On-Off Switching of PEPSE® Controls

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ABSTRACT

A method is described, and examples are given, to turn PEPSE controls on and off. The method can be implemented via schedules, operations, or compiled algorithms. This means that the method can be used with both old PEPSE versions, as well as with the current version.

The essence of the method is that logical switching is used to activate and deactivate the control variable and the convergence criterion, or the goal variable. This switching is a versatile tool, adapting automatically to the conditions that exist in a specific run. Use of the switching ability is easy. The setup of the tool requires some effort, and the details will depend on the specific application.

The development of this method was motivated by analysis situations that need to simulate system control schemes that switch from one physical process or phenomenon to another at a threshold operating state. For instance, control of hot reheat temperature in some fossil boilers is obtained by damper setting (split backpass) over part of the load range and by spray attemperation over the rest of the load range. This case is used as the second example in this paper.

The first example of this on-off switching is a very simple three-component case that is used just to demonstrate the concept. The case has no known practical equivalent.

INTRODUCTION

Some plant control systems have more than one mechanism available for obtaining a set-point value of a physical parameter. For example a boiler's hot reheat temperature may be controlled by attemperation spray, by burner tilt, by backpass damper position, or some other effect. At any one time, only one mechanism may be used, while the others remain at fixed or programmed values. Operating states, load, and other variations dictate the mechanism being used. Thus the system controls are conditional.

PEPSE's modeling capability allows representing a control mechanism as one parameter depending on another. To represent multiple system controls, the modeler can write separate PEPSE controls. There is no explicit provision in PEPSE for conditional phasing between two or more separate controls. To do so would require turning one PEPSE control on and other(s) off, conditioned on the situation.

THE PROBLEM

The coding of PEPSE controls makes no provision for turning the control calculations on or off. When the modeler specifies a control in a data set, PEPSE exercises the control in an attempt to find the answer requested. If two controls are present, they will each attempt to solve their assigned problems even in an application where they are both working on the same goal. User care is needed in setting up such analysis applications to avoid conflicts.

To achieve the needed phasing (on/off), the modeler must help PEPSE by providing the needed additional logical conditions. The calculations include adjusting the "control variable" and examining the "goal variable" for convergence. That is, the value of the goal variable is examined from one iterate to the next, and if the offset of the calculated goal variable from the goal value is within the allowed tolerance, the control is called converged. For a run to terminate successfully, even an "off" control has to satisfy its convergence criterion.

THE SOLUTION

The problem can be solved by introducing a way to get PEPSE to switch the use of physical variables (such as a source-component's flow rate). In addition the convergence criteria, or else the goal variables, for the controls need to be switched on and off. Dummy variables (OPVB) are useful tools in this solution.

The two elements of the switching are the control variable (and its use by the PEPSE heat balance calculations) and the convergence criterion. For the "off" condition, we can stop the control calculation process by tricking the control into concluding that it is converged. This can be done by setting the convergence criterion (tolerance) to a very large value. Convergence of a control is checked by PEPSE's examining the expression

abs (yg - y) ≤ cc * yg,

where: yg is the goal value,

y is the current goal variable value,

cc is the convergence criterion

If the convergence criterion were not set to a large value, the testing by the expression generally would not be satisfied, and the control would conclude that it was not converged. As a result, this "off" control would prevent a run from terminating with a "converged" result. As an aside, an alternative way of tricking the "converged" conclusion would be to set y exactly equal to yg. This latter approach is used in one of the examples presented in this paper.

Then for the "on" condition, we set the convergence criterion to a realistic value, such as 1.E-3, and doing so causes the control to perform its calculations until a good/real answer is obtained.

Switching the control variable is also somewhat tricky. During the "on" condition, we want the control to feed its information to the physical variable that is used in PEPSE's heat balance calculations. During the "off" condition, we want to set the physical variable to some desired value. This can be done by making the control variable an OPVB.

It is important to realize that the control will continue to function as though it were "on" continuously, and thus control results will continue to print, e.g. in a debug output. However, during "off" situations, we have tricked the control mechanism into a converged signal, and we have disconnected its effect on the model through the use of an OPVB as the control variable.

THE FIRST EXAMPLE

To demonstrate the concept, a simple illustration will be used in which a switching mechanism turns a single control on and off. No claim is made that this particular model has any real physical significance. One benefit of this model is that it shows control "on" and "off" conditions within a single run. In the typical, physically realistic case (not this one), a control will be on or off, and not both, during a single run.

This first example has three components, an input, a Type 8 turbine, and an output component, as seen in Figure 1. The complete input data set and the calculated results for the first case with this model are included as Table A-1 in the Appendix.

A control (Card series 84XXXX) is included to adjust the flow from the input component to produce a target power of 100 mW from the turbine. The control is conditional. It is "on" up to iterate 7, and then it is turned "off". There are two ways to obtain this result; one uses PEPSE operations and the second uses compiled algorithms. These are demonstrated in this paper as two stacked cases in a PEPSE run.

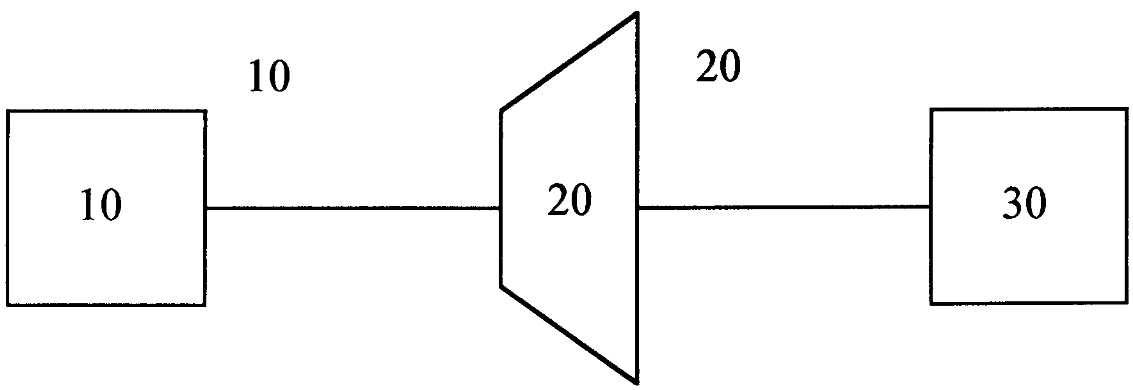

Figure 1. Turbine Submodel to Demonstrate Control Switching

With operations (Card series 88XXXX) it is easy to turn the control "off", and more difficult to turn it back on again later. Therefore, the first case simply turns the control off after iterate 7. Switching is accomplished by use of a binary if (BIF) operation that gives a zero or a one result, dependent on the arguments into it.

The operations that achieve the switching take advantage of a simple algebraic expression:

$$Z = A + (SWITCH * (B - A))$$

where Z symbolizes the PEPSE physical variable, and A and B are dummies, e.g. that appear in control definitions.

Application of this equation gives a value of y that is equal to A when the SWITCH is zero and a value of Z that is equal to B when the SWITCH is one. We can choose the meaning of SWITCH. Suppose that a value of one means that the control is "on". Then B is the dummy control variable and A is the dummy for the value desired when the control is "off".

The zero or one value of the SWITCH is set by the BIF operation, Card 880020, where the real-valued iteration counter, OPVB,1, is compared to a threshold (switching set-point) value. This switch, OPVB,2, is inverted to a 1.0 in OPVB,3 via 880030, which is used then to perform the algebra indicated above for both the physical variable, WWVSC,10, for flow rate and for the convergence criterion for the control, YCNVRG,1. The algebra is developed via operation Cards 880030 through 880050 and 880110 through 880130.

Selected results to demonstrate the switching for this case are shown in Table 1. These values are taken from the complete PEPSE run, included as Table A-1 in the Appendix. Note that the PEPSE tables were obtained by use of the "print-while-iterating" capability. Shown in the Appendix are the special output, control, and operation results tables at iterates 4 and 8.

Table 1

Results[1] for Case 1, Turbine Submodel, With Control Switching Done By Operations

Iterate	Source Flow	x Value	y Value	Control y Goal Value	Convergence Criterion	Convergence?
4	5.268641E6	5.26864E6	1.0E2	1.0E2	1.0E-3	Yes
8	500.	5.26864E6	9.49E-3	1.0E2	2.0E2	Yes

1 Additional details in Appendix Table A-1.

At iterate 4, the control is still "on", having started at iterate 2. The control has a goal variable value of 1.E2 mW and a control variable of 5.26864E6 lbm/hr and a "YES" convergence signal. The convergence criterion is 1.E-3 at this iterate. The physical variable, WWVSC,10, flow rate has been set to the value of the x-variable, OPVB,6, from the control. The operation table in Table A-1 shows that this is a consequence of the BIF operation that gave a switching value of zero for OPVB,2 and 1.0 for OPVB,3.

At iterate 8, the control has been turned "off". This is shown in Table 1 where the convergence criterion is equal now to 200. (to fool the control into setting the "YES" convergence signal). The control still signals a "YES" for convergence, even though the goal variable is now far away from our stated goal value. The BIF operation has caused a change now to a value of 1.0 for the switch, OPVB,2 and 0.0 for OPVB,3. This results in a disconnect of the flow rate variable, WWVSC,10, from the control's x-variable, OPVB,6, as desired.

Referring to the component properties table in Table A-1 shows that the run has terminated, converged, with a flow rate of 500 lb/hr. This latter value is not at all the amount that the control would have set. Thus the control's effect has effectively been turned "off".

The second case uses a compiled algorithm for the switching. The logical structure of compiled algorithms makes it easier to set up both on and off switching. Therefore this case, shown completely in Table A-2, includes both on and off switching. During iterates five to ten, the control is to be "off", and "on" otherwise. Again, realize that some more meaningful condition could be employed in a real analysis case (maybe a pressure condition); but in order to demonstrate the switching within a single run, this one was chosen. It is not a practical application.

To summarize, we want the following results to occur:

"off", iterates 5 to 10

WWVSC,10 = value of our choice, 500 lbm/hr, YCNVRG = 200. (a large value for the control)

"on", all other iterates

WWVSC,10 = the value from the control, OPVB,6,

YCNVRG = 1.E-3

A compiled algorithm (CA), permits conditional (IF-THEN-ELSE) calculations, and, thus, it is well suited to this assignment. A CA, called COMPALGCON, was written to provide the results summarized above. For documentation purposes, this algorithm is included as comments in the data set that is part of Table A-2, to illustrate its content. In actual use, the algorithm is a separate file called ALGDEF.DAT (without the first-column commenting character) that is compiled according to instructions contained in the PEPSE input manual, Ref. 1.

Notice that use of the algorithm by PEPSE is specified by Cards 1001000 and 1001001. Among the arguments passed to the algorithm is OPVB,1. This is the real-valued iteration counter that has been computed by operation 1, Card 880010. This method was used because an integer variable, NTIMES, cannot be communicated to the compiled algorithm feature.

A synopsis of the calculated results for this model are shown in Table 2. Shown are the results for iterates 4, 8, and 15. These were taken from the Special Output and Control tables of Table A-2. These are at stages of the run where the control is initially "on", then "off", then back "on" again. In these PEPSE tables the control is always converged. At iterate 4, the results are the same as those in the first case above.

The results at iterate 8 occur during the "off" period. Notice that the y-variable and the x-variable values are very different from those at iterate 4. Notice also that the convergence criterion is large, thus allowing the control to "think" it is converged.

At iterate 15 the results show that the control has turned back "on". Now the results match those that occurred at iterate 4, as we would expect for an "on" control.

Table 2

Results[2] for Case 2, Turbine Submodel, With Control Switching Done by Compiled Algorithm

Iterate	Source Flow	x Value	y Value	Control Convergence Criterion	Convergence?
4	5.268641E6	5.268641E6	1.0E2	1.0E-3	Yes
8	500.	8.	9.49E-3	2.0E2	Yes
15	5.268659E6	5.26866E6	1.0E2	1.0E-3	Yes

2 Additional details in Appendix Table A-2.

This example has demonstrated an effective method for turning controls off and back on again. Note that both of these cases have been forced to go at least ITRMIN = 15 iterates. If we had not forced it, the run could have stopped at any earlier point where convergence was satisfied.

