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Adding Heat Pumps to GLD

Welcome to the GLD heat pump module instructions. Pages 1-3 of this document provide a technical background on the mathematical model that GLD uses. This background provides a useful framework for understanding the big picture when you are inputting new heat pump data into the program. If you wish to jump right to the instructions for adding heat pump data, start reading from the middle of page 3.

Background on the GLD Heat Pump Module

Description

The heat pump model employed in Ground Loop Design reproduces the complete operational data of any particular unit when supplied with a few representative data points selected from across the range of interest. Data for each pump can be entered into the model and grouped together under manufacturer and series headings. The data need only be input once, and then can be used repeatedly for subsequent modeling sessions. Pump data is stored permanently in the '**pumps**' directory. Many popular pumps from major manufacturers already are included with the program.

In both heating and cooling modes, the *minimum* data required is the capacity and power variations with source inlet temperature. To increase the modeling accuracy, these same variations have to be included at a second flow rate. Even more accurate results can be obtained if correction factors are provided for variations in the load inlet temperature and flow rate. The level of accuracy depends both on the amount of data available and the time the designer wants to invest.

Note that Ground Loop Design's heat pump module allows for both water-to-air and water-to-water pumps.

Theoretical Basis

Capacity and Power

Heat pump capacities and power requirements vary smoothly but significantly for differing source inlet temperatures. Three points taken along both the capacity vs. temperature and power vs. temperature curves are fit to a polynomial equation to

model these variations. The resulting calculated coefficients are then used to generate capacity or power values for any given source inlet temperature.

The basic polynomial equation used for fitting has the form:

$$y = a + bx + cx^2,$$

where a, b, and c are the three coefficients calculated from the fitting routine. For the capacity case, 'y' represents the capacity and 'x' is the desired temperature. For the power-input determination, 'y' is the power and 'x' again is the temperature. **Be aware that these coefficients do change for metric and English units.**

The software stores coefficients for each pump, and then uses the coefficients with the source inlet temperatures chosen by the designer to determine the unit capacity and power.

Flow Rate

To model the effect of the source flow rate on the calculated capacity and power, data from a second flow rate are used. Generally speaking, with different flow rates the shape of the capacity and power curves does not change significantly, but is shifted up or down by a constant factor. This factor is determined for each of the three temperature data points and averaged over those input to obtain the linear flow factor, which is shown on the input screen.

Once the flow factor is determined, the linear capacity or power change per flow unit may be calculated. The program then calculates a new capacity or power at any specified flow rate using the initial values already known from the stored data.

If no data points are entered for a second flow rate, the flow factor is assumed to be the constant value of 1.0. This means that the capacity and power will not vary with changes in flow rate.

Considering the size of the variations (generally only a few percent), this simple model is accurate enough for most pumps. A completely accurate model of the flow rate variations for all possible pumps would require significantly more data entry.

Load Side Corrections

The Ground Loop Design Edit/Add Heat Pumps module also can include corrections to the capacity or power that result from variations in the load side inlet temperature or flow rate. They are entered as correction factors across the desired temperature or flow range. The software again uses the polynomial fitting to model these correction factors. In these cases, a four-coefficient model is used to better model the types of variations that may occur. Three to five points are allowed as data input.

Again, if load side correction data are not included, there will be no capacity or power variations with load temperature or flow, and all correction factors will be 1.0, the standard value.

The load side temperature range will generally be considerably different for water-to-air and water-to-water pumps. Ground Loop Design suggests different initial temperature ranges when the user chooses the water-to-air or the water-to-water pump type option.

Entering Data into the Heat Pumps Module

This section provides step by step instructions for adding a new heat pump series into the heat pump module or editing a pre-existing pump series.

1) Open the Edit/Add Heat Pumps module from the Heat Pumps dropdown menu.

2) After the module opens, notice that there are two selection boxes present in the upper pane, while no pump data is displayed in the lower pane. In the left box, choose to select either one of the manufacturers from the list of existing manufacturers or 'New Series'. If you select a manufacturer, the associated list of pump series available for that particular manufacturer appears in the box on the right. When you choose a pump series, the data for that series appears in the lower panel. If you choose to add a new series for a current or new manufacturer, proceed to step three. Otherwise proceed to step five.

3) If you choose 'New Series' from the manufacturer list on the left, the lower pane becomes active with another selection box that requests direction as to whether to use an existing manufacturer or to create a 'New Manufacturer'.

