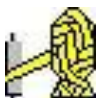
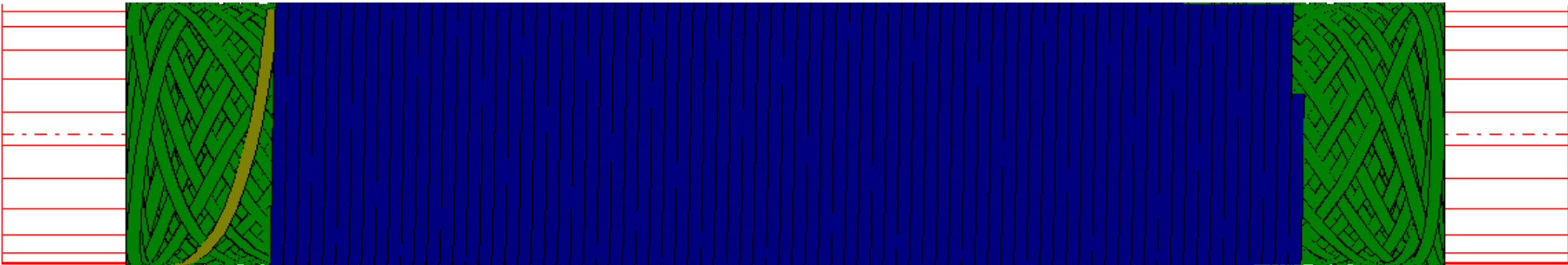


Cadfil – Pipe Winder

Overview

The Cadfil Pipe winding software is designed for higher angle winding (40-90 degrees) on pipes and is ideal for use on 2 axis winders. When Pipe-Winder is included as part of a higher specification package (e.g. Cadfil-Lite) then more machine axes may be available. Pipewinder+ consists of parameter programs Pipe, Multi-Pipe, Hoop, Multi-hoop and Pipe Join paths. This document describes Multi-pipe use. The PipeWinder package includes full post-processing and 3D simulation options.

Multi-layer and angle winding patterns can be quickly generated with both hoop (90 degree) and helical winding. Pipe winding is not suitable for low angles (less than 30 degrees) as this involves winding over an end-cap. For such applications Cadfil-Lite is more suitable. The thickness of the winding and winding times are automatically calculated. Each layer makes allowance for the thickness of the previous winding to ensure band pattern and fibre angles are always optimum. For each layer the 'turning length' at the end where with winding angle is changing for the turning around is automatically calculated. For some applications this length is considered as waste as it is cut away after winding.



Pipe Winder Data Entry sheet

Quick-CAD
— □ ×

Multi-Layer Pipe Winding

Cylinder Radius

Clearance Radius

Fibre Band Width

Band Thickness t0

Start Position (from Chuck/Ref.

Total Length of Winding

Friction Coefficient e.g.0.2

Mandrel Rotation +1/-1

Open

Save

Save As

Exit

Help

Calculate (Update)

Add Layer

Delete Layer

Insert Layer

Material Data

Generate NC Data

UNITS

Fibre

Resin

Number of Rovings

Volume Fraction

Calculate Constant 'Good' length

Layer Number	Hoop/Helical	Start Pos Offset	End Pos Offset	Number of Repeats	Wind Angle	% Cover	Machine FeedRate	Circuits per Layer	Band Pattern	Dwell at each End	Wind Time (Minutes)	Waste Length	Good Length	Total Length	Minimum Position	Maximum Position
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Final Thickness

