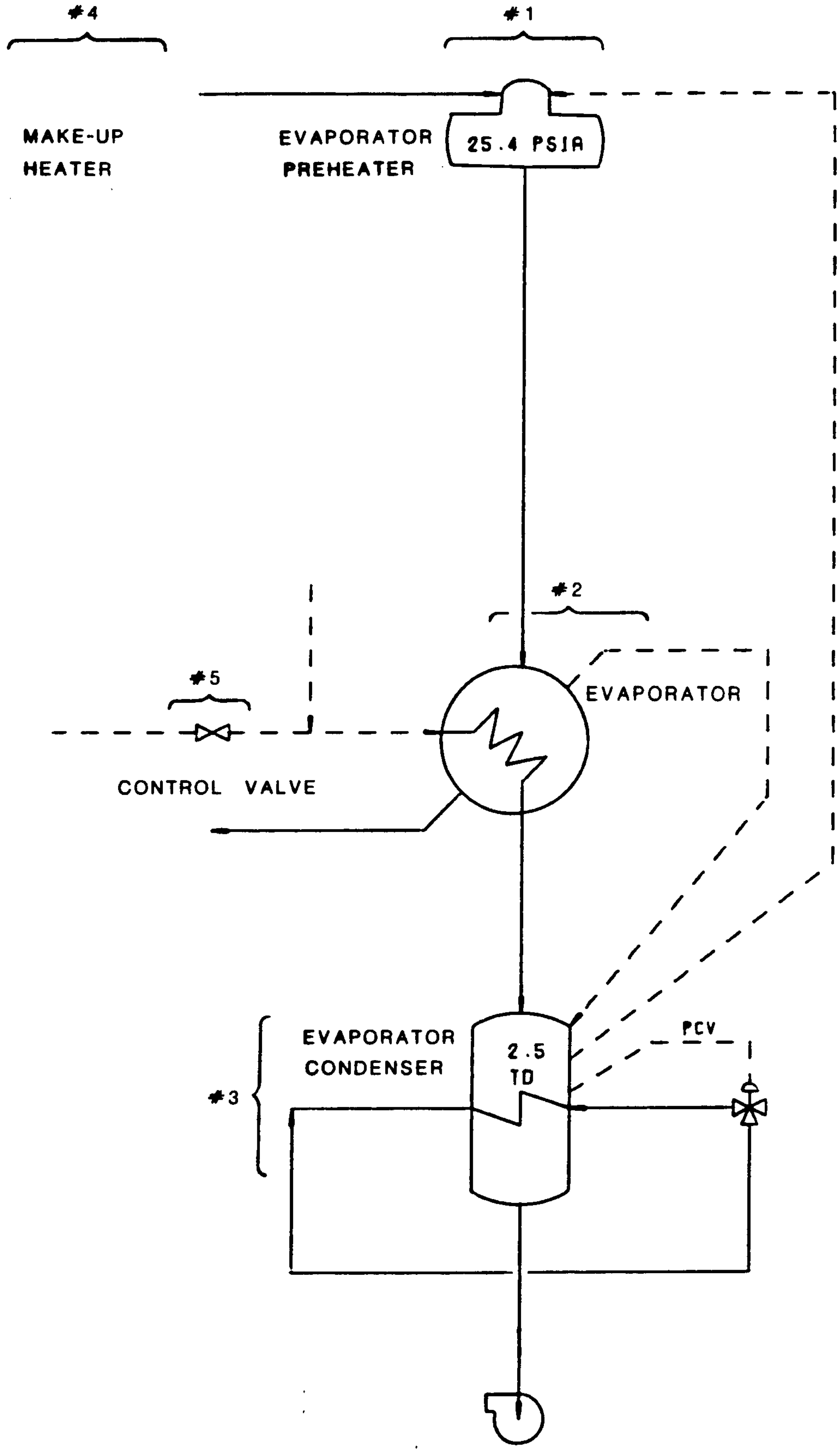


Figure 2.5 Shell and Tube Evaporator

In normal operation, the total distillate flow can be controlled by changing the heater effectiveness of either the evaporator condenser or the evaporator. As in the case of the flash evaporator, there are often condensate bypasses around a previous heater or around the evaporator condenser to control distillate production. There is also the ability to throttle the supply steam to the evaporator coil to increase or decrease distillate production.

The PEPSE® submodel for the Possum Point Unit 4 shell and tube evaporator is shown in Figure 2.6. The preheater has been modeled as a deaerator, the evaporator as a nuclear reheater and the evaporator condenser as a forward draining feedwater heater. The preheater references demand splitter number 744, from the drain of the nuclear reheater. The evaporator condenser references demand splitter number 745, which has a closed "U" port as in the case of the flash evaporator condenser. Again this is to create a mass flow imbalance across the heater. The nuclear reheater demands no steam but condenses to saturation all the steam entering its "T" port. Notice that the loop made by the steam supply to the preheater has been broken at the entrance to the evaporator to allow a solution. Furthermore, since the evaporator blowdown is at saturated water enthalpy at the evaporator pressure it is taken from the preheater drain outlet. This is required since a nuclear reheater has only one drain outlet.