4) After you make your selection, the panel changes to show information about the manufacturer and series. If the series belongs to a new manufacturer, you can edit the manufacturer information. See figure 1.1 below to see what this pane looks like.

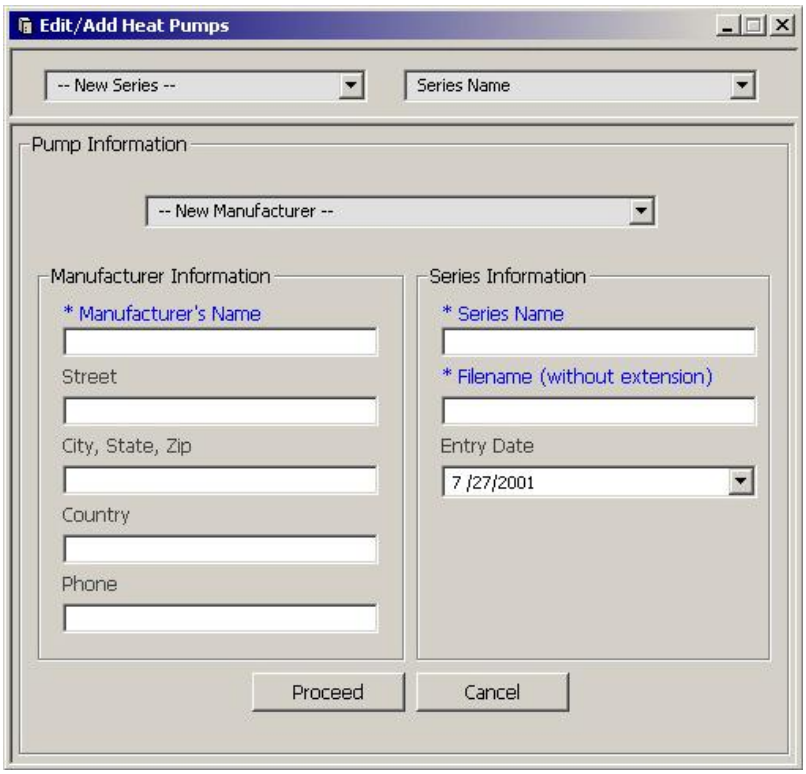

Fig. 1.1 New Manufacturer Information Panel

5) After you enter the information for the new manufacturer, click the 'Proceed' button and all of the info for the series/manufacturer will be stored in the **Pumplist.gld** file. **Note that the info marked with an asterisk must be included before you can proceed.**

6) Now that you have entered the new pump series info (or selected an existing pump series), the Pump Edit pane will appear will appear in the lower pane of the Edit/Add Pumps module, as shown in figure 1.2. There are two sub-panes. The left sub-pane is a list of the pumps already included in the series. The right sub-pane is a series of tabbed panels that contain the data for each pump on the list. In the case of a new series, both the list and the panel section will be empty until a new pump is created. The name of the current manufacturer and series are shown in the selection boxes in the upper pane.

