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## **Introduction**

### **CATIA Version 5 Tubing and Piping Design**

Upon completion of this course the student should have a full understanding of the following topics:

- Creating a run
- Placing Tubing parts
- Managing Tubing connections
- Working with flexible tubes
- Working with flexible Bundles
- Modifying tubes
- Analyzing a tubing system
- Creating a tubing report
- Moving tubing systems in the tree

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## Manual Format

It is important to understand the format of the manual in order to use it most effectively. This manual is designed to be used along with an instructor; however, you will need to do a lot of reading as well, in order to fully understand CATIA Version 5. The exercises in this book will list steps for you to complete, along with explanations that try to inform you what you have just done and what you are getting ready to do. The actual steps are in bold type and the information that follows the steps is for your benefit. Anything that appears in *italics* refers to a message CATIA provides—this includes information in pull-down menus, pop-up windows and other messages.

An example of a step and its explanation is shown below (note: normally the lines will not be there):

---

**Select a location to the right of the origin.** This specifies the other end point of the line. You will continue specifying locations in order to complete your profile. It should appear similar to the diagram shown below.

---

As you can see, the desired action blends in with the text except that it appears in bold. The information following the step explains what that step accomplished and where you are going next. It is important to read this information in order to better your understanding of CATIA Version 5.

Also, you will find that the exercises build upon themselves. Later exercises often assume you know how to do certain steps which have been covered earlier in the course. If you did not quite pick up what you needed to know from an exercise, you will probably want to review it several times before moving onto more advanced sections. The advanced sections assume that you have a good understanding of the previous sections therefore fewer steps will be provided. Eventually, you are expected to be able to create parts without any steps.

## Tubing and Piping design

The Equipment and Systems solution demonstrates how complex models can become within CATIA. Within this solution there are rules and checks that are automatically performed. These checks will make sure that parts will fit, or that the appropriate bend radius is being used, and can automatically add parts like washers and gaskets. The idea is not just to create compatibility within a tubing system, but to create a tubing design that will work within a global system. For example Pipes are used to deliver water to a home the water will need to go into the water heater and then onto the washing machine to wash clothes. The water heater will be a system all to itself, with water coming in and hot water leaving. The water heater will also need to create heat, the heat can be created with gas or electricity, but an energy circuit will need to be defined. How the water heater works might be designed by an outside company, but the systems going up to it will still need to be designed. Once the water is heated it will then need to go into the washing machine, a flexible tube will need to be designed. with the water in the machine it will then need to be disposed of, a disposal system will need to be designed. To design the water system it could be necessary to use six or more different workbenches (Space Reservation, Piping, Equipment reservation, Electrical Part Design, Electrical Harness Assembly, Tubing, Weld Design...) Before using any of the equipment and systems workbenches it will be helpful to have a good understanding of Part Design, Generative shape design and Assembly Design; and a working knowledge of the Catalog Editor.

This book is limited to the Tubing and Piping portions of the Equipment and Systems solution.

The Tubing and Piping workbenches have many similarities. The icons are very similar and the process used to create a system is practically the same. There is also some overlap between the two for work that needs to be done. For these reasons, they are usually taught at the same time. With the workbenches closely related in design and result, mastering Tubing will make learning Piping very easy.

Working with Tubing and Piping will involve a lot of rules. The rules will be created at different levels. Some of the rules can be worked around while others are created by an administrator and cannot be changed. These rules are meant to speed the design process by narrowing the options available and limiting the amount of rework necessary. You may find the rules to be cumbersome at first, as you get used to what they are doing they can become a useful aide. In this class no rules will be created, the rules that are used are default CATIA.

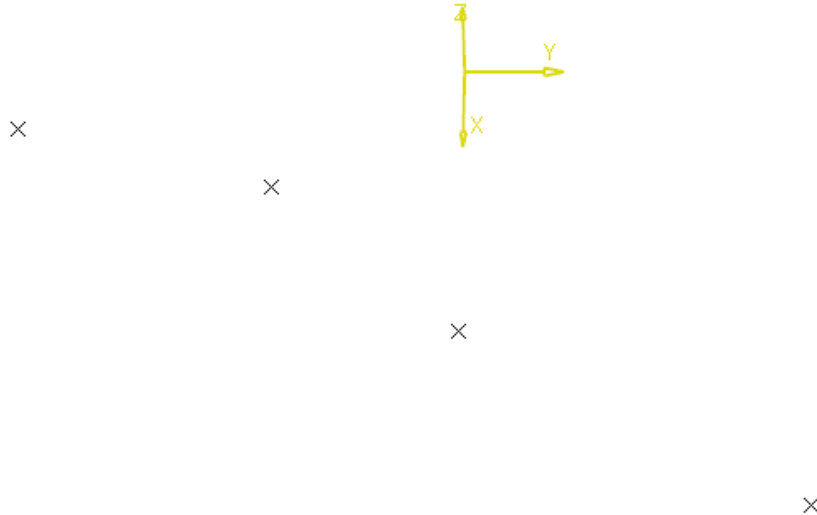
## Basic Tubing

Working with Equipment and Systems will be much different than other solutions in CATIA. There will be times that tubing parts will be placed and then tubes will be created going to them. There will be times that the tubes will need to be placed first and the parts placed along the tube. The thinking is that tubes will be created as the product is designed sometimes there will be frame work to work within other times the tube will be placed and built around. And of course the tubes will have to be modified as the product is revised.

## Routing a Run

To place a tube a run will need to be created. A run is the space reservation for a tube to be placed. The run is NOT a part and cannot be modified outside of the Tubing workbench The run can be the size of the tube or larger to check for clearances. The run will not carry as much information as the tube, making it take less space on the computers active memory and easier to work with. A run can be created between connectors, from a text file, in space, or by a combination of the three. Once a run is created it can easily be modified; control points can be added, turn radius can be resized, and branched off of. The run will carry some of the information for the tube, but the system will not be complete until the tubes are placed. Placing the tubes into a run is similar to placing Tubing parts in a product. This will be discussed later.

**Open the Routing a Run document from the *Routing a Run* directory.** It should appear as shown.

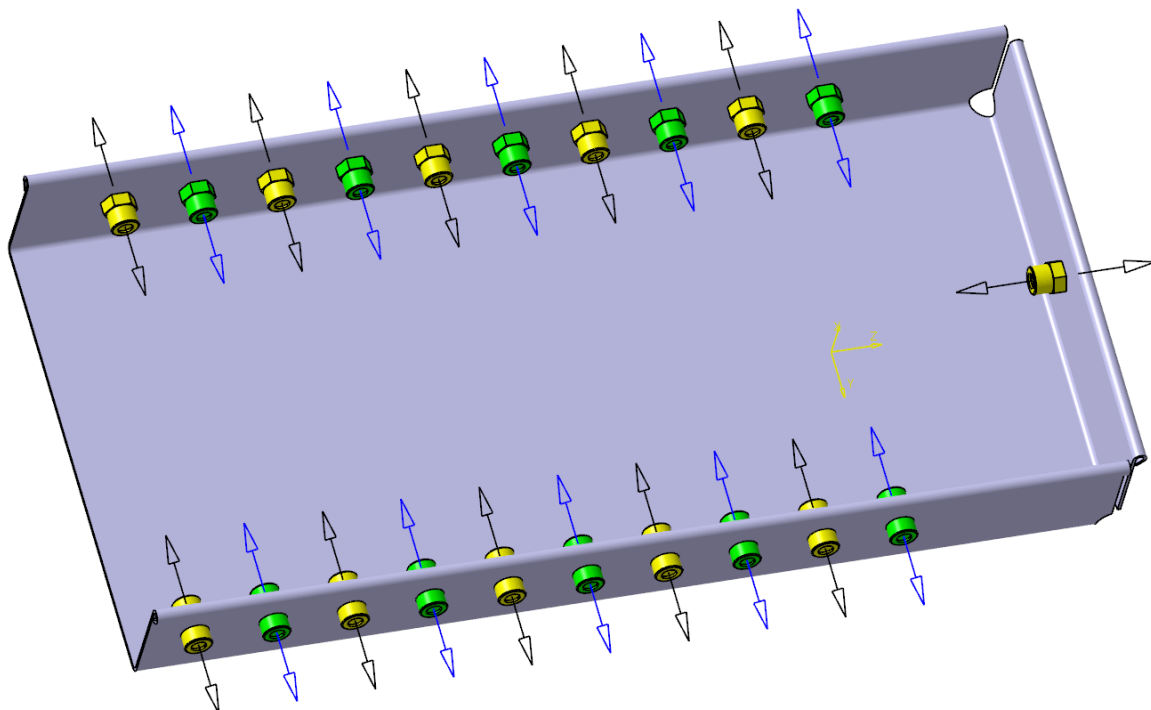



**If not already there, switch to the Tubing Design workbench.** This will allow you to do all things tube. It is available under the *Equipment & Systems* solution and the *Tubing Discipline*.

