# Repair Instructions for Sailplanes and Powered Sailplanes constructed from Fiber Reinforced Plastic (FRP), manufactured by Schempp-Hirth, Flugzeugbau GmbH, Kirchheim/Teck

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## 2. General

Prior to a repair it must be clarified, where and by whom the repair is to be conducted.

All materials used for a repair must either be specified in these Repair Instructions, or in the Maintenance Manual of the aircraft affected, or be stated directly by the manufacturer.

### a) Repairing components constructed from Fiber Reinforced Plastic (FRP)

Should a fracture or damage have occurred to the sailplane/powered sailplane, first the area affected must be thoroughly inspected to determine exactly the extent of damage and the structure. The number of cloth layers and the type of cloth can usually be determined by sanding the broken laminate. If this is not possible, remove a piece of the fractured laminate and ignite it. After the resin is burnt, the type of cloth, the number of layers and the direction of the weave will be evident (only applicable for glass fiber and carbon fiber reinforced structures).

If there is any doubt as to the lay-up of a laminated structure, contact the manufacturer of the aircraft or the company in charge of its service.

### b) Repair work on metal fittings

If - for unknown reasons - damage has occurred to any of the metal fittings on the aircraft, the manufacturer or the company in charge of its service must be contacted in every case.

Repairs involving welding may only be accomplished by persons authorized for aircraft welding.

For all steel parts the "Tungsten inert gas arc welding technique" is employed by the manufacturer.
For all steel combinations - except non-corroding steel - welding electrodes of quality No. 1.7734.2 may be used.

## 3. Materials

### a) Components constructed from fiber reinforced plastic (FRP)

Sailplanes and powered sailplanes manufactured by Schempp-Hirth are constructed from the following materials:

- Glass fiber reinforced plastic (GFRP)
- Carbon fiber reinforced plastic (CFRP)
- Aramid fiber reinforced plastic (AFRP) (SFRP)

The Aramid fiber (a synthetic fiber, also called "Kevlar", DuPont's trade name for this fiber) is usually woven in combination with carbon fiber.

For a specification of the materials used for the construction of the individual aircraft refer to its Maintenance Manual.

For repairs only these specified materials must be used or those substitute materials shown on page 3.2.

### b) Components constructed from metal

Various materials and qualities are used for the metal parts - for repairs of such parts the manufacturer should therefore always be contacted.

## TABLE OF FIBER MATERIALS

| Fiber material | Cloth designation accord. to LN-Specif. | Interglas code or manufacturer's designation | Manufacturer | Weight (g) per $m^2$ | Remarks |
|---|---|---|---|---|---|
| Glass | 8.4545 | 91 110 * | Interglas | 108 | Cross twill |
| Glass | 8.4548 | 92 110 * | " | 163 | Twill weave |
| Glass | 8.4551 | 92 125 * | " | 285 | " " |
| Glass | 8.4554 | 92 140 * | " | 395 | " " |
| Glass | 8.4520 | 92 145 * | " | 220 | Warp direct. |
| Glass rovings EC9-756 K 43 | 8.4674 LN 9103 | - | Gevetex Düsseldorf | - | - |
| Carbon | | 98 140 * | Interglas | 200 | Plain weave |
| Carbon | | 98 160 * | " | 285 | " " |
| Carbon | | CX 14 T | Aerotex Willich | 140 | Unidirect. fabric (tape) |
| Carbon | | 98 340 * | Interglas | 170 | Warp direct. |
| Carbon | | Sigratex KDL 1024 75 mm wide | Sigri, Meitingen | | Warp direct. |
| Carbon fiber rovings | LN 29964 KC 20 FYS | e.g. Tenax HTA 7 12000 | Enka, Wuppertal | - | - |
| Aramid/Carbon | | 98 355 * | Interglas | Aramid 78 Carbon 122 | Cross twill |
| Aramid | | 98 608 * | " | 110 | " " |
| Aramid | | 98 611 * | " | 170 | Plain weave |
| Aramid | | 98 616 * | " | 158 | Warp direct. |

* By Interglas AG, 7900 Ulm - for glass fibers Finish I 550

Resin systems : For the permissible resin systems refer to the Maintenance Manual of the individual aircraft

Surface coating : For information on the gel-coat to be used refer to the Maintenance Manual of the individual aircraft

Resin filler materials

Micro balloons : Union Carbide/Brenntag GmbH
Aerosil : Degussa - Wolfgang
Styrofoam kernels : BASF
Cotton flocks : Schwarzwälder Textilwerke
Rigid foam : Divinycell H 60 by Messrs. Diab Baracuda (equivalent to Conticell C 60)