Final Diameter

Total Wind Time



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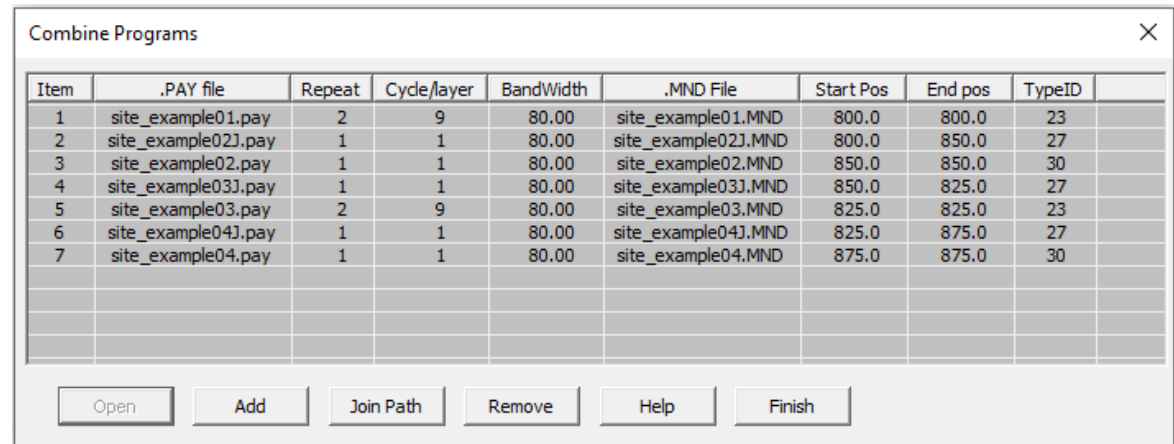
Cadfil- Pipe Winder

Page 2 of 9

Creating a program with pipe-winder is simple. There is a single window dialog box (data entry screen) shown on the previous page of this document. The steps for program generation are:

- 1) Enter the **'Header'** Information – Basic information such as mandrel diameter and the fibre band width that is constant for each layer.
- 2) Click The **'Add layer'** button to activate a new layer. Enter the data specific to that layer such as winding angle etc.
- 3) Click 'Add layer' to add the next layer. Layers can be deleted using the **'Delete layer'** button or a new layer can be inserted part way through the sequence using the **'Insert Layer'** button. In both these cases the **'layer number'** in the left most column is used to select where to insert or delete a layer. The data entry form allows for 10 separate layers. If more are required a second pipe winding can be made using the initial 'mandrel radius' as the final mandrel radius after the first 10 layers.
- 4) Click the **'Calculate (update)'** button to fill out calculated values in the data table. You will be asked to save the data and must give a file name. Error messages will be given if data is incorrect or missing. You must correct the data.

5) After a successful **'Calculate (update)'** the **'Generate NC-Data'** button becomes active, click this to generate the complete winding program, after NC generate the wind times are added to the table. You get an option to view the program in the default text editor (normally notepad).



The screenshot shows a window titled "Combine Programs" with a close button (X) in the top right corner. The window contains a table with the following data:

Item	.PAY file	Repeat	Cycle/layer	BandWidth	.MND File	Start Pos	End pos	TypeID	
1	site_example01.pay	2	9	80.00	site_example01.MND	800.0	800.0	23	
2	site_example02J.pay	1	1	80.00	site_example02J.MND	800.0	850.0	27	
3	site_example02.pay	1	1	80.00	site_example02.MND	850.0	850.0	30	
4	site_example03J.pay	1	1	80.00	site_example03J.MND	850.0	825.0	27	
5	site_example03.pay	2	9	80.00	site_example03.MND	825.0	825.0	23	
6	site_example04J.pay	1	1	80.00	site_example04J.MND	825.0	875.0	27	
7	site_example04.pay	1	1	80.00	site_example04.MND	875.0	875.0	30	

At the bottom of the window, there are six buttons: "Open", "Add", "Join Path", "Remove", "Help", and "Finish".



Cadfil – Pipe Winder Data Entry ‘Header’ Information

Quick-CAD

Cylinder Radius	200.000	Open
Clearance Radius	230.000	Save
Fibre Band Width	1.000	Save As
Band Thickness t0	1.016	Exit
Start Position (from Chuck/Ref.	1250.000	Help
Total Length of Winding	4500.000	Calculate (Update)
Friction Coefficient e.g.0.2	0.100	
Mandrel Rotation +1/-1	1	

Mandrel and machine clearance data

Fibre band data. The thickness updates for each layer to keep the winding angle accurate

Data that is constant for each layer

Get saved data from a file.

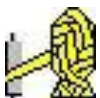
Save new or modified data to a file

Cylinder radius is the radius of the mandrel at the start of winding, radius being half the diameter.

