

DUCT – Duct System Sizing Program

Purpose

The purpose of DUCT is to compute sizes for supply or return air duct systems and to determine the pressure / flow requirements for the fan. The program is limited to round ducts except rectangular to round transitions are available at the air handling unit (AHU) and where rectangular diffuser boots are required.

Methodology

Either the Equal Friction or the Balanced Capacity method may be chosen.

Operation Overview

The Main Window

The main window of DUCT is shown below. This window is used to enter data for:

- File management
- Air Properties
- Air Supply System
- Duct Fittings
- System Type
- Sizing Method
- Duct Size Rounding

ID	Type	Fan Side Connection
1	Air Handling Unit	
2	Straight Duct	1
3	Elbow	2
4	Tee / Wye	3
5	Straight Duct	4-main
6	Diffuser / Grille	5
7	Straight Duct	4-branch
8	Elbow	7
9	Straight Duct	8
10	Diffuser / Grille	9

The menus: The menu items allow files to be read and saved, and the Air Properties to be entered.

The Air Supply Frame: Several different air supply configurations may be modeled with the options available in the Air Supply Frame:

1. Conventional AHU – The supply and return ducts are connected to rectangular openings in the AHU. In this case the lost pressures for the coil(s), filters, and miscellaneous casing losses are input along with the fan total pressure. The total pressure available for the supply and return ducts is then determined. The total available AHU pressure may be proportioned between the supply and return air ducts.
2. Fan Only AHU – The supply and return ducts connect directly to the fan. The internal lost pressures are set equal to zero and fan total pressure is entered. The total available AHU pressure may be proportioned between the supply and return air ducts.
3. Plenum Pressure Given – The supply or return ducts are connected to a plenum with known total pressure. Plenum total pressure is the input, internal losses may be specified and the total pressure may be proportioned between supply and return. The fan total pressure is calculated. The plenums are part of the duct system. On the supply side, air is undergoing a contraction to enter a duct and on the return side the air is undergoing an expansion.
4. Unit Equipment – The external static or total pressure is known in this case and is entered for fan total pressure, internal losses are set equal to zero. The user proportions the total pressure between supply and return ducts.
5. Maximum Velocity Given – An alternative to specifying the system total pressure is to give the maximum allowable velocity for the duct system. This will occur in the first duct section closest to the fan. The system total pressure is then calculated.

The Duct Fittings Frame: Shows a list of all fittings currently in the duct system and the connections between the fittings. Command buttons allow adding, modifying or deleting of fittings. The Add and Modify buttons cause the Fitting Screen to be displayed.

The System Type Frame: Allows a choice between a supply system and a return system. The choice of system type controls the available pressure for the duct system, and the specific fitting files used.

The Sizing Method Frame: Allows a choice between the Equal Friction method and the Balanced Capacity method.

The Duct Size Rounding Frame: Allows a choice between:

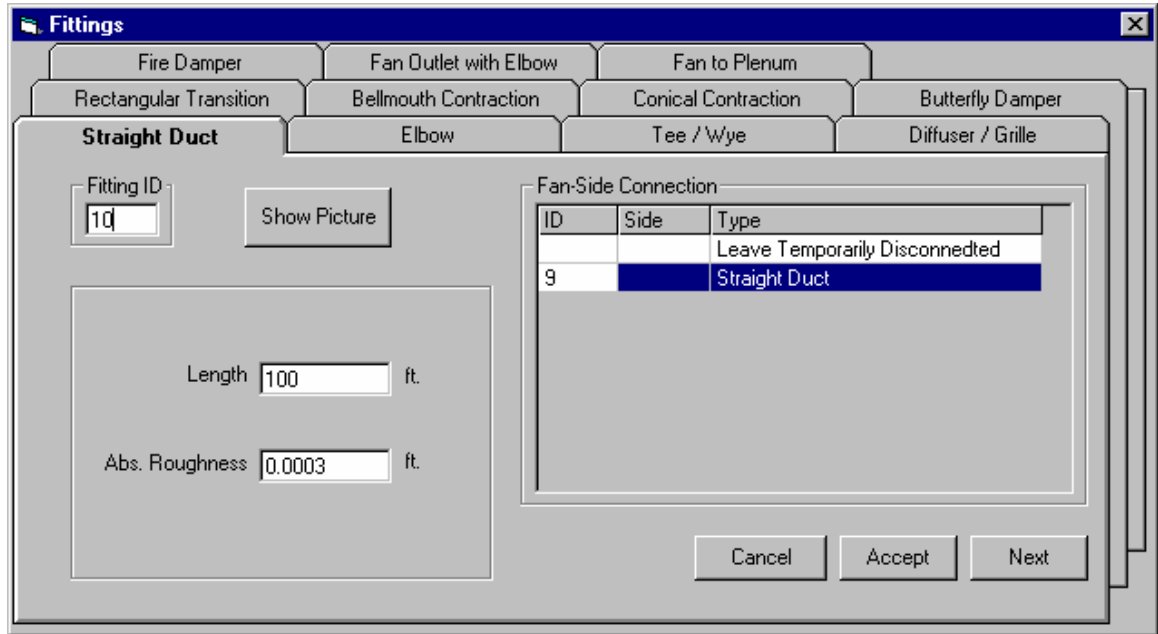
- Rounding to the nearest standard size
- Rounding up to the next largest standard size
- No rounding

In all cases, the duct sizes are first calculated without rounding, followed by the selected rounding. The No Rounding choice is useful when rectangular ducts will be used.