## Flexible Tube Routing

Routing flexible tubes is similar to bendable tubes in the way the connection is made. However, flexible tubes do not use a run as space reservation. Since there is no run to place a tube into, the material or type of tube that is being created will be selected during the routing instead of afterwards. Routing a flexible tube can be done in space, or between connectors; flexible tubes can be placed on top of a surface, or on top of each other. Flexible routing will also allow two different solving modes for the route. The use of a standard algorithm creates a spline, while a flex algorithm can be used to make the tube routing more accurate with respect to the flexibility of the tube.

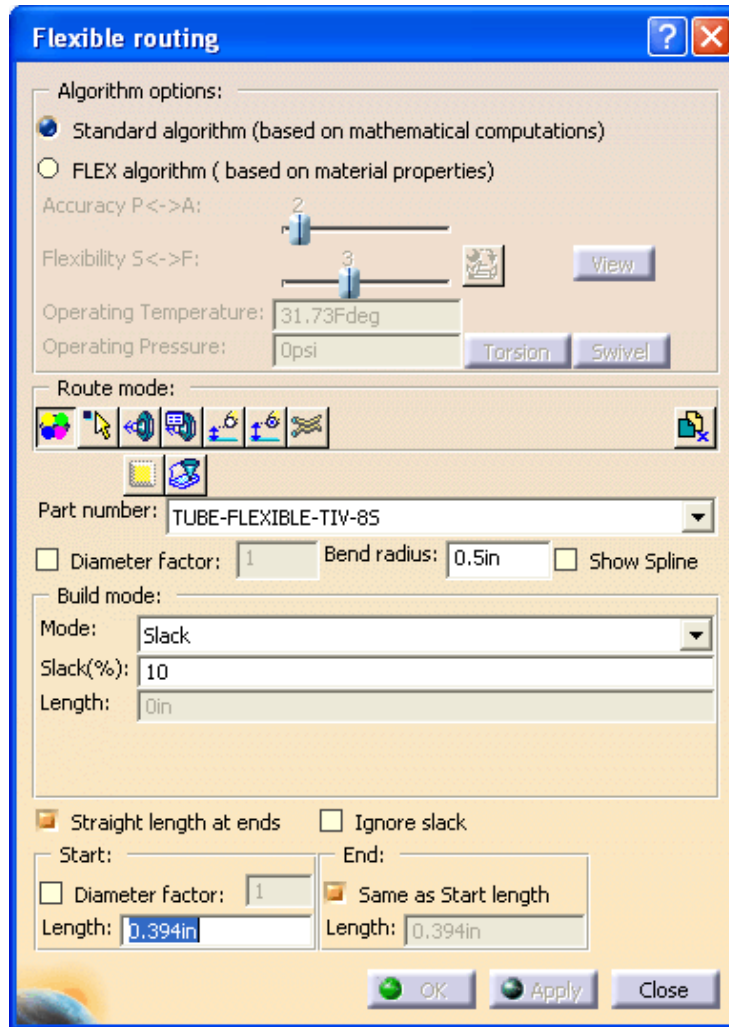
**Open the Flexible Tubes document from the *Flexible Tubes* directory.** It should appear as shown.



**Define a 0.5 inch Line ID with the Select/Query Line ID icon.**  You will now create a number of flexible tubes utilizing the different options available.



Select the Flexible Tube Routing icon.  The Flexible Routing window appears.



*Standard algorithm*

Specifies the flexible tubes will be created from standard splines

*FLEX algorithm*

Specifies the splines will be created with respect to the flexibility or material properties found in the catalog

*Accuracy*

Modifies the solving mode for computation speed

*Flexibility*

Controls the stiffness of the tube



Uses the material associated with the part

*View*

Opens the properties of the material being used

*Operating Temperature*

Specifies the temperature the tube will be operating at

*Operating Pressure*

Specifies the pressure the tube will be operating at

*Torsion*

Applies a torsion on the tube

*Swivel*

Allows the tube to swivel on the connector

*Route mode*



*Select or Indicate*

Makes routing possible through connectors or the active plane



*Select 3D Point only*

Routes through 3D points



*Select a connector*

Routes between connectors



*Part connector dialog*

Routing can be done through a dialog box for any part that has tubing connectors



*Bottom offset*

Puts the bottom of the flexible a set distance from a specified surface



*Center Offset*

Puts the center of the flexible a set distance from a specified surface



*Follow Tube*

Allows routing along an existing tube



*Change to Schematic mode* Switches to schematic mode



*Spec driven*

Allows you to select the *Part number* based on the specs of the part



*Filter definition*

Allows you to filter the parts

*Part number*

The type of tube that will be created

*Diameter factor*

A ratio used to determine the bend radius

*Bend Radius*

The minimum curvature allowed in the flexible tube before failure

*Show Spline*

Shows the spline the flexible tube is following

*Build mode*

*Mode*

Defines the build mode for the flexible routing

*Slack*

Percent of extra length allowed in the flexible

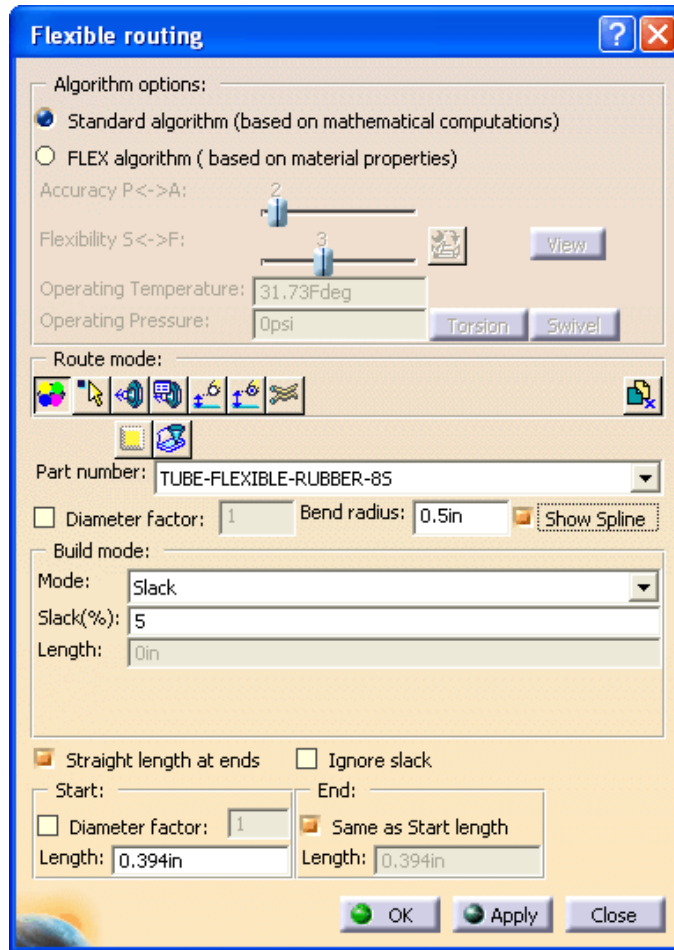
*Length*

Defines the length of the spline

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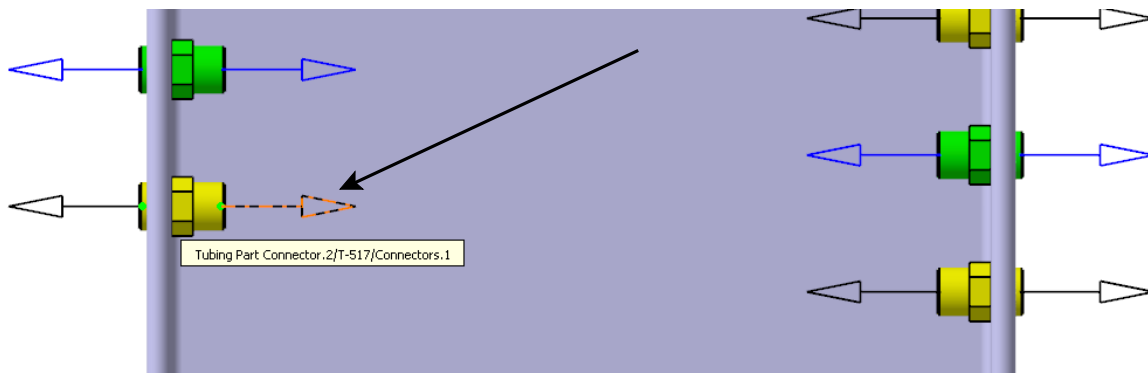
<i>Bend</i>	Creates the flexible with the minimum length spline necessary
<i>Slack(%)</i>	Amount of extra length based on slack
<i>Length:</i>	The straight length of the flexible
<i>Straight length at ends</i>	Defines the distance at the connection that will remain straight before the spline will curve
<i>Ignore slack</i>	Specifies the slack with be ignored for that section
<i>Start</i>	Defines the straight length at the start of the tube
<i>Diameter factor</i>	Specifies the straight length will be related to the diameter of the tube
<i>Length</i>	Defines the straight length
<i>End</i>	Defines the straight length at the end of the tube
<i>Same as Start length</i>	Specifies the end will be the same length as the start
<i>Length</i>	Defines the straight length

Set the **Part number** to be **TUBE-FLEXIBLE-RUBBER-8S**. Turn on the **Show Spline** option and set the **Build mode** to have a **5% slack**. The window should appear as shown. You will use the same settings unless otherwise specified for the rest of the exercise.