There are two solution methods for solving for the thermodynamic conditions around the evaporator system, both of which begin by solving for the steam flow to the evaporator coils. One method would be to solve the complex equations of boiling and condensing heat transfer at the evaporator and using effectiveness to update the steam flow. This method would allow a user to model the effects of fouling of the coils as normally happens on this piece of equipment. However, because of the limitation of the PEPSE® operations, this method is not practical. The other method is to solve for the steam flow with the use of the equations for flow through a control valve. This equation, found in the <u>Control Valve Handbook</u> 1965 by Fisher Controls Company, is:

$$\dot{m} = C_g \, (1.06) \, \frac{\sqrt{P_1}}{\sqrt{v_1}} \quad \sin \left(\frac{3417}{C_1} \sqrt{\frac{P}{P_1}} \right) \qquad (2.5)$$

Where: C_g and C_1 are characteristic constants depending on valve size and type;

P_1 and v_1 are the pressure and specific volume respectively entering the valve, ΔP is the valve pressure drop; and the angle is expressed in degrees.

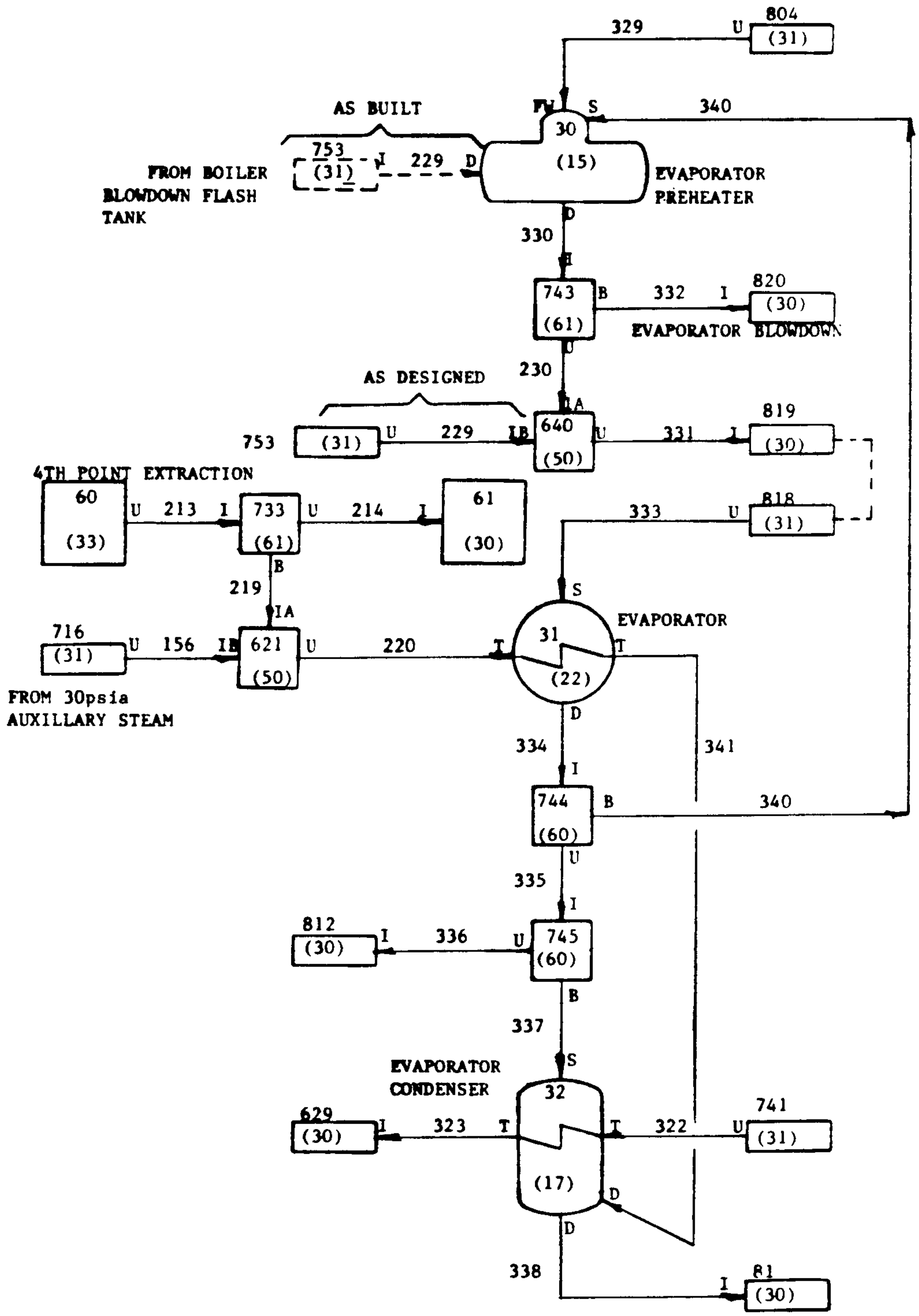


Figure 2.6 Shell and Tube Evaporator Submodel

Using this equation and original design data a relationship was found between C_g and the fractional pressure drop $\Delta P/P_1$ across the valve.

With this relationship (C_g versus $\Delta P/P_1$), shown in Figure 2.7, entered as a schedule, and the relationship C_1 versus C_g also entered as a schedule, the flow to the evaporator coils at any thermodynamic state and pressure drop could easily be calculated. Of course, prior to the release of the latest PEPSE® revision a Taylor Series expansion was written for the sine of an angle expressed in radians.

Once the steam flow to the coil is known, all other flows can be calculated based on known thermodynamic states and mass balances. The shell flow to the evaporator is determined by knowing that the enthalpy rise of the shell flow is the latent heat of vaporization and that the coil flow leaves at saturated water conditions. Evaporator make-up and blowdown are again solved for by mass balances of water and dissolved solids. Finally, a control was written to solve for the evaporator preheater shell pressure so that the mass flow imbalance created at the evaporator condenser is 0.5 ±25 lb/hr.