The Calculate Duct Sizes Button: Computes duct sizes and Fan requirements, and displays the results in a scrolling text window.

The Fittings Window

The Fittings Window is shown below. It allows addition and editing of fittings. Any one of eleven different fitting types may be selected using the tabs. Parameters may be entered for the selected fitting, including a unique Fitting ID.



The Fittings Window is the primary tool for describing the duct network. For each fitting, the following information must be entered:

- The fitting type: selected by choosing the appropriate tab
- The fitting ID: a unique string identifying the fitting
- The specific fitting data: the required data is specific to each fitting type
- The Fan-Side connection: selected by clicking on one of the available fitting in the Fan-Side Connection frame. A fitting may be left disconnected by selecting "Leave Temporarily Disconnected". All fittings must be connected before the system can be sized. Only unconnected fittings are shown in this area.

Note: the Fan-Side Connection for any fitting would be that fitting's immediate neighbor on the side closest to the fan.

The command buttons cause the following actions:

- Show Picture: Shows a sketch of the selected fitting. The sketches were produced by ASHRAE and are part of the AHSRAE Duct Fitting Database Software.
- Cancel: Discards any information entered in this screen and returns to the main screen.
- Accept: Accepts the information entered in this screen and returns to the main screen.
- Next: Accepts the information entered on this screen, and remains in this screen to allow immediate entry of the next fitting.

To minimize the amount of effort required of the user to enter the duct system, the program will make guesses for some of the required inputs. The guesses are the same whether you are entering a supply air system or a return air system. Those guesses include:

- The Fitting Type: a straight duct is assumed as the next fitting type. This should be correct guess nearly half of the time.
- The Fitting ID: is assumed to be an integer, with the smallest unused number being assumed
- The specific fitting data: is assumed to have the same values as the most recent previous occurrence of the same fitting type.
- The Fan-Side Connection: is assumed to be the fitting most recently entered. If the most recently entered fitting is a Tee or a Wye, then the *main* side of the Tee or Wye is assumed. If the most recently entered fitting is a Diffuser, (which may not be a fan-side connection for any other fitting), then the *branch* side of the most recently entered Tee or Wye is assumed. For additional clarification, see examples 1 and 2. Those examples have fittings numbered in the order assumed by the program.

Note: When you enter fittings in the order assumed by the program (starting with the fan and working outward to the diffusers), it is not necessary to click in the Fan-Side Connection frame, because the correct value will already be selected. This is the fastest and simplest way to enter a duct system. You may choose to number and/or enter the fittings in some other order, but much more clicking and typing will be required.

Practical Considerations

It is possible that the input data may fall outside the available fitting data for some fittings. In such cases an approximate equivalent length is used rather than the fitting data. However, in most cases a modification of the input data or the duct system will correct the situation.

Examples:

In the case of a Conical Entrance, A_0/A_1 must be greater than 0.10 and L/D_0 must be greater than 0.025. For the Bellmouth Entrance r/D_0 must be greater than 0 and less than 10.

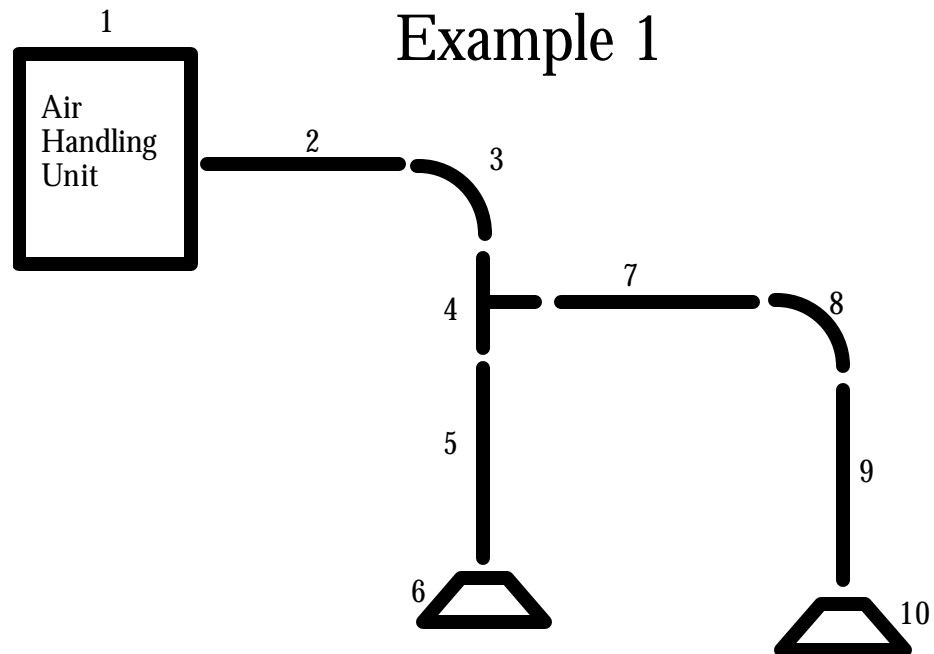
Transitions are sometimes troublesome. Here A_0/A_1 must be greater than 0.1 and the included angle θ must be greater than 10 degrees.