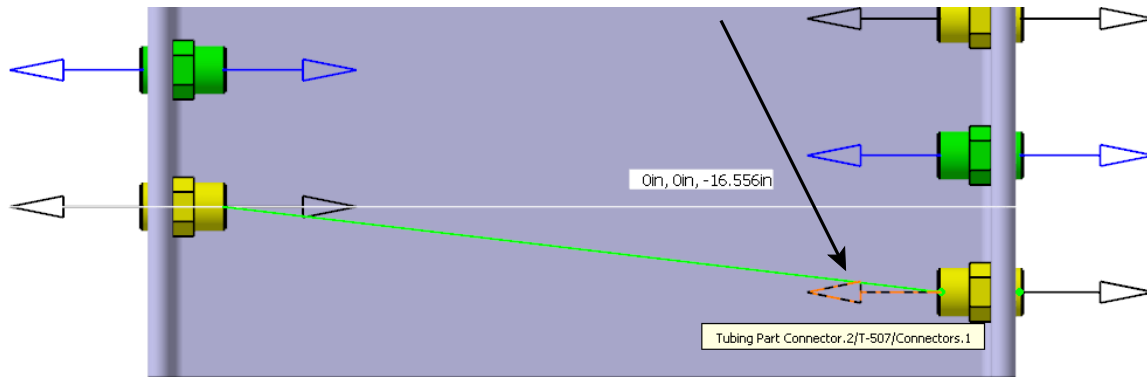


Routing with a flexible tube can be similar to routing a bendable tube in that the routing can be done between connectors.

Select the connector as shown below. Make sure to get the inner connector arrow.

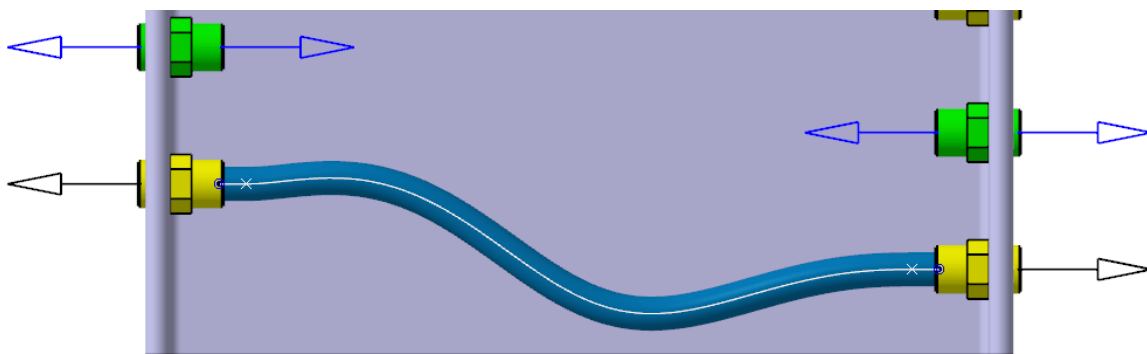


Select the connector on the other side as shown below.



When the second connector is selected, the bundle will automatically be routed. Once the route has been selected it cannot be canceled. It is in the specification tree and will need to be deleted if not satisfactory.

Select **OK**. It should appear as shown below.




This flexible was routed using a standard algorithm. With the standard algorithm there is not as much control but the routing can be performed faster. If the FLEX algorithm is used then the model can get much more complicated by taking into account stiffness, temperature, operating pressure, and gravitational effects.

## Offset from Surface

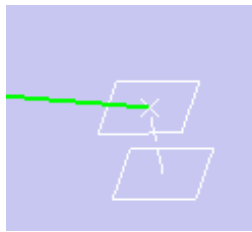
In this section we will cover how to route along a surface or offset from a surface. When routing with surfaces a point will be created at the location selected, if offset a point will be made normal to the surface the specified offset at the location selected. The points can be modified by accessing the part. The spline can be modified by adding tangents or control points the same way.

**Select the Flexible Tube Routing icon.**  The *Flexible Routing* window appears.

**Select the next green connector on the left.**

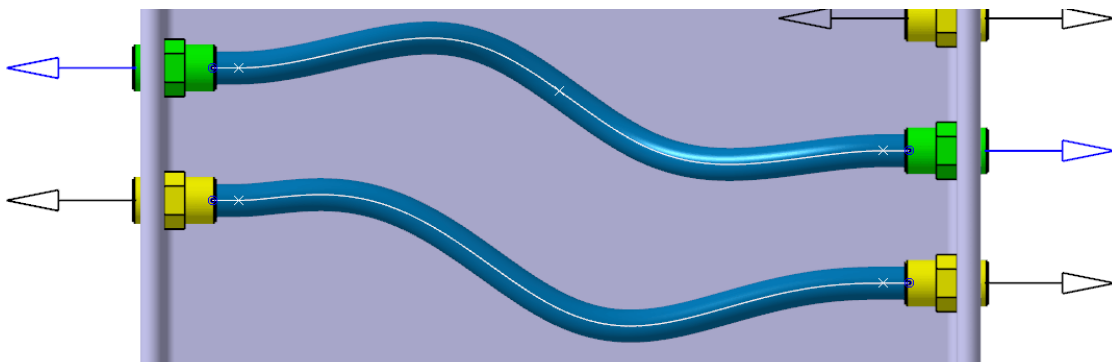
**In the window, select the Center Offset icon to define the *Route mode*.**  This will define an offset between a specified face and the center of the flexible.

**Set the *Offset* to be 0.5.** As you mouse over faces in the display, there will be two planes at the cursor location. The first plane will be tangent to the surface at the point selected. The second plane will be the offset to the center of the flexible being routed.

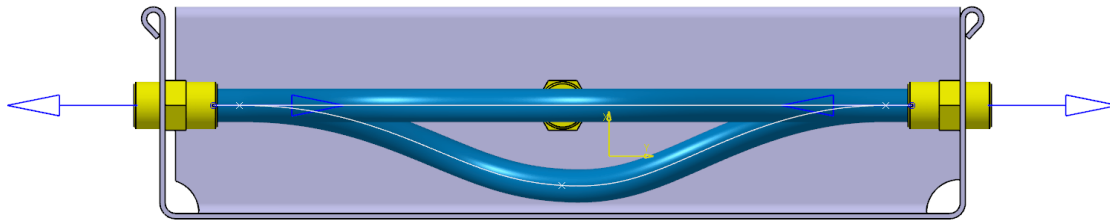


**Select a point about half way between the two connectors.** The offset command will stay active until it is deselected. If a connector is selected, there will be a space created between the connector and the middle of the flexible.

**Select the Select Connector Only icon and select the connector on the other side.**  It should appear as shown.



If you look at a bottom view of the model, you can see that the flexible is offset from the bottom face 0.5in at the location you selected. When putting a point on a surface a tangent direction will not be applied. The point is just a passing point. The tangent direction can be applied later on by going into the definition of the spline.

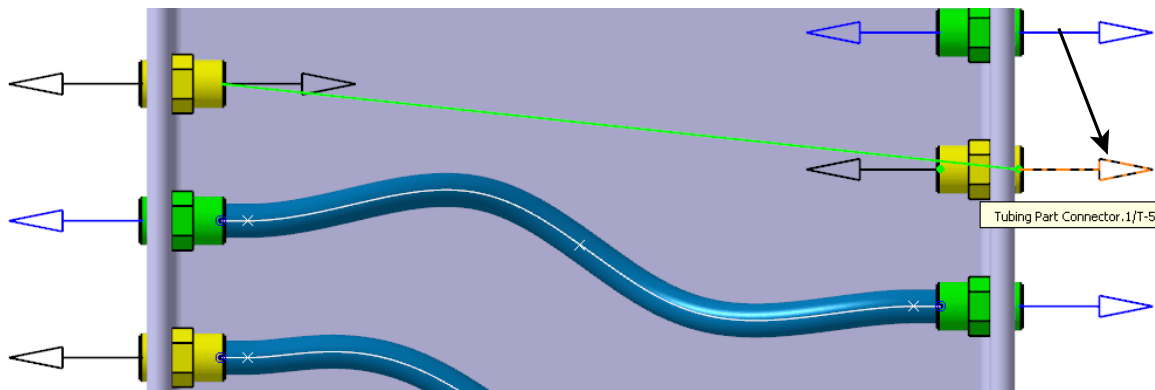


Select **OK**. The flexible tube is created.

