Easy Guide
Composite Components
Composite Components
Using Flowmaster V7, a design engineer can combine several standard Flowmaster components to model complex geometries of individual components.

Application Example
The following example is taken from the automotive industry and represents a silencer model for an automotive exhaust system.

Figure 1 Silencer model
The model uses a combination of standard Flowmaster components including the Fixed Volume, Sharp Edge Orifice and Gas Accumulator components. Each is discussed briefly below.
Fixed Volume Component

The fixed volume component is basically a 2 arm-compressible accumulator that allows the user to model mass accumulation within a cavity that has both inflow and outflow through separate paths in the cavity. It also allows the user to set separate loss coefficients for the inlet and outlet of the volume. For this application we will be using several of these components to model the large volumes in the individual chambers of the silencer. We will set the diameters large and the loss coefficients small since we are using orifices and transitions to model the effects of the flow moving from one chamber to the next.

Sharp Edged Orifice

The sharp edged orifice is a commonly used component in Flowmaster that models the pressure losses as the exhaust passes through small holes in the system. For the muffler in this model it will be used to model the openings between chambers where there is no piping involved. It is also used to model the exit losses of the muffler. The pipe diameter inputs for the orifice are set large to simulate the small hole in a relatively large plate.

Accumulator Gas

This is the standard compressible accumulator component in Flowmaster. For this application we will be using these components to model the large volumes in the individual chambers of the silencer that have perforations to account for the volume and mass accumulation.
Example Data

The example network data are shown below.

Components 1 and 2: Pipe: Cylindrical Gas

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>0.025 m</td>
</tr>
<tr>
<td>Pipe Length 1</td>
<td>0.1 m</td>
</tr>
<tr>
<td>Pipe Length 2</td>
<td>0.15 m</td>
</tr>
<tr>
<td>Friction Data Sub-form</td>
<td></td>
</tr>
<tr>
<td>Friction Option</td>
<td>1 Colebrook White Approximation</td>
</tr>
<tr>
<td>Absolute Roughness</td>
<td>0.025 mm</td>
</tr>
<tr>
<td>Heat Transfer Sub-form</td>
<td></td>
</tr>
<tr>
<td>No. of Internal Nodes</td>
<td>4</td>
</tr>
</tbody>
</table>

Components 3, 4 and 5: Fixed Volume

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter 1</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Pipe Diameter 2</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Total Volume</td>
<td>0.001 m3</td>
</tr>
<tr>
<td>Inflow Loss Coefficient 1</td>
<td>1</td>
</tr>
<tr>
<td>Outflow Loss Coefficient 1</td>
<td>1</td>
</tr>
<tr>
<td>Inflow Loss Coefficient 2</td>
<td>1</td>
</tr>
<tr>
<td>Outflow Loss Coefficient 2</td>
<td>1</td>
</tr>
<tr>
<td>Polytropic Index 1</td>
<td>1.4</td>
</tr>
<tr>
<td>Polytropic Index 2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Component 6: Orifice: Sharp Edge

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>0.03 m</td>
</tr>
<tr>
<td>Orifice Diameter</td>
<td>0.02 m</td>
</tr>
</tbody>
</table>

Component 7: Orifice: Sharp Edge

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Orifice Diameter</td>
<td>0.02 m</td>
</tr>
</tbody>
</table>

Components 8, 9, 10: Transition: Abrupt

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Diameter</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Minor Diameter</td>
<td>0.025 m</td>
</tr>
</tbody>
</table>
To validate the model, a pressure source is added at inlet and outlet and a Compressible Steady State simulation performed.