Clearance Radius is the distance of the payout head (fibre comb or similar) from the mandrel rotation centre, with a mandrel radius of 100mm and clearance radius of 150mm the machine payout head will be 50mm (150-100) from the surface of the mandrel. For machines with more than 2 axis this position can be set automatically in the NC code. For 2 axis machine this must be set manually or a value that is possible (or fixed) on the machine must be entered. If the machine is a large distance from the mandrel accuracy will reduce (variation in wind length and band structure). For large mandrels (more than 1m diameters) a surface clearance of 250mm (10 inches) is OK. For small mandrels (<300mm diameter) a surface clearance of 50-75 mm (2-3 inches) is OK.

Fibre band-width is the true width of the fibres band as it lays onto the mandrel, if you considered it as a tape.

The band thickness is the thickness of the fibre band as it lays down on the mandrel considered as a tape. One way to measure is make a single layer of hoop and the band thickness is half the increase in mandrel diameter.



Cadfil – Pipe Winder Data Entry ‘Header’ Information

Quick-CAD

Cylinder Radius	200.000	Open
Clearance Radius	230.000	
Fibre Band Width	1.000	Save
Band Thickness t0	1.016	
Start Position (from Chuck/Ref.	1250.000	Save As
Total Length of Winding	4500.000	Exit
Friction Coefficient e.g.0.2	0.100	Help
Mandrel Rotation +1/-1	1	Calculate (Update)

Mandrel and machine clearance data

Fibre band data. The thickness updates for each layer to keep the winding angle accurate

Data that is constant for each layer

Get saved data from a file.

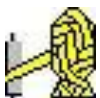
Save new or modified data to a file

Start position. This is the position along the machine carriage where the winding will start. It is measured from a fixed position often the machine chuck face or headstock. This reference is set up in the post-processor configuration file. Your machine supplier or software supplier should be able to advice/or set up this file.

The **total length of winding** is exactly what it says. This included any turning length so if you need a length of tube with an exact wind angle all the way along it you will need to use a longer wind length to allow for the turning length. The waste is automatically calculated. So if you want say 2000mm at 45 degrees enter this data and 'calculate'. If the waste length is given as 200mm then increase the total length of winding to 2200mm. If a negative length is used the winding will start in the negative direction of the carriage, so the start position must be specified to suit this, there is a diagram later in this document. If the new "Calculate constant good length" box is ticked Cadfil finds the layer that has the longest turn (waste) length and then using the total wind length from the header data calculates the 'good' length. Then for all the other layers the length becomes the turn length plus the good length.

The friction coefficient is used to calculate the turning area. Cadfil supplies a default value but this can be changed by the user. If friction is increased the tuning lengths get shorter but if too high a value is used the fibres will slip. Typically a value of 0.1-0.2 is used.

Mandrel rotation +1/-1 is the direction the mandrel rotates, a value of +1 (default) give positive(+) mandrel rotation, -1 gives negative (-) mandrel rotation.



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Cadfil- Pipe Winder

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Layer Data Explained

Layer sequence numbers: up to 10 layers per form can be entered.

Wind angle calculated from band width automatically for hoop winding.

Cover factor is 100% by default but the user can override it here. This can be used to 'adjust' the band width. If a cover factor of 200% is used, the programmed bandwidth will halve so the bands will overlap. For a cover factor of 50% the winding will have gaps. During winding the bandwidth may be slightly different for different wind angles so the user can adjust here.

Layer Number	Hoop/Helical	Start Pos Offset	End Pos Offset	Number of Repeats	Wind Angle	% Cover	Machine FeedRate	Circuits per Layer	Band Pattern	Dwell at each End	Wind Time (Minutes)	Waste Length	Good Length	Total Length	Minimum Position	Maximum Position
1	<input checked="" type="radio"/> <input type="radio"/>	427.4	427.4	1	88.632	100.0	10000.0	1	0	0.0	0.0	3.0	3642.2	3645.2	1677.4	5322.6
2	<input type="radio"/> <input checked="" type="radio"/>	0.0	0.0	1	55.000	100.0	5000.0	24	11	2.2	0.0	857.8	3642.2	4500.0	1250.0	5750.0
3	<input checked="" type="radio"/> <input type="radio"/>	427.4	427.4	1	88.637	100.0	10000.0	1	0	0.0	0.0	3.0	3642.2	3645.2	1677.4	5322.6

Offset calculated from 'Waste length' in order to give constant 'Good' length.