THE SECOND EXAMPLE

The second example of control switching is a real boiler analysis case. See Figure 2 for the PEPSE schematic for this case. As shown, the system has a split backpass in the upper center of the schematic - components 90, 105, 135, and 140. In this system the hot reheat temperature is controlled to the set point value by backpass damper position and by reheat attemperation spray. The flow split to the backpass also impacts the main steam temperature. Therefore, a separate main steam control mechanism is also necessary to obtain this set point.

At low loads the reheat temperature is controlled by backpass damper position. This damper position is characterized in the model by a percent splitter, component 90. The complete input data set for the model is documented in Table A-3.

The flow split fraction determines the heat transfer to the reheater. A preliminary set of runs (model tuning process that was founded on boiler test results) was done over the range of loads to determine the variation of backpass flow split that was required to obtain the set point reheat temperature. In part of this range the reheat spray was zero. The values of flow splits (fraction-values) from these runs were placed in a schedule. This schedule covers the entire operating range of the boiler because, even for high loads, the flow split is a changing quantity.

Note that the schedule of backpass split applies precisely for the specific configuration of the model, the specific fuel, the specific excess air fraction, and other specific conditions. To this extent, this schedule is constraining. A more versatile final model would include a control for the backpass split, that would be switched by the same kind of scheme that is used here for switching the spray flow control.

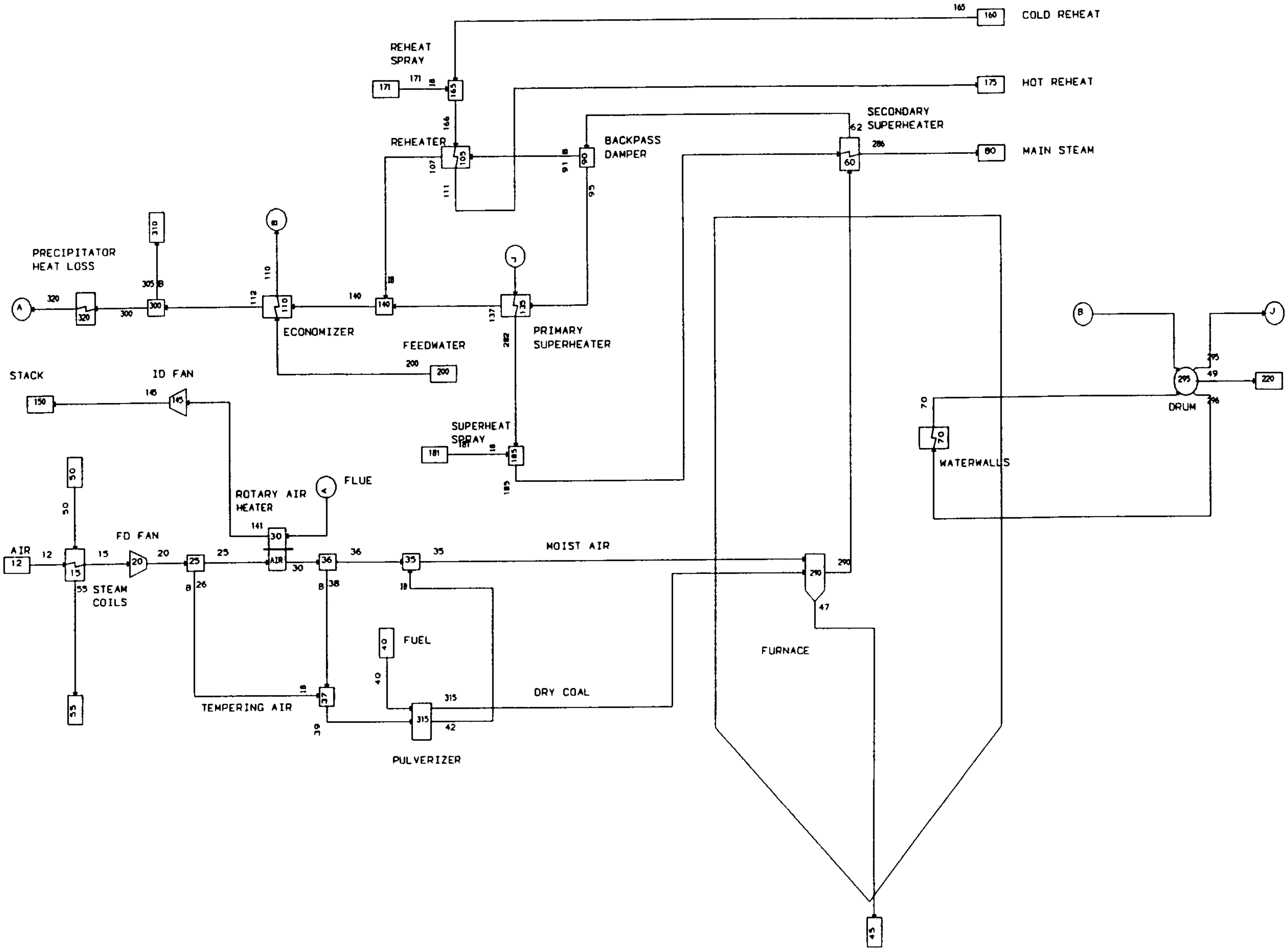

Figure 2. JPM Boiler - Demo Control Switching On/Off

In spite of being constraining, calculated results from this modeling approach can be used to obtain significant insight into the physical processes of the boiler. It also gives scoping values of parameters that can be used to guide design and operation choices, if not to give exact predictions of specific flows and conditions.

At high loads the reheat temperature is controlled by attemperation spray flow. A PEPSE control is included in the model to represent this mechanism.

In this example the switching mechanism chosen was a binary multiplier (1.0 or 0.0) that was used in operations to set both the control and the goal variables. The meaning of the switch values is 1.0 for "on" and 0.0 for "off". The value of the switch/multiplier was set in this example through use of a schedule. The x (independent) variable in the schedule was the main steam flow rate. Flow rate is used here to characterize load.

This multiplier, OPVB,200, was used in operations in a way similar to the first example of Tables 1 and A-1 in the preceding section. There's a slight twist. Here the goal variable is set to the exact goal value during "off" conditions, so that the control mechanism detects convergence. Thereby, no adjustment of the convergence criterion is needed, as was used in the first example for tricking the control to pass the convergence test.

The main steam condition attains its set point by use of superheat attemperation spray. A PEPSE control is used to calculate the amount of spray flow needed. Like the reheat spray flow control, this control requires "on" and "off" switching. The switch, OPVB,123, was set to 1.0 and 0.0 values, as a function of load, via a schedule as a function of steam flow, which is used to characterize load. The schedule for setting the switch has an advantage over use of the BIF operation in this application. With the schedule, it is easier to set the more complex "on" and "off" switching pattern than it is with the BIF.

The superheat spray flow control switch is slightly more complex than the reheat spray switch. Over the load mid-range the control is on, while it is off at low loads and at high loads. This is a result of the fact that the damper action causes the primary superheater to be heat-starved at low and high loads. Thus, no superheat spray is needed in these load ranges. This means that the set point for main steam probably will not be met exactly. In fact it is the case that at low loads neither the superheat nor the reheat set point is met. This can be seen in the component properties tables in the Appendix.

The calculated results selected from Table A-3 for inclusion in Table 3 apply for a low load case. For this load, both the superheat and the reheat spray controls are "off". This can be seen in the operation, control, and special output tables. The switches, OPVB's 200 and 205 have zero values. This disconnects the dummy variables OPVB's 171 and 181 in the controls from the physical variables. See operation results 112 through 116 and 122 through 126. Since the sprays are not active, the main steam and hot reheat set point temperatures are not exactly met, as seen in the special output table.

Table 4 shows results selected from Table A-4, which applies at an intermediate load. In this case, the superheat spray control is "on", and the reheat spray is "off". Review of the operation, control, and special output tables shows this condition. The main steam set point is met exactly, while the hot reheat set point is approximated only.

Table 5 shows results selected from Table A-5, which applies at a higher load case where both of the spray controls are "on". This can be seen in the operation, control, and special output PEPSE tables. Now both of the set point temperatures have been met.

CONCLUDING REMARKS

Two examples have shown that a user can apply existing features to obtain "on" and "off" switching of the effect of controls. The status of the control is determined by PEPSE, subject to conditions defined by the user. Such switching has real applications in power plant analyses, for instance where a boiler control system uses different physical processes to obtain set points at different load conditions.

Table 3

Results[3] for Boiler Model, Case 1 (Low Load) With Control Switching by Schedule, Both Sprays Off

Spray	Flow	Control x Value	y Value	Y Goal Value	Convergence?
SH	0.	2.52E3	0.	0.	Yes
RH	0.	1.0E3	0.	0.	Yes

3 Additional details in Appendix Table A-3.

Table 4

Results[4] for Boiler Model, Case 2 (Intermediate Load), With Control Switching by Schedules, One Spray On and One Off

Spray	Flow	x Value	y Value	y Goal Value	Convergence?
SH	2.24E4	2.24E4	0.	0.	Yes
RH	0.	1.0E3	0.	0.	Yes

4 Additional details in Appendix Table A-4.

Table 5

Results[5] for Boiler Model, Case 3 (High Load), With Control Switching by Schedules, Both Sprays On

Spray	Flow	x Value	Control y Value	y Goal Value	Convergence?
SH	3.487E4	3.487E4	2.7E-1	0.	Yes
RH	1.557E4	1.557E4	2.1E-1	0.	Yes

5 Additional details in Appendix Table A-5.

Operations, through the BIF logical, or schedules can be used to set a 1.0 or a 0.0 value of a switch variable for this purpose through a simple algebraic equation. This switch variable is then available for application via operations to any of the control, goal, or convergence criterion variables.

As an alternative, compiled algorithms are also well-suited to this application. Because it does not involve binary multipliers, this method is probably easier to understand.

There has been no experience, as yet, with use of these methods when control blocks are invoked. This is an opportunity for future work.

REFERENCES

1. Minner, G. L., et al, "PEPSE Manual Volume 1, User Input Description", Halliburton NUS Corporation, Idaho Falls, Idaho, 1994.

Appendix A

This appendix includes complete tabular presentations (Tables A-1 through A-5) of the PEPSE data sets and run results for the models used in this paper.

