PEPSE's Special Option 12 – A Useful Tool for Condenser Analyses

By

Gerald Weber
Senior Engineer, Performance
Midwest Generation Company, EME

And

Gene L. Minner, PhD
Technical Director
Scientech, LLC

ABSTRACT

In this project, PEPSE's Special Option Number 12 is used to analyze the performance of multiple condensers having multiple water boxes. More commonly, option 12 is used for a single condenser. The agreement with measured results gives confidence that the method of calculation can give results that are reliable for system evaluations. As tubes are removed from service, heat transfer area is lost; and, in addition, the circulating water flow rate is reduced. This reduction occurs because of the increased pressure differential that the circulating water pump must supply due to the increased frictional losses. The analysis is performed with varying circulating water pumps in service, and the pumps' performance curve determines the amount of the flow.

The actual plant setting is one where circulating-water-side fouling imposes a need for regular cleaning of the tubes in the condensers. This is done while the unit remains on line, but with one set of water boxes, out of four sets, out of service for the cleaning. Special Option 12 is well suited to analyze this operating condition by representing the out of service water box as 50% tube plugging for the affected condenser.

INTRODUCTION

This paper is an extension of previous work done by the authors, who developed a theoretical method for calculating condenser performance, as it is affected by the circulating water flow balance. The previous work was reported in References 1, 2, and 3. This paper applies the modeling theory and compares the results to performance data that have been measured in a plant setting.

The tool used in the PEPSE analysis is called Special Option Number 12. This tool was not available at the time of the previous work, but it implements the methods that were developed at that time.

The motives for the current paper are to show the results of Special Option 12 in the analysis of a plant for an issue of real practical concern and to show the specific techniques for use of the tool.

The analysis task of interest is to predict the performance of a pair of condensers when one water box circuit in one of the condensers is out of service for cleaning. The two condensers are operated in parallel on the circulating water path, where the circulating water flows to a header from two circulating water pumps in parallel. See the schematic diagram below for a view of this arrangement. Note that the two parallel pumps have been represented in the PEPSE model by a single pump component.

The concept underlying the calculation method is that the circulating water flow rate is set by a balance between the pressure head provided by the pumps and the pressure drop in the rest of the circulating water flow system. There is a curve of pump head versus the flow rate, and there is a "resistance" curve of the circuit's pressure drop versus the flow rate. The balance point of this system is the point where the curves intersect, i.e. where the pump's head curve matches the system's resistance curve, such that the pressure drop and head are equal, and where the flow rates are equal. As some of the condenser's tubes are taken out of service (for example when a water box circuit is out of service for cleaning), a shift of the resistance curve occurs. Typically the resistance curve becomes steeper, shifting the point of intersection to a higher value of head and lower flow rate. Conceptually, this matches with our intuition. In the context of a PEPSE model, Special Option 12 provides the modeling structure to calculate this balance point and its consequent impact on the performance of the condenser. The condenser's performance is calculated using the HEI mode of modeling, see Reference 4. The actual match point is obtained by calculating the flow rate that gives atmospheric pressure at the exit of the circulating water flow path.

The end-results of the use of the model are the condensers' equilibrium shell pressures for the scenarios with all tubes in service and for some tubes out of service.

DESCRIPTION OF THE ACTUAL PLANT SYSTEM OF INTEREST

The generating unit analyzed in this work is a 550 MW Westinghouse cross compound single reheat turbine cycle. There are two separate turbines on the low pressure shaft, each with two ends. Both ends of each turbine exhaust into a separate once through condenser. Each condenser is divided in half to correspond to each end of the turbine. Each half condenser has a separate water box. Therefore there are 2 parallel condensers total and 2 water boxes per condenser. The unit uses river water as circulating water flow source.

There are two units in total, and each shares the outputs of 4 circulating water pumps. It is possible to operate with 3 or 4 pumps in service to allow for maintenance and to allow for removal of a pump in the cooler weather to reduce auxiliary power consumption. A simplified schematic is shown in figure 1 below.

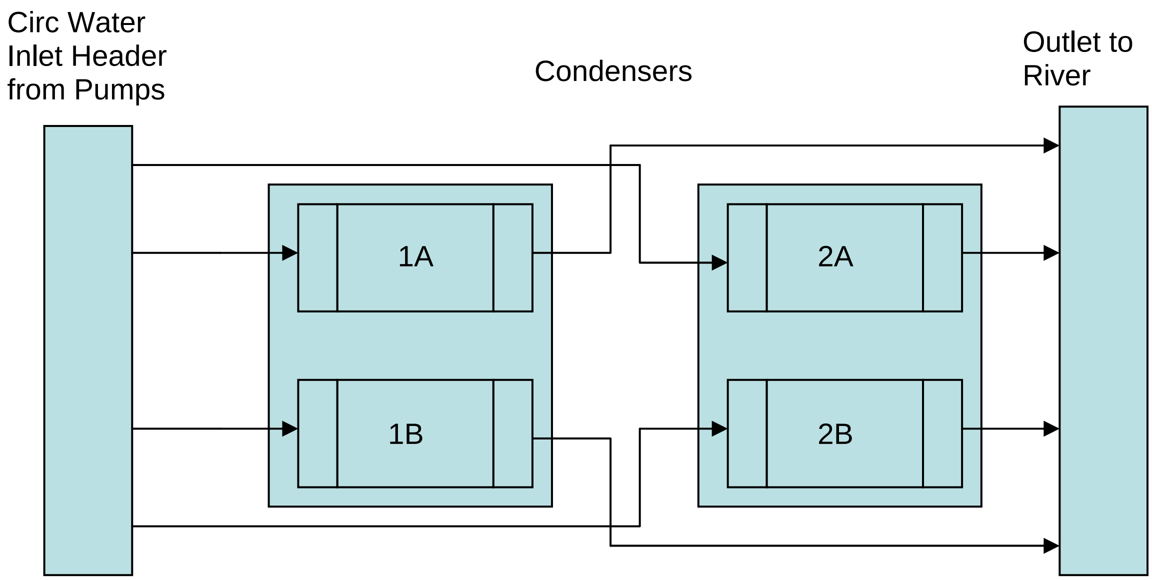


Figure 1 – Simplified Circulating Water Flow Diagram for One Unit

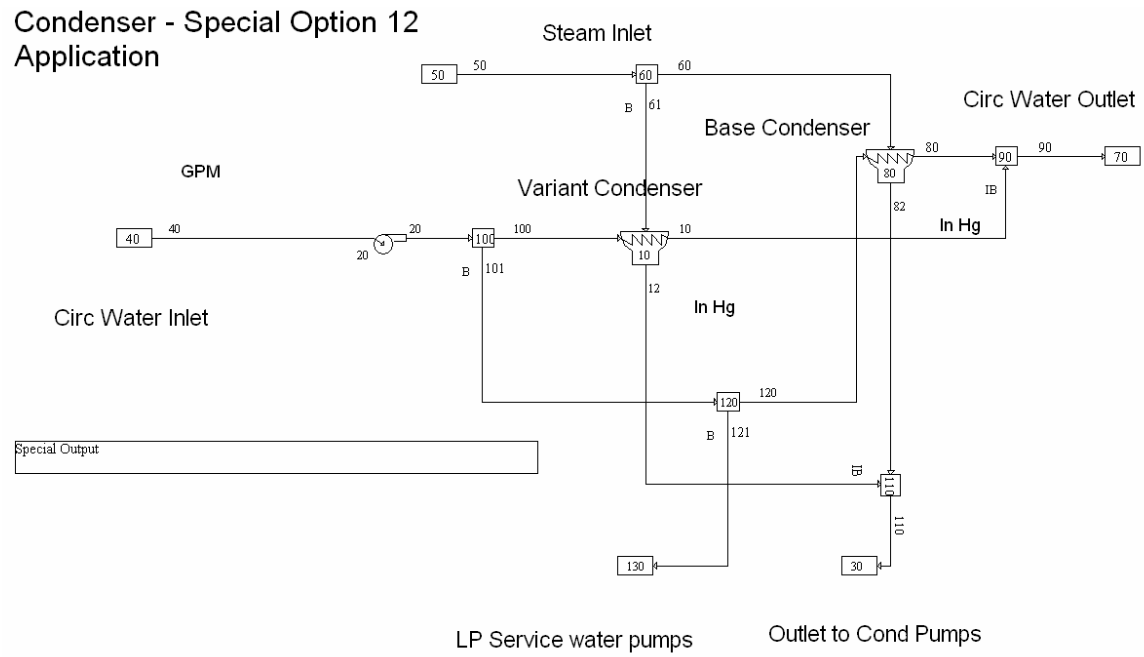
Frequently it is necessary to clean the condenser tubes and water boxes. When this occurs, the affected water box is removed from service and the box that remains in service for the associated condenser receives all of this condenser's share of the circulating water flow. This situation is simulated by modeling the condenser system as 2 condensers in HEI mode. When one water box is removed from service for cleaning, we can simulate this situation in a PEPSE model by plugging 50% of the tubes. Special Option 12 is utilized to model this situation, and results are compared to actual data in an attempt to determine if the model could be utilized to successfully account for this extreme case of plugging.