Each layer can be repeated a number of times. For 'hoop' 1 layer is a single machine traverse, use 2 for a double layer that comes back.

The machine speed can be changed for each layer. A default value is applied but can be overridden.

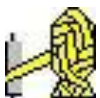
Automatically generated data when the 'Calculate' button is clicked.

New layers can be made using the add/insert buttons or deleted with the delete layer button. The data items are described below.

Hoop/Helical Buttons. Each layer is either hoop or helical. If hoop is selected the wind angle will be calculated to give a helical lead of one band width. If you wish the Bands to overlap or gap for a hoop winding use the 'cover factor' parameter. Helical winding creates a +/- layer at the wind angle specified by the user.

Number of repeats allow the layer to be repeated a number of times. For example with a helical winding setting 3 gives 3 +/- layers. It is not good to set the number of repeats to high numbers as the mandrel radius increases with each layer and the wind angle will thus change slightly with each repeat layer. Eventually gaps will start to appear between the bands. This effect is more pronounced if the mandrel has a small diameter as the change in thickness with each layer will be proportionately more. For hoop winding each layer is a single traverse if an odd number is specified i.e. 1,3,5 the next layer will start at the other end of the winding length.

Wind angle is the helical angle in degrees, 0 is axial 90 is circumferential (hoop). For simple pipe winding (no end caps) angles below 40 degrees are not advisable as the turning length (waste) increased dramatically.



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Cadfil- Pipe Winder

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Layer Data Explained

Layer sequence numbers: up to 10 layers per form can be entered.

Wind angle calculated from band width automatically for hoop winding.

Cover factor is 100% by default but the user can override it here. This can be used to 'adjust' the band width. If a cover factor of 200% is used, the programmed bandwidth will halve so the bands will overlap. For a cover factor of 50% the winding will have gaps. During winding the bandwidth may be slightly different for different wind angles so the user can adjust here.

Layer Number	Hoop/Helical	Start Pos Offset	End Pos Offset	Number of Repeats	Wind Angle	% Cover	Machine FeedRate	Circuits per Layer	Band Pattern	Dwell at each End	Wind Time (Minutes)	Waste Length	Good Length	Total Length	Minimum Position	Maximum Position
1	<input checked="" type="radio"/> <input type="radio"/>	427.4	427.4	1	88.632	100.0	10000.0	1	0	0.0	0.0	3.0	3642.2	3645.2	1677.4	5322.6
2	<input type="radio"/> <input checked="" type="radio"/>	0.0	0.0	1	55.000	100.0	5000.0	24	11	2.2	0.0	857.8	3642.2	4500.0	1250.0	5750.0
3	<input checked="" type="radio"/> <input type="radio"/>	427.4	427.4	1	88.637	100.0	10000.0	1	0	0.0	0.0	3.0	3642.2	3645.2	1677.4	5322.6

Offset calculated from 'Waste length' in order to give constant 'Good' length.

Each layer can be repeated a number of times. For 'hoop' 1 layer is a single machine traverse, use 2 for a double layer that comes back.

The machine speed can be changed for each layer. A default value is applied but can be overridden.

Automatically generated data when the 'Calculate' button is clicked.

Cover factor is 100% by default. This can be set to 'adjust' the band width. If a cover factor of 200% is used the programmed bandwidth will halve so the bands will overlap, with 50% the winding will have gaps. During winding the bandwidth may be slightly different for different wind angles so the user can adjust for this here if required.

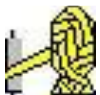
Machine feed rate is the winding speed for each layer. The default is from the SM (configuration) file.

Circuits per layer, is the calculated value of winding program circuits for a full layer. For hoop winding this is always 1.

Band pattern Number is the number of 'starts' and is explained on following pages. There is no pattern as such for hoop winding.

Dwell rotation is additional mandrel rotation at the ends to make a particular band pattern work correctly. The amount of dwell can be minimised by keeping the default band pattern selection mode (mode 0).