Usually a submodel of an evaporator will converge to a solution in about 30 iterations if the condensate and steam supplies are fixed. Because operations lag by an iteration and the preheater must converge on its steam flow at one guess of pressure, the control for pressure must have a minimum iteration interval of 3. The model for the evaporator was checked in a similar manner as the flash evaporator to ensure that an accurate prediction of nature was made.

One final word on the evaporator is that at minimum load there is condensate bypass of the evaporator condenser to insure that the shell pressure is at least 20 psia. At the same time, the normal steam supply to the evaporator coils may be below 20 psia which requires that auxiliary steam at 30 psia is supplied to the coils. To accommodate this feature in the PEPSE® model an "IF" statement was necessary. The basic principle of this IF statement was to test a value for positive or negative. If a positive value was encountered, an answer of 1.0 was desired; if a negative value was tested, an answer of 0.0 was desired. To make this test the following equations were used:

$$X = \frac{a + \sqrt{a^2}}{(a + \sqrt{a^2}) + 1.0E-50} \qquad (2.6)$$

$$Y = 1-X \qquad (2.7)$$

In these equations, it is obvious that if the test value, a, is positive, x will equal 1.0 and y, will equal 0.0. The opposite is true if, a, is negative. The values, X and Y, were then used as multipliers to turn flow from a fixed flow splitter on or off.

As a precaution when working with double precision, as in PEPSE , very small numbers (e.g., 1.0E-11) appear as the result of the calculation a + $\sqrt{a^2}$ if, a, is a negative number. To avoid this difficulty, 1.0E9 is added and subtracted to (a + $\sqrt{a^2}$) to truncate extraneous decimals.

TURBINE EXTRACTION TO THE FOURTH POINT HEATER

Steam can flow in either direction in the extraction line from the IP turbine exhaust. That is, either to the fourth point heater or from the boiler feed pump turbine. Therefore, the geometry shown in Figure 2.8 was necessary. In this geometry, the fourth point heater references demand splitter number 20 which has a closed "U" port. The total steam requirement, described by the sum of the flow in stream 110, from the drain of the fourth point heater, and the flow from the turbine to the evaporator coil, stream No. 114 (this is only for the case when the turbine extraction pressure is greater than 30 psia) is compared against the flow leaving the boiler feed pump (BFPT) exhaust. If the flow requirement is greater than the BFPT supply then the splitter, 13, from the IP turbine exhaust supplies the supplement and the flow from splitter 5 "B" port to the IP turbine is zero. If the opposite is true, then the flow from splitter 13 is zero and splitter 5 allows the excess to go back to the turbine.

POSSUM POINT UNIT 4 PEPSE MODEL

The entire PEPSE model for Possum Point Unit 4 is shown in Figures 2.9 and 2.10. There are 160 components and 218 streams. In order to make all the necessary calculations there are 225 operations, 17 schedules and 5 controls. Because of the large number of operations and the numbering scheme, which allowed for editing, the PEPSE Fortran source had to be recompiled to allow 500 operations and 600 operational variable.

Also, the internal data arrays had to be increased to allow all the information to be read in. Of the 160 components, there are 10 design mode feedwater heaters and 16 turbine components. The entire model will converge to ±100 lb/hr in about 98 iterations requiring over 16 CPU minutes per case.