For the repair of areas not too extensively damaged, the following resin systems (curing faster) are recommended:

For GFRP components:

Resin GE 162 with hardener LAROMIN C 260 (Epikure 113)

or

Resin SCHEUFLER L 285 with hardener 286

For CFRP or CFRP/Kevlar components:

Resin SCHEUFLER L 285 with hardener 286

For components showing extensive damage it is more favourable to use a resin system offering a longer pot life:

For GFRP, CFRP or CFRP/Kevlar components:

Resin GE 163 with hardener LAROMIN C 260 (Epikure 113)

or

Resin SCHEUFLER L 285 with hardener 287

For all resin systems the prescribed curing period and temperature must be observed.

For the preservation of the surface finish of the component concerned, only the area of repair and not the entire component should be heat-treated.

## 4. Kinds of construction

Although the laminated skin of sailplanes and powered sailplanes is a "stressed skin structure", bearing very high loads in some areas, it is for weight-saving reasons on principle very thin.

Depending on size and shape of the individual component, it is either constructed as a pure GFRP, CFRP or CFRP/Kevlar shell (thickness 1 to 3 mm / 0.04 to 0.12 in.), or as a so-called "sandwich" with an outer skin (thickness approx. 1 mm / 0.04 in.), a foam core (thickness 4 to 8 mm / 0.16 to 0.31 in.) and an inner skin (thickness approx. 1 mm / 0.04 in.).

On components constructed from fiber reinforced plastic (FRP), the orientation of the fibers is the absolutely deciding factor for its strength and stiffness.

It is therefore most important that - in any direction of a component to be repaired - at least the same weight-to-area ratio is achieved that it originally had. Special attention must also be paid as to the thickness of the foam core on components constructed as a sandwich.

For the spar flanges of a wing, so-called "rovings" are used, which are the highest stressed structures in flight.

For the repair of components having rovings embedded, the manufacturer must therefore always be contacted.

The kind of construction of the major components is given in the Maintenance Manual of the aircraft concerned.

All components made from fiber reinforced plastic have been heat-treated by the manufacturer during construction of the aircraft. By post-curing the aircraft components, all the chemical reactions causing the resin to cure, have finished, so that even on hot and sunny days the aircraft has sufficient strength.

Repaired areas must therefore also be post-cured - see Maintenance Manual, chapter "permissible resin systems".

## 5. Repair procedures for components constructed from reinforced plastic (FRP)

In order to avoid tension peaks, there must be no abrupt differences in the thickness of the laminate. Also oval or round cut-outs should be made instead of angular openings and the transition from the damaged/repaired area to the sound structure should be made gradually. Added or inserted cloth layers should therefore always be graduated or scarfed out.

As the transfer of the shear load into the lower cloth layers must take place via the length of the overlap or scarf with the bonding force of the resin, the overlap/scarf length depends on the type of cloth, its weight and the orientation of the fibers.

For GFRP the scarf slope is 50 : 1, for CFRP and Aramid fibers the scarf slope is 100 : 1.

Warp-directional cloth or multi-axial knit fabrics (tape) only need to be scarfed in the direction of the fibers.

A table showing the required scarf or overlap lengths is provided in section 8.

On principle it is to say that the repair procedure for GFRP and CFRP is the same, except for the scarf slope and the material used originally.

Repairs on Aramid (Kevlar) components or on parts made from Aramid (Kevlar)/Carbon fibers are more difficult because of the "unpleasant" characteristics of the Kevlar fibers with regard to cutting and sanding them.

For minor repairs it is therefore practicable to substitute the Aramid cloth or Aramid/Carbon cloth by using pure carbon cloth.

For larger repair areas on components having Aramid fibers, the manufacturer should be contacted for his advice.

Cloth of equal material may also be substituted such that the weight-to-area ratio in the direction of the fibers is at least achieved.

Example (1) 1 layer of cloth No. 92125 may be substituted by
2 layers of cloth No. 92110

Example (2) 1 layer of cloth No. 92145 may be substituted by
1 layer of cloth No. 92140 (as both have the same weight-to-area ratio in warp direction)

The foam used for sandwich constructions does not require scarfing - a butt joint (bonded with resin) is sufficient.

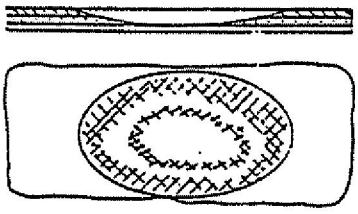
Laminating principles for repairs

In the area of repair, the new cloth layers are always laid up in reverse sequence onto the scarfed out sound original laminate, thus ensuring that the cloth layers taken out are substituted by layers of the same size.