TABLE A-1

CASE 1 FOR TURBINE SUBMODEL WITH CONTROL SWITCHING DONE BY OPERATIONS

LISTING OF INPUT DATA FOR CASE 1

```
= J:\PERFSYS\PEPSE\CHKV59\SRCSWITC - OPNS W BIF TO SWITCH CONTROL ON AND OFF
$
$ THIS RUN IS AN EXAMPLE OF AN IDEA TO TURN CONTROLS ON AND OFF.  BINARY IF
$ (BIF) OPERATIONS ARE USED TO SET SWITCHES THAT HAVE THIS EFFECT.  BASICALLY,
$ THE CONTROL VARIABLE IS MADE A DUMMY (OPVB,6) AND THE SWITCH IS CALLED UPON
$ (THROUGH ITS USE AS A MULTIPLIER) TO CHOOSE WHETHER TO ACTUALLY USE THE DUMMY
$ IN THE MODEL OR NOT.  IN ADDITION, THE CONVERGENCE CRITERION FOR THE CONTROL
$ IS SWITCHED IN A SIMILAR WAY SO AS TO FOOL THE CONTROL INTO BELIEVING IT IS
$ CONVERGED DURING TIMES WHEN THE CONTROL IS TO BE "TURNED OFF".
$
$ THE CONTROL IS SUPPOSED TO ADJUST THE STEAM FLOW TO OBTAIN A SPECIFIC
$ AMOUNT OF POWER.
$ FOR DEMONSTRATION ONLY, THE SWITCHING MECHANISM IS TO TURN THE CONTROL OFF
$ FOR ITERATES ABOVE 7.  THIS SWITCHING BASED ON ITERATE COUNT IS NOT
$ NECESSARILY INTENDED AS A PRACTICAL CASE.  RATHER IT ILLUSTRATES THE
$ CONCEPT.  THIS IS DONE AS FOLLOWS
$
$   Y = A + (SWITCH * (B - A))
$      WHERE THE SYMBOLS HAVE MEANINGS
$           - Y IS THE PHYSICAL (FLOW) VARIABLE, WWVSC,10
$           - A IS A DUMMY SET BY THE USER FOR USE WHEN THE CONTROL
$             IS TO BE OFF, OPVB,101, AND
$           - B IS A DUMMY SET BY THE CONTROL, OPVB,6
$           - SWITCH
$             = 0.0 MEANS CONTROL IS "OFF", THUS Y = A
$             = 1.0 MEANS CONTROL IS "ON",  THUS Y = B
$             THE VALUE OF THE SWITCH IS SET BY TESTING A REAL-VALUED
$             COUNTER, OPVB,1, AGAINST THE "OFF THRESHOLD", OPVB,100
$
*
*** GENERIC INPUT DATA
*
* PRINT WHILE ITERATING TO SHOW EVIDENCE OF CONTROL ON/OFF
*
010110 4      8      15     * ITERATES SELECTED FOR PRINTING
010111 36     39     42     * PRINT CONTROL, SPCL OUT, OPERATION TABLES RESPECTIVELY
*
* CYCLE FLAGS
*
010200 0
*
* CYCLE CONVERGENCE DATA
012000 25     1.0    1.0    0.     0.     0.     15     10000.0
*
```

```
* GLOBAL SUPPRESS, THEN SELECTIVE REACTIVATE
*
020000  NOPRNT
* REACTIVATE TABLES DESIRED
022000 3        6        7        36       39
*
***  MODEL GEOMETRY
*
500100 10       U        20       I
500200 20       U        30       I
*
***  COMPONENT DATA
*
* INPUT/SOURCE
*
700100 33       1.2      1000.    1.E2
*
*
* OUTPUT
*
* RECEIVER
700300 32
*
* TURBINE
*
700200  8       0        2        0        5        0        1        1        0.
700201 .9       500.
*
* END OF BASE DATA
*
* CONTROL FLOW RATE TO OBTAIN DESIRED TURBINE POWER = 1.E5MW
* NOTE THAT THE CONTROL VARIABLE IS A DUMMY, OPVB,6.  THE COEFFICIENT
* OF BHPP CONVERTS THE INTERNAL UNITS BTU/HR TO MW
*
840100  OPVB,6          1.E2,0., 2.9301707E-7,   BHPP,20
840106  2        * START CONTROL AT ITERATE 2
*
* OPERATIONAL VARIABLES FOR USER PARAMETERS
*
870010  1.       * INITIATE REAL-VALUED ITERATION COUNTER
871000  7.       * SWITCHING THRESHOLD, ITERATE COUNT
870070  1.E-3    * REAL CONTROL CONVERGENCE CRITERION
871010  500.     * "USER", FLOW VALUE TO BE USED WHEN CONTROL IS "OFF"
871020  200.     * TRICK CONVERGENCE CRITERION, FOR USE WHEN CONTROL IS "OFF"
*
* OPERATIONS FOR SWITCHING CONTROL VALUE INTO SOURCE FLOW VARIABLE NAME.
* THESE OPERATIONS IMPLEMENT THE FOLLOWING ALGEBRA.
$
$   Z = A + (SWITCH * (B - A))
$     WHERE THE SYMBOLS HAVE MEANINGS
$         - Z IS THE PHYSICAL (FLOW) VARIABLE, WWVSC,10
$         - A IS A DUMMY SET BY THE USER FOR USE WHEN THE CONTROL
```

```
$           IS TO BE OFF, OPVB,101, AND
$         - B IS A DUMMY SET BY THE CONTROL, OPVB,6
$         - SWITCH
$           = 0.0 MEANS CONTROL IS "OFF", THUS Z = A
$           = 1.0 MEANS CONTROL IS "ON",  THUS Z = B
$           THE VALUE OF THE SWITCH IS SET BY TESTING A REAL-VALUED
$           COUNTER, OPVB,1, AGAINST THE "OFF THRESHOLD", OPVB,100
$
*
*
* CALCULATE A REAL-VALUED ITERATION COUNTER
*
*      COUNTER        COUNTER
880010 OPVB,1,        ADD,   ONE,0,         OPVB,1
*
* SET THE SWITCH BY COMPARING THE COUNTER TO THE THRESHOLD
*
*      ITERATE
*      COUNTER        THRESHOLD             BINARY
880020 OPVB,1,        BIF,   OPVB,100,      OPVB,2       * BINARY VALUE
*                                                        = 0. IF COUNTER BELOW/AT THRESHOLD
*                                                        = 1. IF COUNTER ABOVE THRESHOLD
* NEXT INVERT THE BINARY TO CREATE THE SWITCH, WITH
*      1.0 MEANS "ON"
*      0.0 MEANS "OFF"
* (NOTE THAT THE REASON FOR THIS TWO-STEP METHOD IS TO OBTAIN A VALUE OF 1.0
* WHEN EQUALITY OF THE COUNTER WITH THE THRESHOLD OCCURS.  SIMPLY RE-ORDERING
* OPERATION 2 ABOVE WOULD NOT HAVE THIS EFFECT.)
*
880030 ONE,0,         SUB,   OPVB,2,        OPVB,3       * SWITCH
*
* SET UP B - A
*
*        B                     A            B - A
880040 OPVB,6,        SUB,   OPVB,101,      OPVB,4       * B - A  DIFFERENCE
*
* NOW MULTIPLY BY THE SWITCH
*
*      B - A                 SWITCH
880050 OPVB,4,        MUL,   OPVB,3,        OPVB,5       * SWITCHED DIFFERENCE
*
* NOW LOAD THE SWITCHED QUANTITY INTO THE INPUT COMPONENT'S SOURCE FLOW VBLE
*
*        A                   SW*(B-A)          Z
880060 OPVB,101,      ADD,   OPVB,5,        WWVSC,10     * PEPSE PHYSICAL VBLE
*                                                        = OPVB,6 WHEN "ON"
*                                                        = OPVB,101 WHEN "OFF"
*
* NOW SWITCH THE CONVERGENCE CRITERION FOR THE CONTROL
*
*        B                     A            B - A
880110 OPVB,7,        SUB,   OPVB,102,      OPVB,11
```

```
*          B - A                      SWITCH
880120 OPVB,11,        MUL,   OPVB,3,          OPVB,12          * SWITCHED DIFFERENCE
*           A                         SW*(B-A)           Z
880130 OPVB,102,       ADD,   OPVB,12,         YCNVRG,1         * CONVERGENCE CRITERION
*
* CALCULATE GROSS POWER, MW
*
881510 BHPP,20,        DIV,   BTUKWH,0,        OPVB,151
881520 OPVB,151,       DIV,   THOUSD,0,        OPVB,152         * GROSS POWER, MW
*
891560 'INITIAL-GUESS FOR CONTROL'
891561 OPVB,6,         1.E2,I
*
* SPECIAL OUTPUT OF RESULTS
*
891000 'REAL-VALUED COUNTER'
891001 OPVB,1
891010 'INTEGER COUNTER'
891011 NTIMES,0
891020 'ITERATE WHEN CONTROL TURNS OFF'
891021 OPVB,100
891030 'SWITCH (0.=OFF, 1.=ON)'
891031 OPVB,3
891040 'PEPSE PHYSICAL VBLE CONTROLLED'
891041 WWVSC,10
891050 'USER-SET OFF CONDITION VALUE OF FLOW'
891051 OPVB,101
891060 'ON CONDITION VALUE OF FLOW'
891061 OPVB,6
891070 'CONVERGENCE CRIT'
891071 YCNVRG,1
891080 'OFF-CONDITION CONV CRIT'
891081 OPVB,102
891090 'ON-CONDITION CONV CRIT'
891091 OPVB,7
891100 'GROSS POWER, MW'
891101 OPVB,152
/
```

PEPSE CODE BY HALLIBURTON NUS, IDAHO FALLS, ID.
VERSION 59E CREATED 18 MAR 94 DATE 03/28/94. PIP ITERATE = 4 PAGE 1
J:\PERFSYS\PEPSE\CHKV59\SRCSWITC - OPNS W BIF TO SWITCH CONTROL ON AND OFF

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)		VALUE
100	REAL-VALUED COUNTER	OPVB	(1)	4.000000E+00
101	INTEGER COUNTER	NTIMES	(0)	4.000000E+00
102	ITERATE WHEN CONTROL TURNS OFF	OPVB	(100)	7.000000E+00
103	SWITCH (0.=OFF, 1.=ON)	OPVB	(3)	1.000000E+00
104	PEPSE PHYSICAL VBLE CONTROLLED	WWVSC	(10)	5.268641E+06
105	USER-SET OFF CONDITION VALUE OF FLOW	OPVB	(101)	5.000000E+02
106	ON CONDITION VALUE OF FLOW	OPVB	(6)	5.268641E+06
107	CONVERGENCE CRIT	YCNVRG	(1)	1.000000E-03
108	OFF-CONDITION CONV CRIT	OPVB	(102)	2.000000E+02
109	ON-CONDITION CONV CRIT	OPVB	(7)	1.000000E-03
110	GROSS POWER, MW	OPVB	(152)	1.000184E+02

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET		Y VARIABLE/ VALUE FROM ITERATE 4	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 4	CONVG LAST ITN X LIMTD
1	2.9E-07 *	BHPP (20)			OPVB (6)	
		1.00000E+02	-5.3E-10	1.00000E+02	5.26864E+06	YES

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 5

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	OPVB (1) 4.00000E+00	ADD	ONE (0) 1.00000E+00	=	OPVB (1) 5.00000E+00
2	OPVB (1) 5.00000E+00	BIF	OPVB (100) 7.00000E+00	=	OPVB (2) 0.00000E+00
3	ONE (0) 1.00000E+00	SUB	OPVB (2) 0.00000E+00	=	OPVB (3) 1.00000E+00
4	OPVB (6) 5.26864E+06	SUB	OPVB (101) 5.00000E+02	=	OPVB (4) 5.26814E+06
5	OPVB (4) 5.26814E+06	MUL	OPVB (3) 1.00000E+00	=	OPVB (5) 5.26814E+06
6	OPVB (101) 5.00000E+02	ADD	OPVB (5) 5.26814E+06	=	WWVSC (10) 5.26864E+06
11	OPVB (7) 1.00000E-03	SUB	OPVB (102) 2.00000E+02	=	OPVB (11) -1.99999E+02
12	OPVB (11) -1.99999E+02	MUL	OPVB (3) 1.00000E+00	=	OPVB (12) -1.99999E+02
13	OPVB (102) 2.00000E+02	ADD	OPVB (12) -1.99999E+02	=	YCNVRG(1) 1.00000E-03
151	BHPP (20) 3.41277E+08	DIV	BTUKWH(0) 3.41214E+03	=	OPVB (151) 1.00018E+05
152	OPVB (151) 1.00018E+05	DIV	THOUSD(0) 1.00000E+03	=	OPVB (152) 1.00018E+02

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)		VALUE
100	REAL-VALUED COUNTER	OPVB	(1)	8.000000E+00
101	INTEGER COUNTER	NTIMES	(0)	8.000000E+00
102	ITERATE WHEN CONTROL TURNS OFF	OPVB	(100)	7.000000E+00
103	SWITCH (0.=OFF, 1.=ON)	OPVB	(3)	0.000000E+00
104	PEPSE PHYSICAL VBLE CONTROLLED	WWVSC	(10)	5.000000E+02
105	USER-SET OFF CONDITION VALUE OF FLOW	OPVB	(101)	5.000000E+02
106	ON CONDITION VALUE OF FLOW	OPVB	(6)	5.268641E+06
107	CONVERGENCE CRIT	YCNVRG	(1)	2.000000E+02
108	OFF-CONDITION CONV CRIT	OPVB	(102)	2.000000E+02
109	ON-CONDITION CONV CRIT	OPVB	(7)	1.000000E-03
110	GROSS POWER, MW	OPVB	(152)	9.491863E-03

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET		Y VARIABLE/ VALUE FROM ITERATE 8	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 8	CONVG LAST ITN X LIMTD
1	2.9E-07 *	BHPP (20)			OPVB (6)	
		9.49011E-03	1.0E+00	1.00000E+02	5.26864E+06	YES