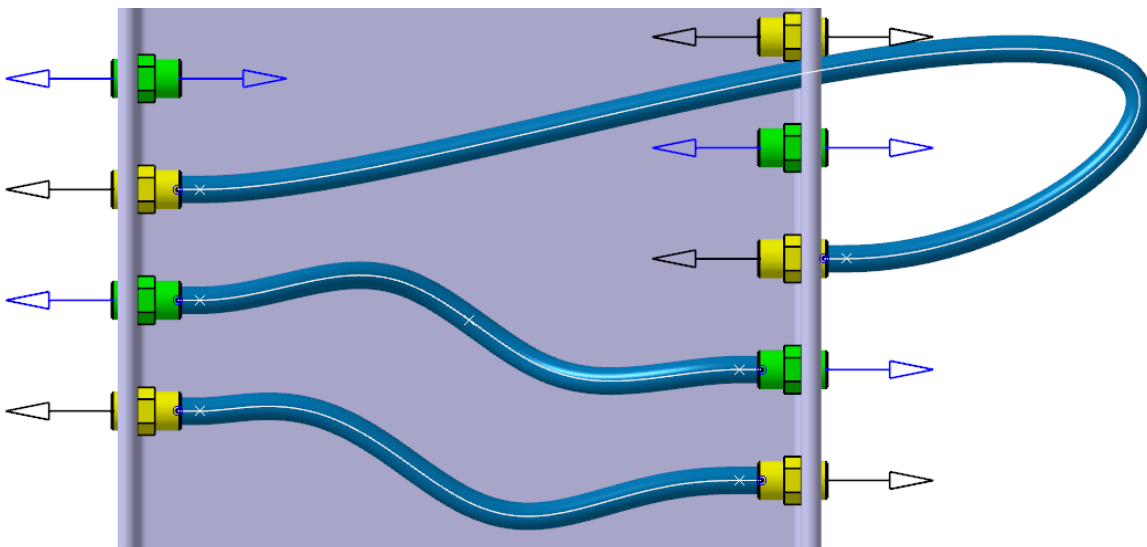
Select the **Flexible Tube Routing** icon.  The *Flexible Routing* window appears.

Select the **third connector on the left**.

Select the next **yellow connector on the right on the outside** as shown below.

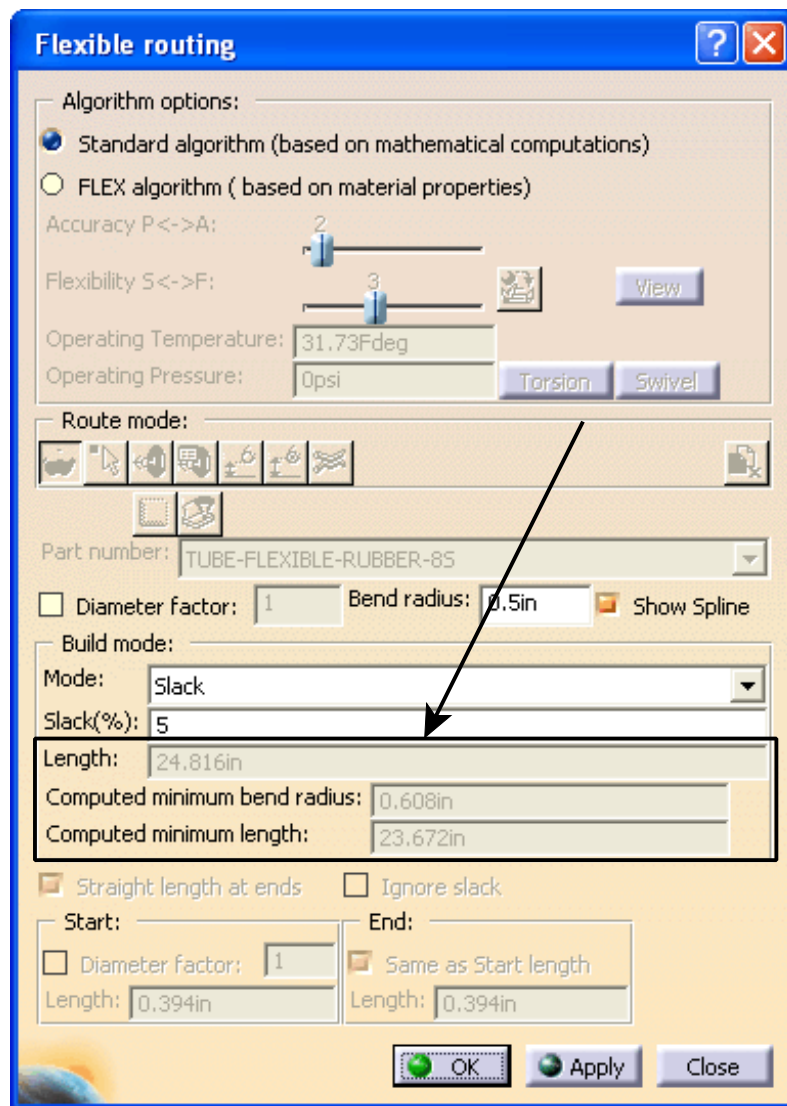


Your flexible tube will go through wall of the tubing box. When routing a flexible tube often the flexible will go through solid parts. Since there are no alternate routes to be selected the routing will be modified after the flexible has been created. If the route should go around an object, then points or routing with an offset will be necessary. Your model should appear as shown below.



The route definition cannot be modified by adding points from this window. If the route needs to go around the tubing box that needs to be done by adding passing points in the spline that is controlling the flexible tube. Notice the sharp curve as the flexible turns around and goes into the connector on the right. That curvature can be problematic as well. By default the flexible will select a minimum curvature that matches the diameter of the Line ID. Currently the routing is done with a 0.5in tube and the bend radius is set to 0.5. The values should be modified before routing if changes need to be made.

The *Flexible Routing* window will change and offer more information once the route has been created. In the *Build mode* section, the *Length* of the flexible is given along with the *Computed minimum bend radius* and the *Computed minimum length*.



These values cannot be modified, but it is still good information to know.

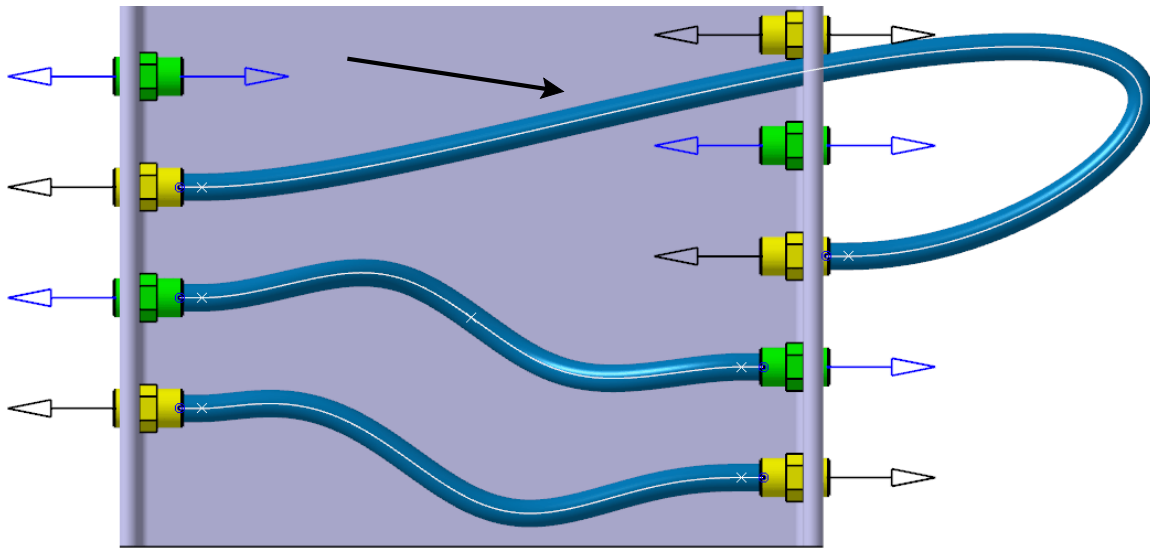
Select **OK**. The tube is created.