Components 11 and 12: Accumulator Gas

<table>
<thead>
<tr>
<th>Inlet Pipe Diameter 11</th>
<th>0.015 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pipe Diameter 12</td>
<td>0.02 m</td>
</tr>
<tr>
<td>Accumulator Volume</td>
<td>0.003 m3</td>
</tr>
<tr>
<td>Initial Temperature</td>
<td>80°C</td>
</tr>
<tr>
<td>Initial Mass Flow Rate</td>
<td>0</td>
</tr>
<tr>
<td>Polytropic Charge</td>
<td>1.4</td>
</tr>
<tr>
<td>Polytropic Discharge</td>
<td>1.4</td>
</tr>
<tr>
<td>Pressure at Node level</td>
<td></td>
</tr>
<tr>
<td>Pat_node_level =</td>
<td>P\text{static} + P\text{dynamic}</td>
</tr>
<tr>
<td>Or Pat_node_level =</td>
<td>P\text{total} -</td>
</tr>
</tbody>
</table>

Components 13 and 14: Pressure Source

| Total Pressure 13     | 4 bar |
| Total Pressure 14     | 1 bar  |

Once our model is confirmed we are then ready to create our data form for the composite component.

There are several steps to doing this. These are listed below and we will discuss each step in detail.

- Creating new composite framework
- Building the underlying model
- Setting configured values
- Assigning a symbol
- Deducing the connections
- Create signal mappings
- Creating data form
- Defining fall through values
- Hiding unwanted fields
- Defining call up values
- Testing completed composite component
Creating new composite framework

The first step is to define a new composite framework. This is done from the ‘Catalogue’ tab in the Project View as shown Figure 2. Expand the component family and right click on the ‘User Defined’ folder. Then select ‘New > Composite Component’.

This will create an empty composite component under the User Defined folder and automatically open a composite schematic window as shown below.

![Creating new composite](image)

**Figure 2 Creating new composite**

This window will look very similar to the standard schematic window with one exception. The tabs in the Network View are different. They include Data, Connections and Data Model. These tabs will be where the customization of the component occurs.

The first step is to rename the component. This is done by changing the name in the Property window in the lower left hand side of the screen. For our example change the name to Main Silencer.
Building the Underlying model

The next step is to create the model that will be underneath the composite component. This is the same model that we created above (without the pressure sources). We can either recreate the model from the beginning or we can simply copy and paste the components from our validation model. Once all the components have been added the schematic should look similar to Figure 3.

![Figure 3 Underlying Model](image)

Note: If you are creating a composite component where the flow direction through the component is important, place the component that is intended to be the inlet of the composite into the schematic first. For this example it is component 1, the cylindrical pipe. This will be used later in the process for defining the component arms.
Assigning a Symbol

After you have created your network the next step is to assign a symbol to the composite. This is done from the Connections tab in the Network View selecting the Symbol button.

This will open the symbol selection dialogue box. Within this window use the file browser to go to the User Defined Symbol Catalogue. This will list all of the symbols in this folder. By selecting any of the symbol names an image of the symbol will be displayed in the lower centre of the selection box. Once you have identified the appropriate symbol, choose the ‘Select’ button to attach it to your composite component. Once you have done this the symbol will appear in the ‘Connections’ tab just to the right of the ‘Symbol’ button.
Deducing the connections

Similar to standard Flowmaster components, composite components have arms associated with the connection points of the components. These are the unconnected ends of the components in the network. Unlike standard components, there is no limit to the number of arms that a composite component can have. To deduce the connections for your composite component, select the Connections tab from your Network Views window.

From this window select the ‘Deduce’ button as shown in Figure 6.
Flowmaster will evaluate the network and produce a connections map similar to the one below. This mapping shows that Arm 1 of the composite component is mapped to Arm 1 of component 1 (Pipe) and Arm 2 of the composite component is mapped to Arm 2 of component 7 (orifice).

Along with setting the arm mappings it also assigns a default placement for each of the arms of the composite component. This is the physical connection point with respect to the symbol. These are initially set to 16 for both arms and these must be changed to suit how the component is going to be used. This number can be set to any value between 0 and 59. These numbers are associated with a position on the symbol as is shown in the diagram below. Position 0 is the mid position on the left side of the symbol and they increase in a anti-clockwise manner around the symbol.
For our example, use placement value of 45 for Arm 1 and 15 for Arm 2. This will produce a symbol similar to that shown if Figure 9.
Create Signal Mappings

Many of the components have signal connections associated with them that the user may want to utilize as part of the composite component. To take advantage of these signal connections they must be mapped to the composite component. This is again done from the Network View window under the ‘Signal Mappings’ header.