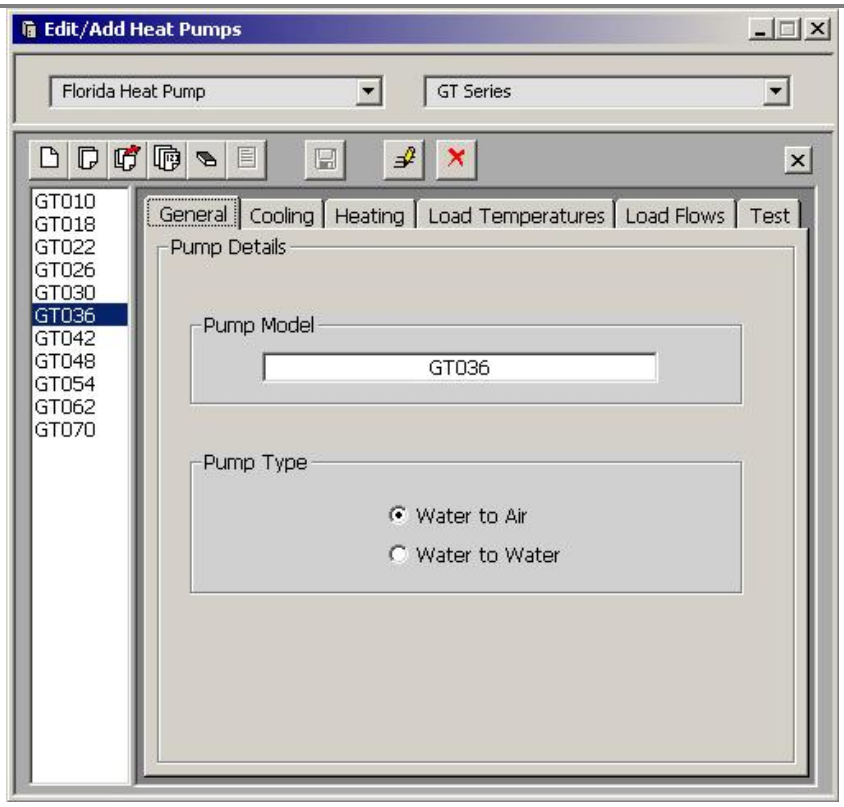

Fig. 1.2 Pump Edit Pane

7) In this step, you can familiarize yourself with the Pump Series control buttons (figure 1.3), which can be found above the list and the pump data panels. They include the Pump Edit controls (*New*, *Copy*, *Remove*, *Reorder*, and *Clear*,) the pump *Save* control, the *Edit Pump Information* control, and the *Delete Series* control.

Fig. 1.3 Pump Series Controls

Pump Edit Controls

The Pump Edit Control buttons are designed to work directly with the pump list. Add new pumps by pressing the *New* button. Add copies of existing pumps with the *Copy* button. Use *Remove* to remove a pump from the list. Press *Reorder* to reorganize the list, both alphabetically and numerically. Use *Clear* to delete all pumps

from the current list. **Be careful not to accidentally delete pumps.**

Save Control

Use the *Save* control button at any time to save the current pump information.

Edit Pump Information Control

The *Edit Pump Information* control button allows you to edit both the series and the manufacturer information for a given pump. **Note, however, that if the manufacturer information is changed, it will change for every series connected to that manufacturer.** 'Proceed' or 'Cancel' will return you to the Pump Edit Pane.

Delete Series Control

The *Delete Series* control button deletes the current series. If the series is the only series of a manufacturer, the manufacturer also will be deleted automatically.

Note: The actual heat pump file (.hpd) will not be deleted from the **pumps** directory. If necessary, the series can be restored by creating a 'New Series'. You only need to provide the appropriate manufacturer and series name, and use the deleted '.hpd' filename for the pump set 'Filename'. Incomplete fields will be recreated from the *.hpd file. If the original file no longer exists, the program creates a new *.hpd file. Incidentally, the same system can be used to add new pump sets obtained from external sources as described below.*

8) The General panel is the first panel you see when you decide to input data for a new pump. It has an input box for the name/model of the pump, and in the 'Pump Type' area, you select whether the pump should be classified as a water-to-air or a water-to-water pump. An example of the pump *General* panel is shown in the lower right pane of figure 1.2, above.

9) Enter the capacity, power and flow rate info pertaining to the source side flow for both heating and cooling using the two tabbed panels labeled

Cooling and *Heating* in the Pump Edit pane. The pump data that you need to enter in these panels usually are available in manufacturer's product specification sheets. Some manufacturers provide very clear data tables while others provide tables that may require you to search carefully for the appropriate data. An example of the *Cooling* panel is shown below in figure 1.4. The *Heating* panel follows an identical format, although the temperatures will be different.