METHOD OF ANALYSIS

A PEPSE model was constructed to perform this analysis. The program's recently-added Special Option Number 12 was used, as it is well-suited to determining circulating water side flow rates, based on balancing of pump head against system pressure losses.

The theoretical foundation for this balancing can be found in earlier papers written by the authors and in the PEPSE Volume 1 Manual, User Input Description, Reference 5.

The schematic diagram below shows the PEPSE model that was used to analyze the scenario posed.



As shown, source component 40 provides the circulating water, and source component 50 provides the LP exhaust steam to the condensers. Pump component 20 accounts for the flow and the head effects of both circulating water pumps for the unit. Downstream of pump 40 is a flow splitter, component 100, that sends the respective cooling flows to the two condensers. More will be said about this flow split later, in Appendix A. Similarly there is a split of the LP steam at splitter 60. The split flows of LP steam are assumed to be equal. Components 10 and 80 represent the two condensers. In fully normal operating state, they are identical, and they receive equal amounts of circulating water flows.

The remaining components in the schematic are needed to complete the model, but they are not of any significant note to warrant further description here.

The components of significant interest to this analysis effort are source 40, pump 20, splitters 100 and 120, and condensers 10 and 80.

The objective of the model is to calculate the shell-side equilibrium pressures in the condensers as tubes are removed from service, e.g. for cleaning or for sealing against leaks.

For additional discussion of the details of the model, see Appendix A. For a comprehensive presentation of the input data to the model, see Appendix B.

MEASURED RESULTS FROM THE PLANT AND COMPARISON TO PEPSE'S RESULTS

In order to calibrate the base case and obtain reasonable agreement, a relative tube roughness of 0.006 inches was used in the modeling. Note that we would not theoretically expect a smooth inside tube in a condenser unless the water is treated or a brush or ball cleaning system is employed. Therefore this seems like a valid reason to increase the roughness within reasonable limits. The roughness affects the accounting of pressure drop in the tubes. When the roughness is increased, the calculated value of K_{misc} decreases because the relative contribution of tube pressure drop increases. The K_{misc} term accounts for pressure drop throughout the remainder of the circulating water train.

The results of the modeling are compared to the actual data with 4 pumps in operation, the same relative roughness, and a circulating water inlet temperature of 79 deg F at full load:

	Cond #1 BP (in Hg)	Cond #2 BP (in Hg)
Actual	1.91	1.91
PEPSE	1.93	1.93

For the 50% plugged case we obtained the following results:

	Cond #1 BP (in Hg)	Cond #2 BP (in Hg)
Actual	2.93	1.82
PEPSE	2.84	1.85

Other comparisons were not always as accurate as the above, but the actual vs the PEPSE results generally agreed within 0.3 in Hg. Suspected causes of any deviations are:

- A cleanliness issue where the condenser being cleaned is significantly more fouled than the 85% cleanliness used in the modeling. If greater fouling occurs, the predicted back pressure is less than the actual as a consequence of the fouling.
- The actual circulating water flow to the condenser is less than assumed in the model. This could be due to more flow being diverted to the other unit that shares the pumps; or one of the valves could be leaking, permitting circulating water to bypass the condenser. A flow reduction such as this would also cause the actual back pressure to shift upward as compared to PEPSE.

Note that, in all cases, the PEPSE prediction was equal to or less than the actual.

One of the reasons the model was developed was to determine how many tubes may actually be plugged and still allow a condenser water box to be removed from service at full load on a hot summer day. To simulate this, the circulating water inlet temperature was input at 90 deg F and the tubes were plugged in various amounts using special option 12.

If the maximum back pressure allowed per the turbine manufacturer is 4.5 in Hg, the figure below shows that just 10% of the tubes could be plugged (in addition to the 50% that are out of service for cleaning) and still allow cleaning with 4 pumps on.

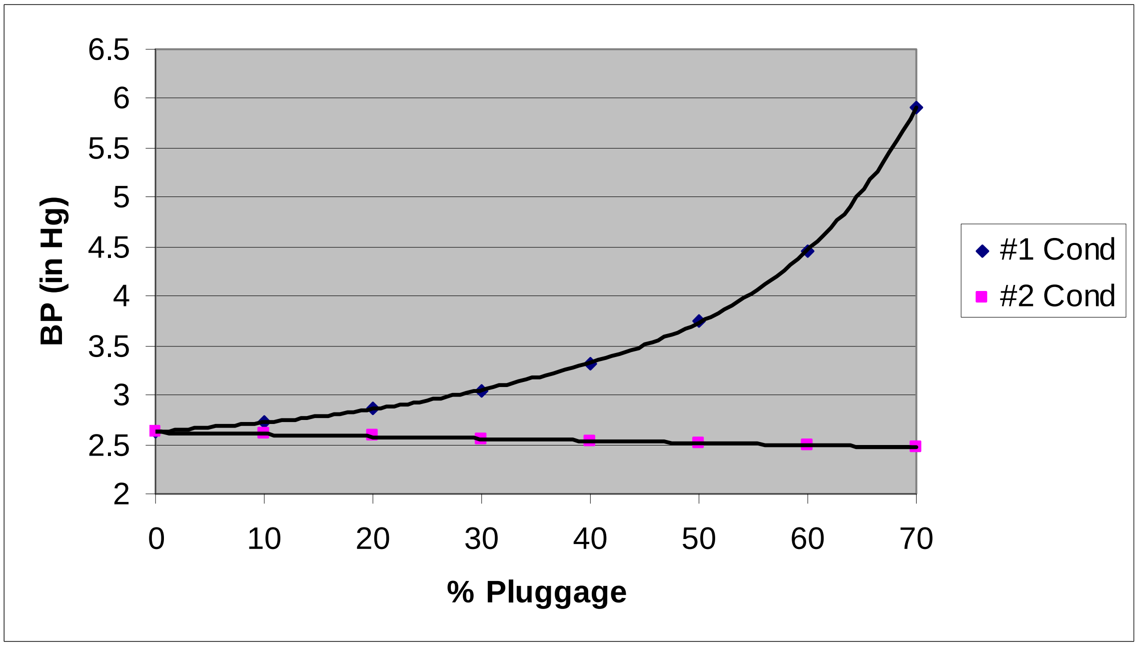


Figure 2 – PEPSE Results with 4 Pumps at Full Load with 90 deg F CWIT

CONCLUSIONS

The PEPSE model's results agree well with actual plant measured results. Significant factors affecting the modeling results and comparison with actual data are:

- Surface fouling affects the surface roughness. It is important to represent this fouling for its effect on pressure drop in the tubes. The model can be used to test input values of roughness to adjust the division of pressure losses between the condenser tubes and the rest of the circulating water system. Specifically, the tubes' wall surface roughness plays an important role in determining the pressure losses inside of the condenser. This impacts the amount of pressure drop that we assign as "miscellaneous", for the rest of the system.

- The actual cleanliness and back pressure deviation from bogey are important. In performing this analysis and reporting the results, we must also consider that if the cleanliness deviates significantly from the base value of 85%, the actual effect will be correspondingly greater. Therefore, as one might expect, the initial value of condenser cleanliness is very important to the results.

- If modeling a system with more than one circulating water pump, ensure that the flow utilized corresponds to the pump manufacturer's system performance curve. The actual system flow is slightly different than just using a multiple of the flow per pump because as more pumps are in operation, the system resistance losses increase. PEPSE does a very good job at matching the flow if the condenser design data, tube roughness, and pump curve data are input to the model.

- If there are any flow extractions after the circulating water pumps such as supplying the low pressure service water pumps, these must be accounted in the model to obtain accurate predictions.

PEPSE's Special Option Number 12 is a convenient tool for performing this type of analysis. Indeed, even though Option 12 focuses on a single condenser, you can use it to analyze multiple-parallel condenser circuits by appending your own customizations to the model. In this project, this meant writing an "extra" control to determine the flow split quantity to the second condenser.