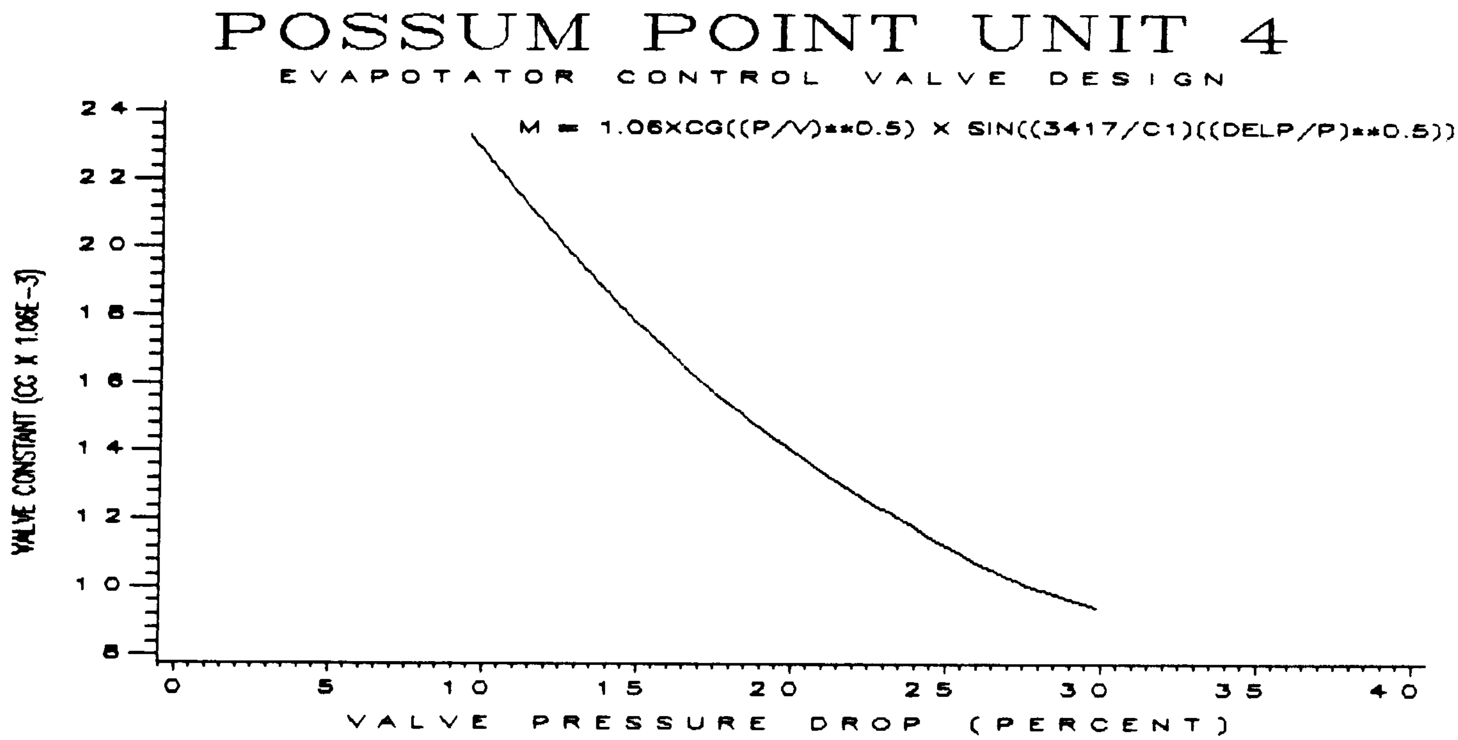


Figure 2.7 Control Valve Constant Cg