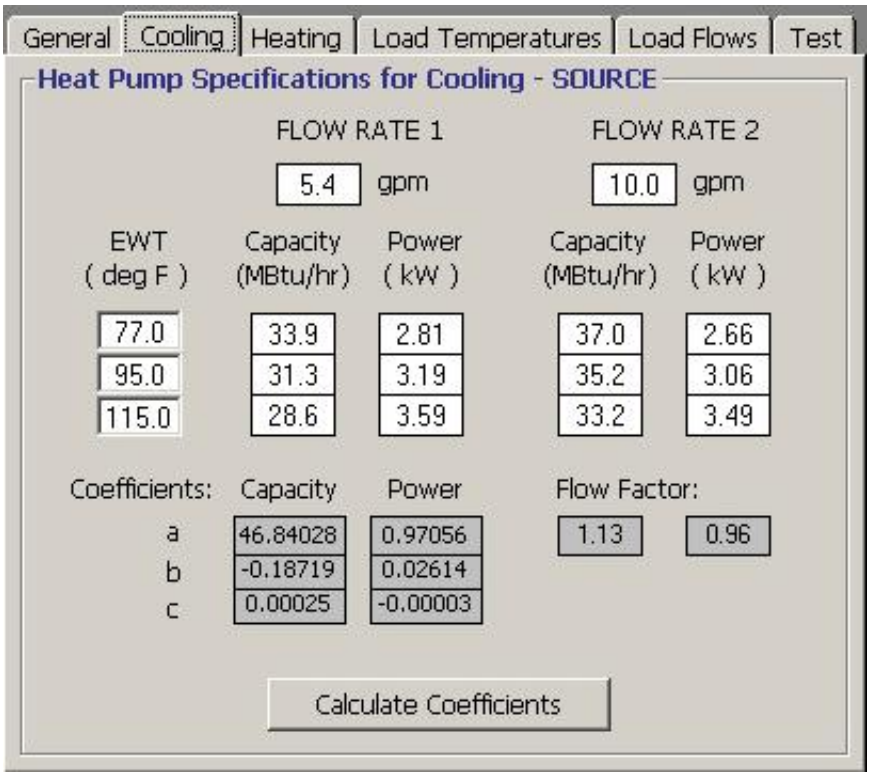

Fig. 1.4 Heat Pump Specifications – Cooling

As can be seen from the figure, the source entering water temperature (EWT) is listed to the left, and the capacity and power requirement of the unit at different flow rates are listed to the right. Once you input the values, you can have the program calculate the coefficients and flow factor from the data you entered. Do so by pushing the 'Calculate Coefficients' button. By calculating these coefficients, the program can accurately model the heat pumps. Note that the *Calculate Coefficients* button turns red when you change any values in the panels, indicating that you must recalculate the new coefficients before proceeding.

Note: If data for only one flow rate are available from the manufacturer's spec sheets, only input the data for the first capacity and power requirements under the section entitled 'FLOW RATE 1'. Leave the data under 'FLOW RATE 2' as zeroes, and the program will ignore them, leaving the flow factor as 1.0 (meaning if you change the flow rate in the loads modules, you will see no difference in calculated results).

10) You can optionally use the *Loads Temperatures* and *Load* Flows tabbed panels of the Pump Edit pane to enter correction factors resulting from variations in inlet temperatures and flow rates. If you choose not to add these correction data (either because you do not have time or the manufacturer has not supplied you with the data), the factors remain at 1.0. In such a case, if you vary the load temperature or flow rate in the Loads Modules, you will see no change in the calculated capacities and/or power input. We recommend that you include as much data as possible from what the manufacturer provides so as to maximize the accuracy of the heat pump module's modeling capabilities. Steps 10 and 11 describe how to enter Loads Temperatures and Loads Flows. If you choose to not enter these data, please proceed to step 12.

11) In the *Loads Temperatures* panel you can input corrections for variations in the load inlet temperature. Enter both the cooling and heating information (taken at the average or standard source temperature and flow rate, and the average load flow rate) on the same panel, an example of which is shown in figure 1.5.

    Occasionally, manufacturers will provide capacity values at the standard temperature with a table of correction factors that can be entered into the Ground Loop Design *Load Temperatures* panel directly. However, more often it is the case where you will have to calculate these factors yourself using data from manufacturer's data sheets. This data sometimes can be a bit of a challenge to find and when you do find it, you will need to have a calculator handy to do some basic calculations (division mostly).

    We calculated the factors shown in figure 1.5 from a manufacturer's list of capacities and power at different entering air temperatures (EAT). This particular manufacturer (like most) provided data capacity and power values over a wide range of EATs. In this example, we calculated the capacity and power factors for 5 cooling EATs and 3 heating EATs. We choose these particular temperatures based on the expected EAT range we would be using in our design work. For this particular example, our standard EAT-WB cooling temp is 67^0F and our standard EAT-DB temp is 70^0F. As these are

our standard cooling and heating EATs, we enter 1.000 for their respective capacity and power factors in the Load Temperatures panel. This is the easy part. For the other EATs, we have to do a simple division calculation. Look through the manufacturer's data sheet and find the capacity for the pump at the first cooling temperature (61^0F in this case). Divide this number by the capacity at 67°F for cooling to calculate the capacity factor. Input this capacity factor into the program. Repeat this calculation using power data for the same temperature (61^0F) and input the power factor into the program. Repeat these steps for each temperature in the heating and cooling sections.