Data for Tee's and Wye's may also fall outside available data. With diverging fittings A_b/A_c and/or A_s/A_c must be greater than 0.1 and less than 0.9 and \dot{Q}_b/\dot{Q}_c and/or \dot{Q}_s/\dot{Q}_c must be greater than 0.1 and less than 0.9. For converging Tee's and Wye's A_s/A_c and/or A_b/A_c must be greater than 0.2 and less than 1.0 and \dot{Q}_b/\dot{Q}_c and/or \dot{Q}_s/\dot{Q}_c must be greater than 0.1 and less than 0.9.

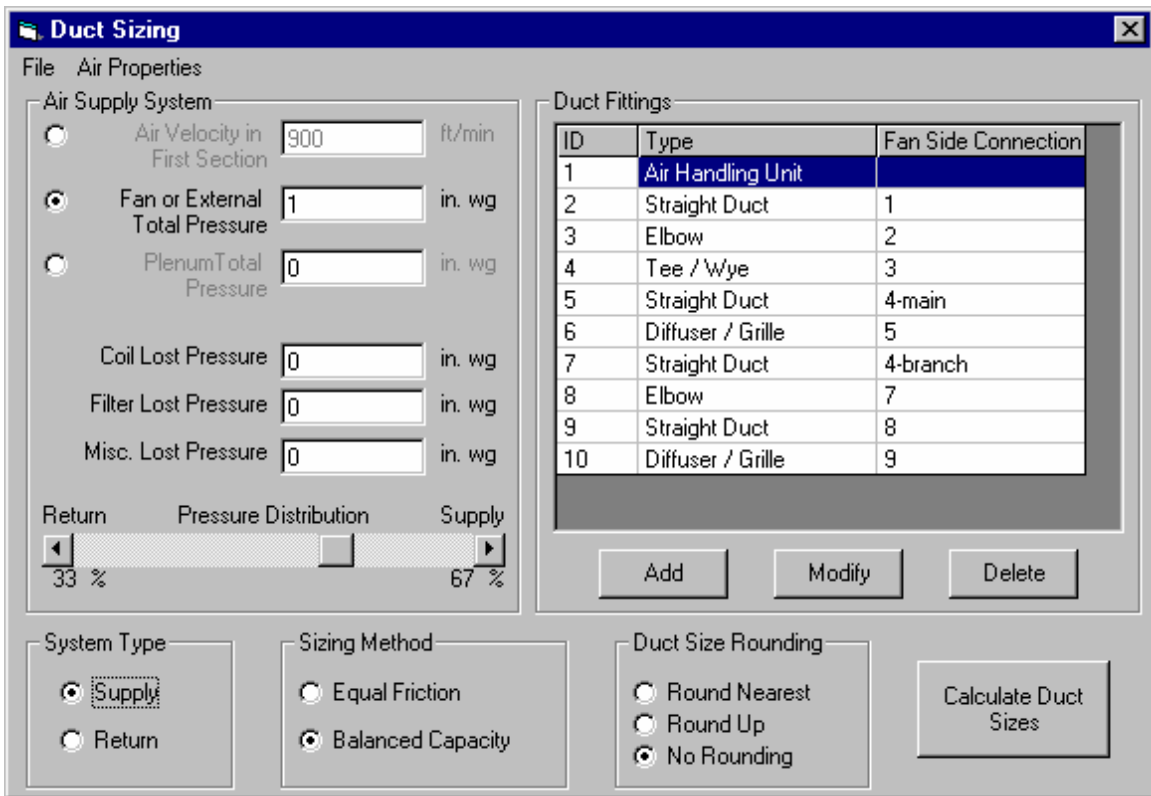
The problem with divided flow fittings usually occurs with a small branch off a large main duct causing A_b/A_c to be too small or A_s/A_c equal to 1.0. To correct the problem, a damper should be inserted in the branch to increase the lost pressure which will yield a larger branch duct, decrease the velocity and increase A_b/A_c . When A_s/A_c equals 1.0, with a diverging system, there is no way to correct the problem short of redesigning the system.