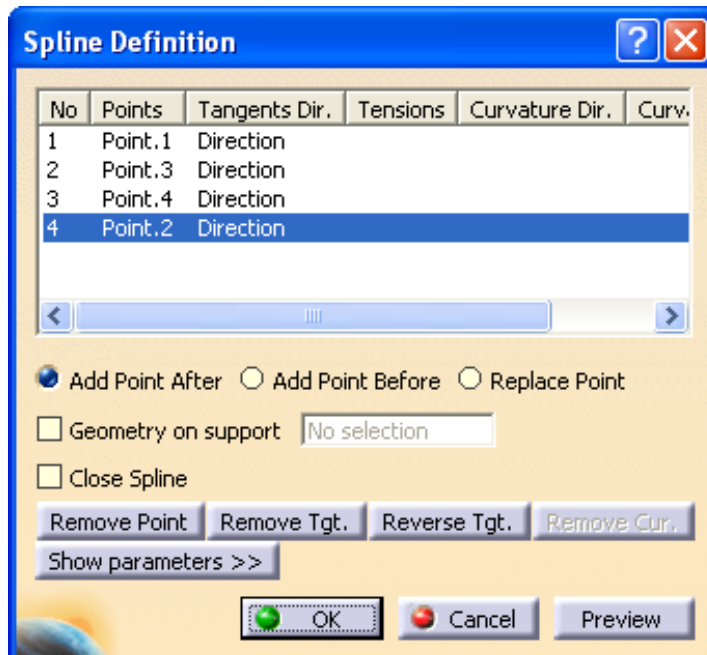
### Routing through predefined points

Since modifying the route cannot be done in the tubing module then modifications will need to be done at the part level. To go around objects using flexibles there are three options the first is to use an offset, second is to route through predefined points, the third option is to modify an existing flexible by adding control points

**Double select on the spline in the flexible as shown.** This will take make the part level active, this will do the same thing as double clicking on the part number in the specification tree.



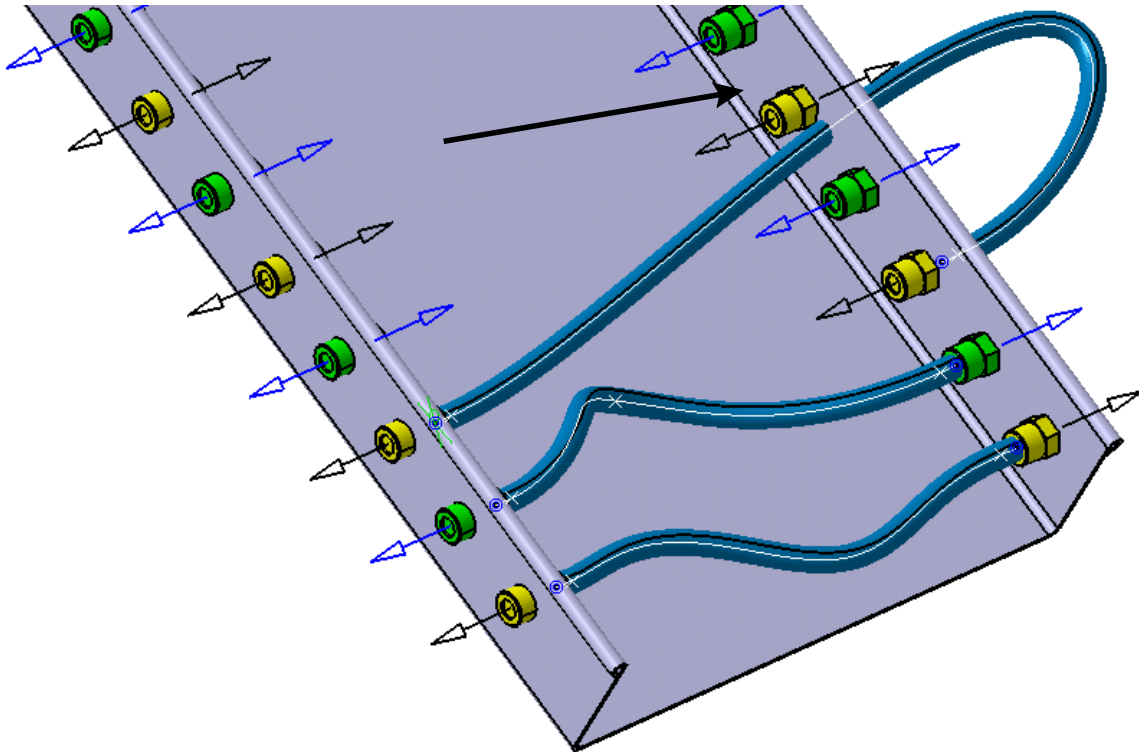
**Double select on the spline again.** This will open the spline definition window.



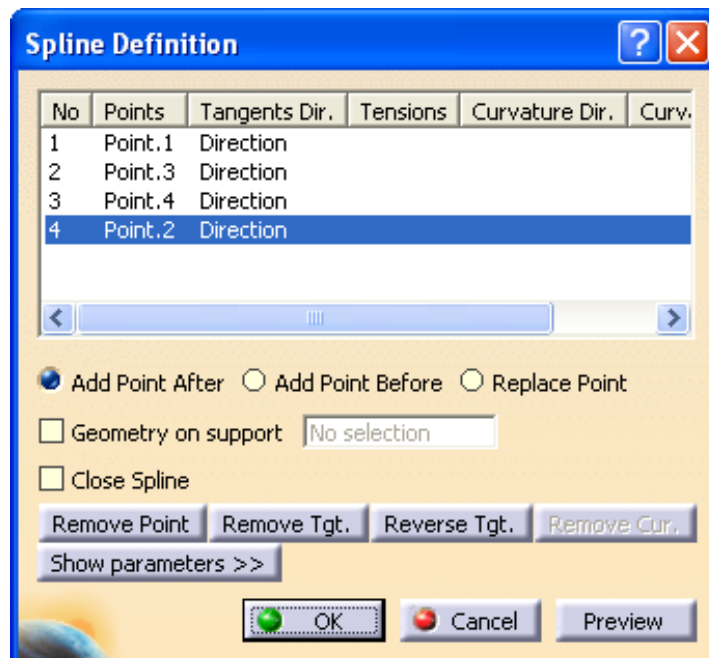
This is the same spline definition window that you would see in wireframe and surfaces. If the route the flexible takes needs to be modified then the spline is what needs to change.

**Select *Cancel*.** Points cannot be added from that window. The passing point that the spline needs to go through will need to be created before the spline can be modified.

**Create a point *On Plane* and select the wall shown the point will be located at H=-5in and V=-13.75in.** This will create a point directly above the connector.



**Double select on the spline again.** The spline definition window will appear.

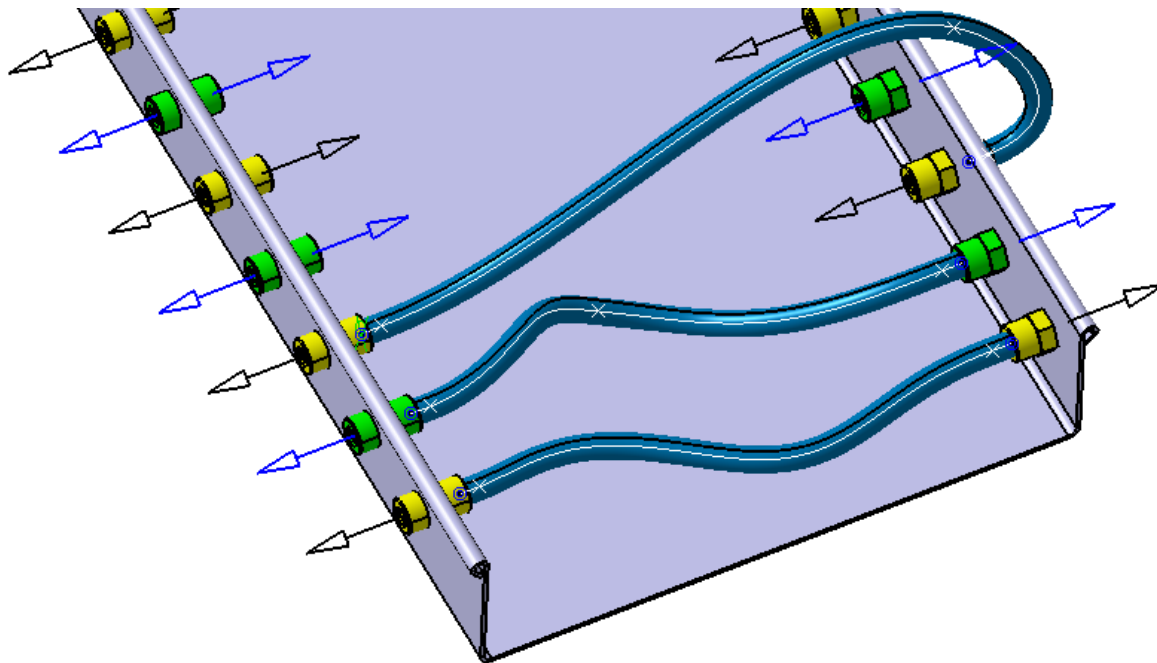


When routing flexibles there will be a straight length at the ends by default. This option creates a minimum straight distance between the flexible and the connector and will be investigated further later on. Right now it is important to be aware of so that the new routing point can be placed correctly. The minimum straight distance is a passing point that is a defined distance normal to the connector. Which means anytime a flexible is routed up to a connector two routing points will be used.