Since this procedure is complicated, here is a sample calculation:

Let's say the capacity of the pump at 67^0F is 30,000 Btu. The capacity of the pump at 64^oF is 28,800 Btu. The *Capacity Factor* at 64^0F then is 28800/30000 = 0.96. Notice that we entered 0.96 in figure 1.5 below.

This is a time consuming activity but it does increase the accuracy of your designs. Remember to click the 'Calculate Coefficients' button when you are done!

Notice how in figure 1.5 we included five points of data for cooling but only three for heating. The software requires a minimum of three data points for its coefficient calculation. You can input more data if desired. **However, no boxes may be left blank!** *Other temperature **and** coefficient values must be set to zero in this case.* As a convenience, '0' buttons are included to quickly set rows to zero.

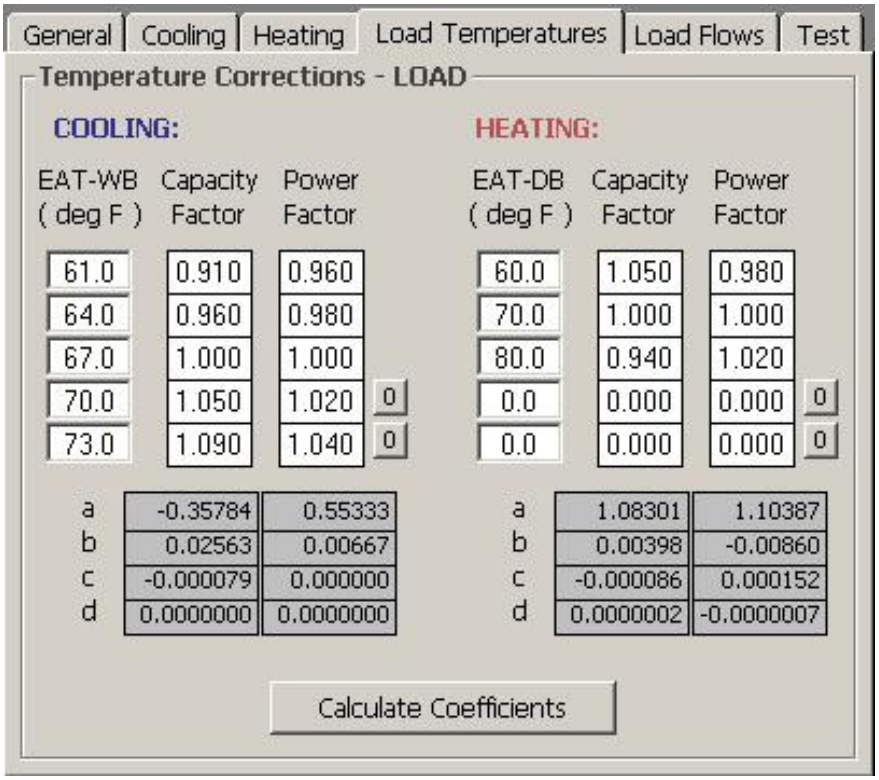

Fig.1.5 Heat Pump Load Temperatures Panel

Note: If correction factors are unknown or unnecessary, they can all be left at the constant value of 1.0, which is the initial condition that exists when a new pump is first added.

12) Next, you have the option of entering corrections for variation in load side flow rates in the *Load Flows* panel. **Note that the system used here is different from the system used in the *Load Temperatures* panel so please read this carefully.** In the *Load Flows* panel, you assign a *nominal* flow rate to the pump and you input the data as percentages of this nominal flow rate. See figure 1.6 for an example.

First, find the manufacturer's data sheet relating flow rates to capacity and power. Next, to get a capacity factor at a flow rate of 80 percent of nominal, for example, divide the capacity of the unit at 80 percent of nominal by the capacity at the nominal flow rate. Input the result of this calculation into the panel. The procedure is identical for the power factors. Usually, you should use data at standard source temperatures and flows, and at the standard load

temperature. Quite often, the manufacturer provides lists of these variations that can be input directly.