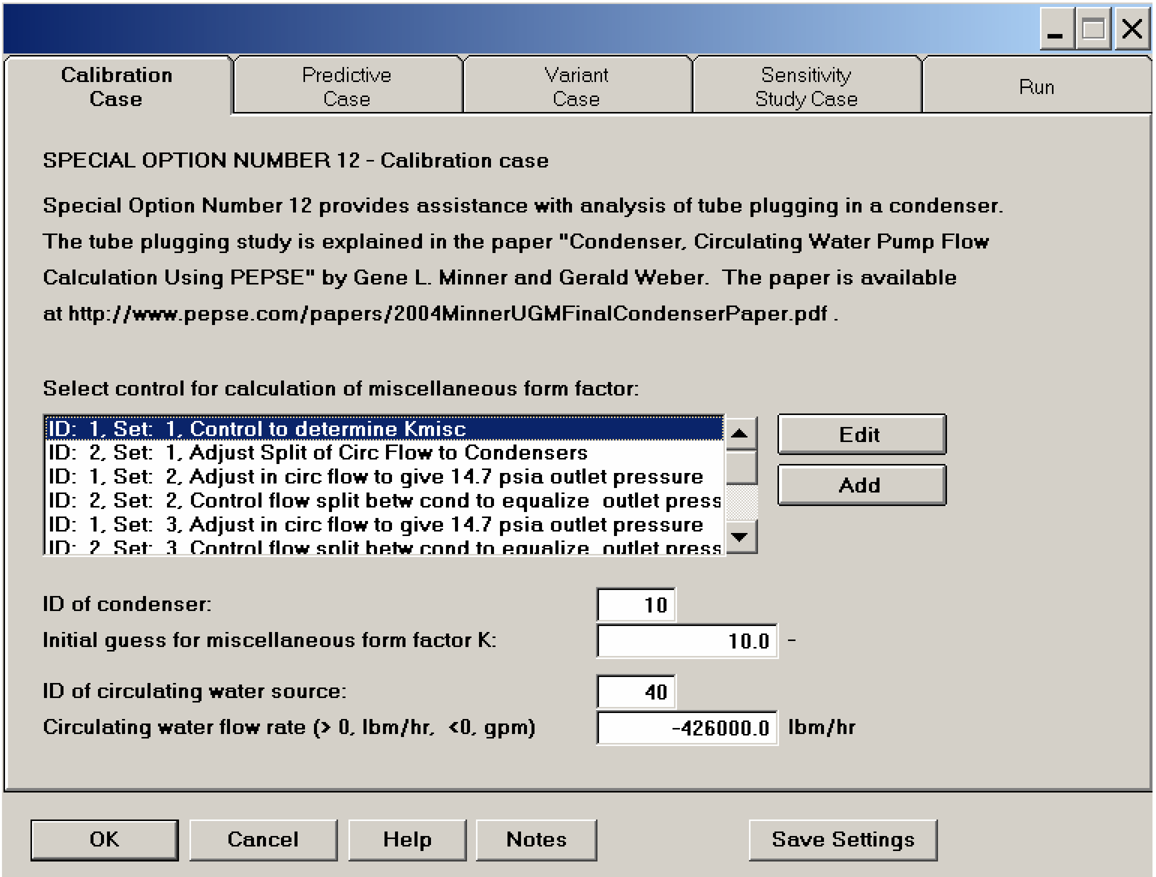
REFERENCES

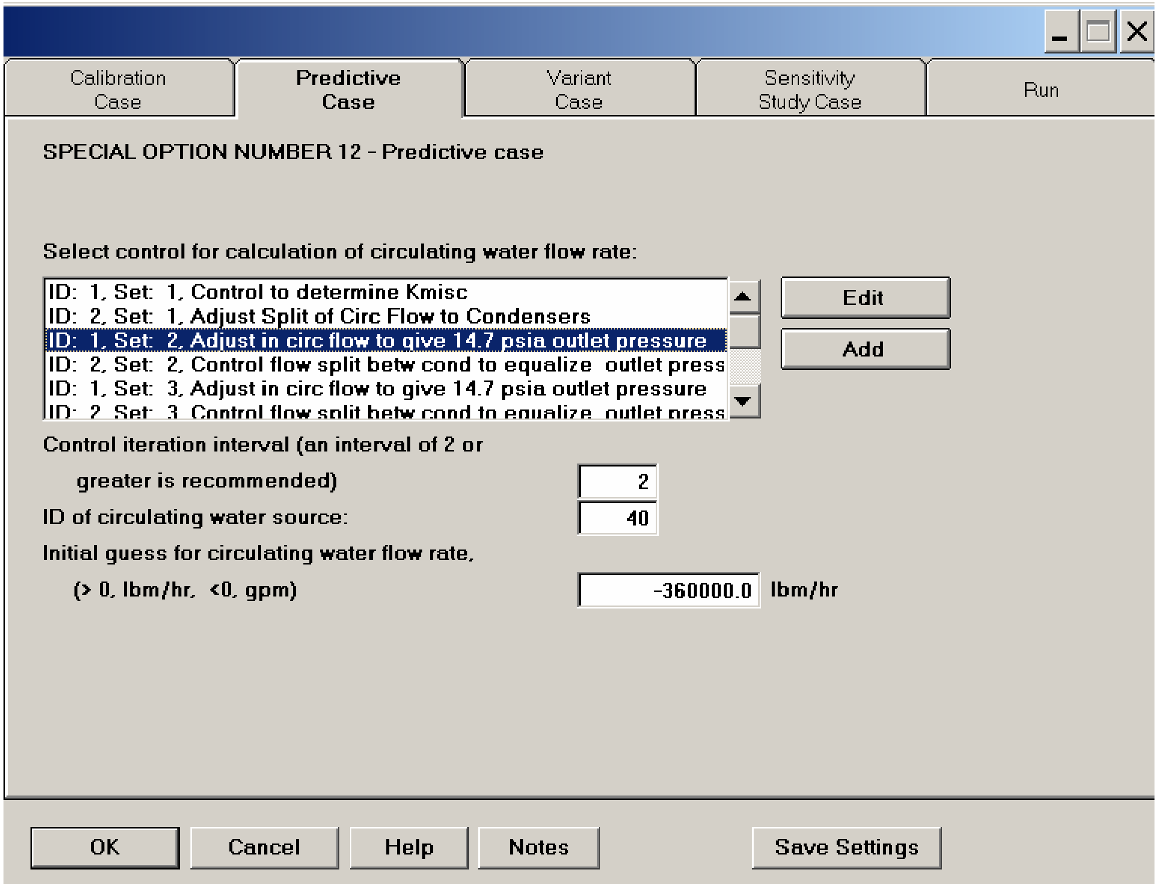
1. Minner, Gene L, and Weber, Jerry, "Condenser Circulating Water Pump Flow Calculation", Proceedings of the 2004 Performance Software User's Group Meeting, Sponsored by Scientech, Chicago, Il, August 10-12, 2004
2. Minner, Gene L, and Weber, Gerald, "Predicting Performance of a Condenser with Plugged Tubes", Paper No. PWR2005-50057, ASME Power Conference, Chicago, Il, April 5-7, 2005
3. Minner, Gene L, and Feigl, Tim, "Calculations of Condenser Performance Using PEPSE", Proceedings of the 2000 Performance Software User's Group Meeting, Sponsored by SCIENTECH, Idaho Falls, Id, June 20-22, 2000
4. Anon., <u>Standards for Steam Surface Condensers</u>, Ninth Edition, Heat Exchange Institute Incorporated, Cleveland, Ohio, 1995
5. Minner, Gene L, et al, <u>User Input Description, PEPSE Manual</u>, Volume 1, Idaho Falls, Id, 2005