**Select the third point down and select the *Add Point Before option*.** This will place the point before the straight length going into the last connector.

**Select the point that was created.** This can be done from the graphical workspace or the specification tree. The route will update when the selection is made.


**Select *OK*.** Your model should look as shown.



**Double select on the Flexible Tubes product.** This will make the product level active so that you can continue tubing.

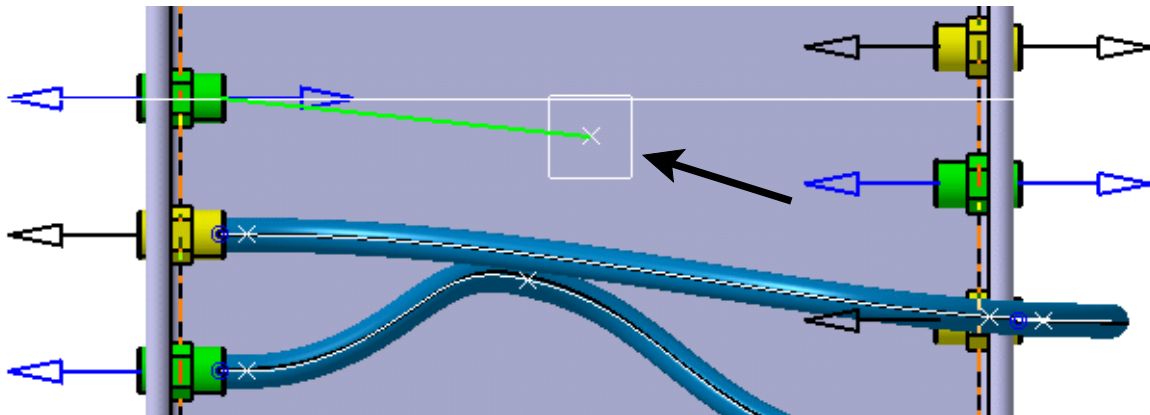
**Select the Flexible Tube Routing icon.**  The *Flexible Routing* window appears.


**Select the next connector on the left on the inside.**

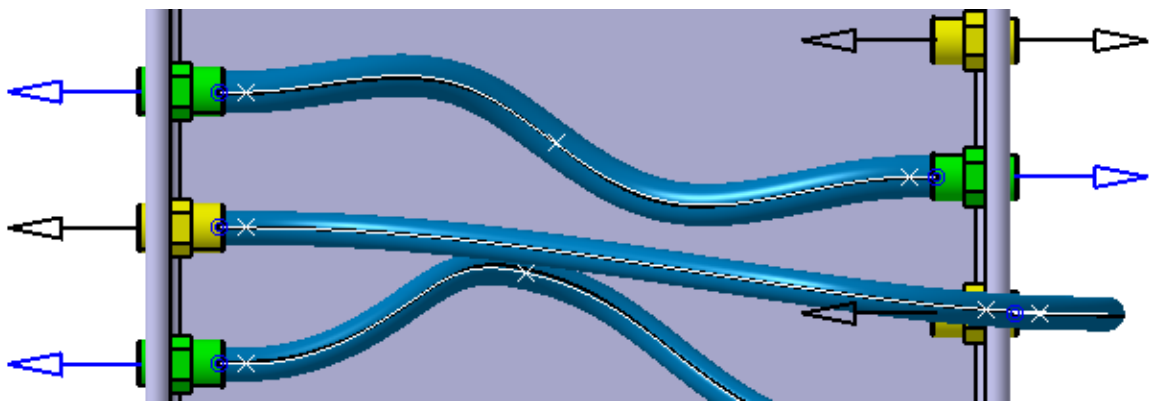
**In the *Flexible Routing* window, select the Bottom Offset icon.**  This option is very similar to the Center Offset icon, but this will offset from the bottom of the tube instead of the center.

**Set the *Offset* to be 0.25in.**

Select the location shown below. Make sure not to select the spline of the other flexible tube since this will change the direction of the offset.



Select the Select or Indicate icon and select the green connector on the right.  The model should appear as shown below.



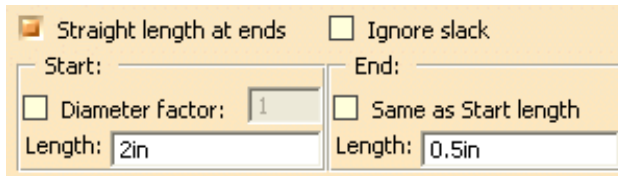
The Flexible will be routed so that the bottom of the flexible is .25in from the surface at the location selected. Since the flexible is following a spline you will want to pay close attention to the spline definition, adding points on a spline can cause the curve around the spline to be lower than the point selected.

Select **OK**. The tube is created.

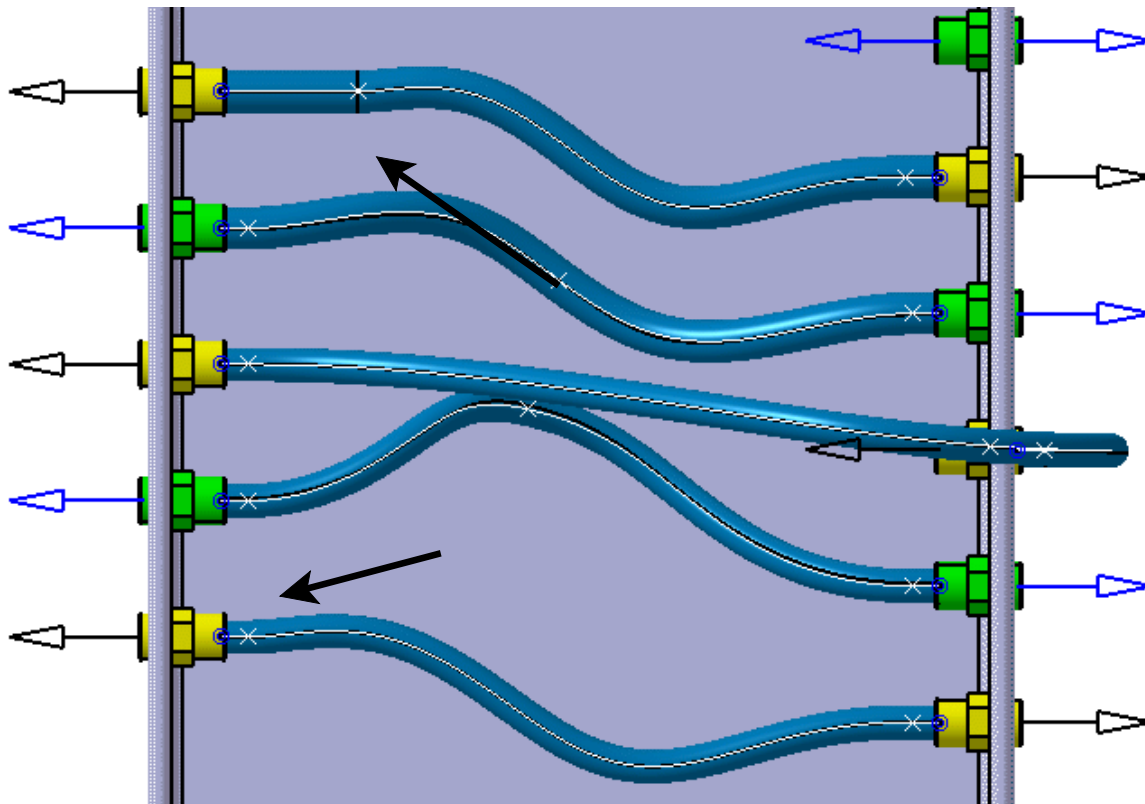
Select the Flexible Tube Routing icon.  The *Flexible Routing* window appears.

At the bottom of the window change the Length for the Start to be 2.0. This will specify that the tube must have a 2 inch straight section at the first connector.

Turn the *Same as Start length* option off and set the Length value to 0.5. The definition window should appear as shown.



Select the next yellow connector on the left and the next yellow connector on the right. Take a second to compare the first flexible routed to the last flexible routed.



Both tubes look very similar but their start and end segments differ. Later we will compare the curves that make up these two tubes to see what their exact differences are.

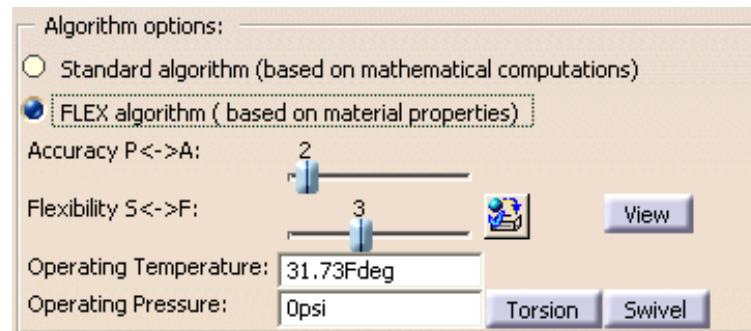
Select **OK**.

