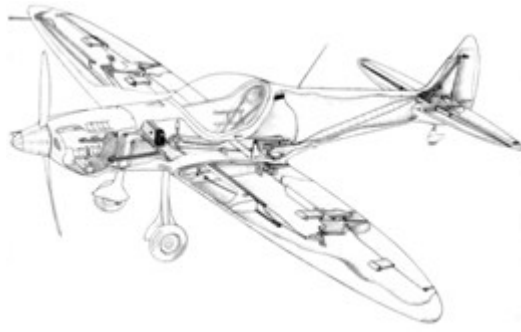


Revision 1.5



Aircraft Assembly Manual

Twister Kit

Revision 1.5

*Silence-Aircraft GmbH,
Kapellenweg 54a,
33415,
Verl
Germany*

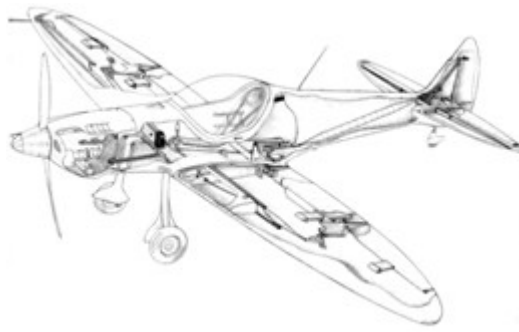


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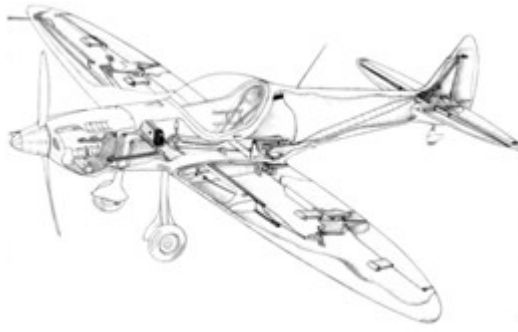
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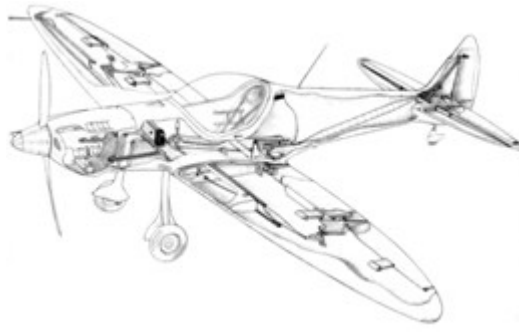
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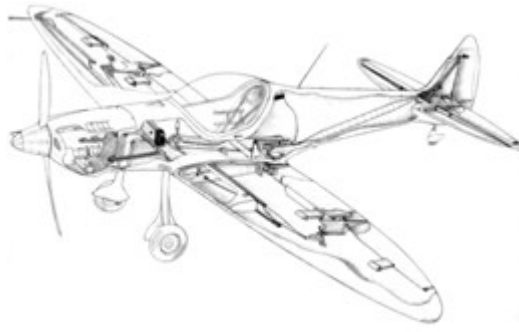
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0 Using this Manual

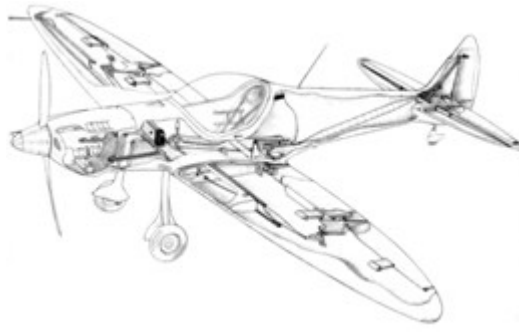
Note: This manual was translated from a German original.

Measurements

The design of the Twister is based on the metric system. All US conversions given in the text are for guidance only. All dimensions in the figures are in millimeters (mm) unless otherwise stated.

MILLIMETERS CONVERTED TO DECIMAL INCHES

MILLIMETERS →	INCH EQUIVALENTS									
	0	1	2	3	4	5	6	7	8	9
↓	0.00000	0.03937	0.07874	0.11811	0.15748	0.19685	0.23622	0.27559	0.31496	0.35433
10	0.39370	0.43307	0.47244	0.51181	0.55118	0.59055	0.62992	0.66929	0.70866	0.74803
20	0.78740	0.82677	0.86614	0.90551	0.94488	0.98425	1.02362	1.06299	1.10236	1.14173
30	1.18110	1.22047	1.25984	1.29921	1.33858	1.37795	1.41732	1.45669	1.49606	1.53543
40	1.57480	1.61417	1.65354	1.69291	1.73228	1.77165	1.81102	1.85039	1.88976	1.92913
50	1.96850	2.00787	2.04724	2.08661	2.12598	2.16535	2.20472	2.24409	2.28346	2.32283
60	2.36220	2.40157	2.44094	2.48031	2.51968	2.55905	2.59842	2.63779	2.67716	2.71653
70	2.75590	2.79527	2.83464	2.87401	2.91338	2.95275	2.99212	3.03149	3.07086	3.11023
80	3.14960	3.18897	3.22834	3.26771	3.30708	3.34645	3.38582	3.42519	3.46456	3.50393
90	3.54330	3.58267	3.62204	3.66141	3.70078	3.74015	3.77952	3.81889	3.85826	3.89763
100	3.93700	3.97637	4.01574	4.05511	4.09448	4.13385	4.17322	4.21259	4.25196	4.29133
110	4.33070	4.37007	4.40944	4.44881	4.48818	4.52755	4.56692	4.60629	4.64566	4.68503
120	4.72440	4.76377	4.80314	4.84251	4.88188	4.92125	4.96062	4.99999	5.03936	5.07873
130	5.11810	5.15747	5.19684	5.23621	5.27558	5.31495	5.35432	5.39369	5.43306	5.47243
140	5.51180	5.55117	5.59054	5.62991	5.66928	5.70865	5.74802	5.78739	5.82676	5.86613
150	5.90550	5.94487	5.98424	6.02361	6.06298	6.10235	6.14172	6.18109	6.22046	6.25983
160	6.29920	6.33857	6.37794	6.41731	6.45668	6.49605	6.53542	6.57479	6.61416	6.65353
170	6.69290	6.73227	6.77164	6.81101	6.85038	6.88975	6.92912	6.96849	7.00786	7.04723
180	7.08660	7.12597	7.16534	7.20471	7.24408	7.28345	7.32282	7.36219	7.40156	7.44093
190	7.48030	7.51967	7.55904	7.59841	7.63778	7.67715	7.71652	7.75589	7.79526	7.83463
200	7.87400	7.91337	7.95274	7.99211	8.03148	8.07085	8.11022	8.14959	8.18896	8.22833
210	8.26770	8.30707	8.34644	8.38581	8.42518	8.46455	8.50392	8.54329	8.58266	8.62203
220	8.66140	8.70077	8.74014	8.77951	8.81888	8.85825	8.89762	8.93699	8.97636	9.01573
230	9.05510	9.09447	9.13384	9.17321	9.21258	9.25195	9.29132	9.33069	9.37006	9.40943
240	9.44880	9.48817	9.52754	9.56691	9.60628	9.64565	9.68502	9.72439	9.76376	9.80313
250	9.84250	9.88187	9.92124	9.96061	9.99998	10.03935	10.07872	10.11809	10.15746	10.19683
260	10.23620	10.27557	10.31494	10.35431	10.39368	10.43305	10.47242	10.51179	10.55116	10.59053
270	10.62990	10.66927	10.70864	10.74801	10.78738	10.82675	10.86612	10.90549	10.94486	10.98423
280	11.02360	11.06297	11.10234	11.14171	11.18108	11.22045	11.25982	11.29919	11.33856	11.37793
290	11.41730	11.45667	11.49604	11.53541	11.57478	11.61415	11.65352	11.69289	11.73226	11.77163