For our example we want to be able to get the pressure inside accumulator component 12 as a measurement output. Therefore we must map the measurement output of the accumulator to the Main Silencer composite.

This is done by selecting the ‘Add’ button just above the Signal Mappings header. This will open a new window that lists all the components in the schematic that have signal connections. By selecting the ‘+’ next to the component, the window will expand to show all available connections for that particular component. These will either be designated with the letters (MO) for Measurement Output or (SI) for signal input.
For this example we expand component ‘12 Accumulator: Gas’ and it shows that it only has a Measurement Output. To proceed, check the box next to the Measurement Output. This will open an additional window which lists all of the variables that could be measured. Select Pressure and select the OK button. This will update the signal mapping window to show that pressure has been selected as the Measurement Output for that component.

Now select OK in the Signal Mapping window and the Network View window will update to show that the measurement output mapping has been added to the composite component.

Similar to the fluid connections, the placement of the signal connections on the symbol can be changed for this example change the placement to 50.

If there are more signal connections desired for a composite component this process can be repeated.
Setting Configured Values

One of the major benefits of composite components is that they allow the user to predefine inputs for the underlying components that never change. This then eliminates the need for these values to be set every time the composite component is used. To do this it is important to understand how you will be using the component in the future and which inputs that you want predefined. You will only want to set configured values for items that will never change.

For this example, we will pre-set the friction data in the pipes and the loss coefficients in the fixed volume components and polytropic index in fixed volume and accumulator components. This is done by simply setting the values in the individual components. Below are the values we will be using for each component.

### Components 1 and 2: Pipe: Cylindrical Gas

<table>
<thead>
<tr>
<th>Friction Data Sub-form</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Option</td>
<td>1 Colebrook White Approximation</td>
</tr>
<tr>
<td>Absolute Roughness</td>
<td>0.025 mm</td>
</tr>
<tr>
<td>Heat Transfer Sub-form</td>
<td></td>
</tr>
<tr>
<td>No. of Internal Nodes</td>
<td>4</td>
</tr>
</tbody>
</table>

*Logic: The pipe material will always be the same*

### Components 11 and 12: Accumulator Gas

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Mass Flow Rate</td>
<td>0</td>
</tr>
<tr>
<td>Polytropic Charge</td>
<td>1.4</td>
</tr>
<tr>
<td>Polytropic Discharge</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*Logic: Pressure and Temperature changes will not be significant enough to affect the Polytropic Index.*
Components 3, 4 and 5: Fixed Volume

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter 1</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Pipe Diameter 2</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Inflow Loss Coefficient 1</td>
<td>1</td>
</tr>
<tr>
<td>Outflow Loss Coefficient 1</td>
<td>1</td>
</tr>
<tr>
<td>Inflow Loss Coefficient 2</td>
<td>1</td>
</tr>
<tr>
<td>Outflow Loss Coefficient 2</td>
<td>1</td>
</tr>
</tbody>
</table>

Logic: Using orifices and transitions to model the flow losses and velocity changes from 1 chamber to the next.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polytropic Index 1</td>
<td>1.4</td>
</tr>
<tr>
<td>Polytropic Index 2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Logic: Pressure and Temperature changes will not be significant enough to affect the Polytropic Index.

Component 7: Orifice: Sharp Edge

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>0.05 m</td>
</tr>
<tr>
<td>Major Diameter</td>
<td>0.05 m</td>
</tr>
</tbody>
</table>

Logic: Set large to simulate significant difference in the flow area to properly model the velocity changes.