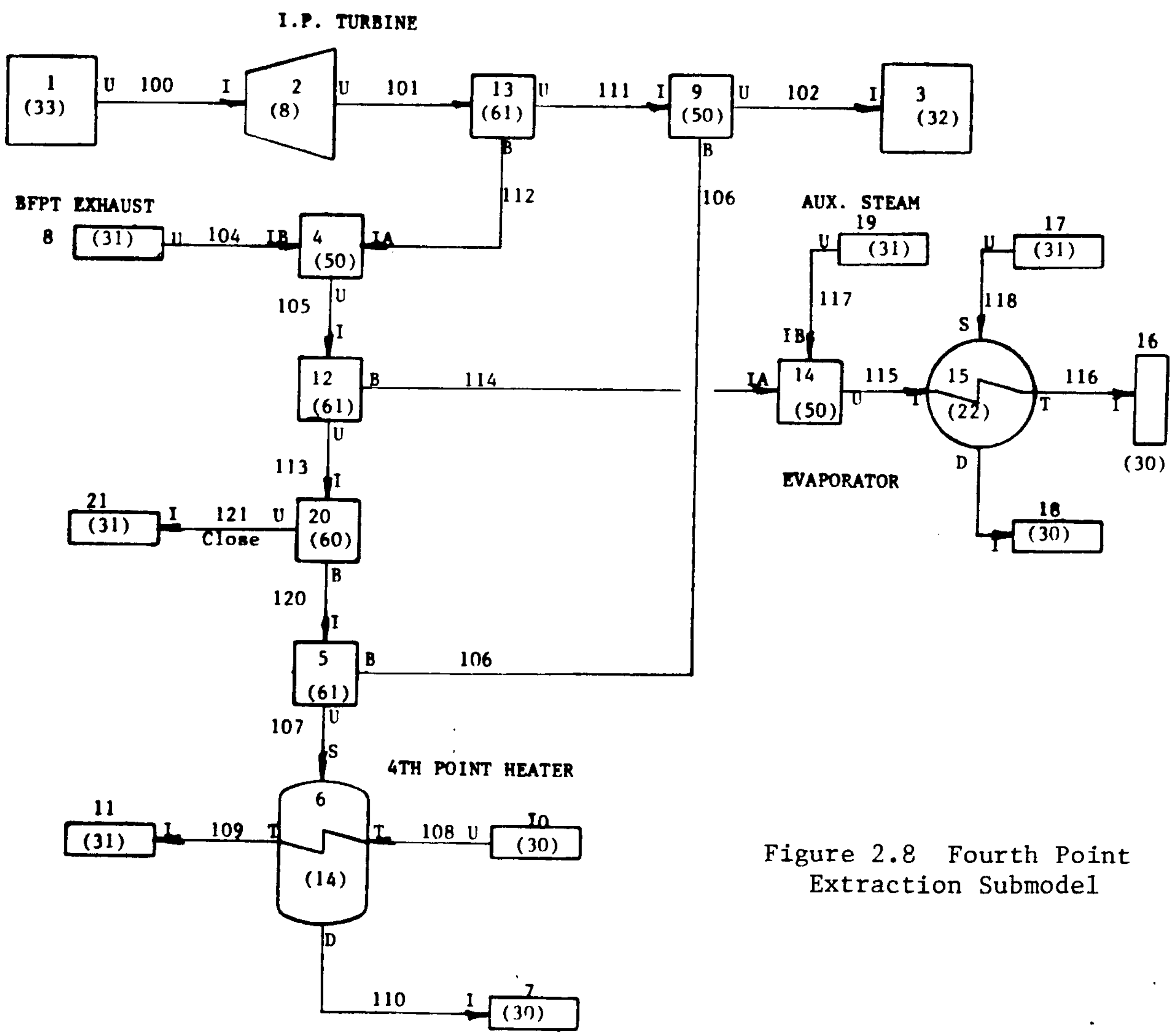
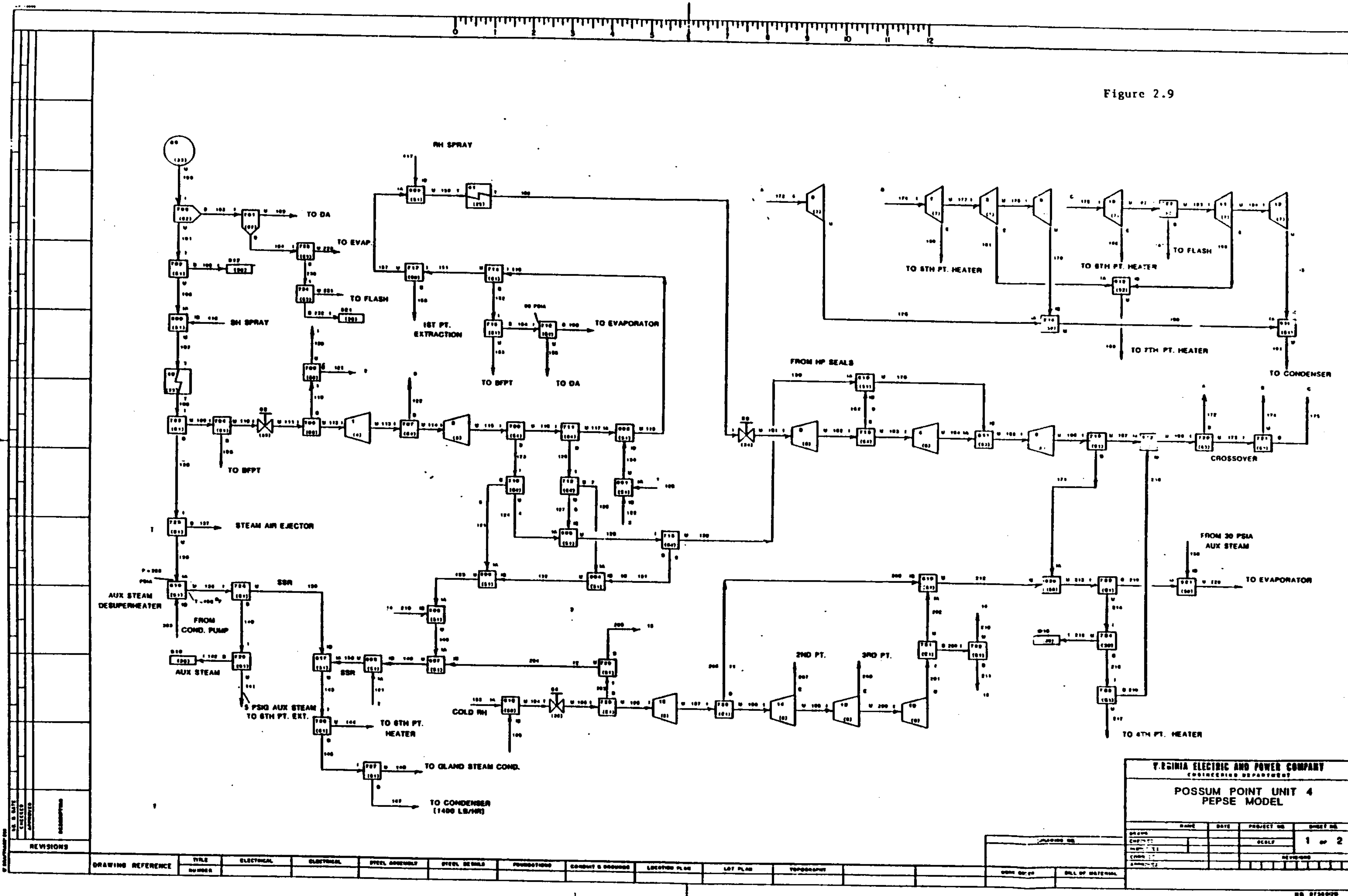