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 9

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	OPVB (1) 8.00000E+00	ADD	ONE (0) 1.00000E+00	=	OPVB (1) 9.00000E+00
2	OPVB (1) 9.00000E+00	BIF	OPVB (100) 7.00000E+00	=	OPVB (2) 1.00000E+00
3	ONE (0) 1.00000E+00	SUB	OPVB (2) 1.00000E+00	=	OPVB (3) 0.00000E+00
4	OPVB (6) 5.26864E+06	SUB	OPVB (101) 5.00000E+02	=	OPVB (4) 5.26814E+06
5	OPVB (4) 5.26814E+06	MUL	OPVB (3) 0.00000E+00	=	OPVB (5) 0.00000E+00
6	OPVB (101) 5.00000E+02	ADD	OPVB (5) 0.00000E+00	=	WWVSC(10) 5.00000E+02
11	OPVB (7) 1.00000E-03	SUB	OPVB (102) 2.00000E+02	=	OPVB (11) -1.99999E+02
12	OPVB (11) -1.99999E+02	MUL	OPVB (3) 0.00000E+00	=	OPVB (12) 0.00000E+00
13	OPVB (102) 2.00000E+02	ADD	OPVB (12) 0.00000E+00	=	YCNVRG(1) 2.00000E+02
151	BHPP (20) 3.23876E+04	DIV	BTUKWH(0) 3.41214E+03	=	OPVB (151) 9.49186E+00
152	OPVB (151) 9.49186E+00	DIV	THOUSD(0) 1.00000E+03	=	OPVB (152) 9.49186E-03

COMPONENT PROPERTIES

COMP	STREAM /PORT		FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
10	IPUT	10/U	0	500.	695.8	1000.00	1.200	1323.0	1.51240	6 .04E-01
20	TGEN	10/I	0	500.	695.8	1000.00	1.200	1323.0	1.51240	6.04E-01
		20/U	0	500.	537.2	500.00	1.070	1258.2	1.51965	1.06E+00
30	OPUT	20/I	0	500.	537.2	500.00	1.070	1258.2	1.51965	1.06E+00

DETAILED TURBINE PERFORMANCE TABLE A

COMPONENT	NUM FLOW ENDS	STAGE GRP REF. CASE (-)	EFFCYS LOAD CASE (-)	MECHANICAL POWER REF. CASE (MW)	MECHANICAL POWER LOAD CASE (MW)	EXTRACT FLOW AT LOAD STEAM EXTRACTION (LBM/HR)	EXTRACT FLOW AT LOAD LIQUID REMOVED (LBM/HR)
20/GENL	1	N.A.	0.90000	N.A.	9.49186E-03	0.	0.

SECTION EFFICIENCY AT LOAD = 0.90000

TABLE A-2

CASE 2 FOR TURBINE SUBMODEL WITH CONTROL SWITCHING DONE BY COMPILED ALGORITHM

LISTING OF INPUT DATA FOR CASE 2

```
= SRCSWITC - COMPILED ALGORITHM FOR SWITCHING
*
* THIS CASE IS SIMILAR TO THE FIRST IN THAT A SWITCHING MECHANISM IS USED
* TO TURN A CONTROL ON AND OFF.  THE SWITCHING MECHANISM USED HERE IS A
* COMPILED ALGORITHM.  BECAUSE OF THE INHERENT IF-THEN-ELSE CONSTRUCT OF THE
* CA FEATURE, THIS IS EASIER TO APPLY AND TO UNDERSTAND THAN WAS THE OPERATION
* APPLICATION IN THE PREVIOUS CASE, ONCE THE CA IS SET UP AND COMPILED.
* IN ADDITION THE CA ALLOWS EASIER OFF AND BACK ON APPLICATION.  THEREFORE
* THIS APPLICATION INCLUDES AN ITERVAL FROM ITERATE 5 TO 10 WHEN THE CONTROL
* IS "TURNED OFF" BY THE ALGORITHM, AND ON DURING OTHER ITERATES.
*
*
* PRINT WHILE ITERATING TO SHOW EVIDENCE OF CONTROL ON/OFF
*
010110 4      8      15      * ITERATES SELECTED FOR PRINTING
                                  *** CARD ABOVE IS A REPLACEMENT CARD. ***
010111 36     39     83      * PRINT CONTROL, SPCL OUT, CA TABLES RESPECTIVELY
                                  *** CARD ABOVE IS A REPLACEMENT CARD. ***
*
* GET RID OF THE OPERATIONS (PREV CASE) USED FOR SWITCHING
*
880028  DELETE
880038  DELETE
880048  DELETE
880058  DELETE
880068  DELETE
880118  DELETE
880128  DELETE
880138  DELETE
*
* SET VALUES BY SPECIAL INPUT
*
890020  'LOW END OFF RANGE'
890021  OPVB,2,        5.,      I
890030  'HI END OFF RANGE'
890031  OPVB,3,        10.,     I
890050  'OFF CONDITION VALUE OF FLOW'
890051  OPVB,5,        5.E2,    I
890080  'OFF CONDITION CONV CRIT'
890081  OPVB,8,        2.E2,    I
890090  'ON CONDITION CONV CRIT'
890091  OPVB,9,        1.E-3,   I
*
```

```
* SPECIAL OUTPUT OF RESULTS
*
891000 'REAL-VALUED COUNTER'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891001 OPVB,1
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891010 'INTERGER COUNTER'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891011 NTIMES,0
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891020 'LOW END OFF RANGE'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891021 OPVB,2
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891030 'HIGH END OFF RANGE'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891031 OPVB,3
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891040 'PEPSE PHYSICAL VBLE CONTROLLED'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891041 WWVSC,10
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891050 'USER-SET OFF CONDITION VALUE OF FLOW'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891051 OPVB,5
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891060 'ON CONDITION VALUE OF FLOW'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891061 OPVB,6
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891070 'CONVERGENCE CRIT'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891071 YCNVRG,1
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891080 'OFF-CONDITION CONV CRIT'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891081 OPVB,8
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891090 'ON-CONDITION CONV CRIT'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891091 OPVB,9
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891100 'GROSS POWER, MW'
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
891101 OPVB,152
                                        *** CARD ABOVE IS A REPLACEMENT CARD. ***
*
* CALL UP COMPILED ALGORITHM, THAT IS USED FOR THE SWITCHING
*
*               START  INTERVAL          NAME
1001000           2        1           'COMPALGCON'
*1001001        NTIMES,0,      OPVB,2,        OPVB,3         * SEARCH AND RANGE
```

```
*
* REPLACE NTIMES WITH REAL-VALUED COUNTER ON THE 1001001 CARD -
* USING NTIMES IN THE CA CALL CAUSES ALTERATION OF THE VALUE OF
* NTIMES, WHICH IS BAD.
*
1001001   OPVB,1,      OPVB,2,    OPVB,3   * SEARCH AND RANGE
1001002   WWVSC,10,    OPVB,5,    OPVB,6   * CONTROLLED VBLE AND SWITCH VALUES
1001003   YCNVRG,1,    OPVB,8,    OPVB,9   * CONVERGENCE CRIT AND SWITCH VALUES
*
*************************************************************************
*
* FOR DOCUMENTATION OF ITS CONTENT, THE COMPILED ALGORITHM IS SHOWN
* BELOW. NOTE THAT ALL LINES BELOW ARE "COMMENTS" BY PLACING AN
* ASTERISK IN COLUMN 1. THE ACTUAL ALGORITHM THAT IS COMPILED DOES
* NOT HAVE THESE ASTERISKS.
*
*************************************************************************
*
*COMPALGCON
*$
*$ THIS COMPILED ALGORITHM PERFORMS SWITCHING OF VARIABLES X4 AND X7
*$ SUBJECT TO CONDITIONS ON VARIABLE X1. IN THE PRESENT CASE THIS
*$ SWITCHING IS INTENDED FOR TURNING A CONTROL ON AND OFF. AS DEFINED,
*$ THE CONTROL IS OFF WHEN THE VALUE OF X1 IS IN THE RANGE X2 TO X3
*$ (DURING THIS TIME, THE REAL/PHYSICAL VARIABLE, X4, ASSOCIATED WITH THE
*$ DUMMY CONTROL VARIABLE. IS SET TO A USER-SPECIFIED VALUE X5 AND THE
*$ CONVERGENCE CRITERION X7 IS SET TO A USER-SPECIFIED VALUE X8 TO FOOL
*$ THE CONTROL INTO CALLING ITSELF "CONVERGED"). THE CONTROL IS ON WHEN
*$ THE VALUE X1 IS OUTSIDE OF THE SEARCH RANGE. IN THIS CASE THE PEPSE PHYSICA
*$ VARIABLE X4 IS SET TO X6 (WHICH IS THE "DUMMY" THAT ACTUALLY APPEARS
*$ AS THE X-CONTROL VARIABLE IN THE CONTROL STATEMENT). IN THIS CASE, THE
*$ CONVERGENCE CRITERION IS SET TO A REALISTIC TOLERANCE VALUE, X9.
*$
*$ VARIABLES
*$ X1 = TEST VARIABLE FOR SWITCHING CONTROL ON AND OFF (IN RANGE, CONTROL "OFF"
*$ X2 = LOW END OF "OFF" RANGE
*$ X3 = HIGH END OF "OFF" RANGE
*$ X4 = PHYSICAL PEPSE VARIABLE, E.G. SOURCE FLOW, BEING CONTROLLED (EXCEPT
*$      WHEN CONTROL IS "OFF")
*$ X5 = VALUE FOR PHYSICAL VARIABLE WHEN CONTROL IS "OFF"
*$ X6 = VALUE FROM DUMMY IN CONTROL, USED WHEN CONTROL IS "ON"
*$ X7 = CONVERGENCE CRITERION VARIABLE NAME FOR THIS CONTROL
*$ X8 = VALUE FOR CONVERGENCE CRITERION (LARGE), SET INTO X7 WHEN CONTROL "OFF"
*$ X9 = VALUE FOR CONVERGENCE CRITERION (REALISTIC), SET INTO X7 WHEN CONTROL
*$      IS "ON"
*$
*IF
* X1 .GE. X2 .AND. X1 .LE. X3
*THEN
*$
*$ CONTROL IS TO BE "OFF"
*$
```

```
*  X4 = X5;
*$
*$  AS A TEST, "LOSE" THE CONVERGED VALUE OF CONTROL VBLE OPVB,6, SHOWN
*$  HERE SYMBOLICALLY AS X6
*$
*  X6 = X1;
*  X7 = X8
*ELSE
*$
*$  CONTROL IS TO BE "ON"
*$
*  X4 = X6;
*  X7 = X9
*ENDIF
.

******** THE FOLLOWING CARDS WERE NOT USED


          880130
          880120
          880110
          880060
          880050
          880040
          880030
          880020
```

PEPSE CODE BY HALLIBURTON NUS, IDAHO FALLS, ID.
VERSION 59E CREATED 18 MAR 94 DATE 03/28/94. PIP ITERATE = 4 PAGE 1
SRCSWITC - COMPILED ALGORITHM FOR SWITCHING

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)	VALUE
100	REAL-VALUED COUNTER	OPVB (1)	4.000000E+00
101	INTERGER COUNTER	NTIMES(0)	4.000000E+00
102	LOW END OFF RANGE	OPVB (2)	5.000000E+00
103	HIGH END OFF RANGE	OPVB (3)	1.000000E+01
104	PEPSE PHYSICAL VBLE CONTROLLED	WWVSC (10)	5.268641E+06
105	USER-SET OFF CONDITION VALUE OF FLOW	OPVB (5)	5.000000E+02
106	ON CONDITION VALUE OF FLOW	OPVB (6)	5.268641E+06
107	CONVERGENCE CRIT	YCNVRG(1)	1.000000E-03
108	OFF-CONDITION CONV CRIT	OPVB (8)	2.000000E+02
109	ON-CONDITION CONV CRIT	OPVB (9)	1.000000E-03
110	GROSS POWER, MW	OPVB (152)	1.000184E+02