Example 1

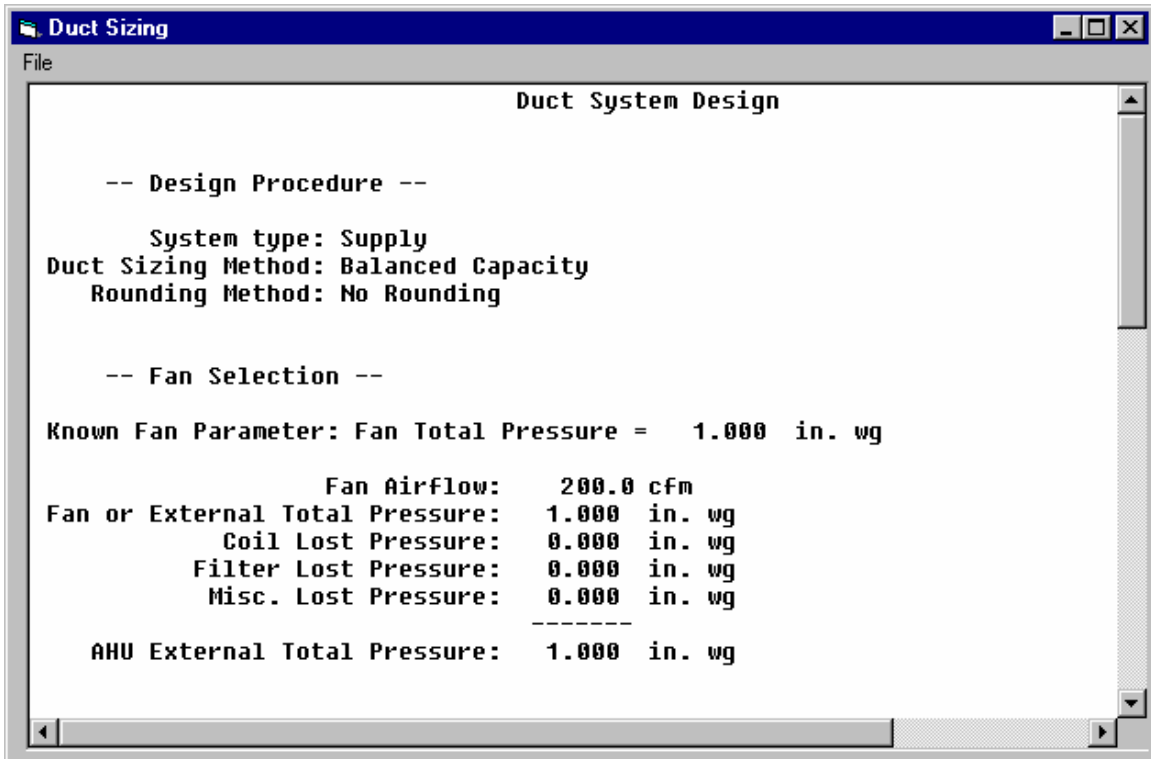
The software distribution CD contains an example duct system in a file named "Example 1.df". The sketch for this system is given below. Note that the fittings are numbered, starting with 1 at the AHU, and increasing sequentially as you move away from the fan. At the Tee (fitting 4), numbering continues on the main side of the TEE, until the diffuser is reached (fitting 6). Then numbering continues from the branch side of the TEE.



The Main Screen for this example is shown below. Notice the information provided in the Duct Fittings Frame. Each of the fittings are listed, showing the ID, Type and Fan Side Connection. The fan side connection for fitting 3 (the elbow) is fitting 2 (the straight duct). The fan side connection for fitting 5 (a straight duct) is fitting 4-main (the main side of the Tee).

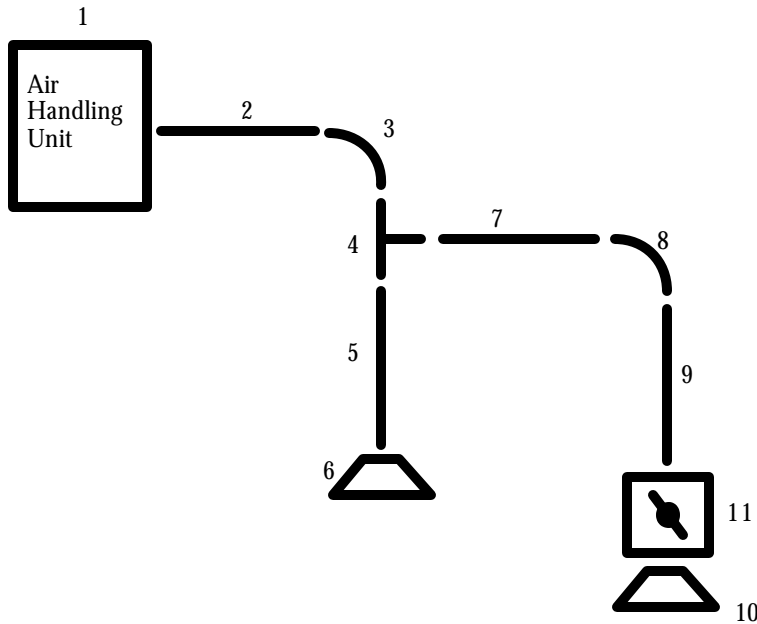


Pressing the Calculate Duct Sizes button will bring up the window for viewing the results of the calculations (after a brief delay). That screen is shown below. Menu items on this screen allow saving and printing. This screen is actually simple text editor. If you wish, you might add titles, notes or comments to the file before you save or print the file.