## FLEX algorithm

Tubes will flex differently based on the material properties of the materials in them. The change in flexibility can effect design. When modeling with the Flex algorithm the model created will more closely resemble what the properties for that type of tube would result in. When using the FLEX algorithm flexibility can be modified by the flexibility slider or by applying a material.

Select the Flexible Tube Routing icon.  The *Flexible Routing* window appears.

Select the **FLEX algorithm** option. With this option selected the *Accuracy* and *Flexibility* sliders will become available along with some additional options.

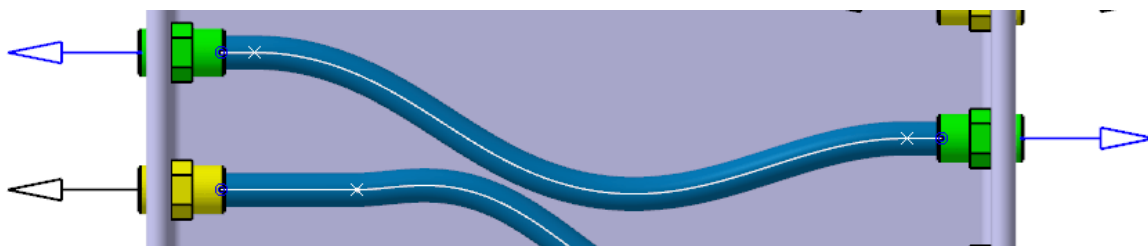


The flex algorithm incorporates quite a bit of knowledge into the flexible tubes that are routed. This extra knowledge is an attempt to make the flexible tube as accurate to the actual tube as possible. With the *FLEX algorithm* turned on, the tubes will be built with respect to a selected gravity as well as a defined operating temperature and pressure. You may also specify that the tube swivels or be in torsion with the connectors.

Slide the *Accuracy* slider all the way to the right and set the *Flexibility* slider to be 4.

Change the *Straight length at ends* to be 0.5 for both ends.

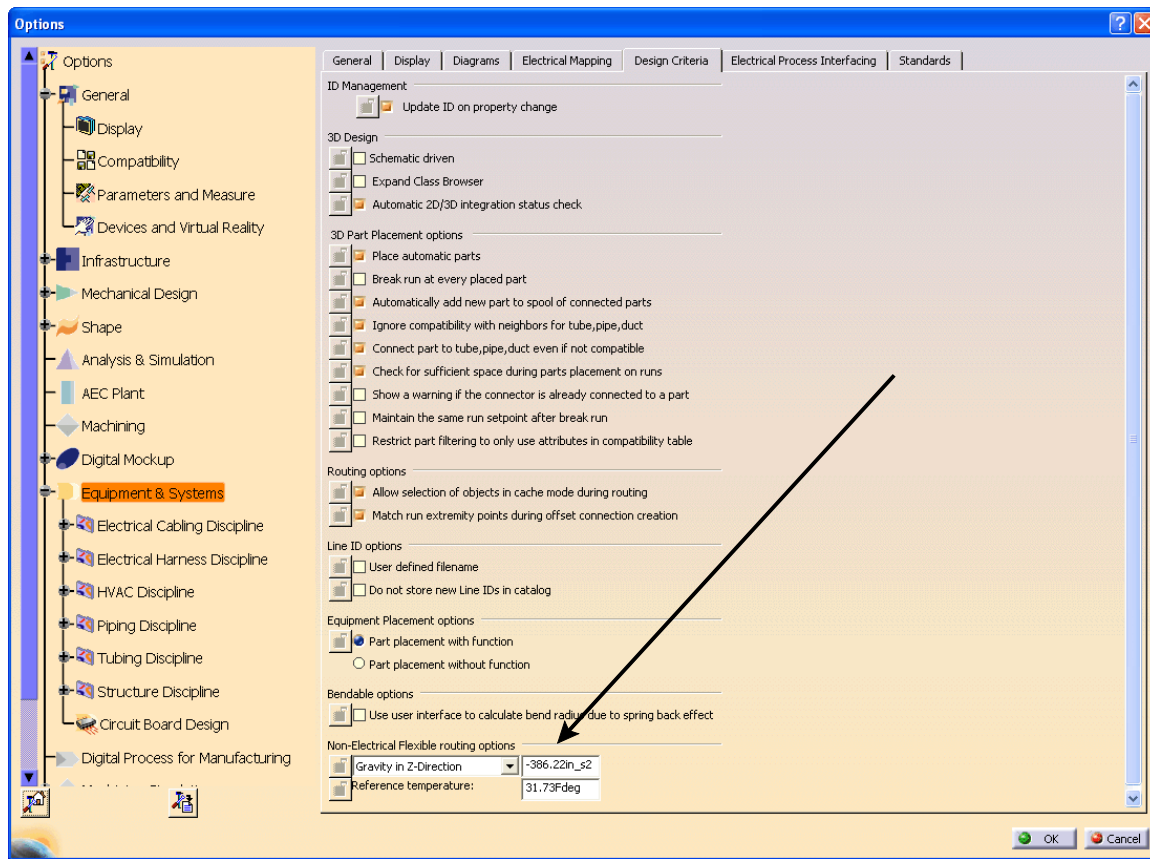
Select the next green connector on the left and the next green connector on the right. The run will be created and will look different than the first one. The parameters are all the same but the FLEX algorithm provides a different solution.



Select **OK**.

Under the *Tools* pull down menu select *Options*. Then select the *Equipment and Systems* branch and the *Design Criteria* tab. At the bottom are the flexible routing options.

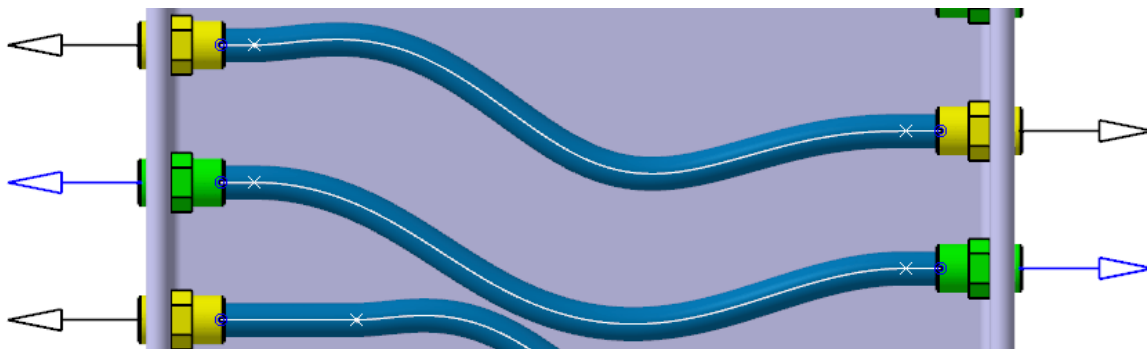




Select the *Gravity in Y-Direction* option.

Select **OK**. The flexible that was created before the gravity was changed will not change unless it is updated. The change in gravity will not be noticed until a new flexible is created.

Create another flexible tube in exactly the same manner as the last one using the next set of yellow connectors. It should appear as shown.

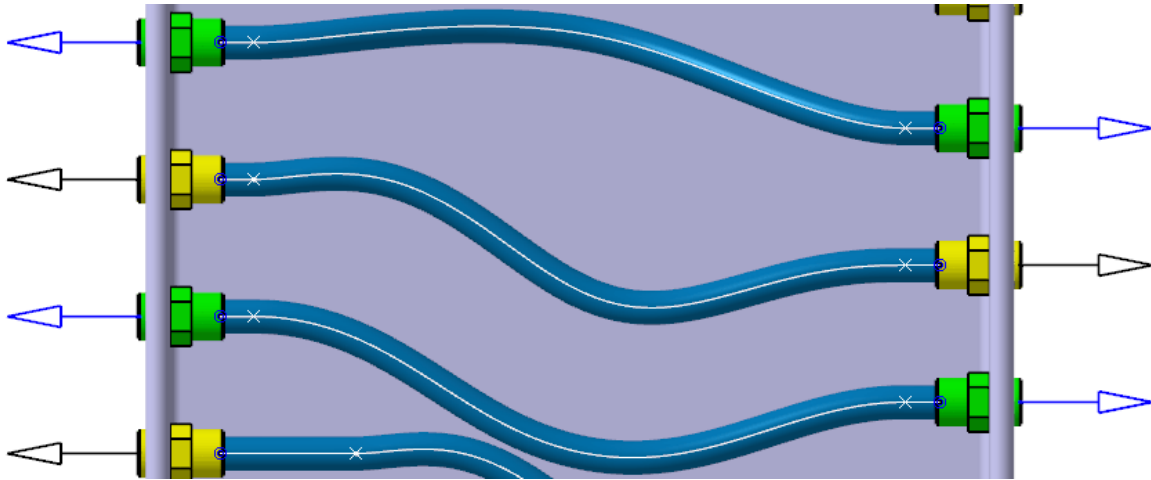


The difference is not very noticeable but the change or direction of gravity did affect the new tube.