SRCSWITC - COMPILED ALGORITHM FOR SWITCHING

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET		Y VARIABLE/ VALUE FROM ITERATE 4	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 4	CONVG LAST ITN X LIMTD
1	2.9E-07 *	BHPP (20)			OPVB (6)	
		1.00000E+02	-5.3E-10	1.00000E+02	5.26864E+06	YES

SRCSWITC - COMPILED ALGORITHM FOR SWITCHING

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)	VALUE
100	REAL-VALUED COUNTER	OPVB (1)	8.000000E+00
101	INTERGER COUNTER	NTIMES (0)	8.000000E+00
102	LOW END OFF RANGE	OPVB (2)	5.000000E+00
103	HIGH END OFF RANGE	OPVB (3)	1.000000E+01
104	PEPSE PHYSICAL VBLE CONTROLLED	WWVSC (10)	5.000000E+02
105	USER-SET OFF CONDITION VALUE OF FLOW	OPVB (5)	5.000000E+02
106	ON CONDITION VALUE OF FLOW	OPVB (6)	8.000000E+00
107	CONVERGENCE CRIT	YCNVRG (1)	2.000000E+02
108	OFF-CONDITION CONV CRIT	OPVB (8)	2.000000E+02
109	ON-CONDITION CONV CRIT	OPVB (9)	1.000000E-03
110	GROSS POWER, MW	OPVB (152)	9.491863E-03

SRCSWITC - COMPILED ALGORITHM FOR SWITCHING

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET	Y VARIABLE/ VALUE FROM ITERATE 8	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 8	CONVG LAST ITN X LIMTD
1	2.9E-07 * BHPP (20)			OPVB (6)	
	9.49011E-03	1.0E+00	1.00000E+02	8.00000E+00	YES

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)	VALUE
100	REAL-VALUED COUNTER	OPVB (1)	1.500000E+01
101	INTERGER COUNTER	NTIMES (0)	1.500000E+01
102	LOW END OFF RANGE	OPVB (2)	5.000000E+00
103	HIGH END OFF RANGE	OPVB (3)	1.000000E+01
104	PEPSE PHYSICAL VBLE CONTROLLED	WWVSC (10)	5.268659E+06
105	USER-SET OFF CONDITION VALUE OF FLOW	OPVB (5)	5.000000E+02
106	ON CONDITION VALUE OF FLOW	OPVB (6)	5.268659E+06
107	CONVERGENCE CRIT	YCNVRG (1)	1.000000E-03
108	OFF-CONDITION CONV CRIT	OPVB (8)	2.000000E+02
109	ON-CONDITION CONV CRIT	OPVB (9)	1.000000E-03
110	GROSS POWER, MW	OPVB (152)	1.000188E+02

SRCSWITC - COMPILED ALGORITHM FOR SWITCHING

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET		Y VARIABLE/ VALUE FROM ITERATE 15	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 15	CONVG LAST ITN X LIMTD
1	2.9E-07 *	BHPP (20)			OPVB (6)	
		1.00000E+02	-3.6E-06	1.00000E+02	5.26866E+06	YES

COMPONENT PROPERTIES

COMP	STREAM /PORT		FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
10	IPUT	10/U	0	5268659.	695.8	1000.00	1.200	1323.0	1.51240	6.04E-01
20	TGEN	10/I	0	5268659.	695.8	1000.00	1.200	1323.0	1.51240	6.04E-01
		20/U	0	5268659.	537.2	500.00	1.070	1258.2	1.51965	1.06E+00
30	OPUT	20/I	0	5268659.	537.2	500.00	1.070	1258.2	1.51965	1.06E+00

DETAILED TURBINE PERFORMANCE TABLE A

COMPONENT	NUM FLOW ENDS	STAGE GRP EFFCYS REF. CASE (-)	STAGE GRP EFFCYS LOAD CASE (-)	MECHANICAL POWER REF. CASE (MW)	MECHANICAL POWER LOAD CASE (MW)	EXTRACT FLOW AT LOAD STEAM EXTRACTION (LBM/HR)	EXTRACT FLOW AT LOAD LIQUID REMOVED (LBM/HR)
20/GENL	1	N.A.	0.90000	N.A.	1.00019E+02	0.	0.

SECTION EFFICIENCY AT LOAD = 0.900 00

TABLE A-3

BOILER EXAMPLE RESULTS AT LOW LOAD
BOTH SPRAYS ARE OFF

LISTING OF INPUT DATA FOR CASE 1

```
*
* EIKON/PEPSE USER :        USER
*             DATE :        04/04/89
*             TIME :        10:37
*     DATA FILE ID :        JPMBLR
*    MODEL FILE ID :        JPMBLR
*
=   JPM BOILER - DEMONSTRATE ON/OFF SWITCHING OF SPRAY CONTROLS
*
* THIS MODEL IS THE DESIGN STAGE OF JPM's BOILER.
*
* THIS MODEL USES A COMBINATION OF SCHEDULES, CONTROLS, AND OPERATIONS
* TO DETERMINE THE "ON"/"OFF" STATUS OF SUPERHEAT AND REHEAT SPRAYS.
* WHEN THE SPRAYS ARE "ON", THE CONTROL DETERMINES THE QUANTITY OF
* SPRAY TO OBTAIN THE SET-POINT TEMPERATURES FOR REHEAT AND MAIN
* STEAM.
*
* THIS COMBINATION OF FEATURES IS A PARTIAL SIMULATION OF THE ACTUAL
* CONTROL SYSTEM OF THE BOILER THAT USES A LOAD-DEPENDENT SCHEME TO
* OBTAIN SET-POINT VALUES. FOR EXAMPLE, OVER A PART OF THE OPERATING
* RANGE, THE REHEAT TEMPERATURE IS SET BY VARIATION OF THE BACKPASS
* DAMPER. OVER ANOTHER (HIGH LOADS) THE REHEAT TEMPERATURE IS SET BY
* QUANTITY OF SPRAY FLOW.
*
* IN THIS MODEL, THE DAMPER EFFECT IS DETERMINED BY A PEPSE SCHEDULE
* THAT SETS THE DAMPER SPLIT FLOW AS A FUNCTION OF MAIN STEAM FLOW.
* THE TABULAR VALUES IN THIS SCHEDULE WERE CALCULATED IN A SEPARATE
* SET OF PEPSE RUNS THAT USED PEPSE CONTROLS TO OBTAIN THE QUANTITIES
* OF DAMPER SPLIT TO MEET THE REHEAT SET POINT UNDER LOAD CONDITIONS
* WHERE THE SPRAY WAS INACTIVE.
*
* THE "ON"/"OFF" SWITCHING OF THE PEPSE CONTROL WAS ATTAINED BY
* TRICKING THE CONTROL MECHANISM RELATIVE TO CONVERGENCE AND THE
* CONTROL VARIABLE. THIS TRICKING IS DISCUSSED IN COMMENTS WHERE
* THE SCHEDULES, CONTROLS, AND OPERATIONS ARE SPECIFIED BELOW.
*
*
*** GENERIC INPUT DATA
*
* UNITS FLAGS
010000 ENGLISH,    ENGLISH
*
* CYCLE FLAGS
010200 0,     0,     0,     0,     0,     0,     0.,    0.
```

```
*
* CYCLE CONVERGENCE DATA
012000 200,   0.,    1000.,  0.,    0.,    0.,    10,    1.0E5
*
* OUTPUT TABLE SUPPRESSION DATA
020000 NOPRNT                                          * GLOBAL SUPPRESSION
022000 1  3  17  20  24  35  36  39  42  47  74        * ACTIVATION BY LIST
*
*    GEOMETRY CARDS
*******************************************************************
*
500120 12    U    15    T
500150 15    T    20    I
500550 15    D    55    I
500200 20    U    25    I
500250 25    U    30    T
500260 25    B    37    IB
500300 30    T    36    I
501410 30    D    145   I
500350 35    U    290   IA
500360 36    U    35    IA
500380 36    B    37    IA
500390 37    U    315   PA
500400 40    U    315   RC
500500 50    U    15    S
502860 60    T    80    I
500700 70    T    75    T
500750 75    T    295   RI
500950 90    U    135   S
500910 90    B    105   S
501110 105   T    175   I
501070 105   D    140   IB
501100 110   T    295   FW
501120 110   D    300   I
502820 135   T    185   IA
501370 135   D    140   IA
501400 140   U    110   S
501450 145   U    150   I
501650 160   U    165   IA
501660 165   U    105   T
501710 171   U    165   IB
501810 181   U    185   IB
502850 185   U    60    T
502000 200   U    110   T
502900 290   U    60    S
502910 60    D    90    I
500470 290   B    45    I
502800 295   ST   135   T
502300 295   DC   70    T
500490 295   BD   220   I
503000 300   U    320   T
503050 300   B    310   I
```

```
500410 315    PC     290    IF
500420 315    MA     35     IB
503200 320    T      30     S
*
*****************************************************************
*    COMPONENT DATA
*****************************************************************
*
*************** HEAT EXCHANGERS
*
* REHEATER
701050 28     1      2.425E+6      630.   955.
701054 3      0      2      38.0   12.    10.64  184.
701055 39.    10.    2.06   2.39   5.21   4.55   783.
701056 803.   0.9    26.    0.     0.     0.
701057 -1.301 0.     0.     0.     0.     0.
701058 0.     0.     0.0    0.     0.     0.     0.
* COMBINED ECONOMIZER
701100 28     1      2.65E+6       2133.  465.
701104 3      0      2      11.5   24.    23.    184.
701105 23.    10.    1.78   2.19   4.42   4.55   766.
701106 778.   0.9    26.0   0.     0.     0.
701107 -.4742 0.     0.     0.     0.     0.
701108 0.     0.     0.0    0.     0.     0.     0.
* PRIMARY SUPERHEATER
701350 28     1      2.65E+6       2133.  900.
701354 3      0      2      38.    12.    8.63   184.
701355 52.    17.    1.7    2.06   5.21   4.55   803.
701356 820.   0.9    26.0   0.     0.     0.
701357 -.5221 0.     0.     0.     0.     0.
701358 0.     0.     0.0    0.     0.     0.     0.
* SECONDARY SUPERHEATER
700600 28     1      2.65E+6       2000.  800.
700604 3      1      1      36.    16.    34.41  29.    45.    4.
700605 1.54   1.9    1.9    26.1875 820.  820.
700606 0.9    26.0   0.     0.     0.
700607 -.4263 0.     0.     0.     0.     0.
700608 0.     0.     0.0    0.     0.     0.     0.
* STEAM COILS
700150 20     100.
700151 0.     0.     0.     0.     0.     0.     0.
* AIR HEATER
700300 21     3
700303 0.064  0.     0.     0.     0.     0.     0.     0.
+      0.     0.
700304 94.66  543.9  658.7  290.5  1799677.      2057715.
* WATERWALLS
700700 29     1      290
700704 0.2    1      66.8   761.   1.
700705 2.31   2.75   3.75   698.   820.   26.
700706 0.     0.     0.     0.     0.
700707 0.     0.     0.     0.     0.     0.
```

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*  WATERWALL PENDANTS
700750  29        1         290
700754  0.2       1         58.       200.      1.
700755  2.31      2.75      3.75      762.      820.      26.
700756  0.        0.        0.        0.        0.
700757  0.        0.        0.        0.        0.        0.
*  PRECIPITATOR TEMP LOSS
703200  27        0.        0.        0.        0.
*
*************** SOURCES, SINKS, AND VALVES
*
*  AIR INLET
700120  31        72.       14.7      1.5E6     0.        0.        0
700123  AIR,0.6
*  FUEL INLET
700400  31        88.       2500.     394559. 0.          0.        0
*  AIR HEATER STEAM INLET
700500  31        110.      80.       0.        0.        1380.     0
*  COLD REHEAT STEAM
701600  31        630.      501.      2.425E+6            0.        0.        0
*  REHEAT SPRAY SOURCE
701710  31        379.      2133.     1000.     0.        0.        0
*  SUPERHEAT SPRAY SOURCE
701810  31        379.      2133.     2500.     0.        0.        0
*  FEEDWATER INLET
702000  33        465.      2133.     2.703E+6            0.        0.        0
*  BOTTOM ASH OUTLET
700450  30
*  STEAM COIL OUTLET
700550  30
*  SUPERHEAT OUTLET
700800  32
*  GAS OUTLET
701500  30
*  HOT REHEAT OUTLET
701750  30
*  BLOWDOWN OUTLET
702200  30
*  FLYASH OUTLET
703100  30
*
*************** PUMPS, COMPRESSORS, AND FANS
*
*  FD FANS
700200  43        16.       1.        1.        0.8
700201  0.        0.        0.
*  ID FANS
701450  43        15.       1.        1.        0.8
701451  0.        0.        0.
*
*************** MIXERS
*
```