Example 1 - Modified to insert a new fitting into an existing model

To demonstrate simple editing of the duct system, a butterfly-damper will be inserted between the last diffuser (fitting 10) and the straight duct (fitting 9). The butterfly-damper will be labeled as fitting 11.



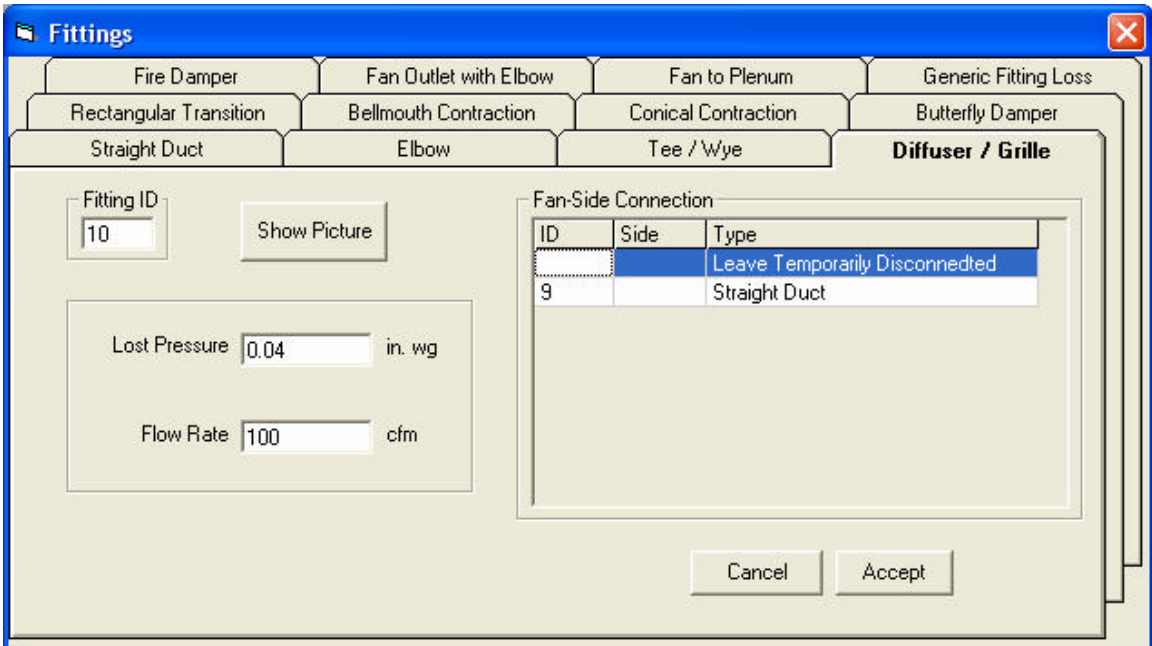
To create and insert this new fitting, perform the following steps:

- 1) Select fitting 10 (diffuser) and press the modify button.