Part Numbers

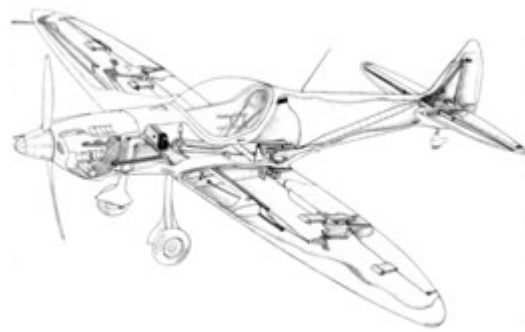
The part numbers refer to the bill of materials, which is delivered as a separate document.

Printing the Manual

The layout of this manual is adjusted for letter size paper.

Abbreviations

CF	cotton flock
MB	microballoons
FRP	fiber-reinforced plastic
FC	fiber composite
UD	unidirectional

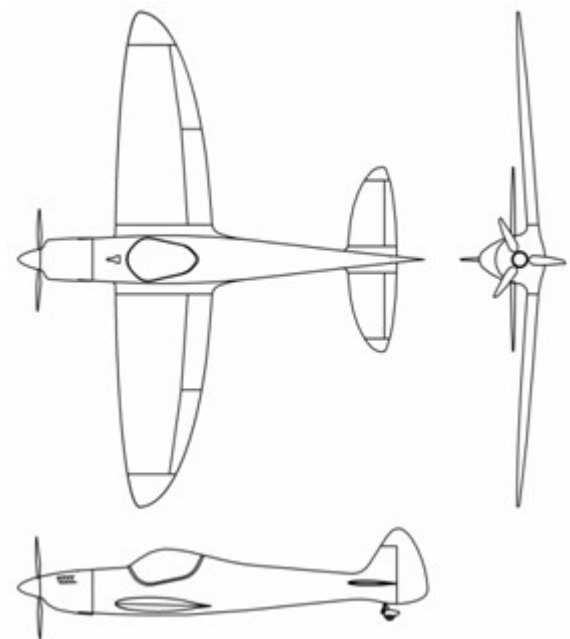


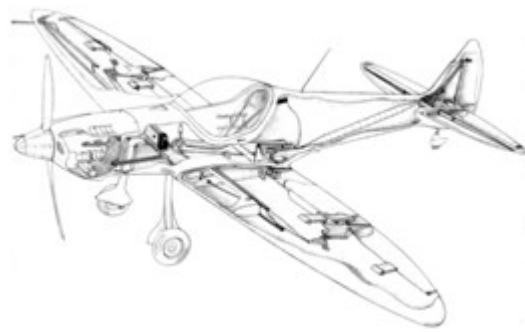
1.1 Specifications

The *Twister* kit consists of structural components made from honeycomb fiber glass composites, with spars and additional reinforcements made of carbon fiber reinforced plastic. For extra safety, an aramid honeycomb monocoque (cockpit cell) is used.

The *Twister* is an aerobatics-capable cantilever low-wing plane with cruciform tail unit, retractable two-wheel landing gear and flap system. Optionally a rescue system can be installed in the cockpit cell. There are two fuselage variants: one prepared for mounting a rescue system and one for use without a rescue system.

Wing span:	7.5 m (24.6 ft)
Length:	6.18 m (20.28 ft)
Wing area:	8.718 m ² (93.84 sq ft)
Max. take-off weight (MTOW):	420 kg (881.95 lb)
Max. wing loading:	40.15 kg/m ² (8.22 lb/sq ft)
Elevator span:	2.8 m (9.19 ft)
Elevator area:	1.65 m ² (17.76 sq ft)
Crew:	1
Engine:	Jabiru 2200





Strength

The *Twister* is certified for the following load factors:

+6 / -4g at 400 kg (882 lb) take-off weight at 209 km/h (113 kt/130 mph) maneuvering speed

Do not exceed these load factors. Especially, avoid wide rudder movements at speeds above 209 km/h (113 kt/130 mph).