```
*  PRIMARY AIR/TEMPERING AIR MIXER
700370  50       1       0.
*  GAS PASS MIXER
701400  50       0       0.
*  REHEAT SPRAY MIXER
701650  50       1        0.
*  SUPERHEAT SPRAY MIXER
701850  50       1       0.
*  DRUM INLET MIXER 2
*  AIR MIXER
700350  50       1       0.
*
*************** SPLITTERS
*
*  GAS PASS SPLITTER
700900  63       0.      0.45
*  TEMPERING AIR SPLITTER
700250  61       0.      236685.
*  PRIMARY AIR SPLITTER
700360  60       0.      954000. 0.      0       0.
700361  1
*  PRECIPITATOR
703000  69       0.      0.      0.
703001  RCO2,0.,         RH2O,0.,        RSO2,0.,        RO2,0.
703002  RN2,0.,          RCO,0.,         RH2,0.,         RC,0.,          RS,0.
703003  RASH,0.996,      RETH,0.,        RMTH,0.,        RARG,0.
*
*************** CLASS 7 COMPONENTS
*
*  COMBUSTOR
702900  70       1       3       12      0.2
702901  1975.    0.      0.      0.0017  0.003   0.
702902  0.6      88.     88.     0.      0.      -1.     0.015
*  STEAM DRUM
702950  73       1       40      2080.   0.      0.01    1.
702951  5.       0.      0.      0.
702959  5        0       0.      0.      0.
*  PULVERIZER
703150  74       0       36      0       0.3     0.05    150.
703151  2.42     0.      0.      0.
703159  7        5       0.5     0.      0.
*
*
*  TYPE 1 STREAMS TO ACCOUNT FOR CHANGE IN ELEVATION
*      STYPE     DD      LL      FRICF           FORMK           EODSTR          ZZOUT           ZZIN
600700  1,       2.31,   68.83,  -1.E-8,         -1.E-8,         -1.E-8,         820.,           698.
600750  1,       2.31,   58.,    -1.E-8,         -1.E-8,         -1.E-8,         820.,           762.
602820  1,       1.70,   100.,   -1.E-8,         -1.E-8,         -1.E-8,         803.,           783.
*
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***  END OF BASE DECK ***
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* SCHEDULES FOR MULTI LOAD OPERATION
*
800100  'RHT STM FLOW'
810100          0.,       600.,     1200.,    1750.,    2700.,    3000.
810110  0.0,    11.5,     594.9     1149.4    1657.7    2535.7    2812.9
820100  1000.,  1000.
830100  1,      WWVSC,    160,      WW,       200
830105  5
800200  'RHT STM PRESS'
810200          0.,       600.,     1200.,    1750.,    2700.,    3000.
810210  0.0,    6.1,      122.9     242.8     352.7     542.5     602.4
820200  1.,     1000.
830200  2,      PPVSC,    160,      WW,       200
830205  5
800300  'RHT STM TEMP'
810300          0.,       600.,     1200.,    1750.,    2700.,    3000.
810310  0.0,    458.65,   526.,     560.7     592.5     647.3     664.7
820300          1.,       1000.
830300  3,      TTVSC,    160,      WW,       200
830305  5
800400  'PA AIR/FUEL RATIO'
810400          0.,       600.,     1200.,    2000.,    2700.,    3000.
810410  0.0,    17.57,    4.02,     2.94,     2.65,     2.42,     2.39
820400  1.,     1000.
830400  4,      XRATAC    315,      WW,       200
                ,
830405  5
800500  'EXCESS AIR'
810500          0.,       600.,     1200.,    1750.,    2700.,    3000.
810510  0.0,    .316,     .28,      .25,      .20,      .20,      .20
820500  1.,     1000.
830500  5,      EXAIR,    290,      WW,       200
830505  5
800600  'REHEAT GAS SPLIT'
810600  900.0   1000.0    1100.0    1200.0    1300.0    1400.0    1500.0    1600.0
810601  1700.0  1800.0    1900.0    2000.0    2100.0    2200.0    2300.0    2400.0
810602  2500.0  2600.0    3000.0
810610  0.0     .5736     .5486     .5282     .5111     .4967     .4844     .4736     .4643
810611          .4560     .4487     .4421     .4362     .4308     .4259     .4215     .4174
810612          .4137     .4102     .3987
820600  1.,     1000.0
830600  6,      FRSPL,    90,       WW,       286
800800  'FEEDWATER PRESS'
810800          0.,       600.,     1200.,    1750.     2700.,    3000.
810810  0.0,    1840.,    1616.4    1755.2    1882.5    2102.3    2171.8
820800  1.,     1000.
830800  8,      PPVSC,    200,      WW,       200
830805  5
800900  'FEEDWATER TEMP'
810900          0.,       600.,     1200.,    1750.,    2700.,    3000.
810910  0.0,    311.65,   363.3     395.7     425.4     476.8     493.0
820900  1.,     1000.
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830900	9,	TTVSC,	200,	WW,	200			
830905	5							
801000	'DRUM PRESSURE'							
811000		0.,	600.,	1200.,	1750.,	2700.,	3000.	
811010	0.0,	1815.,	1557.5	1688.6	1808.7	2016.2	2081.7	
821000	1.,	1000.						
831000	10,	PPDRUM,	295,	WW,	200			
831005	5							
801200	'SPRAY WATER TEMPERATURE'							
811200		0.,	600.,	1200.,	1750.,	2700.,	3000.	
811210	0.0,	264.,	301.8	328.0	351.9	393.2	406.3	
821200	1.,	1000.						
831200	12,	TTVSC,	171,	WW,	200			
831205	5							
801300	'AIR IN TEMPERATURE'							
811300		0.,	600.,	1200.,	2000.,	2700.,	3000.	
811310	0.0,	167.,	154.,	124.,	94.,	88.,	71.	
821300	1.,	1000.						
831300	13,	TTVSC,	12,	WW,	200			
831305	5							
801500	'FURNACE EXIT TEMPERATURE'							
811500		1000.	1250.	1500.	2000.	2500.	3000.	
811510	.4	1008.	1369.	1611.	1912.	2093.	2214.	
811520	.45	1338.	1700.	1941.	2243.	2424.	2254.	
811530	.5	1603.	1965.	2206.	2507.	2688.	2809.	
811540	.55	1819.	2181.	2422.	2724.	2905.	3025.	
821500	1.,	1000.						
831500	15,	TEXF,	290,	WW,	286,	FRSPL,		90
831505	5							
801600	'SSH HTTIRH MULT'							
811600		0.	1000.0	1250.0	1500.0	2000.0	2500.0	3000.0
811610	0.40	-.8954	-.8954	-.7668	-.6811	-.5740	-.5098	-.4669
811620	0.45	-.7730	-.7730	-.6445	-.5588	-.4517	-.3874	-.3446
811630	0.50	-.6752	-.6752	-.5468	-.4609	-.3538	-.2896	-.2467
811640	0.55	-.5951	-.5951	-.4666	-.3809	-.2738	-.2095	-.1667
821600	1.,	1000.	1.0					
831600	16,	HTTIRH,	60,	WW,	286,	FRSPL,		90
801700	'PSH HTTIRH MULT'							
811700		0.	1000.0	1250.0	1500.0	2000.0	2500.0	3000.0
811710	0.40	-.3841	-.3841	-.4400	-.4772	-.5238	-.5518	-.5704
811720	0.45	-.4325	-.4325	-.4884	-.5256	-.5722	-.6002	-.6188
811730	0.50	-.4712	-.4712	-.5271	-.5643	-.6109	-.6389	-.6575
811740	0.55	-.5028	-.5028	-.5587	-.5960	-.6426	-.6706	-.6892
821700	1.,	1000.	1.0					
831700	17,	HTTIRH,	135,	WW,	286,	FRSPL,		90
801800	'RHT HTTIRH MULT'							
811800		0.	1000.0	1250.0	1500.0	2000.0	2500.0	3000.0
811810	0.40	-2.5996	-2.5996	-2.2155	-1.9595	-1.6395	-1.4475	-1.3195
811820	0.45	-1.9821	-1.9821	-1.5980	-1.3420	-1.0220	-.8300	-.7020
811830	0.50	-1.4881	-1.4881	-1.1040	-.8480	-.5280	-.3360	-.2080
811840	0.55	-1.0839	-1.0839	-.6999	-.4439	-.1238	.0682	.1962
821800	1.,	1000.	1.0					