Since this procedure is complicated, here is a sample calculation:

Let's say that according to the manufacturer's spec sheet, the capacity at the nominal flow rate of 1140 CFM is 30,000 Btu. The spec sheet also shows that the capacity at 912 CFM is 29,220 Btu. From this data we can calculate the % of nominal flow **and** the Capacity Factor.

% of nominal flow: 912 CFM/1140 CFM = 80%
We enter this 80% value in figure 1.6 as necessary.

Sometimes the manufacturer pre-calculates the % of nominal flow and includes it on the spec sheet, decreasing your calculation workload. Sometimes however, the spec sheet will list a value say of 900 CFM instead of 912 CFM, leading to 900/1140 = 78.9%. You would then have to enter "78.9%" instead of "80%".

Capacity Factor: 29220 Btu/ 30000 Btu =0.974
We enter this value in figure 1.6.

Remember to click the 'Calculate Coefficients' button when you are done!

Once again, you need to input a minimum of three points for the coefficient calculations, and '0' buttons are provided for quickly setting the unused rows to zero. **Remember - boxes must be set to 0 if they are not used!**

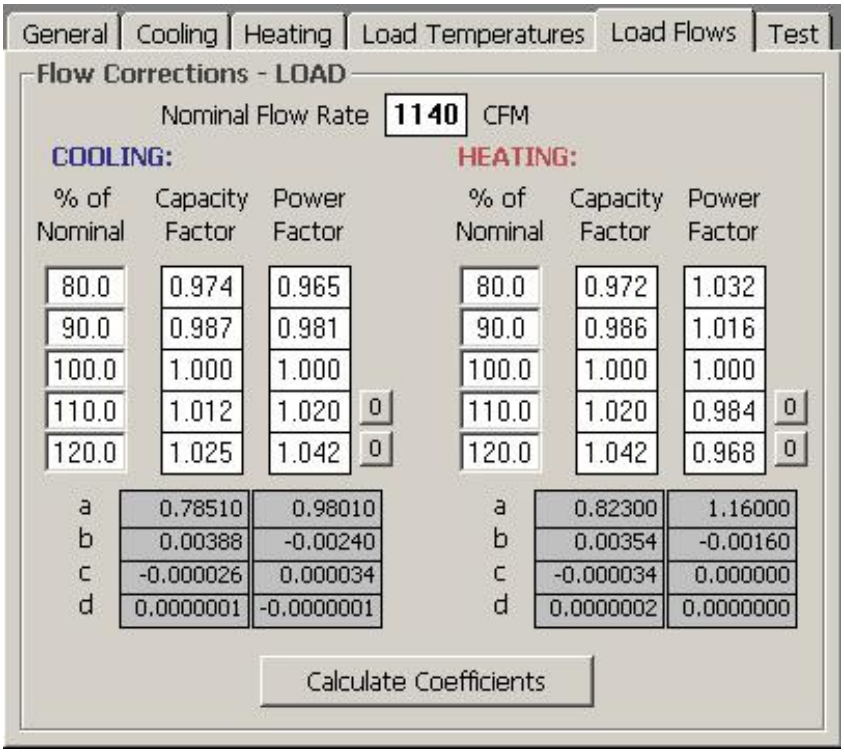

Fig. 1.6 Heat Pump Load Flows Panel

13) Now that you have finished inputting the data for your pump, use the *Test* panel as a final check. By testing the data directly here, you can see if you made any mistakes in the data input process.

A sample Test panel is shown in figure 1.7. As you can see from the figure, you can directly edit both the source and load entering water and air temperatures as well as the flow rates. Click the "Test" button to perform the calculation to see what capacity, power, and EER/COP result from your chosen input parameters. Average values are used initially, but by varying the parameters you can see how well the newly created model matches the data set you used for data entry (you can compare the calculated results with the data in the manufacturer's data sheets).