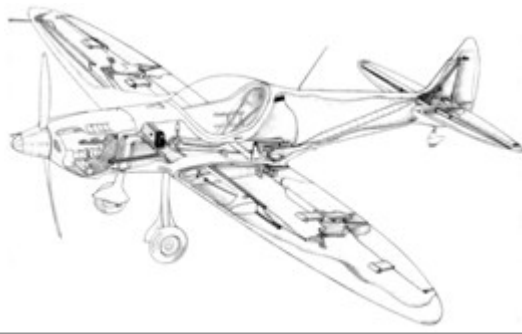
Maximum Flight Speeds

Speeds converted for sea level

Stall speed, 30° flaps:	V_{SF}	75kph (40.47kt/46.60mph)
Stall speed, no flaps:	V_S	85kph (45.87kt/52.82mph)
Maneuvering speed:	V_A	209kph (112.78kt/129.87mph)
Maximum speed:	V_{NE}	300kph (161.88kt/186.41mph)
	V_D	330kph (178.07kt/205.05mph)
Maximum speed, 30° flaps:	V_{FE}	125kph (67.45kt/77.67mph)

When using a rescue system, the maximum speed is limited to the maximum speed specified for the rescue system.

Load calculations are based on JAR23.



1.2 Materials and Tools

The *Twister* is primarily built from fiber composites. The structural honeycomb sandwich components are vacuum molded by the manufacturer.

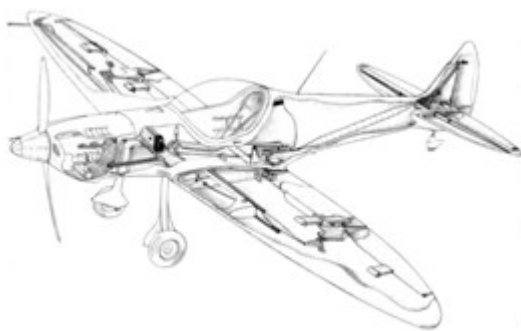
The builder has to carry out the following tasks:

- Laminating joint tapes
- Adjusting and installing the ribs into the structural components
- Sanding and filling the surfaces
- Mechanical assembly
- Wiring/laying the wire harnesses
- Painting

If you are not sure about the tasks listed above, ask a professional.

Important: If any component is damaged, e.g. by sanding through the fiberglass skin, contact the manufacturer in order to determine whether the component can still be used or can be repaired!

To build the *Twister* you need a work area measuring at least 8m x 4m (26ft x 13ft). With an area this size you will need mount the wings to the fuselage in the outside.

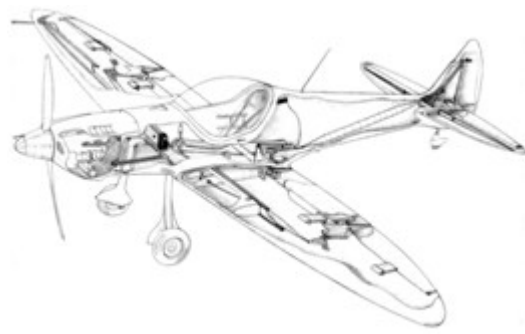


The following table lists all fiber composites used in the *Twister*. **Materials printed in blue have to be applied by the builder.**

List of Fiber Composites Used In the *Twister*

Fabrics

Description	Weave type	Finish	Interglas no.	Fabric width
Fiberglass fabric 105g/m ²	Twill	FK144	91111	1000mm (39.37")
Fiberglass fabric 163g/m ²	Twill	FK144	92110	1000mm (39.37")
Fiberglass fabric 280g/m ²	Twill	FK144	92125	1000mm (39.37")
Fiberglass fabric 296g/m ²	Twill	FK144	92626	1000mm (39.37")
Aramid fabric 170g/m ²	Twill	Washed	-	1000mm (39.37")
Carbon fabric 200g/m ²	Twill	-	-	1000mm (39.37")
Carbon fabric 245g/m ²	Twill	-	-	1000mm (39.37")
Carbon fiber tape 125g/m ²	UD	Epoxy	-	25mm (0.98")
Carbon fiber tape 300g/m ²	UD	Epoxy	-	50mm (1.97")
Carbon fiber tape 300g/m ²	UD	Epoxy	-	75mm (2.95")
Peel-ply 100g/m ²	Twill	-	-	500mm (19.69")
Peel-ply 95g/m ²	Linen	-	-	500mm (19.69")
Peel-ply tape 95g/m ²	Linen	-	-	60mm (2.36")
Fiberglass tape 10g/m ²	30° braid	-	-	25mm (0.98")
Fiberglass tape 20g/m ²	30° braid	-	-	40mm (1.57")
Carbon fiber roving 1610 Tex	-	Epoxy	-	-



Resin / Hardener

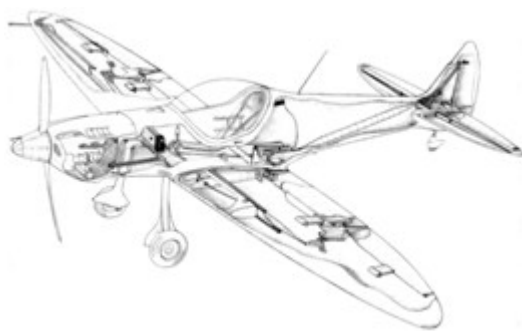
Scheufler L285 + H286
Cyanoacrylate glue ("super glue"), medium
viscosity

Fillers

Cotton flock
Thixotropic agent (Cabosil or equivalent)
Glass bubbles 0.12g/cm³ (119.86oz/cu ft)
Micro balloons

Support Materials

Description	Thickness	Density
Aramid honeycomb, 3.2mm (0.13") cell diameter	3mm (0.12")	48kg/m ³ (3lb/cu ft)
Aramid honeycomb, 3.2mm (0.13") cell diameter	3mm (0.12")	29kg/m ³ (1.81lb/cu ft)
Aramid honeycomb, 3.2mm (0.13") cell diameter	5mm (0.20")	48kg/m ³ (3lb/cu ft)
Aramid honeycomb, 3.2mm (0.13") cell diameter	5mm (0.20")	29kg/m ³ (1.81lb/cu ft)
Aramid honeycomb, 3.2mm (0.13") cell diameter	7mm (0.28")	48kg/m ³ (3lb/cu ft)
Aramid honeycomb, 3.2mm (0.13") cell diameter	10mm (0.39")	48kg/m ³ (3lb/cu ft)