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831800  18,      HTTIRH,  105,     WW,      286,     FRSPL,            90
801900  'ECON HTTIRH MULT'
811900           0.       1000.0   1250.0   1500.0   2000.0   2500.0   3000.0
811910  0.40     -.6900   -.6900   -.6394   -.6057   -.5635   -.5382   -.5214
811920  0.45     -.5986   -.5986   -.5480   -.5142   -.4721   -.4468   -.4299
811930  0.50     -.5254   -.5254   -.4748   -.4411   -.3989   -.3736   -.3567
811940  0.55     -.4655   -.4655   -.4149   -.3812   -.3390   -.3137   -.2969
821900  1.,      1000.    1.0
831900  19,      HTTIRH,  110,     WW,      286,     FRSPL,            90
*
* THE NEXT TWO SCHEDULES SET SWITCHES FOR THE SH AND RH SPRAY CONTROLS BASED
* ON THRESHOLD VALUES OF MAIN STEAM FLOW
*        1.0 SIGNALS "ON"
*        0.0 SIGNALS "OFF"
*
802000    'SH SPRAY SWITCH'
812000              0.0        1200.000    1200.001    2350.000    2350.001    3000.000
812010    0.0       0.0        0.0         1.0         1.0         0.0         0.0
822000    1.0       1000.0
832000    20,       OPVB,      200,        WW,         286
802100    'RH SPRAY SWITCH'
812100              0.0        1500.000    1500.001    3000.000
812110    0.0       0.0        0.0                     1.0                     1.0
822100    1.0       1000.0
832100    21,       OPVB,      205,        WW,         286
*
* CONTROLS
* TO BALANCE DRUM
*840100   WWVSC,    200,       1.0,        5.0E5,      1.0,        BBEIBC,     295
*840105   5,        2
*840109   150000.,  3000000.
*840106   10
* TO BALANCE DRUM USING FURNACE EXIT TEMP
*840100   TEXF,     290,       1.0,        5.0E6,      1.0,        BBEIBC,     295
*840109   1300.,    2600.
*840107   .75
*
* TO SET GAS PASS SPLIT FOR REHEAT TEMP
*840200   FRSPL,    90,        1.0,        1.0,        1.0,        OPVB,       125
*840209   0.35,     0.55
*840205   5,        2
*840206   11
*840207   .5
*
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
*
* THE CONTROLS ARE SWITCHED "ON" AND "OFF" BY TRICKING THE CONTROL VIA
* THE GOAL VARIABLES.  THESE GOAL VARIABLES ARE OPVB'S 123 AND 130 THAT
* HAVE BEEN SET BY OPERATIONS, CARDS 881150 AND 881250 (BELOW).
*  WHEN THE CONTROL IS TO BE "ON" THE GOAL VARIABLE IS
*   THE ABSOLUTE VALUE OF THE DIFFERENCE BETWEEN THE CALCULATED
*   TEMPERATURE AND THE TARGET TEMPERATURE.  THE STATEMENT OF THE
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*    CONTROL BELOW ASKS THIS DIFFERENCE TO BE EQUAL TO 0.0 WITH A
*    TOLERANCE OF PLUS OR MINUS 0.5.
*    WHEN THE CONTROL IS TO BE "OFF" THE GOAL VARIABLE IS
*    EQUAL TO 0.0, WHICH IS IDENTICALLY EQUAL TO THE GOAL VALUE
*    SPECIFIED IN THE CONTROL (THUS THE CONTROL LOGIC CONCLUDES THAT
*    THE CONTROL IS CONVERGED).
*
*  TO MAINTAIN SH STEAM TEMP
*
*  NOTE THAT OPVB,181 IS THE CONTROL DUMMY FOR WWFIXB,181, THE SPRAY
*  FLOW THAT IS BEING CONTROLLED WHEN THE CONTROL IS "ON".  OPERATIONS
*  ARE USED TO SET THE PHYSICAL VARIABLES, WWVSC, USING SWITCHING FOR
*  THE "ON"/"OFF" STATUS.
*
840300  OPVB,181,       .0,.5,     1.0,OPVB,123
840309  0.,       150000.
840305  5,        2
840306  10
840307  .5
*  TO MAINTAIN RH STEAM TEMP - SPRAY
*
*  NOTE THAT OPVB,171 IS THE CONTROL DUMMY FOR WWFIXB,171, THE SPRAY
*  FLOW THAT IS BEING CONTROLLED WHEN THE CONTROL IS "ON"
*
840400  OPVB,171,       .0,.5,     1.0,OPVB,130
840409  0.,       50000.
840405  5,        2
840406  10
840407  .5
*
*** OPERATIONAL VARIABLES
*
* OPVB(3) = FRACTION OF CONVECTIVE PASS HEAT TRANSFER AREA, REHEATER WATERWALLS
870030  0.1
*
* OPVB(4) = FRACTION OF CONVECTIVE PASS HEAT TRANSFER AREA, PSH WATERWALLS
870040  0.1
*
* SET POINT FOR SH AND RH TEMP CONTROL
870050  955.0
*
*  INITIAL-GUESS VALUES OF SPRAY FLOWS
*
871710  1000.
871810  2500.
*
***  OPERATIONS
*
* SET BOILER EFFICIENCY FLUE GAS TEMPERATURE = AIR HEATER UNCORR. TEMPERATURE
880010  TTUNCT, 30     EQL,              ETTFG,1
*
* SET BOILER EFFICIENCY UNACCOUNTED LOSS = FURNACE COMPONENT UNACCOUNTED LOSS
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880020 UFUNL,290       EQL,            ELUNSP,1
*
*
* CALCULATIONS FOR BOILER EFFICIENCY BY INPUT-OUTPUT METHOD
*
* FIRST CALCULATE OUPUT (HEAT TO WORKING FLUID); ADD WORKING FLUID OUTFLOWS
*       MAIN STM                       HOT RH
880100 BBSTRM,        286,     ADD,   BBSTRM,111,   OPVB,10
*                                     BLOWDN
880110 OPVB,          10       ADD,   BBSTRM,47     OPVB,10
*
* NOW SUBTRACT WORKING FLUID INFLOWS
*                                     FW
880120 OPVB,          10       SUB,   BBSTRM,200    OPVB,10
*                                     COLD RH
880130 OPVB,          10       SUB,   BBSTRM,165    OPVB,10
*                                     RH SPRAY
880140 OPVB,          10       SUB,   BBSTRM,171    OPVB,10
*                                     MS SPRAY
880150 OPVB,          10       SUB,   BBSTRM,181    OPVB,10
*
*
* NEXT CALCULATE INPUT (FUEL CHEM ENERGY PLUS CREDITS)
*
* ADD INPUT TERMS
880300 QHHVFL,0       ADD,     QHBTOT,0      OPVB,20        * FUEL CHEM AND CREDIT TOTAL
*
* NOW CALCULATE I/O EFF
880400 OPVB,10        DIV,     OPVB,20       OPVB,40
*
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
*
* OPERATIONS FOR SUPERHEAT SPRAY CONTROL -
* THE EFFECT OF THE OPERATIONS IS EXPLAINED IN THE COMMENTS BELOW 881150
*
881120 TT,286,         SUB,    OPVB,5,       OPVB, 201   * DELTA T, I.E. (ACTUAL - DESIRED)
881130 ONE,0,          ABS,    OPVB,201,     OPVB, 201   * ABSOLUTE VAL OF DELTA T
881140 OPVB,201,       MUL,    OPVB,200,     OPVB, 123   * SWITCHED ABS DELTA T, GOAL VBLE
881160 OPVB,181,       MUL,    OPVB,200,     WWVSC,181 * SWITCHED SH SPRAY FLOW
*
* NOTE THAT OPERATION 115 HAS SET THE GOAL VARIABLE
*    OPVB,123 = SWITCH * ABS(TT,286 - OPVB,5)
*   WHERE (THE SWITCH IS OPVB,200, WHICH IS SET BY SCHEDULE)
*    SWITCH IS 1.0, WHEN THE SPRAY CONTROL IS ON, AND
*           0.0, WHEN THE SPRAY CONTROL IS OFF, AND
*    OPVB,5 IS THE TARGET VALUE OF TEMPERATURE
*   THUS
*    OPVB,123 IS ABS(TT,286 - OPVB,5) WHEN CONTROL IS ON, AND
*            0.0 WHEN CONTROL IS OFF
*
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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* OPERATIONS FOR REHEAT SPRAY CONTROL -
* THE EFFECT OF THE OPERATIONS IS EXPLAINED BELOW CARD 881250
*
881220 TT,111,        SUB,   OPVB,5,       OPVB, 206      * DELTA T, I.E. (ACTUAL - DESIRED)
881230 ONE,0,         ABS,   OPVB,206,     OPVB, 206      * ABSOLUTE VAL OF DELTA T
881240 OPVB,206,      MUL,   OPVB,205,     OPVB, 130      * SWITCHED ABS DELTA T, GOAL VBLE
881260 OPVB,205,      MUL,   OPVB,171,     WWVSC,171      * SWITCHED RH SPRAY FLOW
*
*  NOTE THAT OPERATION 125 HAS SET THE GOAL VARIABLE
*     OPVB,130 = SWITCH * ABS(TT,111 - OPVB,5)
*   WHERE (THE SWITCH IS OPVB,205, WHICH IS SET BY SCHEDULE)
*     SWITCH IS 1.0, WHEN THE SPRAY CONTROL IS ON, AND
*            0.0, WHEN THE SPRAY CONTROL IS OFF, AND
*     OPVB,5 IS THE TARGET VALUE OF TEMPERATURE
*   THUS
*     OPVB,130 IS ABS(TT,111 - OPVB,5) WHEN CONTROL IS ON, AND
*              0.0 WHEN CONTROL IS OFF
*
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
*
* AIR HTR COILS
871490 190.
881500 TT,141,        ADD,   TT,25,        OPVB, 150
881510 OPVB,150,      DIV,   TWO,0,        OPVB, 151
881520 OPVB,151,      SUB,   OPVB,149,     OPVB, 152
*
*** SPECIAL OUTPUT VARIABLES
*
891010 'UNCORRECTED GAS EXIT TEMP.'
891011 TTUNCT, 30
891020 'BOILER EFF BY I/O METHOD'
891021 OPVB,40
891030 'BOILER EFF BY HT LOSS METHOD'
891031 EFBLRD,0
891040 'FURNACE EXIT TEMP'
891041 TEXF, 290
891050 'COAL FLOW'
891051 WWVSC, 40
891060 'STEAM FLOW'
891061 WW, 286
891070 'ECON GAS OUT TEMP'
891071 TT, 112
891080 'REHEAT GAS SPLIT'
891081 FRSPL, 90
891090 'AIR FLOW'
891091 WW, 35
891100 'GAS FLOW'
891101 WW, 300
891200 'TOTAL BLR HT CREDIT'
891201 QHBTOT, 0
891210 'SH SPRAY SWITCH,     1.=ON,  0.=OFF'
891211 OPVB,200
```

```
891220 'RH SPRAY SWITCH,     1.=ON,  0.=OFF'
891221 OPVB,205
891230 'SH SPRAY FLOW'
891231 WW,181
891240 'RH SPRAY FLOW'
891241 WW,171
891250 'MAIN STEAM TEMPERATURE'
891251 TT,-286
891260 'HOT REHEAT TEMPERATURE'
891261 TT,-111
*
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
*
*
*** HEAT LOSS BOILER EFFICIENCY CALCULATION
*
900000 1         77.        14.7
*
* FLUE GAS DESCRIPTION
900110 320       0.0
*
* COMBUSTION AIR
900210 25
*
* FUEL DESCRIPTION
900310 40        0.0
*
* TEMPERING AIR
900510 26
*
* AUX. DRIVE HEAT CREDIT
*90061020       * FD FAN
*900620145      * ID FAN
*
* UNBURNED CARBON IN STACK
901110 140
*
* UNBURNED CARBON IN REFUSE
901120 47
*
* DUST COLLECTION
901210 305
*
* RADIATION LOSS = 0.17%
901610 290       0.0017
*
* UNACCOUNTED HEAT LOSS = 1.50%
901910 0.0150
*
* MODIFICATIONS OF BASIC DESCRIPTION
*
*** WITH NEW COALS
```