Creating the Data Form

Before creating the data form it is advantageous to look at all the data items that will need to be completed for all of the components and determine if any of them can be combined into a single item. Below is a list of components and the data items that need to be completed for each one of them. From this you can see that there are several fields that can be combined to reduce the total number of input fields from 20 to 14.
<table>
<thead>
<tr>
<th>Component</th>
<th>Data item</th>
<th>Same As Component No.</th>
<th>Custom Field Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Pipe: Cylindrical Gas</td>
<td>Length</td>
<td>Unique</td>
<td>Inlet Pipe Length</td>
</tr>
<tr>
<td>1 Pipe: Cylindrical Gas</td>
<td>Diameter</td>
<td>2, 8,9,10 (minor dia.)</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>2 Pipe: Cylindrical Gas</td>
<td>Length</td>
<td>Unique</td>
<td>Internal Pipe Length</td>
</tr>
<tr>
<td>2 Pipe: Cylindrical Gas</td>
<td>Diameter</td>
<td>1, 8,9,10 (minor dia.)</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>3 Fixed Volume</td>
<td>Total Volume</td>
<td>Unique</td>
<td>Chamber 2 Volume</td>
</tr>
<tr>
<td>4 Fixed Volume</td>
<td>Total Volume</td>
<td>Unique</td>
<td>Chamber 3 Volume</td>
</tr>
<tr>
<td>5 Fixed Volume</td>
<td>Total Volume</td>
<td>Unique</td>
<td>Chamber 5 Volume</td>
</tr>
<tr>
<td>6 Orifice: Sharp Edge</td>
<td>Orifice Diameter</td>
<td>Unique</td>
<td>Internal Orifice Dia.</td>
</tr>
<tr>
<td>7 Orifice: Sharp Edge</td>
<td>Orifice Diameter</td>
<td>Unique</td>
<td>Exit Diameter</td>
</tr>
<tr>
<td>8 Transition: Abrupt</td>
<td>Minor Diameter</td>
<td>1, 2, 9, 10</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>9 Transition: Abrupt</td>
<td>Minor Diameter</td>
<td>1, 2, 8, 10</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>10 Transition: Abrupt</td>
<td>Minor Diameter</td>
<td>1, 2, 8, 9</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>11 Accumulator: Gas</td>
<td>Pipe Diameter</td>
<td>Unique</td>
<td>Equiv. Flow Dia. Chamber 1</td>
</tr>
<tr>
<td>11 Accumulator: Gas</td>
<td>Total Volume</td>
<td>Unique</td>
<td>Chamber 1 Volume</td>
</tr>
<tr>
<td>11 Accumulator: Gas</td>
<td>Initial Temperature</td>
<td>12</td>
<td>Initial Temperature</td>
</tr>
<tr>
<td>12 Accumulator: Gas</td>
<td>Pipe Diameter</td>
<td>Unique</td>
<td>Equiv. Flow Dia. Chamber 4</td>
</tr>
<tr>
<td>12 Accumulator: Gas</td>
<td>Total Volume</td>
<td>Unique</td>
<td>Chamber 4 Volume</td>
</tr>
<tr>
<td>12 Accumulator: Gas</td>
<td>Initial Temperature</td>
<td>11</td>
<td>Initial Temperature</td>
</tr>
</tbody>
</table>
Now that we have determined all of the inputs that will be required for our silencer we are ready to build the data form.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>Diameter of all Pipes within the composite</td>
</tr>
<tr>
<td>Inlet Pipe Length</td>
<td>Length of pipe on the Inlet side of the silencer</td>
</tr>
<tr>
<td>Internal Pipe Length</td>
<td>Length of the pipe that is internal to the silencer</td>
</tr>
<tr>
<td>Chamber 1 Volume</td>
<td>Total volume in Chamber 1</td>
</tr>
<tr>
<td>Chamber 2 Volume</td>
<td>Total volume in Chamber 2</td>
</tr>
<tr>
<td>Chamber 3 Volume</td>
<td>Total volume in Chamber 3</td>
</tr>
<tr>
<td>Chamber 4 Volume</td>
<td>Total volume in Chamber 4</td>
</tr>
<tr>
<td>Chamber 5 Volume</td>
<td>Total volume in Chamber 5</td>
</tr>
<tr>
<td>Equivalent Flow Diameter</td>
<td></td>
</tr>
<tr>
<td>Chamber 1</td>
<td>Equivalent diameter of all holes in the pipe through chamber 1 (inlet pipe)</td>
</tr>
<tr>
<td>Equivalent Flow Diameter</td>
<td>Equivalent diameter of all holes in the pipe through chamber 4 (internal pipe)</td>
</tr>
<tr>
<td>Chamber 4</td>
<td></td>
</tr>
<tr>
<td>Internal Orifice Diameter</td>
<td>Diameter of orifice between chamber 2 and chamber 3</td>
</tr>
<tr>
<td>Exit Diameter</td>
<td>Diameter at the exit of the main silencer</td>
</tr>
<tr>
<td>Initial Temperature</td>
<td>Temperature inside the silencer at the start of the analysis</td>
</tr>
</tbody>
</table>
To create the data form we must switch to the Data Model tab in the Network Views window and select the 'Create/ Edit' button as is shown below.