Tools

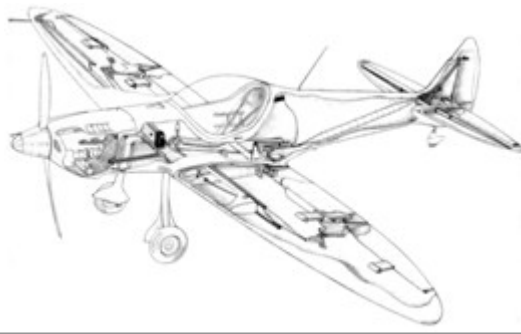
To build the *Twister* you need the following tools:

- Paint brush
- Scissors
- Power drill
- Pop rivet pliers
- Set of wrenches and screwdrivers
- Torque wrench

General Torques for Screw/Bolt Connections
(Bolts/screws slightly greased)

M5	5Nm
M6	9Nm
M8	23Nm
M10	46Nm

- Twist drill set, 1-12mm (.040"-0.50")
- Long nose pliers, long type
- Caliper gauge
- Set of files
- Sanding paper (80, 100, 220, 500 wet sanding paper)
- 2 ratchet straps, each 8m (25 ft) long
- Rotary grinding/cutting tool (e.g. Dremel)
- Reciprocating saw (e.g. Jig Saw)
- Orbital DA sander
- Spray gun
- Vise (5" or 6" clamping length)
- Tape measure (metric)
- Wooden stir sticks (e.g. tong depressors)
- Mixing cup (un-waxed)
- Disposable protective gloves (Latex or Nitrile)
- 100° countersink
- Scales 0-2,000g (0-oz), 0.5g (0.02oz) precision (balance beam or electronic)
- Nicopress tool (e.g. from Aircraft Spruce)
- Mold release wax
- Polypropylene packaging tape, 50mm (2") wide
- Keyhole saw 25-70mm (1"-2.75")
- Level, ca. 300mm (12") long



1.3 Fiber Composite Basics

Plastics in General

For thousands of years human existence depended on natural materials. Clothing, tools, and utensils were made from leather, metal, stone, clay and other substances provided by nature.

Most manmade materials like porcelain, glass, and metal alloys were discovered more or less by accident.

When important raw materials started to become scarce and expensive at the beginning of the 20th century, an intensive search for synthetic (artificial) substitutes ensued. Natural materials alone could no longer satisfy the emerging technical requirements of the fast-growing industries.

In the course of time a myriad of compounds, including numerous plastics, were synthesized from natural raw materials such as coal, coal tar, crude oil, and natural gas.

Combining different materials to form a composite with enhanced properties and synergies is a common process in nature: the section of a strand of merino wool or a bamboo stem shows structures similar to the cross section of a unidirectional carbon fiber reinforced epoxy resin (CF-EP). Nature remains the model not only for the microstructure of fiber reinforced plastics, but also for the application of lightweight design principles.

The use of fibers as construction materials is based on the following four paradoxes of materials:

1. The Paradox of the Solid Material

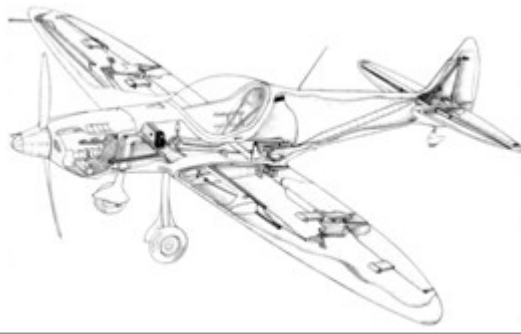
The actual strength of a solid material is much lower than its calculated theoretical strength (F. Zwicky).

2. The Paradox of Fiber Form

The strength of a material in fiber form is many times higher than that of the same material in another form; the thinner the fiber, the greater the strength (A. A. Griffith).

3. The Paradox of the Free Clamped Length

The shorter the length between the clamps, the higher the measured strength of a sample (fiber).



4. The Paradox of Composite Materials

When taken as a whole, a composite can withstand stresses that would break the weaker component, whereas the composite's stronger component can exhibit a greater percentage of its theoretical strength than when loaded singly (G. Slayter).

Fiber Composites

The principle of combining different materials to form a composite with enhanced properties is just as common in nature as in lightweight engineering.

This design method copied from nature has virtually revolutionized many fields of technology, with the result that now for the first time extremely strong, but at the same time lightweight materials with superior characteristics are available.

In particular the aerospace industries benefit from these low structural weights, which allow considerable fuel savings and performance gains.

In space flight, high-performance fiber composites are used mainly for economic reasons. In view of the high fuel costs, space agencies are prepared to spend up to 25,000 euros for every kilogram saved. In aviation the figure is 250-750 euros per kg, in the automotive industry 0- 2.50 euros per kg (with the exception of racing).

As fiber composites are usually more expensive than compact materials (e.g. metals) and place higher demands on design and processing technologies, there is little incentive to use them in normal automotive engineering, whereas their benefits for the aerospace industries are obvious.

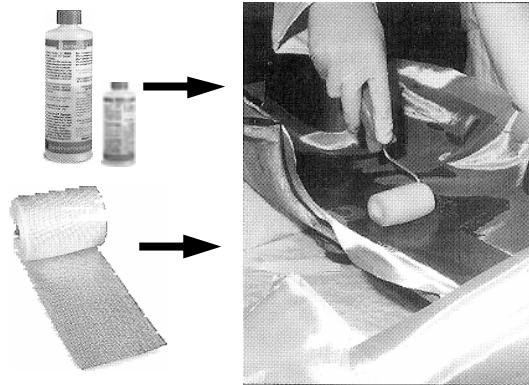
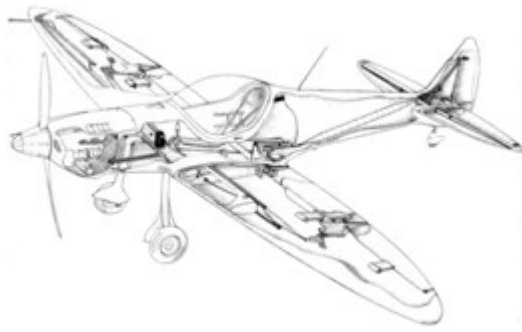
With falling prices and growing, more generally available processing know-how composites are now widely used. Motor sports, model construction and sports equipment design today could hardly be imagined without them.