Figure 2.8 Fourth Point Extraction Submodel

Figure 2.9


RH SPRAY
TO DA
TO EVAP.
TO FLASH
SH SPRAY
1ST PT. EXTRACTION
TO EVAPORATOR
TO BFPT
TO DA
TO BFPT
STEAM AIR EJECTOR
AUX STEAM DESUPERHEATER
FROM COND. PUMP
SSR
AUX STEAM
5 PSIG AUX STEAM TO 6TH PT. EXT.
SSR
TO 6TH PT. HEATER
TO GLAND STEAM COND.
TO CONDENSER (1400 LB/HR)
COLD RH
2ND PT.
3RD PT.
FROM HP SEALS
TO 5TH PT. HEATER
TO 6TH PT. HEATER
TO FLASH
TO 7TH PT. HEATER
TO CONDENSER
CROSSOVER
FROM 30 PSIA AUX STEAM
TO EVAPORATOR
TO 4TH PT. HEATER
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PEPSE MODEL
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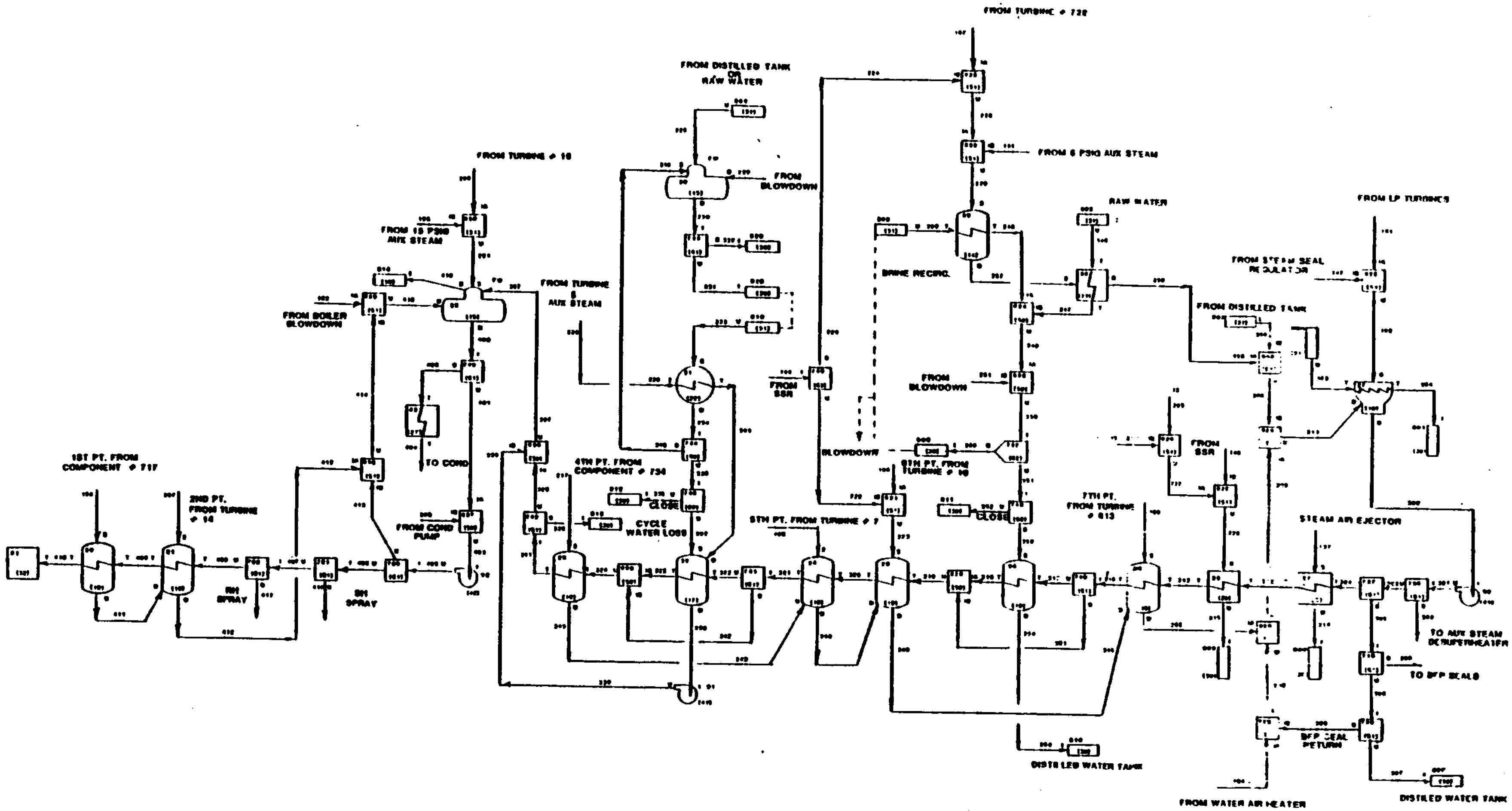
REVISIONS
DRAWING REFERENCE

Figure 2.10



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POSSUM POINT UNIT 4
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Section 3

PEPSE CODE SUGGESTIONS

From working with the Possum Point Unit 4 model, two suggestions for improvement of the code were recognized. One relates to the effect separate groups of components can have on the unit model and a method for reducing this effect and, therefore, reducing computer time. The other relates to a more user friendly method of writing operations.

SUBMODELS

When the submodels designed for the Possum Point Unit 4 model are operated separately, the feedwater heaters and controls will generally converge to ±1 lb/hr in 25 iterations. However, when the boundary conditions (pressures and temperatures entering the submodel) have not converged and change each iteration, as in the main unit model, imbalances at the evaporator condensers of 200 to 300 lb/hr can exist after 98 iterations. For a model with 10 design mode feedwater heaters one run with 98 iterations can take 16 CPU minutes, which is cost prohibitive for some users. From debug analysis, and from sensitivity analysis on the evaporators, we deduced that these long run times could be reduced if the two evaporators were allowed to converge during each iteration of the entire model. Therefore, a suggestion was sent to Energy Incorporated to allow user definable subgroups inside the main model.

These subgroups should be handled by the code in a similar manner as a chain of feedwater heaters. That is, for a user definable group of components, the code would solve the group a specified number of iterations before continuing to the rest of the cycle. The difference between a subgroup and a feedwater chain is that a subgroup may have schedules, operations and controls associated it. Therefore, the code would have to solve these special options after each subgroup iteration just as if the subgroup were an entire model.

A suggested format for the user input would be to have another card series to specify components of the group and any special options used with the group. For example, for a group identification YYY the following cards might be used:

Subgroup Identification Card, 90YYYS S = 0 to 5

1-I To 45-I List the user component numbers of the feedwater heaters, turbines and heat exchangers in a subgroup.

Subgroup Iteration Card, 90YYY6

1-I Enter the number of internal subgroup iterations. Defaults to the number of feedwater heaters or 5 if no feedwater heaters are present.