This will then open the 'Analytical Model Editor'. It is in this editor that we define each of the input fields and assign their context dependency. Using our list from the previous page we can begin to add the data items in the correct order. This is done by selecting the Add Existing button in the 'Analytical Model Editor' which will open the 'Feature Selection' window as is shown in Figure 14 and Figure 15 respectively.
Figure 14 Analytical Model Editor
Scroll down the list and find Pipe Diameter. You will see that there are multiple entries for many of the fields. This will allow you to use more than one instance of the input. You do need to be careful to ensure that they are input fields and not output fields though. This is shown in the lower left hand side of the window.

Place a check mark next to the Pipe Diameter field and select OK. You will then see that this item has been added to the Analytical Model Editor. You will also see that the Necessity table on the right side of the editor now has several Simulation types visible.

This portion of the editor is used to tell Flowmaster which fields are mandatory, optional or context dependent for each of the available analysis types. For the Main Silencer this will only be used in Compressible Steady State, Compressible Transient and Compressible Flow Balancing applications. For each of these simulation types set the requirement to Mandatory. This is done by selecting the drop down menu next to the analysis type.
We now need to add the other required fields for our component. Repeat the process above and select the following fields and select the same necessity type for each:

- **Inlet Pipe Length:** Inlet Pipe Length
- **Internal Pipe Length:** Length

Note: there is not a default field type for Internal Pipe Length so we chose an Equivalent field simply named Length.
The next 5 fields are very similar in that they represent volumes in the different chambers in the Silencer. Flowmaster does not have 5 independent volume features in the standard database, but the Analytical Model Editor provides the capability to create new features in the database. This is done by selecting the Add New… button in the Features table. This will then open a series of windows that will step you through creating the new feature. The first of these is the Feature Type.
Figure 18. Feature Type

This window is used to select the type of feature we would like to add. For the Volume fields we want to use a Real data type, so this is selected and then press OK. This will then open the Feature Edit window. This window is used to create the following items for our example:

- Feature Name : Volume 1
- Designate if it is an Input field or Output field : Input
- Add any field specific help if required : NA
- Specify the Units for the field : volume(m3)

Once these items are entered select OK and set the Necessity values as we did before.

Repeat this step for each of the volume fields for Volume 1 to Volume 5.
We need to now add the 5 remaining fields. There are existing fields in the editor to accommodate these remaining fields. Use the Add Existing… button to include these remaining fields as per the list below.

**Equivalent Flow Diameter Chamber 1:** Arm 1 Diameter
**Equivalent Flow Diameter Chamber 4:** Arm 2 Diameter
**Internal Orifice Diameter:** Orifice Diameter
**Exit Diameter:** Diameter
**Initial Temperature:** Initial Temperature

Once these are all added select OK and return to the Data Model tab. You will be able to see all the data items that have been added to the composite.
The next step is to create the custom names for each of the fields and defining how they are linked to the components within the composite components. First we will create the custom names where required. On page 25 of the application guide is list of all the input fields with a description of each field. Comparing that list to our input field names we can see that there are 10 of the 13 fields that we will want to create custom names for. Below is a summary of the fields and the custom names we have chosen.