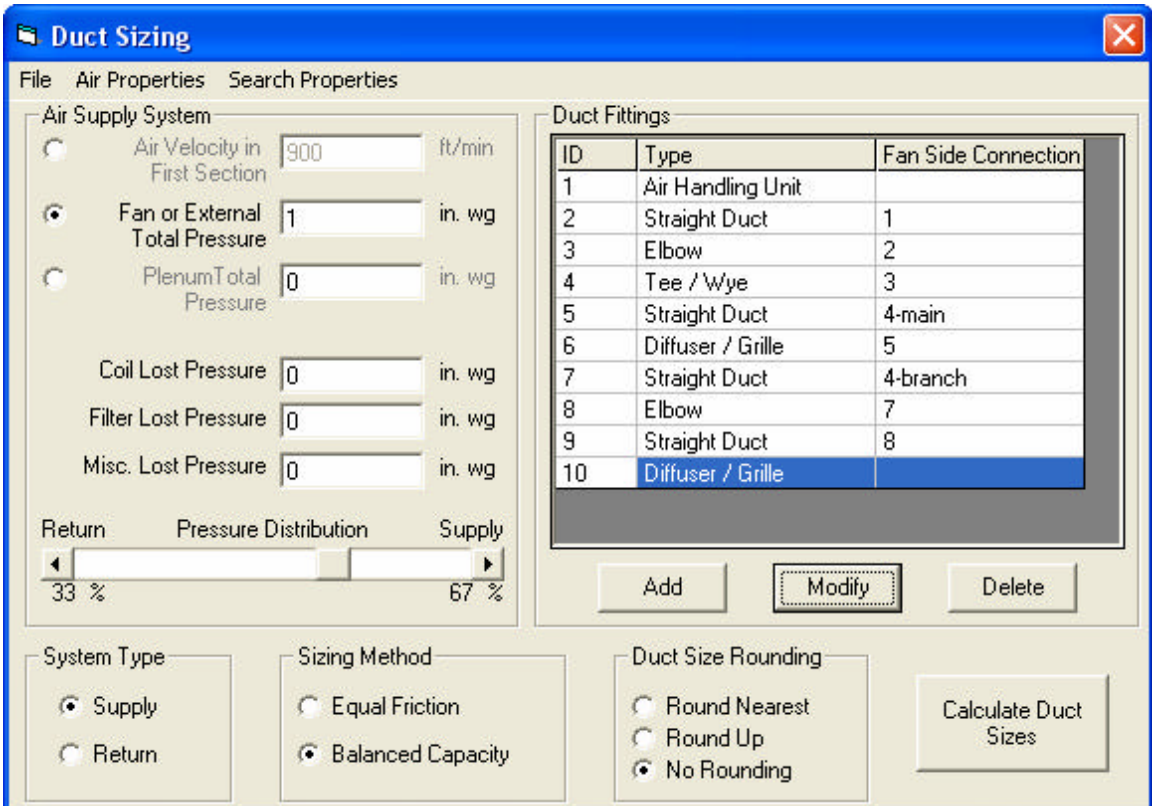
The screenshot shows the 'Duct Sizing' software interface. The 'Duct Fittings' table is visible, with fitting 10 selected. The 'Modify' button is highlighted. The 'Air Supply System' section shows 'Fan or External Total Pressure' selected with a value of 1 in. wg. The 'Sizing Method' is set to 'Balanced Capacity'. The 'Duct Size Rounding' is set to 'No Rounding'. The 'Calculate Duct Sizes' button is also visible.

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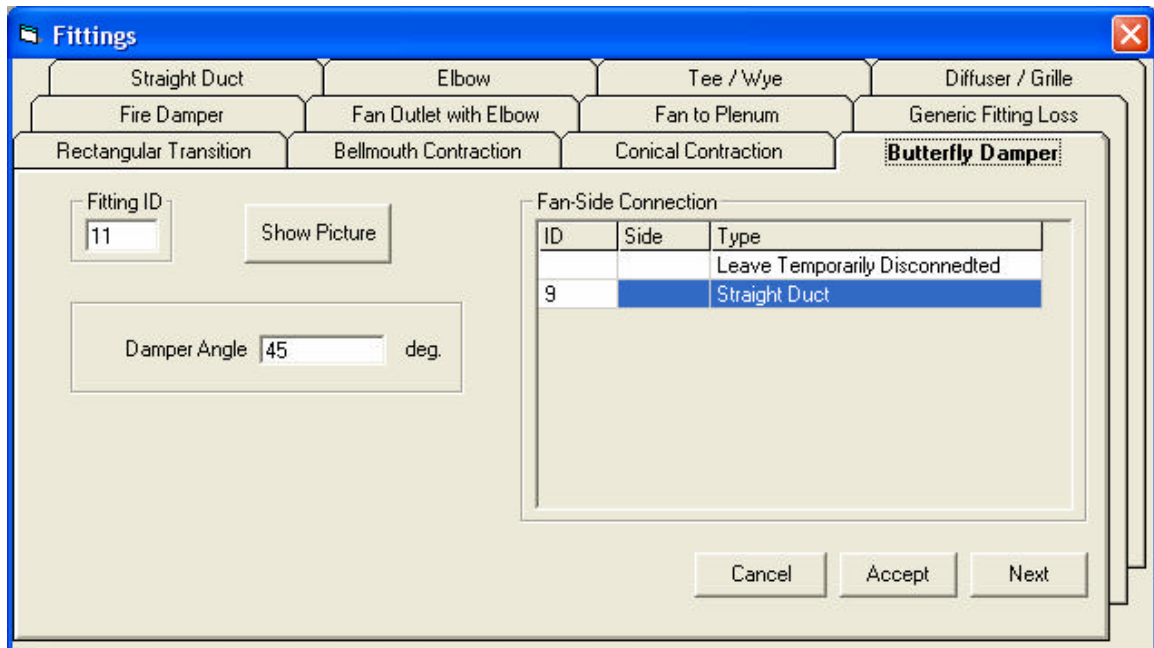
- 2) In the Fittings screen that that appears, select “*Leave Temporarily Disconnected*” and press the *Accept* button. This breaks the connection between the diffuser and the straight duct.