Select **OK**.

Go back to *Tools, Options* and change the gravity to be in the **x**-direction.

Create another flexible tube between the next two green connectors using the same parameters as the last two. This time there is a noticeable change.



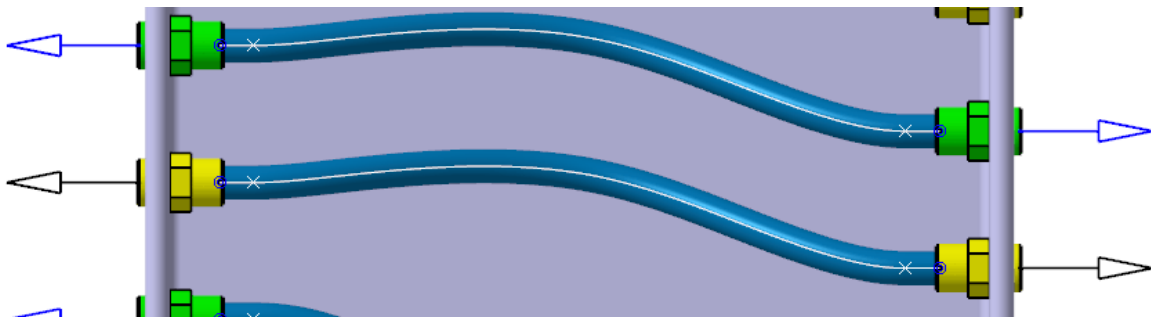
The tube is laying in the negative x direction. If the tube was supposed to hang in the positive direction then the value for gravity would need to be positive.

Select **OK**. The tube is created.

In the specification tree, press the right mouse button on the flexible that was created with gravity in the y-direction. This will be the last flexible between yellow connectors. The selection will need to be done in the specification tree to get the correct menu.

Select the *FlexTube-XXX.object* then select **Definition** from the contextual menu. The *Definition* window should appear. The second tube from the top should also be highlighted.

Select **Apply**. The flexible will be updated using the gravity in the x-direction.



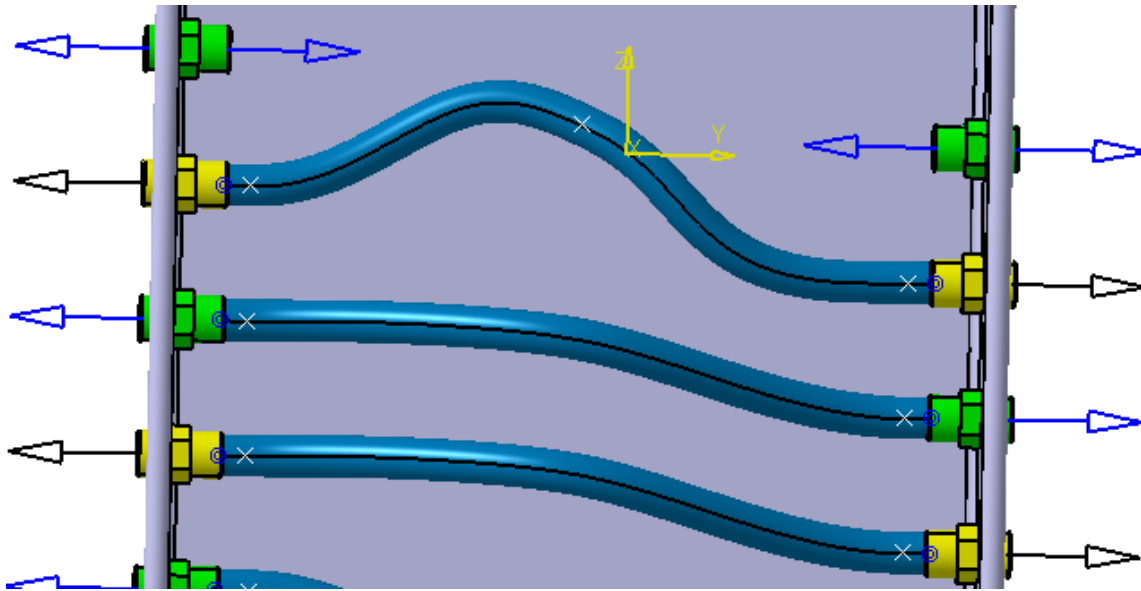
Select **OK**.

Select the Flexible Tube Routing icon.  The *Flexible Routing* window appears.

Switch back to *Standard algorithm*.

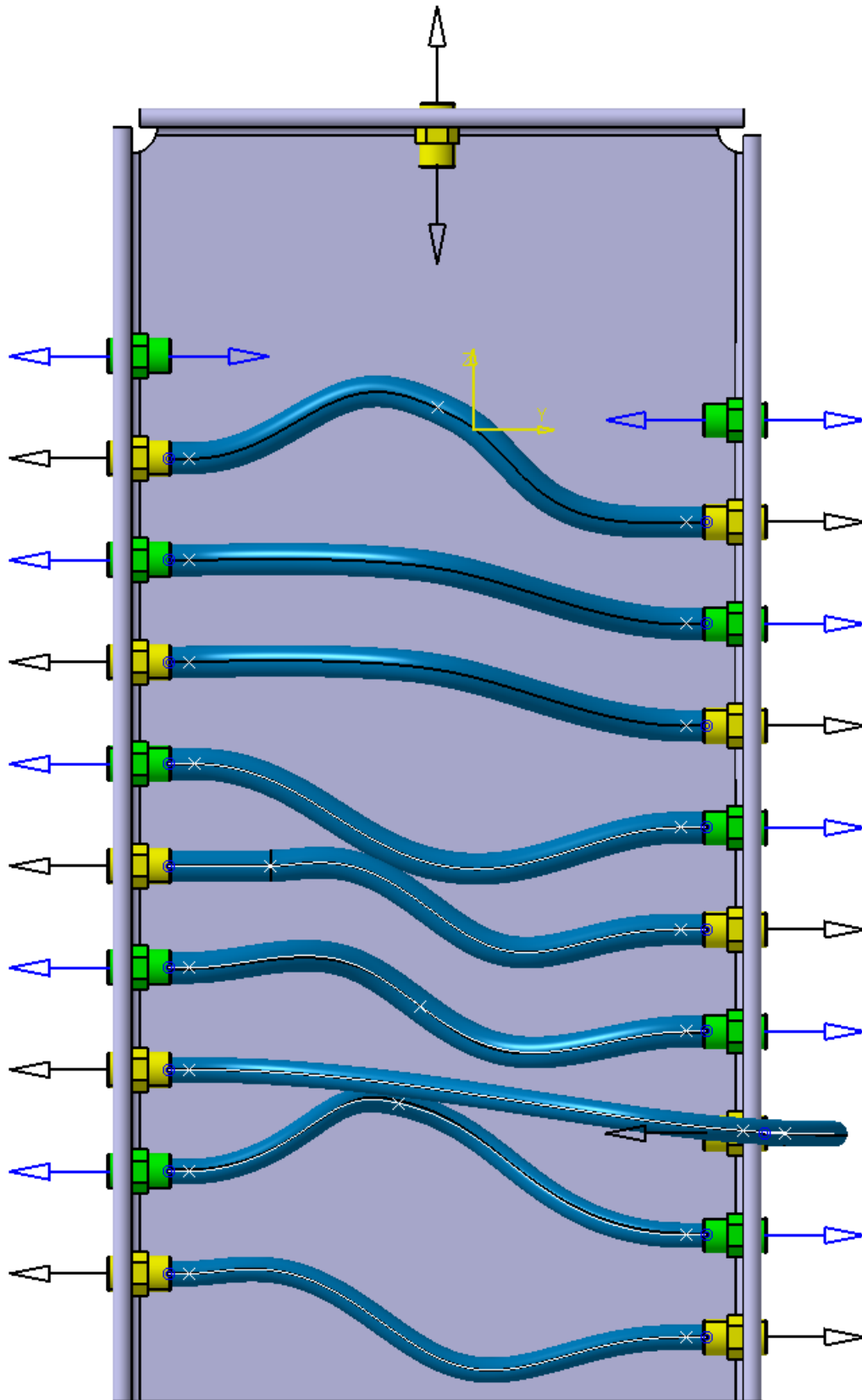
Select the yellow connector on the left then the point in the middle and the yellow connector on the right. Your model should look as shown.





Passing points can be used for routing. Flexibles work differently than bendable tubes. When using flexibles the route keeps a link to the points. If the point moves the run will need to be updated and will show the changes. This will also create external references which are important to keep track of.

Your model should look like this.



Save and close your document.