- Internal Pipe Length: Length
- Chamber 1 Volume: Volume 1
- Chamber 2 Volume: Volume 2
- Chamber 3 Volume: Volume 3
Chamber 4 Volume: Volume 4
Chamber 5 Volume: Volume 5
Equivalent Flow Diameter Chamber 1: Arm 1 Diameter
Equivalent Flow Diameter Chamber 4: Arm 2 Diameter
Internal Orifice Diameter: Orifice Diameter
Exit Diameter: Diameter

To create the custom name select the Length input field in the Data Model tab. This will then display the properties of the field. These properties include Default Value, Minimum and Maximum Value and many others. The first property in the list is Custom Name. For the Length field add “Internal Pipe Length” as the value.
You will see the field name in the Data Model update. Repeat this for all the fields in the list. When you are finished the Input field list should be similar to the figure below.
Now that we have all of our custom names created we are ready to associate them to the components underneath the composite components. To do this we again look at the Data Model tab and expand the Parts list at the bottom of the window. This shows a list of all the components and nodes that are included in the composite component. Furthermore, if we expand any one of the components we can see all input and output fields that are associated with that particular component. It is here where we can now link the custom fields to the component fields.

This is done by highlighting the custom field name and checking the appropriate field name under the individual components that you want to associate the custom field with. It is important to make sure that the “Check for Fall Thru” radio button is selected. It should also be noted that that multiple component fields can be associated with a single custom field.
Figure 23 Field Mapping
Previously we defined field mappings which we can now use as a guide for mapping all of the fields. This table can be rearranged to clarify the mapping.

<table>
<thead>
<tr>
<th>Custom Field Name</th>
<th>Component</th>
<th>Data item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>1 Pipe: Cylindrical Gas</td>
<td>Diameter</td>
</tr>
<tr>
<td></td>
<td>2 Pipe: Cylindrical Gas</td>
<td>Diameter</td>
</tr>
<tr>
<td></td>
<td>8 Transition: Abrupt</td>
<td>Minor Diameter</td>
</tr>
<tr>
<td></td>
<td>9 Transition: Abrupt</td>
<td>Minor Diameter</td>
</tr>
<tr>
<td></td>
<td>10 Transition: Abrupt</td>
<td>Minor Diameter</td>
</tr>
<tr>
<td>Inlet Pipe Length</td>
<td>1 Pipe: Cylindrical Gas</td>
<td>Length</td>
</tr>
<tr>
<td>Internal Pipe Length</td>
<td>2 Pipe: Cylindrical Gas</td>
<td>Length</td>
</tr>
<tr>
<td>Chamber 1 Volume</td>
<td>11 Accumulator: Gas</td>
<td>Total Volume</td>
</tr>
<tr>
<td>Chamber 2 Volume</td>
<td>3 Fixed Volume</td>
<td>Total Volume</td>
</tr>
<tr>
<td>Chamber 3 Volume</td>
<td>4 Fixed Volume</td>
<td>Total Volume</td>
</tr>
<tr>
<td>Chamber 4 Volume</td>
<td>12 Accumulator: Gas</td>
<td>Total Volume</td>
</tr>
<tr>
<td>Chamber 5 Volume</td>
<td>5 Fixed Volume</td>
<td>Total Volume</td>
</tr>
<tr>
<td>Equivalent Flow Diameter</td>
<td>11 Accumulator: Gas</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>Chamber 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent Flow Diameter</td>
<td>12 Accumulator: Gas</td>
<td>Pipe Diameter</td>
</tr>
<tr>
<td>Chamber 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Orifice Diameter</td>
<td>6 Orifice: Sharp Edge</td>
<td>Orifice Diameter</td>
</tr>
<tr>
<td>Exit Diameter</td>
<td>7 Orifice: Sharp Edge</td>
<td>Orifice Diameter</td>
</tr>
<tr>
<td>Initial Temperature</td>
<td>11 Accumulator: Gas</td>
<td>Initial Temperature</td>
</tr>
<tr>
<td></td>
<td>12 Accumulator: Gas</td>
<td>Initial Temperature</td>
</tr>
</tbody>
</table>

The Figure below shows the proper mapping for the Inlet Pipe Length. We can see from the Table above that the Length of component no. 1 is the proper field to map. So first, highlight Inlet Pipe Length in the custom fields and then expand component 1 to show all the input fields.