Applications in mechanical engineering are also gaining ground.

The Principle

A fiber composite (FC) is the result of combining several materials:

- 1.) the matrix (e.g. epoxy or polyester resin), which gives shape to the final component, and
- 2.) the reinforcing, highly tensile fibers (usually glass, aramid, or carbon)



*Manual lamination
using a foam roller*

Simply speaking, fiber composites can be compared with reinforced concrete, where a brittle, shape-giving material (concrete) is reinforced by steel.

The fibers are embedded in a liquid mass of reactive resin and fixed in place when the resin hardens in the mold. This technique can be used to manufacture even complex or very large parts in one operation with relatively little effort.

The processing method is chosen according to the number and size of the parts to be manufactured as well as structural strength requirements and other properties such as transparency, surface finish, dimensional stability, etc.

The general rule is that a fiber composite results only from the combination of resin and fibers, i.e. it is produced directly by the processor.

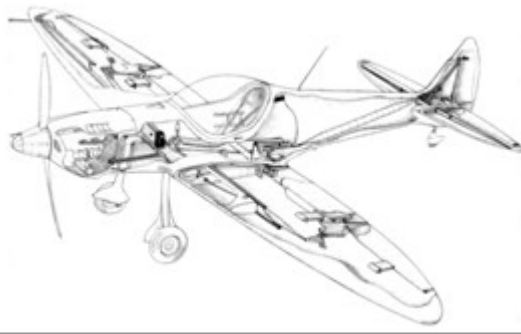
Therefore the properties of the end product depend almost entirely on careful processing and curing as well as on component design (fiber orientation, fiber percentage, number of plies, and fabric).

Strength

The strength of a fiber composite is determined to a large extent by the reinforcing fiber.

Two types of strength are distinguished: static and dynamic.

Static strength is a measure of a material's behavior under simple loads (tension, compression, bending), whereas **dynamic strength** is a measure of a material's behavior under frequent load changes (bending cycles with variable force and frequency and the resulting combination of tensile, compressive, and shear stresses).



A high dynamic strength is particularly needed for components which are subject to frequent bending cycles (e.g. struts in aircraft construction).

Even after several tens of thousands load reversals, epoxy resins suffer only the smallest decrease in strength and therefore have the highest dynamic strength.

Matrix

This is a reactive resin which acts as a binder, supporting the fibers and transferring to them the forces acting on the molded part. This requires that the resin adheres well to the fibers.

Essentially, the reactive resin determines the following properties: chemical resistance, aging resistance, scratch resistance, electrical properties, and shrinkage during curing.

Density, thermal conductivity, thermal expansion, and specific heat depend on the proportions of reactive resin, curing agent, fibers, and fillers.

Fibers

The mechanical properties of molded materials, e.g. tensile, bending and impact strength, as well as the ability to absorb energy, are mainly influenced by the fibers. These properties can be influenced by the choice of fiber materials, the fiber content, and the orientation of the fibers.

Curing

The properties of the cured and molded reactive resin (i.e. of the molded part) depend not only on the starting material, but also very much on the control of the curing process. Knowledge of the processes involved in the curing of reactive resin is therefore crucial.

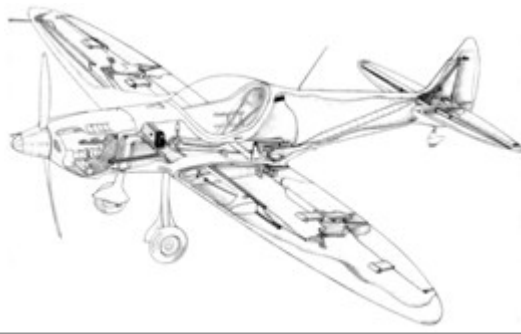
Curing, i.e. when the liquid compounds of reactive resin solidify into three-dimensionally cross-linked products, can take place as one of three reaction types:

Polymerization

(e.g. unsaturated polyester resins)

Under the effects of reactive agents, e.g. peroxides and accelerators, the double bonds of the starting components react with each other, releasing heat in the process. The molecules of the starting components cross-link to form macromolecular structures called polymers.

When several starting materials, such as unsaturated polyester and styrene, are made to react as described above, the process is called copolymerization.



Polymerization does not start until a certain time after the reactive agents have been added. Thereafter the resin compound solidifies relatively quickly. This involves heat generation and a rapid increase in viscosity, but no release of volatile products. Once started, the curing process cannot be stopped or reversed.

Polyaddition

(e.g. epoxy resins)

Unlike polymerization, the polyaddition reaction requires the addition of a much higher quantities of reactive agents, with the additional difference that these quantities are calculated on the basis of the desired end-product.

Therefore the properties of the end product are influenced both by the reaction resin and the reactive agent used. In polyaddition, the transition from the liquid to the solid state generally takes place more slowly and uniformly than in polymerization. The reaction releases heat.

Polycondensation

(e.g. phenol formaldehyde resins)

In polycondensation, the reaction of the starting components releases by-products, e.g. water.

The reaction can be controlled in a step-by-step process. In general precondensed resins are used, which in most cases can be cured by applying heat.

Elongation at Break

When subjected to tensile stress, the resin must not break before the fibers. Otherwise, cracks in the resin will cause the whole part to fail. The elongation at break of the resins should therefore always be greater than that of the reinforcing fibers.

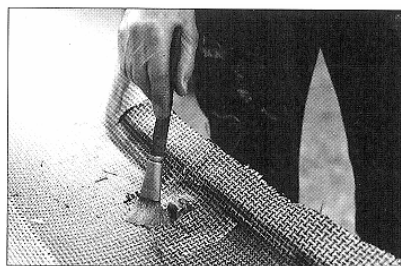
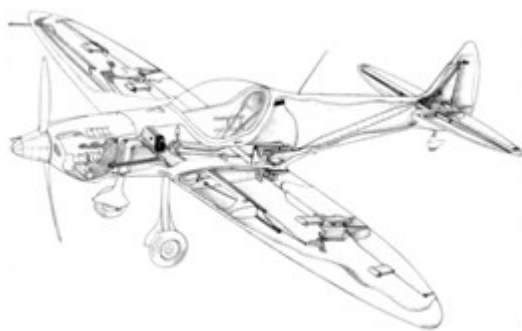
Adhesion Between Resin and Fibers

Another important factor in the quality of a composite is the adhesion between the resin and the reinforcing fibers. Higher adhesion results in higher strength.