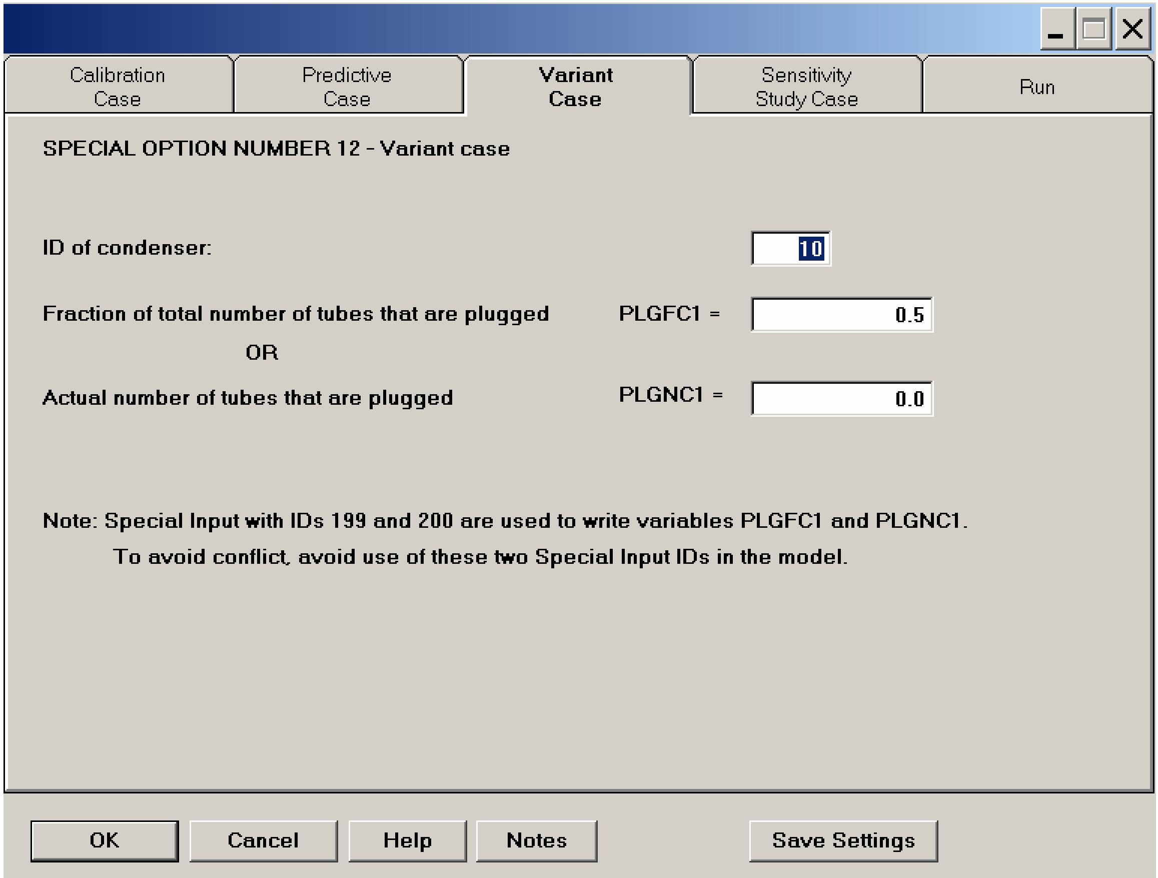
APPENDIX A - DETAILS OF THE PEPSE MODEL AND ANALYSIS

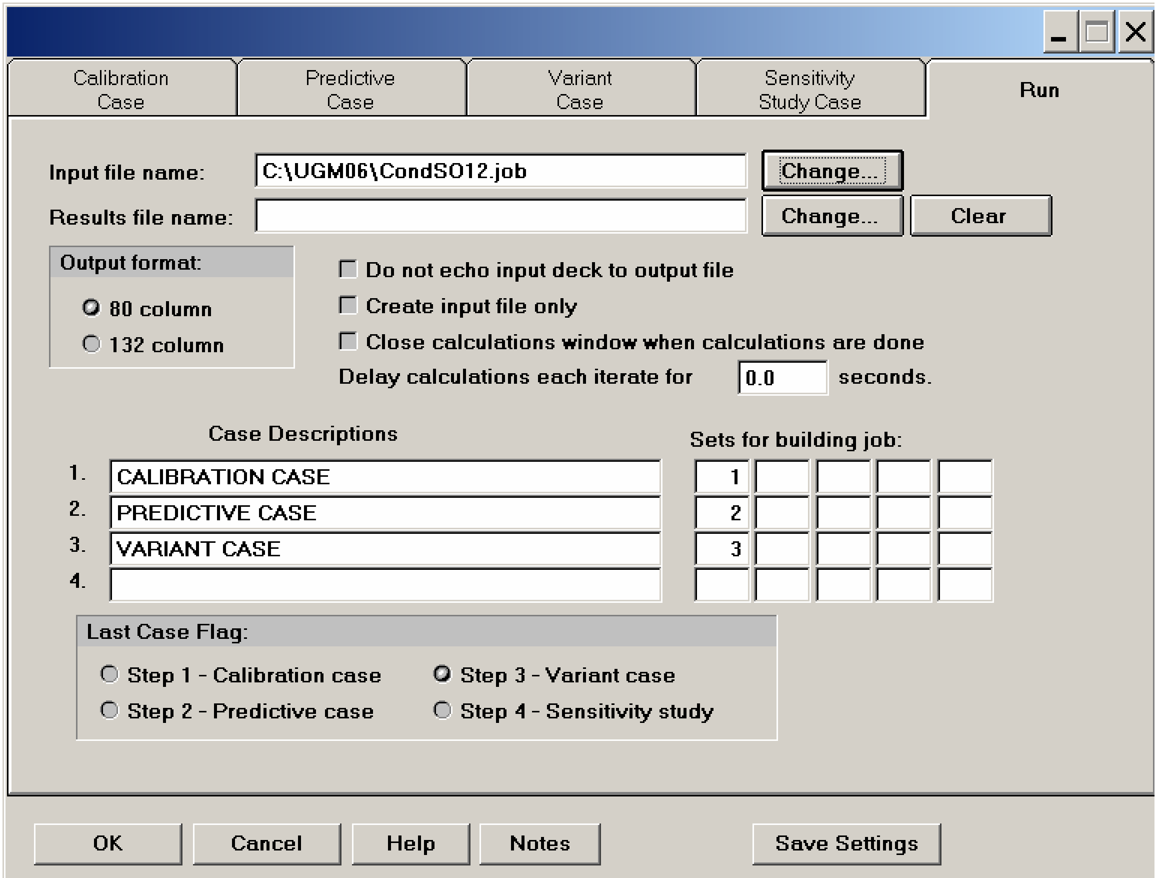
This appendix describes details of the use of PEPSE, focusing on Special Option 12 and its requirements.

Special Option 12 is accessed by the following sequence from the graphics program's **PEPSE Data Toolbar**, **SF**, **Special Option 12**, leading to a dialog box with several tabs as shown below.


Calibration Case
Predictive Case
Variant Case
Sensitivity Study Case
Run
SPECIAL OPTION NUMBER 12 - Calibration case
Special Option Number 12 provides assistance with analysis of tube plugging in a condenser.
The tube plugging study is explained in the paper "Condenser, Circulating Water Pump Flow Calculation Using PEPSE" by Gene L. Minner and Gerald Weber. The paper is available at http://www.pepse.com/papers/2004MinnerUGMFinalCondenserPaper.pdf .
Select control for calculation of miscellaneous form factor:
ID: 1, Set: 1, Control to determine Kmisc
ID: 2, Set: 1, Adjust Split of Circ Flow to Condensers
ID: 1, Set: 2, Adjust in circ flow to give 14.7 psia outlet pressure
ID: 2, Set: 2, Control flow split betw cond to equalize outlet press
ID: 1, Set: 3, Adjust in circ flow to give 14.7 psia outlet pressure
Edit
Add
ID of condenser:
10
Initial guess for miscellaneous form factor K:
10.0
-
ID of circulating water source:
40
Circulating water flow rate (> 0, lbm/hr, <0, gpm)
-426000.0
lbm/hr
OK
Cancel
Help
Notes
Save Settings


Calibration Case
Predictive Case
Variant Case
Sensitivity Study Case
Run
SPECIAL OPTION NUMBER 12 - Predictive case
Select control for calculation of circulating water flow rate:
ID: 1, Set: 1, Control to determine Kmisc
ID: 2, Set: 1, Adjust Split of Circ Flow to Condensers
ID: 1, Set: 2, Adjust in circ flow to give 14.7 psia outlet pressure
ID: 2, Set: 2, Control flow split betw cond to equalize outlet press
ID: 1, Set: 3, Adjust in circ flow to give 14.7 psia outlet pressure
Edit
Add
Control iteration interval (an interval of 2 or
greater is recommended)
2
ID of circulating water source:
40
Initial guess for circulating water flow rate,
(> 0, lbm/hr, <0, gpm)
-360000.0
lbm/hr
OK
Cancel
Help
Notes
Save Settings


Calibration Case
Predictive Case
Variant Case
Sensitivity Study Case
Run
SPECIAL OPTION NUMBER 12 - Variant case
ID of condenser:
10
Fraction of total number of tubes that are plugged
PLGFC1 =
0.5
OR
Actual number of tubes that are plugged
PLGNC1 =
0.0
Note: Special Input with IDs 199 and 200 are used to write variables PLGFC1 and PLGNC1.
To avoid conflict, avoid use of these two Special Input IDs in the model.
OK
Cancel
Help
Notes
Save Settings



For the work to analyze a fixed amount of plugging, the sensitivity study case was not used. The last of the dialogs above shows a completed form for actually running the cases that were used for the present study. Later the sensitivity study feature was used to develop the curves that are shown in the main body of the paper.

There are two primary functions of Special Option 12. The first is to determine the miscellaneous form loss factor for its contribution to the system resistance curve. The second function is to apply this form loss factor for prediction of circulating flow rate under varying amounts of tubes in-service (and its complement, tubes out-of-service).