Subgroup Schedule Card, 91YYYS S = 0 to 5 (Optional Card)

1-I To 15-I List the schedule numbers applying to the subgroup.

Subgroup Control Card, 92YYY0 (Optional Card)

1-I To 5-I List the control numbers applying to the subgroup.

Subgroup Special Option Card, 93YYY0 (Optional Card)

1-I Enter the first operation applying to the subgroup.

2-I Enter the last operation applying to the subgroup.

USER FRIENDLY OPERATIONS

The Possum Point Unit 4 model has 225 operations, 196 of which are required for the heat balance. With this number of operations, editing and debugging a model under development is an unwieldy task. In fact, because operations do not lend themselves to easy documentation, even a small error in a submodel can take several man-hours to correct.

One method to circumvent this problem, without eliminating the flexibility offered by operations, would be to allow actual FORTRAN subroutines as part of the model input data. The input required for subroutines would be to enter each subroutine name (7 characters or less) and the list of variable that are passed to the subroutine. Each variable would be input in the same format as presently used for operations, that is by listing the variable name and component number. Subroutines would obviously require another card series for input. An example input might be:

Subroutine Card, 9600N0 Where: N is the subroutine number 1-5.
Enter the subroutine name 1-A.

Subroutine Variable Card, 9600NS S = 1 to 9

1-A	Enter alpha numeric name of the first variable used in the subroutine.
2-I	Enter user identification number of the model location of the first variable
.	
.	
.	
25I	

Note that if subroutines are allowed, the user must input the first and last operation, and the subroutine name or number on the 93YYY0 card mentioned above.

Section 4

EVAPORATOR SENSITIVITY ANALYSIS

PROCEDURE

Because Possum Point Unit 4 was designed to operate with either evaporator in service, and with auxiliary steam to either evaporator there has been some question as to which arrangement results in the best performance. To answer this question, a base case run of the model at full load (4 valves wide open) was compared to five slightly different arrangements of the plant cycle. An effort was made in each of the five runs to change only one variable at the time so that the cost of each change from the original heat balance would be known. Then a basecase at 2VWO (valves wide open) was compared to a run at the same load with the change of auxiliary steam to the flash evaporator.

The full load basecase was with all equipment in normal service. That is, the original condensate bypass was allowed around the flash evaporator and the pressure drop through the evaporator control valve was the same as the original design. Furthermore, raw water at ambient temperature was distilled in the conventional evaporator rather than flash evaporator distillate. Finally, boiler blowdown from the flash tank was routed to the conventional evaporator to reflect as-built geometry.

The five changes to the full load basecase cycle were:

1) Take the flash evaporator out of service.
2) Return the flash evaporator to service and remove the conventional evaporator.
3) Change the blowdown from waste in (2) to the flash evaporator.
4) Close the flash evaporator bypass in (2).
5) Close the extraction steam to the flash evaporator and use desuperheated auxiliary steam from the 20 psia supply in (4) above.

Of these five changes, only number 3 required additional geometry and operations. The additional geometry was two fixed percent splitters on the discharge of the blowdown flash tank (numbers 753 and 764) and an infinite sink. The word 'FRSPL', from the two splitters, was then used as a multiplier to find the dissolved solids from the boiler blowdown to either the conventional evaporator or the flash evaporator.

RESULTS

The results of this study are shown in Table 4.1. Here it is clear that for all arrangements of the evaporators there is no significant effect on heat rate except for the case when auxiliary steam is used. For the latter case, the heat rate increased by 139 Btu/kWh at 4VWO with an increase in distillate flow of 11963 lb/hr. Using the most recent fuel cost for this unit, the cost of each additional pound of water is 0.461¢. In comparison, from the basecase the shell and tube evaporator can be operated simultaneously with the flash evaporator in the normal operating mode to produce an additional 15910 lb/hr of distillate at a cost of only 0.2 Btu/kWh, a net savings at 138.8 Btu/kWh.

At 2 VWO the cost of operating the flash evaporator on auxiliary steam was 192 Btu/kWh. Again using current fuel costs, the additional 11,500 lb/hr of water generated costs 0.481¢ per pound. Similar savings would be realized at this load if the shell and tube evaporator were operated rather than auxiliary steam supplied to the flash evaporator.

Besides the expense of operating the flash evaporator with auxiliary steam, a small improvement of 1.2 Btu/kWh can be realized if a pipeline is constructed to route the boiler blowdown from the flash tank to the flash evaporator as was originally proposed. This change would also require the inclusion of spray nozzels in the flash chamber of the evaporator.

RECOMMENDATIONS

From this study, recommendations were sent to the station to reduce the use of auxiliary steam for evaporation which should be replaced by operating both evaporators simultaneously. This would allow additional make-up production at a negligible cost. In the situation when auxiliary steam absolutely must be used, the station should compare a contract price for portable demineralization with the cost of $4.60/1000 lb and take the lesser cost alternative.

Also since the effect on heat rate is so small for a relatively wide range of normal operation of the low pressure systems, future models of units less than 200 MW will not include design mode feedwater heaters below the deaerator. However, design mode evaporators will be incorporated because of the tendency of plant operators to use auxiliary steam for distillation.

In the near future, these design mode submodels of evaporators will be used to compare test data to design outputs at the test boundary conditions. These tests and comparisons will become part of Vepco's component performance test program which has been useful in the past to locate system problems and justify maintenance expenditures.