To facilitate adhesion, glass fabrics are treated with coupling agents (silanes, various finishes), which allow the strongest possible (chemical) bonding to the resin.

The exceptions are aramid fibers (Kevlar®, Twaron®) and polyethylene yarns (Dyneema®), for which no chemical coupling agents are available.

Carbon fibers are coated with epoxy resin.



Manual lamination: carbon-
aramid fabric being
impregnated with epoxy resin

Glued Bonds

Cyanoacrylate-based glues (super glue) and epoxy resin show superior adhesion on various materials and are used to bond plastics, metals, wood, glass, concrete, ceramics, etc.

The strength of a glued bond is determined by the following glue properties:

the strength of the adhesive (cohesion)

its “stickiness” on surfaces (adhesion)

Preparing the Surface

The bonding surfaces are cleaned in order to remove any adhering foreign matter, such as dirt, rust, scale, paint, varnish, etc. The most common method of cleaning is by mechanical means (sanding and brushing). Even for less severely loaded bonds cleaning the surfaces is essential in order to achieve the desired bond strength, given that foreign matter is often the root cause of bond failure.

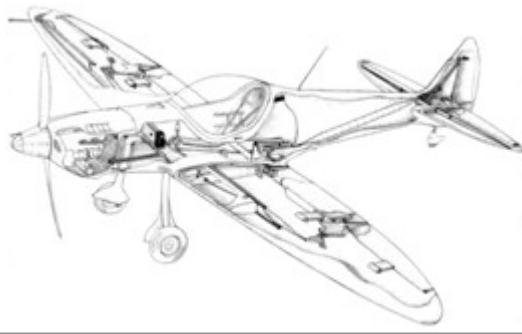
For this reason, peel-plies are applied on most bonding surfaces of the Silence. These fabrics, which are marked by a blue or red thread, are pulled off by hand. The resulting rough surface is ideal for bonding. After pulling off the peel-ply, do not touch or soil the bonding surfaces.

Fitting

This step involves the removal of burrs and, in the case of large bonding surfaces, the parallel alignment of the bonding surfaces of the parts.

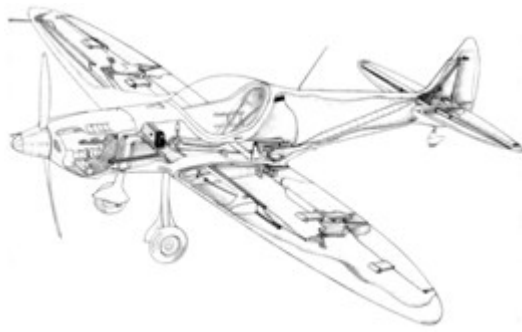
Degreasing

Use organic solvents or hot (approx. 60-80°C [140-176°F]) water containing 1%-3% of a liquid detergent to degrease surfaces. However, bear in mind that some detergents, e.g. dish-washing liquid, can contain small quantities of silicone compounds, which as residues can prevent the glue from wetting the surfaces properly.



Degreasing is one of the most important prerequisites for proper wetting, so it should be carried out regardless of whether the surface will be treated further.

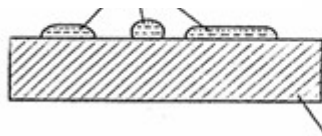
Suitable **solvents** are, among others, various alcohols and acetone. Although they were frequently used in the past, do not use chlorinated hydrocarbons (CHC), such as chloroform, methylene chloride, TRI, carbon tetrachloride, etc., unless it is absolutely necessary. CHC are harmful to health and poorly biodegradable. Building the Silence does NOT require the use of CHC, so for the above reasons they should not be used!



To check for proper degreasing you can pour a few drops of distilled water on the surface:

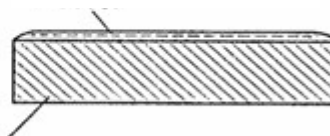
Water collects into droplets

a) Poorly degreased:



Water forms a film

b) Well degreased:



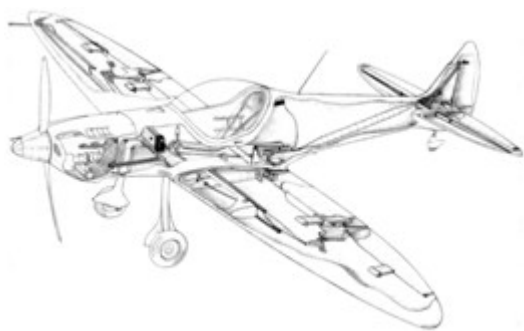
Part to be bonded

Manual Lamination

Manual lamination (hand lay-up) is the oldest, simplest and most common method. The technical requirements are minimal, so it is mainly used for minor series and simple part geometries, as well as for building the Silence. The molded part is cured at room temperature without application of pressure.

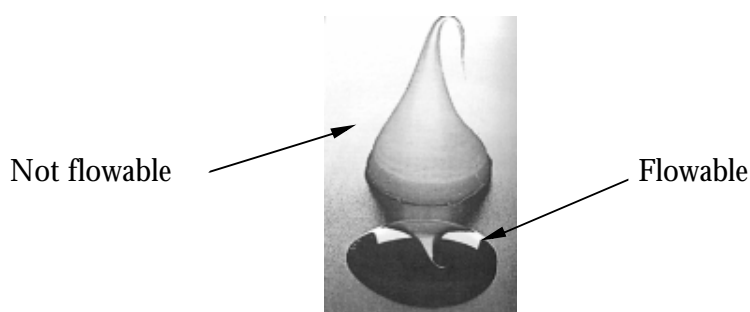
Ambient conditions of the working area: min. 20°C (68°F) room temperature, around 60% humidity, good ventilation.





Cotton Resin Mix (CF)

As reinforcing fibers, cotton flock is mixed into the resin. The amount of cotton flock used depends on the desired viscosity of the cotton resin mix. Usually the amount of cotton flock is increased until the cotton resin mix stops flowing.