In order for Special Option 12 to perform its function successfully, the basic PEPSE model must include the curve of pump head versus flow rate, and it must include geometric descriptions of the internals of the condensers, which is a standard part of the input for an HEI mode condenser. The specific condenser inputs include the number of tubes, the diameter of the tubes, the length of the tubes, and the wall roughness of the tubes, along with a reasonable value of the form loss factor for the tubes themselves, accounting for entrance and exit losses and for any losses due to bends.

The analysis task requires three cases, a “calibration” step, a “predictive” step, and a “variant” step.

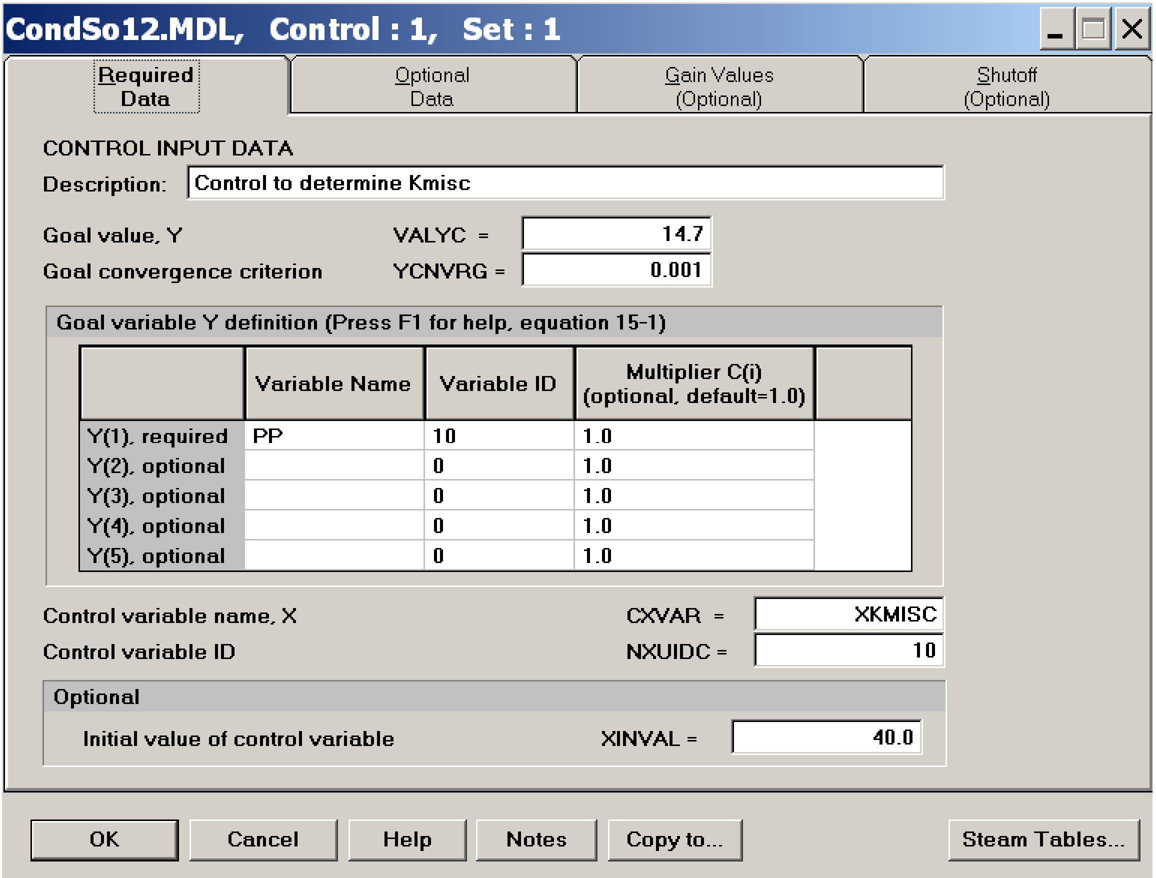
The first case, the “calibration” step, calculates a factor to account for miscellaneous pressure losses in the circulating water system. That is, this step determines an otherwise-unknown form loss factor to account for the pressure drop contribution exclusive of the condenser itself. This calibration is done under normal operating conditions of the condenser. Since the result accounts for hydraulic losses exclusive of the condenser itself, we assume that this loss factor also applies under off-normal operating conditions, such as tubes-out-of-service.

The second case is run as a verification of the results from the calibration step. It is called the “predictive” case, and it uses the form loss factor result from the calibration step. To attain verification, its results must match the results of the first case.

The third case uses the results from the calibration case to calculate the total circulating water flow and the flow split at component 100 and to calculate the consequent shell-side performance of the two condensers. This is under condition of variance of one of the condensers, condenser 10 in the present work. The anticipated variance is tube plugging, an amount which is easily specified on the “variant” form. This is the case of real interest.

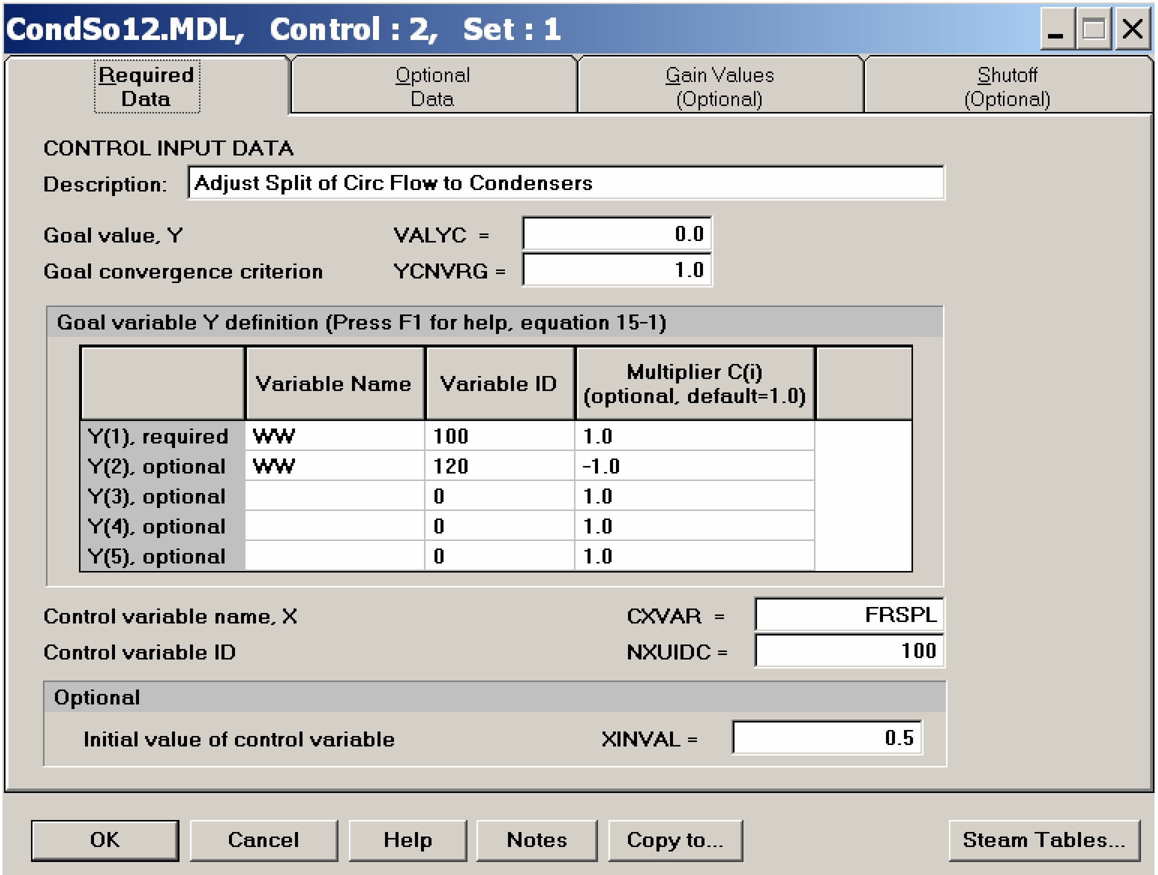
To perform the analyses of these cases, controls must be user-defined to calculate the desired quantities. These controls can be developed independent of Special Option 12, or they can be defined by “adding” them via the input forms of Special Option 12; see the forms above.

The control needed in the calibration step is for calculation of the miscellaneous form loss factor. See the completed form for the control below.



The control variable is the form factor, XKMISC, for the condenser, and the goal variable is PP, the pressure exiting the condenser. The goal value is 14.7 psia, the atmospheric pressure at the exit of the circulating water circuit. Obtaining atmospheric pressure at the system outlet assures that the pump's pressure rise is equal to the resistive pressure drop of the circulating water circuit.