Flowmaster applies a sorting logic and inactivates any field that could not match the data type that you have chosen so it is easy to see that length is the only option for this component. Check the box next to Length.
Repeat this for each of the items in the table and take care to include all the fields when one custom field has multiple entries.

Figure 24 Inlet Pipe Mapping
Defining Custom Result Fields and Mapping Pass Up Values

Now that we have all of the input fields defined and mapped we want to determine what results from the individual components we want reported as a result for the composite component. By default Flowmaster will provide standard results for flow rate, pressures, and temperatures for the composite as whole so we need not be concerned about these.

Note: If we are interested in a particular result internal to the composite such as a node pressure we must attach a gauge to the node and map the custom result to the result of the gauge. For our example we are only going to be concerned with the Gas Mass and Pressure in the chambers 1 and 4. Therefore we will have 4 custom result fields to create.

To create these we again go to the Analytical Model Editor and add additional fields this time making sure all the fields are Output fields. Similar to the Inputs we will map these to existing fields in the database. Below are the fields that we will use.

| Gas Mass: | Chamber 1 Gas Mass |
| Chamber Pressure: | Chamber 1 Pressure |
| Cavity Gas Mass: | Chamber 2 Gas Mass |
| Pressure: | Chamber 2 Pressure |
Now that the custom result fields have been added we need to customize the names in the same manner as we did the input fields. Use the list above to create the custom names.

The final step is to map the Pass Up values for the results. This is done in exactly the same manner as the inputs except select the “Check for Pass Up” radio button.
Select the custom result and the appropriate result for the underlying component. Below is a table that shows the correct mapping for our component.

<table>
<thead>
<tr>
<th>Custom Field Name</th>
<th>Component</th>
<th>Data item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber 1 Gas Mass</td>
<td>11 Accumulator: Gas</td>
<td>Gas Mass</td>
</tr>
<tr>
<td>Chamber 1 Pressure</td>
<td>11 Accumulator: Gas</td>
<td>Pressure</td>
</tr>
<tr>
<td>Chamber 2 Gas Mass</td>
<td>12 Accumulator: Gas</td>
<td>Gas Mass</td>
</tr>
<tr>
<td>Chamber 2 Pressure</td>
<td>12 Accumulator: Gas</td>
<td>Pressure</td>
</tr>
</tbody>
</table>

Figure 27 Mapping Pass-Up Values
Testing Completed Composite Component

Now that we have completed the Silencer composite component we want to verify that it is providing the same results as the network it is based on. We can do this by building a simple model and compare the results to those of the network in Appendix A.

Create a network like the one below with the following inputs.

![Figure 28 Test network](image)

**Component 1: Main Silencer**

- Pipe Diameter: 0.0250 m
- Inlet Pipe Length: 0.1000 m
- Internal Pipe Length: 0.1500 m
- Chamber 1 Volume: 0.0010 m³
- Chamber 2 Volume: 0.0010 m³
- Chamber 3 Volume: 0.0010 m³
- Chamber 4 Volume: 0.0030 m³
- Chamber 5 Volume: 0.0010 m³
- Equivalent Flow Dia Chamber 1: 0.0150 m
- Equivalent Flow Dia Chamber 4: 0.0200 m
- Internal Orifice Diameter: 0.0200 m
- Exit Diameter: 0.0250 m
Initial Temperature  80.0 °C

Component 2: Pressure Source
Total Pressure:  1 Bar

Component 3: Pressure Source
Total Pressure:  4 Bar

Now run a compressible steady state analysis and compare the results for the Chamber 1 gas mass and pressure with those same items for component 5 Accumulator: Gas and the results for Chamber 2 gas mass and pressure with component 6 Accumulator: Gas.

If the composite is created correctly these results should match.