Micro Balloon Resin Mix (MB)

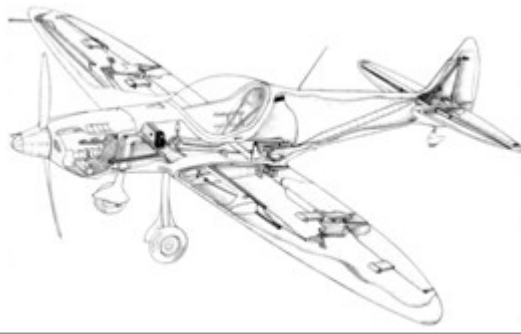
Micro balloons (glass bubbles) are used as fillers with extremely low weight. In the Twister they are used in locations which are not subject to high loads or subject only to compressive stresses.

Processing Temperature

The right temperature is essential for processing epoxy resins. This applies not only to storage and processing, but also to curing and post-treatment of the resins and molded materials. Below are some simple guidelines, which can help you to process epoxy resins and optimize product quality by choosing the right temperature and adhering to some basic rules.

Storing Epoxy Resins

Store epoxy resins at a temperature between 15°C and 25°C (59-77°F). When stored for longer periods at temperatures below 15°C (59°F), resins and hardeners can crystallize, which leads to the separation of the components. Dissolve the crystals by heating and continuous stirring before using the material, and also before transferring it to another container. Crystallization does not affect the quality of the resins and hardeners, so they can be used normally when the crystals have completely dissolved.



Processing Epoxy Resins

Process cold-curing epoxy resin systems at room temperature (20-25°C [68-77°F]).

By choosing the right temperature you can decisively influence both the processing properties of the resin as well as the properties of the cured molded materials. In general, changes in processing temperature have the following effects:

Increasing the temperature:

- ⇒ reduces the viscosity (the resin flows more freely),
- ⇒ improves the wetting of the fibers, and
- ⇒ shortens the processing time.

Conversely, decreasing the temperature leads to higher viscosity and poorer wetting of the fibers. On the other hand, lower temperatures can increase the processing time. Please note, however, that at temperatures below 15°C (59°F) the curing process slows down considerably, so that thin-walled laminates may still not be cured after several days, if the temperatures are too low.

Advantages of a Slightly Higher Processing Temperature

A very low viscosity is particularly favorable for manual lamination, because low-viscosity resins can impregnate fibers and fabrics much better. However, reducing the viscosity by adding thinners or solvents is only possible to a limited extent and can cause the molecular chains to break. On the other hand, by raising the temperature by only 5°C (9°F) you can reduce the viscosity by almost 50% without affecting cross-linking properties.

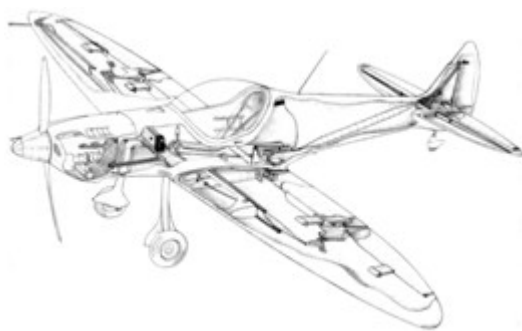
For optimum working, slightly warm the resin and the forms.

Resins should have a minimum temperature of 25°C (77°F) for processing. To achieve this, you can heat the container, e.g. in a water bath, before use. By raising the temperature to a maximum of 35°C (95°F) you can lower the viscosity even further.

However, keep in mind that a temperature increase of 10°C (18°F) reduces the processing time by 50%. Mix small quantities of heated resin and process them quickly.

Curing Epoxy Resins

When epoxy resins cure, they undergo a chemical process, in which the molecules of the individual components react with one another to form long, cross-linked molecular chains. Epoxy resins cure by the process of polyaddition, i.e., for each element in the resin there must be a certain number of elements from the hardener component. If the mixing ratio is not precisely observed, unlinked elements will be left behind in one of the components. This incomplete cross-linking can result in reduced strength of the molded materials.



Even if the mixing ratio is absolutely correct, some molecules which have not found a reaction partner will still be left behind, as in any chemical reaction. However, for optimum strength it is necessary to achieve the highest possible degree of cross-linking. In addition to adhering precisely to the required mixing ratio, you can achieve almost 100% cross-linking by controlled heating (annealing). However, the resin must be heated carefully under controlled conditions in order to avoid warping.

If done properly, the annealing enhances the mechanical strength and, in particular, raises the temperature at which resins begin to distort. For these reasons annealing is mandatory e.g. for structural parts in aircraft construction.

Annealing Fiber Composite Parts

When using cold-curing epoxy resin systems, you can first leave the parts to cure at room temperature and then finish them, if necessary. Anneal all fiber composite parts before painting. Place all parts in suitable room in such a way that they are not distorted or stressed and heat them slowly. Do not raise the temperature by more than 20°C (28°F) per hour. Maintain the target temperature for at least 18 hours. The epoxy resin system used for the Twister (lamination resin L285 / hardener H286) requires 18 hours of annealing at 80°C (176°F).

1.4 Safety

Over the last few years epoxy and polyester resins have become increasingly important and are now used in a wide range of applications. Despite this, so far no severe health problems have been reported which could be attributed to dermatological or toxic effects of liquid plastics. These positive results were made possible by appropriate safety precautions, i.e. compliance with industrial hygiene regulations and selection of compatible resin/hardener systems.

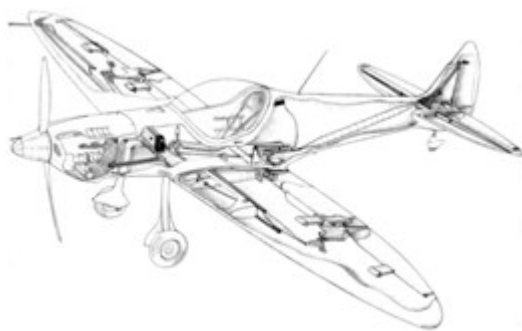
Years of experience in processing epoxy resin systems have shown that health risks can be prevented by adopting the usual general precautions for handling chemicals and following the health and safety precautions recommended by the manufacturers of epoxy resin systems and stipulated by the authorities.