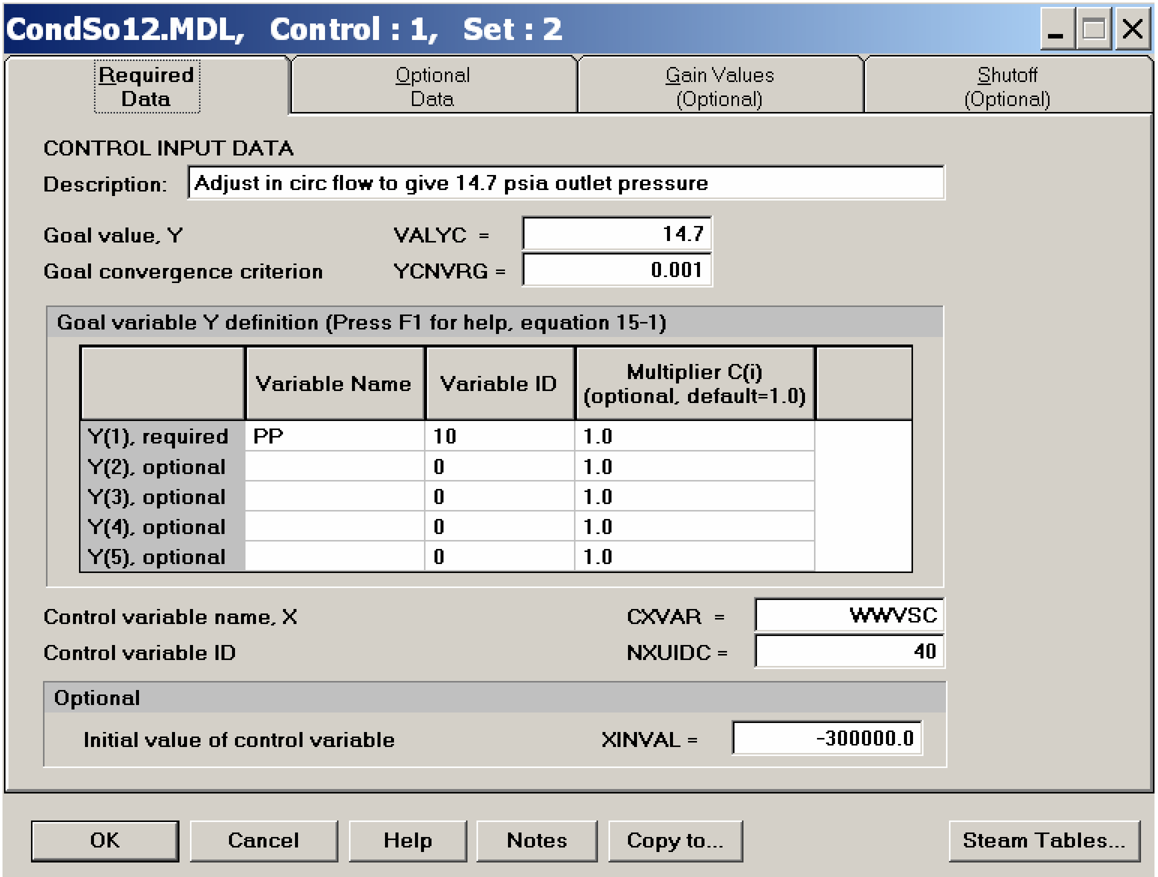
In addition to the flow control presented above, it is necessary to obtain the flow split at component 100. In normal operation, we assume that the flows to the two identical condensers are equal. Reference to the schematic diagram shows that circulating water flow branches to the LP service water pumps at splitter 120. In this situation, the branch flow rate is a known quantity. Specifying the flow split at 100 must account for this branch flow rate. To account for it in the general case, we could write a control, or we could write operations. Because it is easier to write a control than to write the combination of operations, we chose to write a control for this purpose, Control #2 below.



It is important to realize that we have also written operations that equate the XKMISC values for the two condensers.

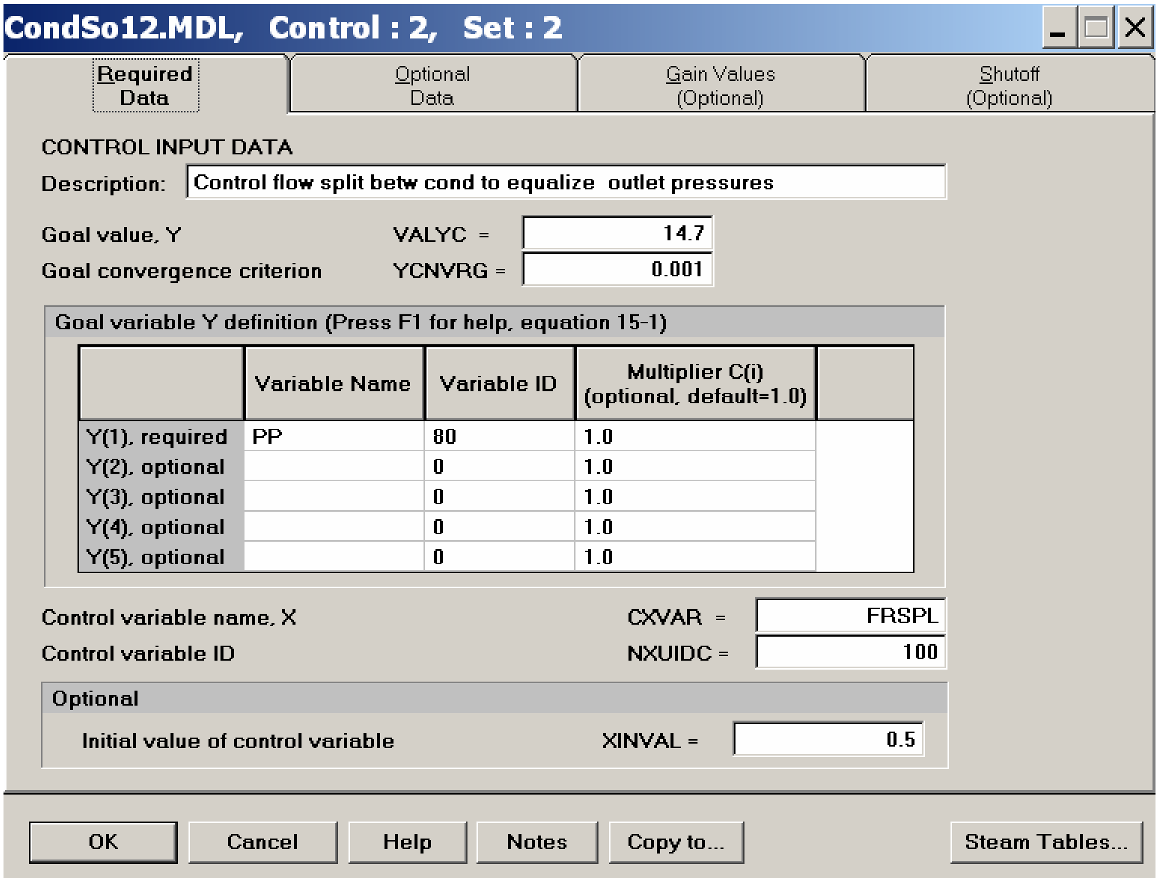
The results of the calculated pressure values at the exits of the two condensers must match. If the pressures do not match, there is a hydraulics modeling difference between the two. This should be corrected and the case rerun, until there is a match.

Once a converged result has been obtained in the calibration step, the predictive case is next, as it assures that all is well in the model. The running of this case should be routine. This case will include a new control to replace the one used to calibrate the miscellaneous loss factor. Now, the XKMISC value from the first case is used automatically. The new control is used to calculate the total circulating water flow rate at source component 40. See the completed form below. Note that this is control number 1 of SET 2, replacing control number 1 of the first case, SET 1.



The control variable is WWVSC, the flow at the circulating water source. The goal variable remains PP, the pressure exiting the circulating water system. As seen, this control is entered in the SET 2 data.