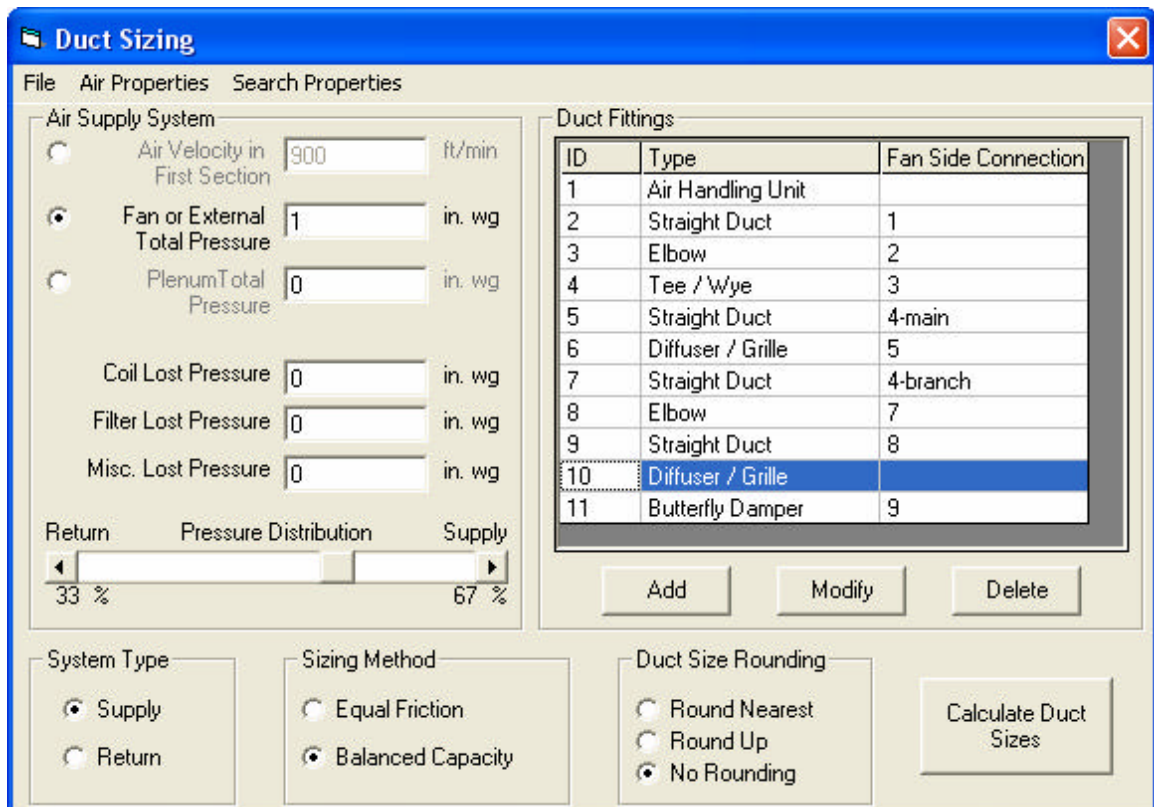
- 3) Notice in the figure below that there is now no Fan Side Connection for the diffuser.



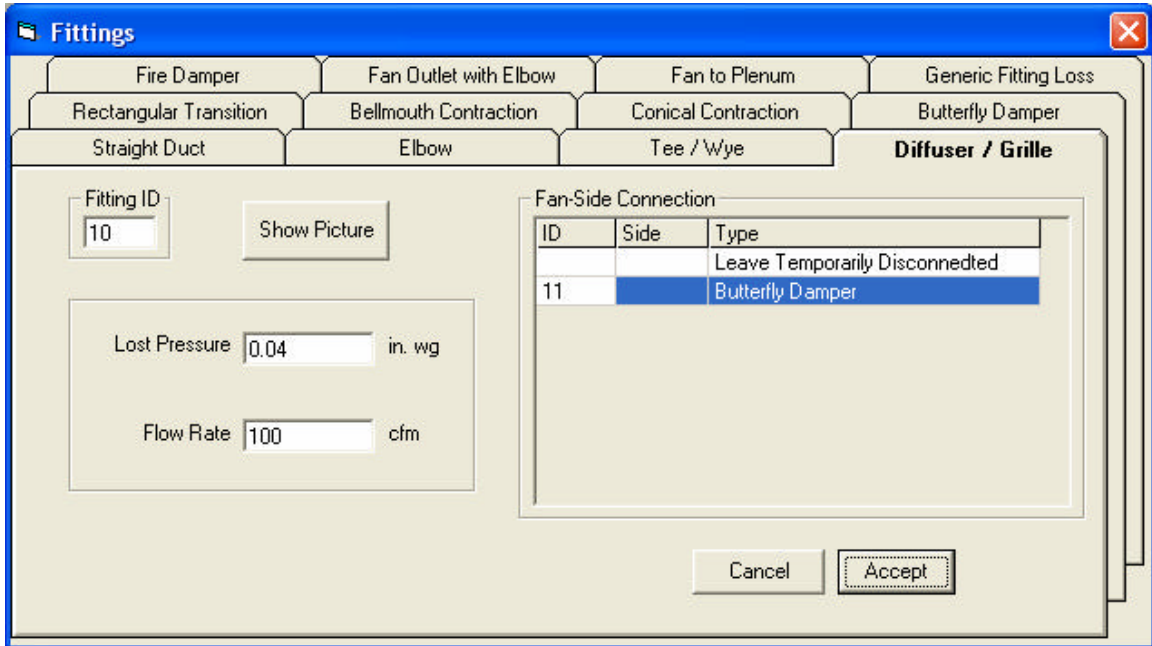
- Press the **Add** button and select the **Butterfly Damper tab** on the next screen. Change the damper angle to 45 degrees. Notice that the fitting 9, the straight duct, was automatically chosen as the Fan-Side Connection. Press the **Accept** button to accept this fitting and return to the previous screen