```
*  JPM BOILER WITH VARIOUS COAL BLENDS
700403 FUEL,  8394.,  SSVL,  0.0,     C,      .4839,  H2,     .0348,  S,      .0035
700404 O2,     .1161,  N2,     .0067,  H2O,    .3030,  ASH,    .0520
*
*  SPECIAL INPUT OF FEEDWATER FLOW TO SET LOAD CONDITION FOR ANALYSIS
*
= J:\PERFSYS\PEPSE\CHKV59\UGM94PA - JPM BLR W/ WFW = 1.E6
891510 'FEEDWATER FLOW'
891511 WWVSC,        200,    1.E6,    I
*
*  SCREEN DISPLAY OF KEY RESULTS
*
080001 WWVSC,171,    WWVSC,181
/
```

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 63

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	TTUNCT(30) 3.35068E+02	EQL		=	ETTFG (1) 3.35068E+02
2	UFUNL (290) 1.50000E-02	EQL		=	ELUNSP(1) 1.50000E-02
10	BBSTRM(286) 1.41537E+09	ADD	BBSTRM (111) 1.41960E+09	=	OPVB (10) 2.83497E+09
11	OPVB (10) 2.83497E+09	ADD	BBSTRM (47) 8.14873E+03	=	OPVB (10) 2.83498E+09
12	OPVB (10) 2.83498E+09	SUB	BBSTRM (200) 3.60801E+08	=	OPVB (10) 2.47418E+09
13	OPVB (10) 2.47418E+09	SUB	BBSTRM (165) 1.24960E+09	=	OPVB (10) 1.22457E+09
14	OPVB (10) 1.22457E+09	SUB	BBSTRM (171) 0.00000E+00	=	OPVB (10) 1.22457E+09
15	OPVB (10) 1.22457E+09	SUB	BBSTRM (181) 0.00000E+00	=	OPVB (10) 1.22457E+09
30	QHHVFL(0) 1.44646E+09	ADD	QHBTOT (0) 2.51681E+07	=	OPVB (20) 1.47162E+09
40	OPVB (10) 1.22457E+09	DIV	OPVB (20) 1.47162E+09	=	OPVB (40) 8.32124E-01
112	TT (286) 9.09451E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (201) -4.55486E+01
113	ONE (0) 1.00000E+00	ABS	OPVB (201) -4.55486E+01	=	OPVB (201) 4.55486E+01
114	OPVB (201) 4.55486E+01	MUL	OPVB (200) 0.00000E+00	=	OPVB (123) 0.00000E+00
116	OPVB (181) 2.51667E+03	MUL	OPVB (200) 0.00000E+00	=	WWVSC (181) 0.00000E+00

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 63

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
122	TT (111) 8.89867E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (206) -6.51332E+01
123	ONE (0) 1.00000E+00	ABS	OPVB (206) -6.51332E+01	=	OPVB (206) 6.51332E+01
124	OPVB (206) 6.51332E+01	MUL	OPVB (205) 0.00000E+00	=	OPVB (130) 0.00000E+00
126	OPVB (205) 0.00000E+00	MUL	OPVB (171) 1.00667E+03	=	WWVSC (171) 0.00000E+00
150	TT (141) 3.24732E+02	ADD	TT (25) 1.52178E+02	=	OPVB (150) 4.76910E+02
151	OPVB (150) 4.76910E+02	DIV	TWO (0) 2.00000E+00	=	OPVB (151) 2.38455E+02
152	OPVB (151) 2.38455E+02	SUB	OPVB (149) 1.90000E+02	=	OPVB (152) 4.84550E+01

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET	Y VARIABLE/ VALUE FROM ITERATE 63	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 63	CONVG LAST ITN X LIMTD
3	1.0E+00 * OPVB (123)			OPVB (181)	
	0.00000E+00	(0.0E+00)	0.00000E+00	2.51667E+03	YES
4	1.0E+00 * OPVB (130)			OPVB (171)	
	0.00000E+00	(0.0E+00)	0.00000E+00	1.00667E+03	YES

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)		VALUE
101	UNCORRECTED GAS EXIT TEMP.	TTUNCT	(30)	3.350964E+02
102	BOILER EFF BY I/O METHOD	OPVB	(40)	8.321239E-01
103	BOILER EFF BY HT LOSS METHOD	EFBLRD	(0)	8.358384E-01
104	FURNACE EXIT TEMP	TEXF	(290)	1.809272E+03
105	COAL FLOW	WWVSC	(40)	1.723202E+05
106	STEAM FLOW	WW	(286)	9.900000E+05
107	ECON GAS OUT TEMP	TT	(112)	5.975872E+02
108	REHEAT GAS SPLIT	FRSPL	(90)	5.511000E-01
109	AIR FLOW	WW	(35)	1.417671E+06
110	GAS FLOW	WW	(300)	1.535047E+06
120	TOTAL BLR HT CREDIT	QHBTOT	(0)	2.516810E+07
121	SH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(200)	0.000000E+00
122	RH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(205)	0.000000E+00
123	SH SPRAY FLOW	WW	(181)	0.000000E+00
124	RH SPRAY FLOW	WW	(171)	0.000000E+00
125	MAIN STEAM TEMPERATURE	TT	(-286)	9.094469E+02
126	HOT REHEAT TEMPERATURE	TT	(-111)	8.898668E+02

TABLE A-4

BOILER EXAMPLE RESULTS AT INTERMEDIATE LOAD
SH SPRAY IS ON, AND RH SPRAY IS OFF

PEPSE CODE BY HALLIBURTON NUS, IDAHO FALLS, ID.
VERSION 59E CREATED 18 MAR 94 DATE 03/29/94. PAGE 3
J:\PERFSYS\PEPSE\CHKV59\UGM94PA - JPM BLR W/ WFW = 1.3E6

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 175

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	TTUNCT(30) 3.46972E+02	EQL		=	ETTFG (1) 3.46972E+02
2	UFUNL (290) 1.50000E-02	EQL		=	ELUNSP(1) 1.50000E-02
10	BBSTRM(286) 1.90648E+09	ADD	BBSTRM (111) 1.85891E+09	=	OPVB (10) 3.76539E+09
11	OPVB (10) 3.76539E+09	ADD	BBSTRM (47) 1.10705E+04	=	OPVB (10) 3.76540E+09
12	OPVB (10) 3.76540E+09	SUB	BBSTRM (200) 4.91504E+08	=	OPVB (10) 3.27389E+09
13	OPVB (10) 3.27389E+09	SUB	BBSTRM (165) 1.61409E+09	=	OPVB (10) 1.65980E+09
14	OPVB (10) 1.65980E+09	SUB	BBSTRM (171) 0.00000E+00	=	OPVB (10) 1.65980E+09
15	OPVB (10) 1.65980E+09	SUB	BBSTRM (181) 7.96069E+06	=	OPVB (10) 1.65184E+09
30	QHHVFL(0) 1.96509E+09	ADD	QHBTOT (0) 2.73411E+07	=	OPVB (20) 1.99243E+09
40	OPVB (10) 1.65184E+09	DIV	OPVB (20) 1.99243E+09	=	OPVB (40) 8.29056E-01
112	TT (286) 9.54994E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (201) -6.36268E-03
113	ONE (0) 1.00000E+00	ABS	OPVB (201) -6.36268E-03	=	OPVB (201) 6.36268E-03

114	OPVB (201) 6.36268E-03	MUL	OPVB (200) 1.00000E+00	=	OPVB (123) 6.36268E-03
116	OPVB (181) 2.24099E+04	MUL	OPVB (200) 1.00000E+00	=	WWVSC (181) 2.24099E+04
122	TT (111) 9.42074E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (206) -1.29256E+01
123	ONE (0) 1.00000E+00	ABS	OPVB (206) -1.29256E+01	=	OPVB (206) 1.29256E+01
124	OPVB (206) 1.29256E+01	MUL	OPVB (205) 0.00000E+00	=	OPVB (130) 0.00000E+00
126	OPVB (205) 0.00000E+00	MUL	OPVB (171) 1.00667E+03	=	WWVSC (171) 0.00000E+00
150	TT (141) 3.35191E+02	ADD	TT (25) 1.37986E+02	=	OPVB (150) 4.73177E+02
151	OPVB (150) 4.73177E+02	DIV	TWO (0) 2.00000E+00	=	OPVB (151) 2.36588E+02
152	OPVB (151) 2.36588E+02	SUB	OPVB (149) 1.90000E+02	=	OPVB (152) 4.65884E+01

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET	Y VARIABLE/ VALUE FROM ITERATE 175	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 175	CONVG LAST ITN X LIMTD
3	1.0E+00 * OPVB (123)			OPVB (181)	
	6.36268E-03	(-6.4E-03)	0.00000E+00	2.24099E+04	YES
4	1.0E+00 * OPVB (130)			OPVB (171)	
	0.00000E+00	(0.0E+00)	0.00000E+00	1.00667E+03	YES

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)		VALUE
101	UNCORRECTED GAS EXIT TEMP.	TTUNCT	(30)	3.469719E+02
102	BOILER EFF BY I/O METHOD	OPVB	(40)	8.290558E-01
103	BOILER EFF BY HT LOSS METHOD	EFBLRD	(0)	8.329106E-01
104	FURNACE EXIT TEMP	TEXF	(290)	1.998648E+03
105	COAL FLOW	WWVSC	(40)	2.341069E+05
106	STEAM FLOW	WW	(286)	1.309413E+06
107	ECON GAS OUT TEMP	TT	(112)	6.586295E+02
108	REHEAT GAS SPLIT	FRSPL	(90)	4.955422E-01
109	AIR FLOW	WW	(35)	1.897758E+06
110	GAS FLOW	WW	(300)	2.057212E+06
120	TOTAL BLR HT CREDIT	QHBTOT	(0)	2.734109E+07
121	SH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(200)	1.000000E+00
122	RH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(205)	0.000000E+00
123	SH SPRAY FLOW	WW	(181)	2.240989E+04
124	RH SPRAY FLOW	WW	(171)	0.000000E+00
125	MAIN STEAM TEMPERATURE	TT	(-286)	9.549936E+02
126	HOT REHEAT TEMPERATURE	TT	(-111)	9.420744E+02

TABLE A-5

BOILER EXAMPLE RESULTS AT HIGH LOAD
BOTH SPRAYS ARE ON

PEPSE CODE BY HALLIBURTON NUS, IDAHO FALLS, ID.
VERSION 59E CREATED 18 MAR 94 DATE 03/29/94. PAGE 3
J:\PERFSYS\PEPSE\CHKV59\UGM94PA - JPM BLR W/ WFW = 2.E6

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 59

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	TTUNCT(30) 3.61168E+02	EQL		=	ETTFG (1) 3.61168E+02
2	UFUNL (290) 1.50000E-02	EQL		=	ELUNSP(1) 1.50000E-02
10	BBSTRM(286) 2.92364E+09	ADD	BBSTRM (111) 2.85542E+09	=	OPVB (10) 5.77906E+09
11	OPVB (10) 5.77906E+09	ADD	BBSTRM (47) 1.65597E+04	=	OPVB (10) 5.77908E+09
12	OPVB (10) 5.77908E+09	SUB	BBSTRM (200) 8.38049E+08	=	OPVB (10) 4.94103E+09
13	OPVB (10) 4.94103E+09	SUB	BBSTRM (165) 2.47660E+09	=	OPVB (10) 2.46443E+09
14	OPVB (10) 2.46443E+09	SUB	BBSTRM (171) 5.26473E+06	=	OPVB (10) 2.45916E+09
15	OPVB (10) 2.45916E+09	SUB	BBSTRM (181) 1.23847E+07	=	OPVB (10) 2.44678E+09
30	QHHVFL(0) 2.93947E+09	ADD	QHBTOT (0) 2.20125E+07	=	OPVB (20) 2.96148E+09
40	OPVB (10) 2.44678E+09	DIV	OPVB (20) 2.96148E+09	=	OPVB (40) 8.26201E-01
112	TT (286) 9.55271E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (201) 2.70711E-01
113	ONE (0)	ABS	OPVB (201)	=	OPVB (201)

	1.00000E+00		2.70711E-01		2.70711E-01
114	OPVB (201) 2.70711E-01	MUL	OPVB (200) 1.00000E+00	=	OPVB (123) 2.70711E-01
116	OPVB (181) 3.48688E+04	MUL	OPVB (200) 1.00000E+00	=	WWVSC (181) 3.48688E+04
122	TT (111) 9.55214E+02	SUB	OPVB (5) 9.55000E+02	=	OPVB (206) 2.14176E-01
123	ONE (0) 1.00000E+00	ABS	OPVB (206) 2.14176E-01	=	OPVB (206) 2.14176E-01
124	OPVB (206) 2.14176E-01	MUL	OPVB (205) 1.00000E+00	=	OPVB (130) 2.14176E-01
126	OPVB (205) 1.00000E+00	MUL	OPVB (171) 1.55669E+04	=	WWVSC (171) 1.55669E+04
150	TT (141) 3.47111E+02	ADD	TT (25) 1.10869E+02	=	OPVB (150) 4.57980E+02
151	OPVB (150) 4.57980E+02	DIV	TWO (0) 2.00000E+00	=	OPVB (151) 2.28990E+02
152	OPVB (151) 2.28990E+02	SUB	OPVB (149) 1.90000E+02	=	OPVB (152) 3.89899E+01

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET	Y VARIABLE/ VALUE FROM ITERATE 59	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 59	CONVG LAST ITN X LIMTD
3	1.0E+00 * OPVB (123)			OPVB (181)	
	2.70711E-01	(-2.7E-01)	0.00000E+00	3.48688E+04	YES
4	1.0E+00 * OPVB (130)			OPVB (171)	
	2.14176E-01	(-2.1E-01)	0.00000E+00	1.55669E+04	YES

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)		VALUE
101	UNCORRECTED GAS EXIT TEMP.	TTUNCT	(30)	3.611690E+02
102	BOILER EFF BY I/O METHOD	OPVB	(40)	8.262015E-01
103	BOILER EFF BY HT LOSS METHOD	EFBLRD	(0)	8.300439E-01
104	FURNACE EXIT TEMP	TEXF	(290)	2.151711E+03
105	COAL FLOW	WWVSC	(40)	3.501868E+05
106	STEAM FLOW	WW	(286)	2.014869E+06
107	ECON GAS OUT TEMP	TT	(112)	7.359429E+02
108	REHEAT GAS SPLIT	FRSPL	(90)	4.353971E-01
109	AIR FLOW	WW	(35)	2.748235E+06
110	GAS FLOW	WW	(300)	2.986752E+06
120	TOTAL BLR HT CREDIT	QHBTOT	(0)	2.201249E+07
121	SH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(200)	1.000000E+00
122	RH SPRAY SWITCH, 1.=ON, 0.=OFF	OPVB	(205)	1.000000E+00
123	SH SPRAY FLOW	WW	(181)	3.486884E+04
124	RH SPRAY FLOW	WW	(171)	1.556694E+04
125	MAIN STEAM TEMPERATURE	TT	(-286)	9.552711E+02
126	HOT REHEAT TEMPERATURE	TT	(-111)	9.552145E+02