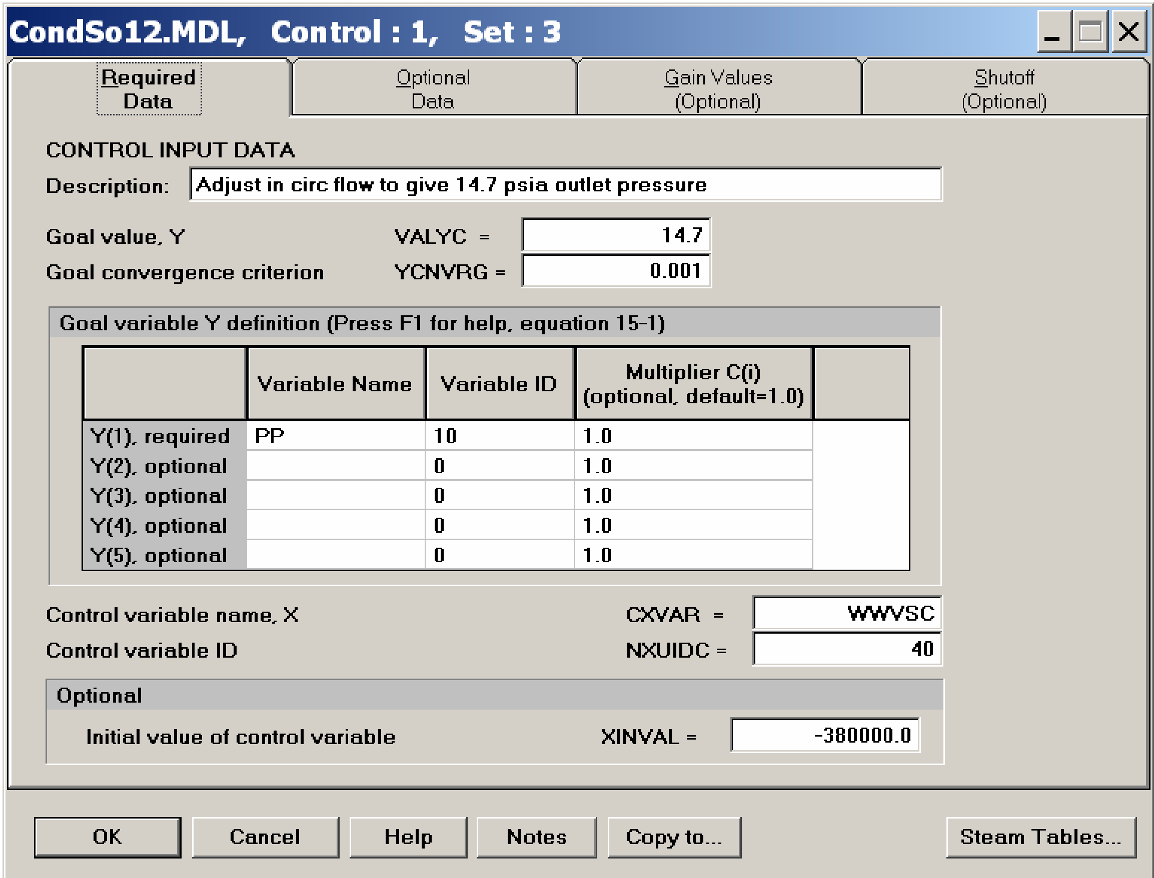
It is best to assume, also, that the flow split at component 100 is unknown, as this forms an additional validation check. A new control is written to calculate this split in order to provide the known pressure value, 14.7 psia, at the circulating water exit from the second condenser. This is written as control number 2, SET 2.



To verify that this case is “good”, we look at the results of the case, specifically the total circulating water flow rate, the split of flow at component 100, and the pressure values exiting the circulating water sides of the two condensers. These values must match those seen in the calibration case.

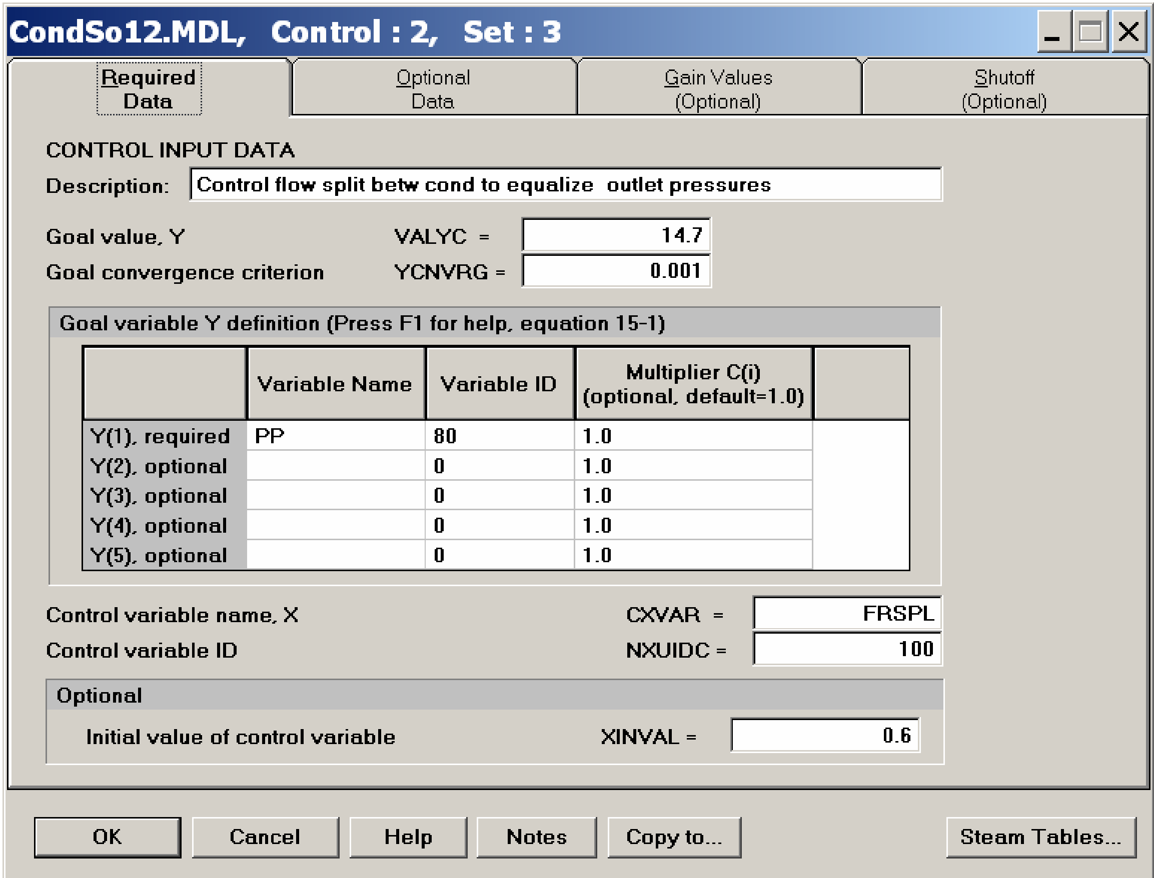
A successful comparison of the results from the first two cases warrants moving on to the third, “variant”, case where you can account for tubes out-of-service by specifying an input for the quantity of tubes plugged. If the system includes only a single condenser, this analysis case is routine. Because of the “plugged” tubes in one of the two condenser branches, the split of circulating water flow to the two condensers is now truly unknown. So, we need a control, similar to control #2 in the case above to calculate this flow split for us.

To account for the flow-pressure effect of the condenser (#10) that has tubes out of service, we can use virtually the same control, #1 as we used in SET 2, for the predictive verification case, discussed above.



The only difference that is seen in the SET 3 control above is that a new initial value is being used.

To determine the flow split to the second, “base”, condenser (#80), we repeat the use of the additional known reality – that the pressure of the circulating water exiting that condenser must also be 14.7 psia. This enables us to write a control for use in this case. Its completed form is shown below.



The control variable is FRSPL, the fractional flow split, at component 100. The goal variable is PP, the pressure exiting the circulating water system of the “base” condenser.

These two controls interact to calculate both the total circulating water flow and the split of flows to the two condensers. Note that this control is #2, entered in the SET 3 data. This control is very similar to control #2 of the previous two SETs. The difference is the initial value of the flow split fraction.

In those controls above where the initial value has changed, there is good reason to do so. Without these changes, attempting to run produces a nonconverged result. This happens due to excessive pressure drop in one or the other condenser resulting in a coded built-in fixup. The fixup causes a disconnect of cause and effect in the functionality of flow and pressure drop, thus preventing the controls from doing their jobs.