Note: From experience gained it is recommended to use a fine cloth for the uppermost layer, thus achieving a long-lasting good surface quality.

For repairs the final layer should therefore always be a fine cloth - e.g. No. 92110, or one being identical with the component's original uppermost layer - laid up in addition to the scarfed-in layers. This also serves the purpose that - on sanding the area of repair - first this layer and not the lower stressed layers will get damaged.


damaged area



scarf joint

protective layer


substitute layers

Resin and/or the gel coat will only adhere to a roughened surface. Therefore all areas to be bonded, laminated or painted require sanding! Use a coarse dry sand paper (80 to 150 grit) prior to laminating. For repainting sand the old gel coat using a wet (or dry) sand paper with 240 to 320 grit. If the top layer of a laminate was covered with Nylon cloth, roughening is not required, provided the surface is clean and free from grease.

## 5.1 Repairing a pure glass fiber shell

Repair example of a component laid up from

1 x 92 110 ※ (A) outside
1 x 92 125 # (B)
1 x 92 140 ※ (C) inside

1. Determine the type of cloth, the number of layers and the orientation of the weave.

2. Determine the length of the scarf joint in compliance with section 8.

   92 110 : 5 mm (0.20 in.)
   92 125 : 10 mm (0.39 in.)
   92 140 : 15 mm (0.59 in.)

   Total length of scarf joint therefore is 30 mm (1.18 in.).

   Experience in repairs has shown that by assuming 15 mm (0.59 in.) for each layer, a determination of the total length of a scarf joint is also possible.

3. Remove damaged laminate using a sanding block (80 to 150 grit) or an angle grinder and scarf the sound laminate to the width required for the scarf joint.

4. For holes with a diameter of more than 50 mm (1.97 in.), a support must be attached to the inside, thus preventing a sag of the laid-up cloth layers.
   The support can be made from thin plywood (to be sealed with resin) or from a thin laminate, bonded to the inside with the aid of an adhesive compound.

   If the repair area is not accessible from the inside, trim the opening in the shell to an oblong shape, thus permitting the backing plate to be inserted from the outside and rotated to cover the hole. It is then glued in position with the aid of a cord loop or nail (driven through the plate), by which it is drawn against the inner skin.

5. Clean area to be re-laminated (if necessary, sand again and remove the dust with a vacuum cleaner).

6. Cut glass cloth layers to the required size and lay them up as follows (for the assumed laminate):

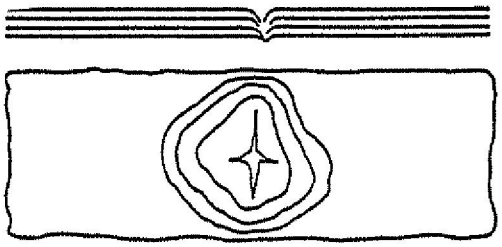
   (A) 1 x 92 110 ※ (the largest layer)
   (B) 1 x 92 125 #
   (C) 1 x 92 140 ※ (the smallest layer)
   (D) 1 x 92 110 (the protective layer, size same as C)

7. After curing trim off the protruding edges and sand the entire repair area to level the overlaps, which must then show about the scarf length previously determined. Above the former area of damage the layers A) through C) must not be harmed as otherwise the thickness of the laminate would be insufficient.

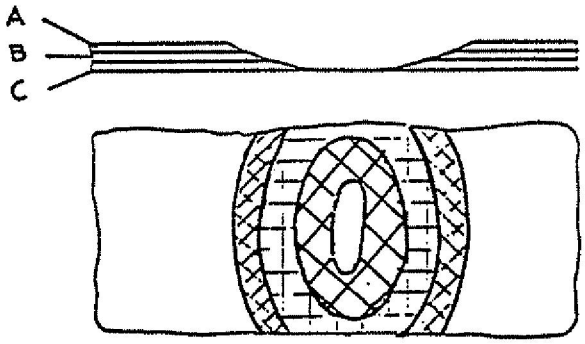
Repairing a pure shell (ctd.)

For re-coating the damaged area refer to section 7.