Two cases have to be distinguished:

- a) the effects of resins and the hardeners in their pure, unmixed state
- b) the effects of the mixture of resin and hardener, as it is processed

Toxicity data (like LD₅₀ values, etc.) of the individual products do not necessarily provide reliable information as to whether a system is compatible when processed in practice.

Provided that the processing instructions like mixing ratio and curing conditions have been observed, the molded materials are completely inert and harmless after curing.



Health complaints therefore arise in the time between the mixing of resin and hardener and the setting of the mixture.

In this context, a distinction is made between skin irritation and allergies:

Skin Irritation

In the case of acute skin irritation red patches develop, e.g. on the back of the hands, the fingers and in parts of the face and neck. When a suitable protective skin cream is applied and the instructions for hygienic processing are meticulously observed, the symptoms disappear within one or two days to two weeks. During this time the patches flake off and the itching stops. Long-term studies and evaluation of data obtained from the daily practice at the workplace have shown that in the majority of employees this dermatosis does not develop into anything more serious than a harmless irritation of the skin. In other words, the skin adapts (desensitization). Like in other cases of work-related dermatosis it might be advisable not to remove the affected person from the workplace at the first signs of skin irritation, but to give the skin time to adapt and desensitize.

Allergies

Allergies are uncontrolled defensive reactions of the body. The many symptoms range from swellings to very itchy pustules and blisters. In this case, the best advice is a change of workplace.

Safety Precautions

Apart from some operational installations the personal hygiene of the processor is the most important factor. Most health hazards are the result of carelessly handling dangerous substances.

The packaging of all hazardous substances carries **danger notices** (R phrases) and **safety advice** (S phrases) which must be observed.

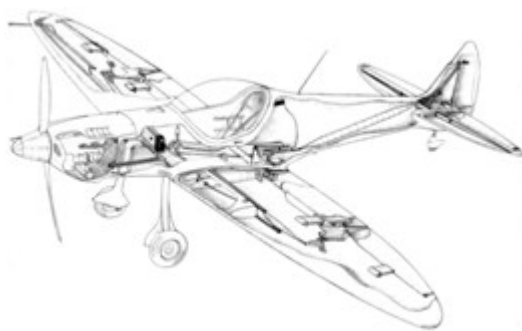
⇒ **Avoid direct contact with the skin.**

Use protective gloves and/or special skin protection salves; avoid secondary contamination (transfer via items which should normally be clean, such as telephone handsets, door handles etc.); immediately remove spilled substances and drips on containers (with cleaning cloth, cleaner).

⇒ **Immediately remove any soiling of the skin with paper towels.**

Wash the affected skin areas with cold water and a hand cleanser, dry the skin and apply skin cream.

⇒ **Avoid inhaling resin and hardener vapors.**



Also avoid inhaling the sanding dust of epoxy resins. Wherever possible, do not transport open containers with chemicals over long distances. Mix resin and hardener near the processing site.

⇒ **Do not eat, drink or smoke while working.**

After finishing work and before using the toilet, wash your hands thoroughly.

⇒ **Only use special, gentle hand cleansers for skin cleansing. Do not use solvents** (like acetone), because they dry out and chap the skin. Unsuitable skincare is often the cause of sensitization.

⇒ **If possible, only use disposable paper towels to dry your hands.**

After washing your hands, apply a moisturizing skin cream.

Operating Requirements and Standard Operating Procedures

A sensible division of the working areas and an economic work sequence can help to reduce contact times with chemicals. This applies regardless of the toxicity of the product used: it is a known fact that the toxic effects depend on the amount and duration of exposure.

Ensure sufficient ventilation of the working areas, if possible by installing an extraction system. The air flow must carry the vapors away from the processor, therefore an extractor directly at the mold is recommended. Vapors from solvents, e.g. styrene, are heavier than air and best extracted near the floor.

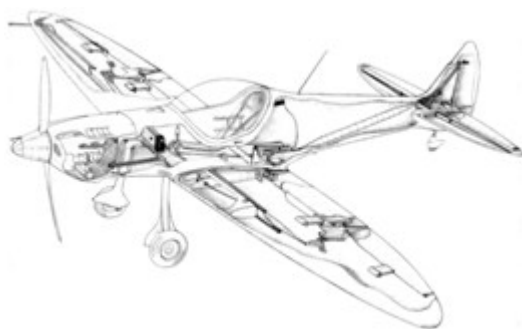
Gloves, protective creams, washing solutions, paper towels and a first-aid kit (including a bottle of eye-rinsing solution) must be provided.

In case of severe vapor and dust formation use light gas masks with dust and A2 filters for organic vapors.







Instruct any people working with you to keep their workplace clean and tidy.

Using disposable tools (paper cups, wooden spatulas, disposable brushes, etc.) can also help to keep the workplace clean. Any residues of cured resin adhering to the tools are inert.

Persons whose main task is to cut glass, aramid, or carbon fibers should not carry out lamination work directly afterwards, as the fiber dust can cause microscopic skin injuries.



Danger Notices On Chemicals Containers

 <p>Danger Notices</p> <p>R 36/38: Irritates the eyes and skin. R 43: Skin contact can cause sensitization.</p> <p>Irritant</p>	 <p>Danger Notices</p> <p>R 34: Causes chemical burns. R20/21/22: Harmful to health if inhaled, swallowed, or allowed to contact the skin. R 43: Skin contact can cause sensitization.</p> <p>Caustic</p>
 <p>Danger Notices</p> <p>R 34: Causes chemical burns. R 20/21/22: Harmful to health if inhaled, swallowed, or allowed to contact the skin. R 43: Skin contact can cause sensitization.</p> <p>Harmful to health</p>	 <p>Danger Notices</p> <p>R 51/53: Toxic to aquatic organisms, can retain its harmful effects in waters for longer periods.</p> <p>Hazardous to the environment</p>
 <p>Danger Notices</p> <p>R 10: Flammable. R 20: Harmful to health if inhaled. R 36/38: Irritates the eyes and skin.</p> <p>Highly flammable</p>	 <p>Danger Notices</p> <p>R 7: Can cause fire. R 22: Harmful to health if swallowed. R 34: Causes chemical burns.</p> <p>Supportive of combustion</p>