APPENDIX B – PEPSE DATA FILE

This appendix contains a complete listing of the *.job file that was used for the analysis cases of this paper. As such, it constitutes a comprehensive record of all details. Interpretation of the data in the file can be made by reference to the Volume 1 PEPSE manual, “User Input Description”.

```
010001  80  PRINT
010101   0.0
*
*
*       DATE: Monday, June 19, 2006
*       TIME: 2:47 PM
*      MODEL: C:\UGM06\CondSO12.MDL
*    JOB FILE: C:\UGM06\CondSO12.job
*
*
*
*
=CALIBRATION CASE
*
000200   1
*
*
****************************
*  GENERIC INPUT DATA
*****************************
*
*
*
* Cycle Flags
010200   0  0  0  0  0  0  0.0  0.0  0  0  0  0  0  0  0  0.0
*
010000  ENGLISH  ENGLISH
*
*
*
012000   800  0.0  0.0  0.0  0.0  0.0  15  0.0
*
****************************
*  STREAMS
*****************************
*
*
500400   40   U       20   I
500500   50   U       60   I
500610   60   B       10   S
500600   60   U       80   S
500100   10   T       90  IB
500800   80   T       90  IA
500900   90   U       70   I
500200   20   U      100   I
```

```
500120   10   D      110  IB
500820   80   D      110  IA
501100  110   U       30   I
501000  100   U       10   T
501010  100   B      120   I
501200  120   U       80   T
501210  120   B      130   I
*
******************************
*  COMPONENTS
*****************************
*
*
*
* Cond 71
700800   10  0  5  0.0  -3.
700805   7  0.779  0.875  480.  21376.  1  -0.85  0  0.0  0  0  0.006  0.0
   +  10.89  0.0  0.0  0.0  10.
710802   0.0  0.0
710803   0.0  0.0
700801
700802
700803
700804
700806
700807
700808
710801
710805
700809   0.0  0.0  0.0  0.0  0
*
* Cond 71
700100   10  0  5  0.0  -3.
700105   7  0.779  0.875  480.  21376.  1  -0.85  0  0.0  0  0  0.006  0.0
   +  10.  0.0  0.0  0.0  10.
710102   0.0  0.0
710103   0.0  0.0
700101
700102
700103
700104
700106
700107
700108
710101
710105
```

700109   0.0 0.0 0.0 0.0 0
*
* LP service water pumps
701300   30
701302   0
*
* CONDENSATE TO PUMPS
700300   30
700302   0
*
* CIRCULATING WATER INLET(3 pumps/2)
700400   31 79.2 14.7 -460000. 0.0 0.0 0
700402 0 0 0
*
* CONDENSER WATER DISCHARGE
700700   32
700702   0
*
* STEAM INLET TO CONDENSERS(using ACTest5 with 5% degradn)
700500   33 150. 1.5 2450000. 0.0 1025. 0
700502 0 0
*
* Circ water pump
700200   41 27.7 0.85 0.9 0.9
700201   0.0 1. 0.0 0.0 0.0 30.
700206   0
*
* hotwell
701100   50 1 0.0
*
* circ water outlet
700900   50 1 0.0
*
* Splitter for LP service water pumps
701200   60 0.0 25525394. 0.0 0 0.0
701201   0
*
*
701000   63 0.0 0.56
*
*
700600   63 0.0 0.5
*
****
* SPECIAL FEATURES
****

```
*
*
*
*
800100 "CWP FLOW VS PRESSURE(PUMP CURVE)"
* X VALUES
810100   340000.  410000.  460000.  495000.  524000.  550000.
  +   572000.  600000.
* Z AND Y VALUES
810110   0.0  40.  35.  30.  25.  20.  15.  10.  0.0
810108  KEEP
* MULTIPLIERS
820100    1.  1.  1.  0.0  0.0  0.0  0  0  0
* SCALE FLAGS
820101    0  0  0
*
* FLOW VS CWP PRESSURE REQUIRED
830100   1  PHEAD  20  WVGPM  40
830102   0
830101    0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
   +  0  0  0  0  0  0  0  0  0  0  0  0  0
830108  KEEP
*
*
*
* Control to determine Kmisc
840100 XKMISC  10  14.7  0.001  1. PP  10
840105    2  0
840106    5  40.
840107    0.5  0.0  0.0
840109    8.  30.
*
* Adjust Split of Circ Flow to Condensers
840200 FRSPL  100  0.0  1.  1. WW  100  -1. WW  120
840206    0  0.5
840209    0.4  0.6
*
*
*
* PSI to InHg conversion
870010   0.491
*
*
*
* Low temp condenser BP (InHg)
880020    PP  12   DIV   OPVB  1   OPVB  2
```

```
880021    0.0  0.0  0.0
880025    0  0  0.0
*
* Low temp condenser BP (InHg)
880030    PP  82   DIV   OPVB  1   OPVB  20
880031    0.0  0.0  0.0
880035    0  0  0.0
*
* Flow in gpm
880040    WVGPM  40   EQL   OPVB  10
880041    1.  1.  1.
880045    1  0  0.0
*
* Equate kmisc values
881010    XKMISC  10   EQL   XKMISC  80
881011    1.  1.  1.
881015    1  0  0.0
*
*
*
*
*
890010 "Low temp InHg"
890011 OPVB  2 0.0   U
890013
*
892010 "Total Circ Flow"
892011 WVGPM  40 0.0   U
892013
*
892020 "Frac Split following Pump"
892021 FRSPL  100 0.0   U
892023
*
892030 "Flow to Variant Condenser"
892031 WVGPM  100 0.0   U
892033
*
892040 "Flow to Base Condenser"
892041 WVGPM  120 0.0   U
892043
*
892050 "Variant Condenser Tube Out p"
892051 PP  -10 0.0   U
892053
*
```

```
892060 "Base Condenser Tube Out p"
892061 PP  -80 0.0   U
892063
*
892110 "Variant Condenser p Loss Factor"
892111 XKMISC  10 0.0   U
892113
*
892120 "Base Condenser p Loss Factor"
892121 XKMISC  80 0.0   U
892123
*
*
*
* OUTPUT GLOBAL SUPPRESSION CARD
020000 PRINT    PRINT    NOPRNT
020002 NOPRNT   * Geometry Configuration of Model
020004 NOPRNT   * Stream Properties
020005 NOPRNT   * Comparison of Component Port Test Data With Stream Properties
020015 NOPRNT   * Detailed Mixer Performance Output
020016 NOPRNT   * Detailed Splitter Performance Output
020021 NOPRNT   * Second Law of Thermodynamics Performance - Components
020022 NOPRNT   * Second Law of Thermodynamics Performance - Streams
020023 NOPRNT   * Second Law of Thermodynamics Performance - System
020024 NOPRNT   * Material Descriptions Used in the Model
020025 NOPRNT   * First Law of Thermodynamics Performance - Envelope
020032 NOPRNT   * Input Schedule Number N Table of Values
020033 NOPRNT   * Variable References to Schedule Tables
020034 NOPRNT   * Controls Input
020037 NOPRNT   * Definitions of Special Operations Specified
020059 NOPRNT   * Stream Transport Properties
020078 NOPRNT   * Nonzero Operational Variables
*
*
*****************************
*    END OF BASE DECK
*****************************
*
*
.
000100  SAVE
*
=PREDICTIVE CASE
*
000200   1  2
*
```

```
*
*****************************
*  GENERIC INPUT DATA
******************************
*
*
*
*****************************
*  STREAMS
******************************
*
*
*
******************************
*  COMPONENTS
*****************************
*
*
*
******************************
*  SPECIAL FEATURES
*****************************
*
*
*
*
*
* Adjust in circ flow to give 14.7 psia outlet pressure
840100 WWVSC  40  14.7  0.001  1. PP  10
840105    2  0
840106    4  -300000.
840107    0.8  0.0  0.0
840109    -470000.  -300000.
*
* Control flow split betw cond to equalize  outlet pressures
840200 FRSPL  100  14.7  0.001  1. PP  80
840205    5  0
840206    10  0.5
840207    0.5  0.0  0.0
840209    0.3  0.7
*
*
*
*
*
*
```

```
*
*
*
*
.
000100  SAVE
*
=VARIANT CASE
*
000200   1  2  3
*
*
*****************************
*  GENERIC INPUT DATA
******************************
*
*
*
*****************************
*  STREAMS
******************************
*
*
*
******************************
*  COMPONENTS
*****************************
*
*
*
******************************
*  SPECIAL FEATURES
*****************************
*
*
*
*
*
* Adjust in circ flow to give 14.7 psia outlet pressure
840100 WWVSC  40  14.7  0.001  1. PP  10
840105    2  0
840106    4  -380000.
840107    0.8  0.0  0.0
840109    -420000.  -250000.
*
* Control flow split betw cond to equalize  outlet pressures
```

```
840200 FRSPL  100  14.7  0.001  1. PP  80
840205    5  0
840206    10  0.6
840207    0.5  0.0  0.0
840209    0.3  0.8
*
*
*
*
*
*
*
*
*
*
*
* END NOTES
* SPECIAL OPTION 12
891990 "Number of tubes plugged"
891991 PLGNC1 10    0.0 I
892000 "Fraction of tubes plugged"
892001 PLGFC1 10   0.5 I
.
```