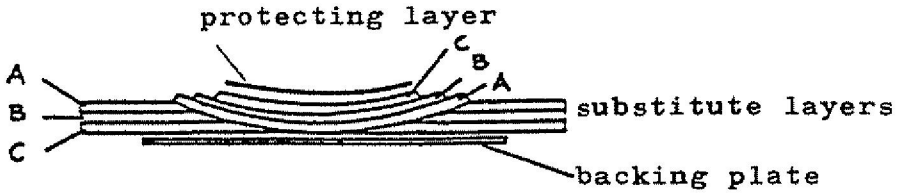
Damages not reaching down to the innermost layer are repaired in the same manner and only those layers are substituted (by making scarf joints) that have been harmed.



damaged aera



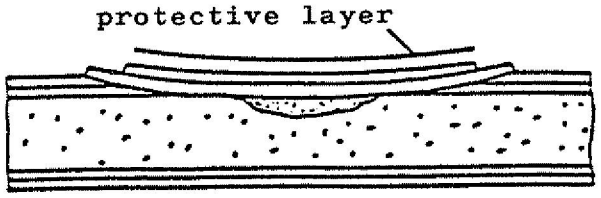

scarf joint



## 5.2 Repairing a sandwich shell

### A) Only outer laminate destructed

1. Determine the type of cloth, the number of layers and the orientation of the weave.
2. Determine the length of the scarf joint in compliance with section 8.
3. Remove damaged laminate, scarf sound laminate to width required for scarf joint. Remove destructed foam - be cautious not to harm the inner laminate.
4. Cut substitute cloth layers to required size and shape (sequence of lay-up in reverse of sound layers) and do not forget the additional protective layer (size to match smallest layer).
5. Fill up the area where the foam was removed with a microballoon/resin mixture (small pieces of foam may be added) and make sure that the surface is level and free from waves so that the glass laminate to be laid up does not protrude above the contour.
   If the area of repair is small, apply substitute cloth layers "wet in wet", otherwise let mixture cure, sand to proper contour and
6. Lay-up substitute cloth layers in the correct sequence - see "repairing a pure shell".
7. Sand repaired area after curing. If necessary, apply filler and sand again. Note that directly above the former area of damage only the protective layer may get harmed.
8. Apply gel-coat - see section 7.




Note: If under pressure of time, the curing of the repaired area may be accelerated by using a heater - but only once the resin has set, otherwise air in the core may expand and form air voids.

## 5.2 Repairing a sandwich shell

B) Sandwich totally destructed (see sketch on page 5.2.3)

1. Determine type of cloth, number of layers and weave orientation of inner and outer laminate.

2. Determine length of scarf joint/overlap for inner and outer laminate in compliance with section 8.

   The substitute cloth layers for the inner skin are always overlapped (and not scarfed in) as the thin laminate might break when trying to scarf it.

3. Remove damaged outer laminate from where it is not firmly attached to the foam core and remove the foam until its proper bonding to the inner laminate is evident. Then remove more foam as required for overlapping the substitute cloth layers.

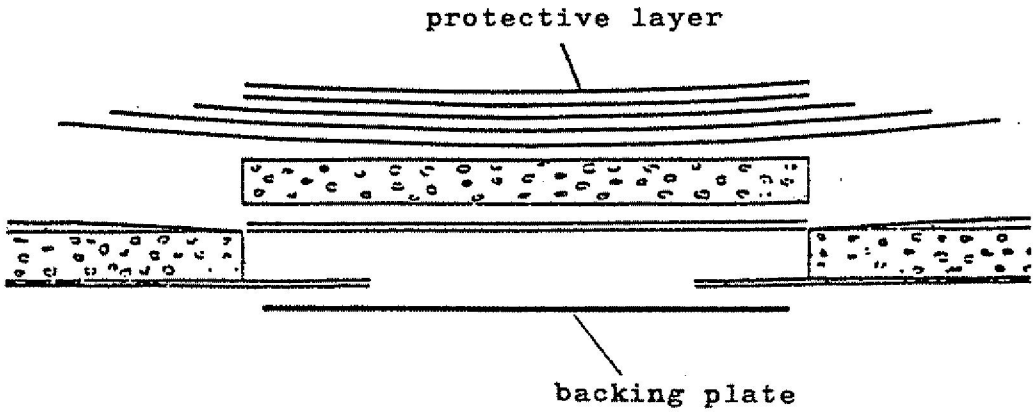
   In order to avoid that the protruding edge of the inner laminate breaks off, attach from the inside a support made from thin plywood (to be sealed with resin) or from a thin laminate using an adhesive compound.