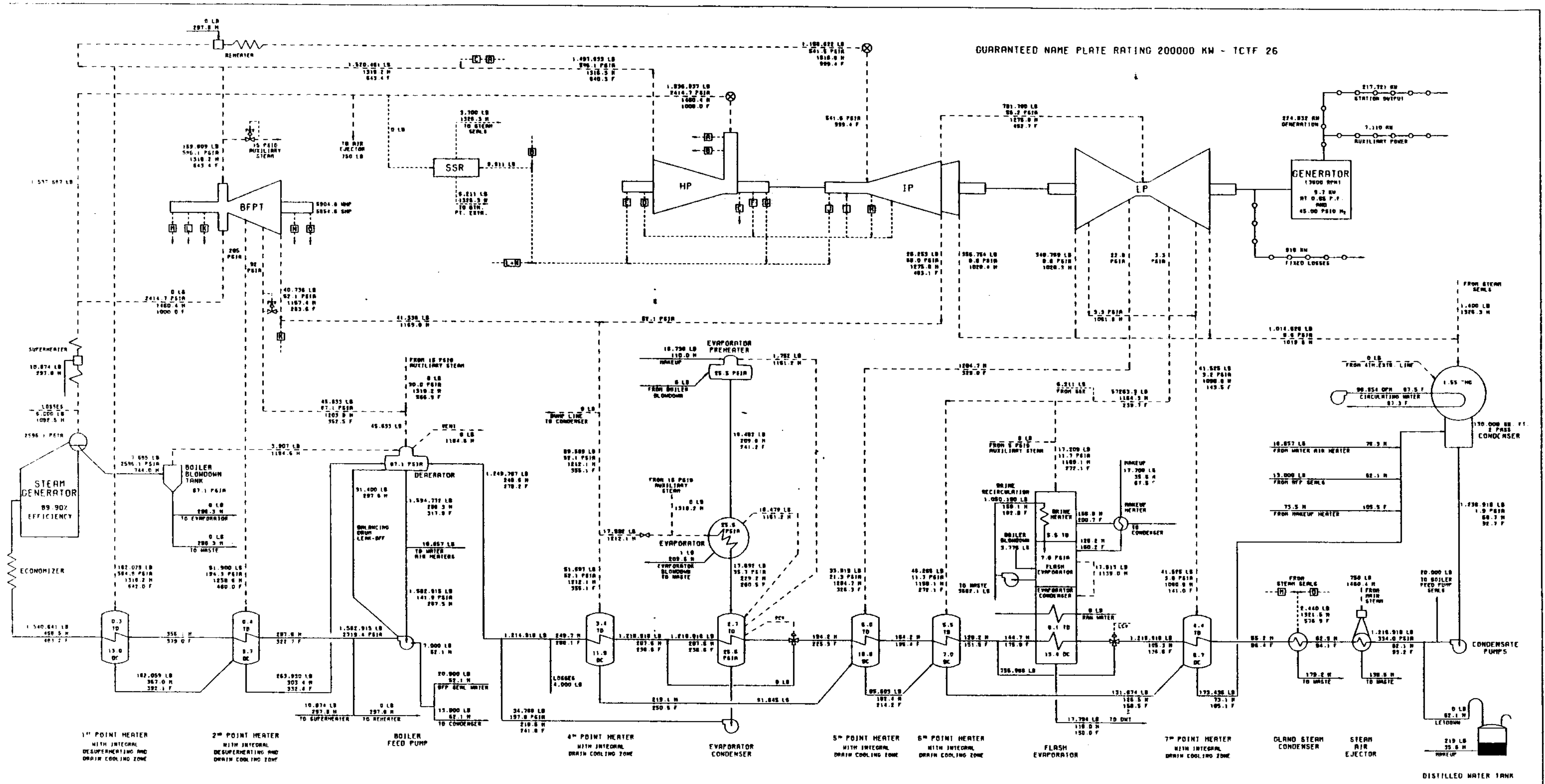
Table 4.1

EVAPORATOR SENSITIVITY

POSSUM POINT UNIT 4

	Description of Model	Net Output (kW)	Net Turbine Heat Rate (Btu/kWh)
4 VWO			
0)	Base case	217648.	8120.4
1)	Flash evaporator out of service	217660.	8119.9
2)	Conventional evaporator out of service	217657.	8120.2
3)	(2) and blowdown to flash evaporator	217687.	8119.0
4)	(2) and no condensate bypass for flash evaporator	217653.	8120.3
5)	(4) and auxiliary steam to flash evaporator	218199.	8259.3
2 VWO			
0)	Base case	155311.	8177.8
*1)	Auxiliary steam to flash evaporator	150576.	8372.9

*Control for equivalent throttle flow ratio did not converge.



BASIS OF HEAT BALANCE CALCULATIONS

LEAKAGES

LEGEND

STATION HEAT RATE = BOILER DUTY / (STATION OUTPUT X BOILER EFFICIENCY) = 9030 BTU/KWH

TURBINE HEAT RATE = BOILER DUTY / TOTAL GENERATION = 8118 BTU/KWH

Figure 1.1

VIRGINIA ELECTRIC AND POWER COMPANY
FOSSIL AND HYDRO TECHNICAL SUPPORT
PERFORMANCE, TESTS AND RESULTS

POSSUM POINT UNIT 4
HEAT BALANCE DIAGRAM
224 MEGAWATTS
--NORMAL--

	NAME	DATE	FILE NO.	SHEET NO.
DRAWN				1 OF 5
CHECKED				
INSPECTED				
CORRECT				REVISIONS
APPROVED				

DRAWING NO.
HBPPT-4