Wind time is the layer wind time, a total is shown at the bottom. Times are calculated at NC generate stage. **Waste length** is the length out of the total wind length used for turning, where the wind angle is not true. Half of this amount will be at each end.



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Cadfil- Pipe Winder

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Control buttons to add, delete or insert layer data into the table

Control button to change material data for calculations

UNITS [mm]

Fibre	Owens-Corning Type 30 SE 1200-735
Resin	Sample Polyester
Number of Rovings	1
Volume Fraction	28.4%

Band Pattern Mode Select
0: Automatic, Use Minimum Dwell

Feed Rate Mode Select
0: Constant F value

Material Data

Generate NC Data

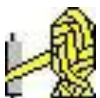
Calculate Constant 'Good' length

Final Thickness 4.064 Final Diameter 408.1 Total Wind Time 1005.932

Other useful information

When the data has been entered the NC file can be generated with a single 'click'

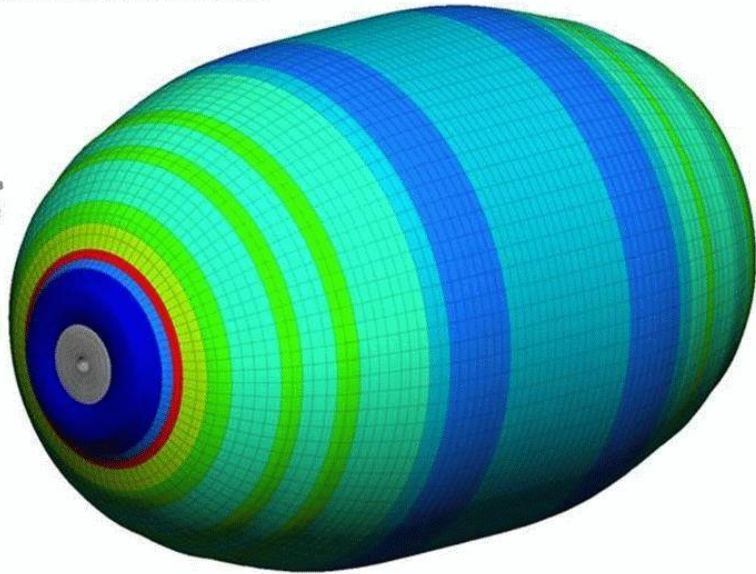
The Pull down menu for band pattern and feed rate mode selection are shown above. There are three options for band pattern, the user can choose that a pattern of 1 is automatically selected for each layer or the pattern with the smallest dwell is selected. In manual mode the user selects from a pattern table for each layer.



Contour Plot
Layered Solid Composite Stresses(Normal X Stress (solid), Ply #1_BOT)

1.743E+03
1.570E+03
1.396E+03
1.222E+03
1.049E+03
8.753E+02
7.018E+02
5.282E+02
3.546E+02
1.811E+02

Max = 1.743E+03
3D 6849
Min = 1.811E+02
3D 121



Cadfil can be used to create finite element geometry and data for import into your analysis package. Finite element interfaces are an add on package to Cadfil Lite, more details can be found at <https://www.cadfil.com/help/html/cadfil-fea-interface.html> .

On a doubly curved surface such as a dome, the angle and thickness are continuously variable. With multi-layer windings it is difficult and time consuming to create fibre architecture in analysis packages. Cadfil offers a number of solutions, customers successfully produce Cadfil data for use in Nastran, Patran, Femap, Hyperworks, Optistruct, ABAQUS and ANSYS and others.

Cadfil deals with winding geometry and fibre architecture and also for some cases can create boundary conditions and load cases. It is possible to specify Orthotropic material data directly from the Cadfil database which is open for the user to add or remove materials as needed.

All Cadfil software is complete with USB datakey and a comprehensive online or offline help. Telephone support and software upgrades for the first 12 months are also included in the purchase price. Cadfil-Lite also includes Cadfil Pipe-winder options. Cadfil Axsym contains the Cadfil Lite options.

For further information on CADFIL filament winding software contact:

Crescent Consultants Ltd
2 Springfield
Kegworth
Derby, DE74 2DP
England



Tel: +44 (0)7958 647196
Email: sales@cadfil.com

Web: <https://www.cadfil.com>



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Cadfil- Pipe Winder

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