4. Lay-up substitute layers onto inner skin. Cutting the cloth to exactly the size needed is recommended, as it is beneficial to continue working "wet in wet" by filling up the hollow space with a mixture of resin, microballoons and styrofoam kernels - provided the repair area does not exceed about the size of a fist. For larger areas a new foam layer must be used (inner skin already applied and cured) and glued in position using a resin/micro balloon mixture. This pre-fabricated layer may be pre-shaped with the aid of a hair dryer, but must in any case be pressed down to the proper contour by means of weights.
   After curing sand the foam sandwich layer to be slightly "undersized" so that later the outer laminate does not protrude above the contour.

Sandwich totally destructed (ctd.)

5. Lay-up outer cloth layers as described in chapter A).
   For their better bonding, coat the foam with a resin/ microballoon mixture and apply layers "wet in wet".

6. For the remaining steps of the repair continue as described in chapter A).



## 5.3 Splicing rovings and multi-axial knit fabrics

In the fuselage and also in other components there are reinforcements made from rovings or from multi-axial knit fabrics (ribbons/tapes).

As it is most difficult to determine the exact number of such rovings or tapes while clearing the damaged area, the manufacturer of the aircraft or the company in charge for its service must always be contacted for instructions concerning the repair of components having rovings/tapes as reinforcement.

Exception: The frame of the canopy - no consultation required for this component.

NOTE : For the repair of components constructed from rovings, the resin system type L 335 / hardener type 335 through 340 is n o t permissible!

## 6. Repair work on metal fittings

If - for unknown reasons - damage has occurred to any of the metal fittings on the aircraft, the manufacturer or the company in charge of its service must be contacted in every case.

Repairs involving welding may only be accomplished by persons authorized for aircraft welding.

For all steel parts the "Tungsten inert gas arc welding technique" is employed by the manufacturer.
For all steel combinations - except non-corroding steel - welding electrodes of quality No. 1.7734.2 may be used.

## 7. Re-coating (painting) damaged areas

Usually the process of re-coating a repaired area is more difficult and labourous than firstly expected.

The following is to be observed:

- Prior to applying the gel-coat, the repair area must be perfectly re-profiled - use a polyester filler for this (as used for cars).

- Hand-sand the existing gel-coat surrounding the repaired area with a 240 to 320 grit wet sand paper so that the new gel-coat will properly adhere and be flush with the original coating after sanding.

  The area to be sanded for re-coating must therefore always be larger than the area of the repair.

- Clean the repaired area carefully - to be free from any dust - and apply the gel-coat either with a brush (for smaller patches) or with a spray gun (approx. 500 g needed per square meter). The transition from the existing to the new coating must show no steps, thus facilitating the subsequent finishing process.

- Sand re-coated area (after gel-coat has fully hardened) first with a 240 to 400 grit wet sand paper, then sand again with a 500 to 800 grit paper.

  Should imperfections require another coating, always first roughen the surface using a 320 grit paper (or coarser).

- Finally polish the sanded "finished" area with the aid of a polish compound or hard wax applied with a buffing wheel.

WARNING: For repairs on control surfaces always observe their weight limits and hinge moments - see Maintenance Manual of the aircraft affected !

## 8. Lengths of scarf joints (splices) for various fabrics

Glass fiber cloth (per layer)

| Cloth designation | Weight (g) per $m^2$ (without resin) | Thickness (mm) (with resin) | Length (mm) of scarf joint * |
|---|---|---|---|
| 91 110 | 108 | 0.12 | 5 |
| 92 110 | 163 | 0.18 | 5 |
| 92 125 | 276 | 0.30 | 10 |
| 92 140 | 390 | 0.43 | 15 |
| 92 145 | 220 | 0.24 | 15 (longit.) |

Carbon fiber and Aramid fiber cloth (per layer)

| Cloth designation | Weight (g) per $m^2$ (without resin) | Thickness (mm) (with resin) | Length (mm) of scarf joint * |
|---|---|---|---|
| 98 140 (CF 200) | 200 | 0.30 | 15 |
| 98 160 (CF 285) | 285 | 0.43 | 25 |
| 98 340 (warp direct.) | 170 | 0.25 | 15 (longit.) |
| SIGRATEX Tape (KDU 1024) | 210 | 0.25 - 0-32 | 30 (longit.) |
| CX 14 T (multi-axial knit fabrics) | 140 | 0.21 | 25 (longit.) |
| Aramid/ Carbon 98355 | 200 | 0.35 | 15 |

Scarfing sandwich core materials (e.g. Divinycell or honey comb) is not required.

* Scarf joints (splices) with a length of less than 5 mm (0.20 in.) make no sense!

Conversion: 1 mm = 0.03937 in.