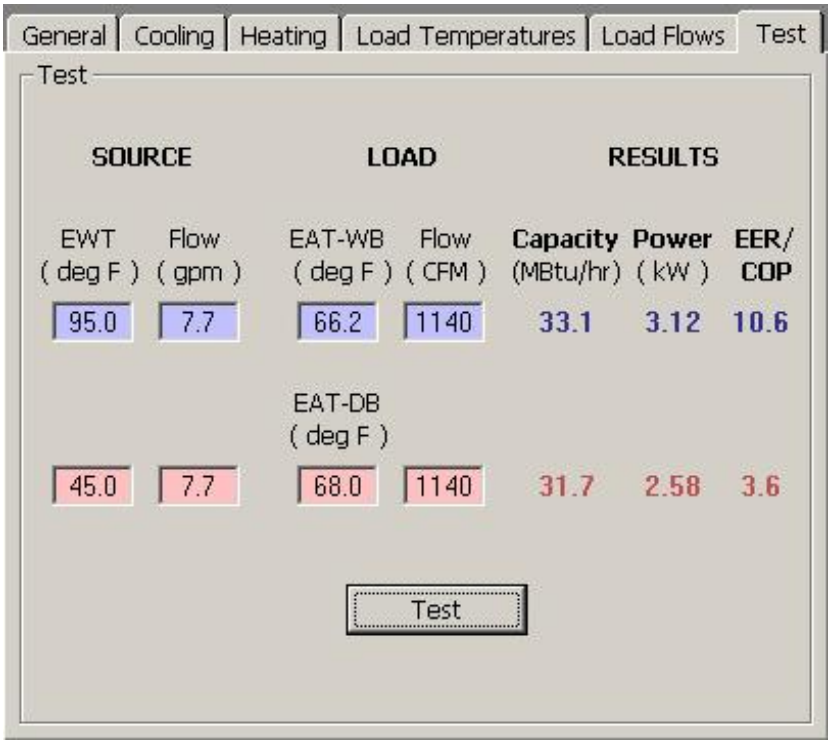

Fig. 1.7 Heat Pump Test Panel

Often, any input errors will be evident to you immediately from the test (by comparing the test results with the input sheet). Additionally, you can use this test to make certain that the pump data are accurate over the particular range of temperatures, flows, etc. that you typically use, and then modify the data if necessary.

14) After editing or adding pumps and calculating all the necessary coefficients (make sure you hit the calculate button in each panel that you added/modified data), you should make sure to save everything by clicking the *Save* button on the Pump Series control bar. After you save the pumps, the *Save* button becomes disabled.

15) Click the close button in the upper right hand corner of the lower pane to close the Pumps Edit Pane, and click the close button in the upper right hand corner of the Edit/Add Heat Pumps window to close the Edit/Add Heat Pumps module. If you close it without saving edited data, a dialog box will appear that reminds you to save the data before closing.

Additional Information

Heat Pump File Descriptions

There are two types of files created by the Edit/Add Heat Pumps module. The first is the **Pumplist.gld** file, which maintains the current master list of manufacturers and the series associated with those manufacturers. The **Pumplist.gld** file also includes the filenames (without the '.hpd' extension) of the heat pump data files associated with the individual series.

The second type of file is the '.hpd', heat pump data file, for each individual series of pumps. This file type keeps track of all the data input by the user as well as the pump names and the coefficients calculated within the module. Since '.hpd' files cannot be deleted by the program (unless they are accidentally overwritten), many difficulties usually can be overcome by just adding new pump sets or, if necessary, editing the **Pumplist.gld** file directly. The format of the **Pumplist.gld** file is given in the Preface, page 3.

Adding Pump Sets Obtained From External Sources

To provide the greatest amount of flexibility to the user, Ground Loop Design allows you to obtain heat pump data files (*.hpd files) from external sources. For example, you can copy a heat pump set from a fellow designer, or even download a set from a participating heat pump manufacturer's website.

Since the original **Pumplist.gld** file does not contain a reference to the externally obtained data set, you must add it manually. The procedure for this is as follows:

1. Place the '*.hpd' file into the **\Ground Loop Design\pumps** folder.
2. Add a 'New Series'.
    a. If the series belongs to an existing manufacturer, choose the appropriate manufacturer.

    b. If the series belongs to an unlisted manufacturer, choose 'New Manufacturer' from the list.
3. Provide the 'Series Name' and 'Manufacturer Name', as required.

4. Under 'Filename', **type the *existing* filename** of the series to be added. Note- the existing filename is the *.hpd file the user just put into the pumps folder in step 1 above.

5. Click "Proceed". Ground Loop Design will open the heat pump file for editing and will include it in its Heat Pump Database. Additionally, if this is a new manufacturer, any included manufacturer information will become visible for this pump set. Since the **Pumplist.gld** file has been modified, it will register the new pumps for use in all modules opened afterward.