- At this point, the new butterfly damper has been connected to the straight duct. Now the diffuser must be connected to the butterfly damper. Select the diffuser (fitting 10), and press the **Modify** button.

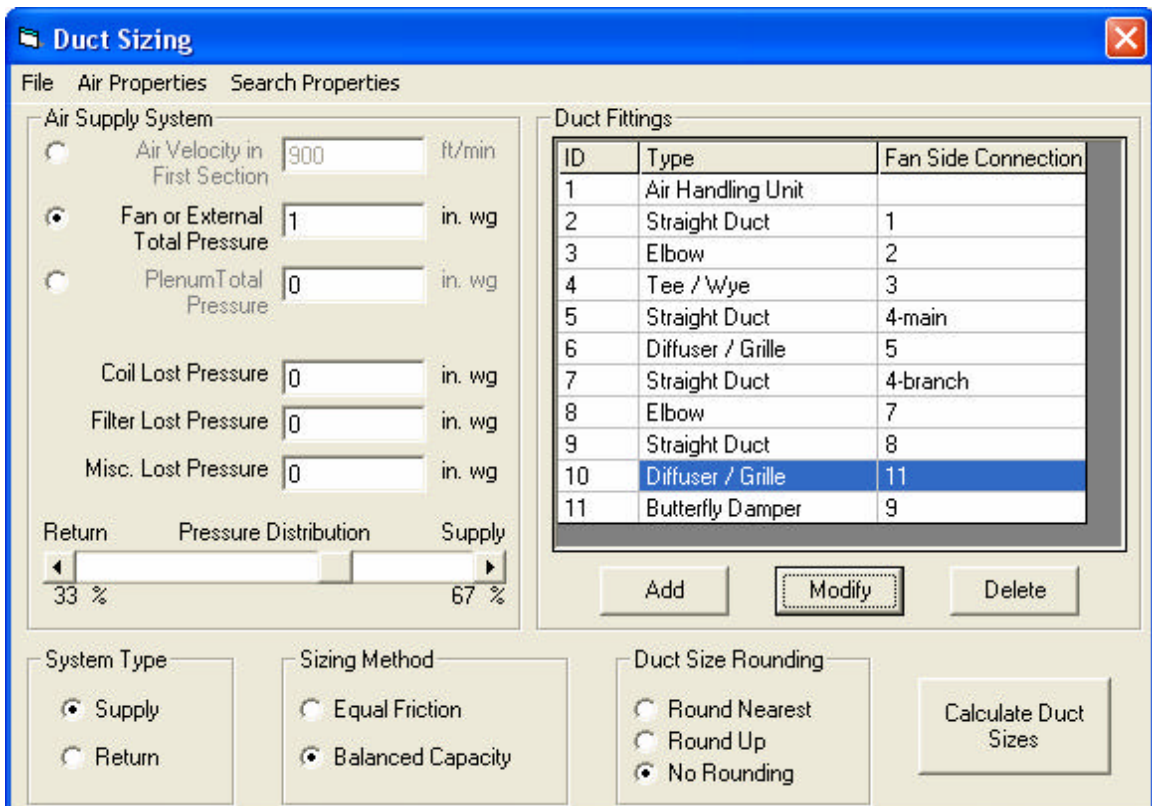


- 6) The Fittings screen appears with fitting 10 selected. The program has automatically selected the Butterfly Damper (fitting 11) as the Fan-Side Connection, because it is the only fitting available. To accept this new connection, press the *Accept* button.



- 7) The duct system has been modified. The Duct Fitting list shows that:
 Fitting 10 – Diffuser / Grille is connected to Fitting 11 – Butterfly Damper
 Fitting 11 – Butterfly Damper is connected to Fitting 9 – Straight Duct

Note: even though the fittings look out of order, they are properly connected. The order of the fittings in the list has no real meaning.



Example2

The software distribution CD also contains a file named "Example 2.df". The sketch for this example file is shown in the next figure. Again, the fittings are numbered in the order assumed by the program.

