GENERAL KNOWLEDGE OF AIRCRAFT

Compendium for teaching SPL theory

VER.3. - 04.02.2020

The content of this compendium is part of the theory requirements for the course "General Knowledge of Aircraft" in the AMC for the EASA-FCL for the SPL licence and the amendments to Part SFCL The numbers of the sections refer to the syllabus

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Content

Subject "General Knowledge of Aircraft"

This compendium is a completely new publication and replaces the compendium that previously formed the teaching material for the course "Instrument & Material Theory" for the s-certificate, which was the theory basis for the national but ICAO-approved s-certificate.

In 2008, gliding in Denmark was covered by the EASA Part M regulations on equipment, and in 2019, glider operations have been regulated by the EASA Part SAO regulations, and as of April 8, 2020, glider training in Denmark has also been regulated by the EASA Part SFCL regulations. This has created the need for rewriting the compendium for the course "General Knowledge of Aircraft". The paragraph numbers used in this Compendium are the same as can be found in EASA AMC1 FCL.115; FCL.120.

The compendium is intended for teachers and students who participate in the theoretical training on the equipment side of the SPL certificate.

The compendium is linked and designed so that students preparing for class can read it directly on a PC or tablet. Teachers of the subject will necessarily have to go deeper into the material when preparing lessons and producing presentation material.

It is hoped that the illustrations and links provided in the compendium will help the reader to understand the topics. If there are any ambiguities, errors or suggestions for improvement, the editorial team would be grateful for any comments.

The basis for the compendium has been prepared by Jan Bagge, North Zealand Gliding Club and Lars Sverre Rasmussen, PFG. DSvU thanks the authors for their voluntary work on the compendium. Simultaneously with the editing of the compendium, the draft AMC (Acceptable Means of Compliance) for Part SFCL has been received, and the compendium has therefore been adjusted to the scope of the subject General Knowledge of Aircraft in this draft.

The editing is completed in December 2019.

Danish Gliding Union December

2019

8.1 Aircraft structure (Airframe)

The vast majority of gliders in Denmark are manufactured in Europe, and thus must comply with the European glider construction standard (EASA CS-22), and this construction standard has two categories for glider certification:

U = Utility (glider for traditional use) A = Aerobatic

"Utility" is limited to a load of -2.65 G and + 5.3 G, while "Aerobatic" must be able to withstand -5-0 G and +7.0 G. Within the CS-22 construction standard, a distinction is also made between pure gliders with a maximum flying weight of 750 kg and gliders with an auxiliary engine of max. 850 kg.

Gliders must meet many other criteria to comply with the CS-22, and it goes too far to get into these criteria in this theory course. However, since gliders are also used for competition, they must be divided into different classes so that the aircraft can be compared during competition. These competition classes are:

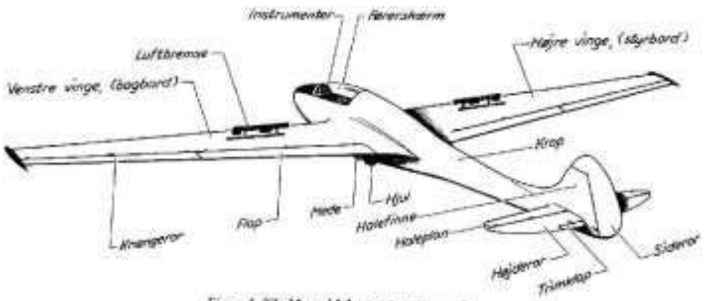
- ✓ Open class without restrictions
- ✓ 18-metre class without restrictions (except for the 18-metre span)
- ✓ FAI 15-metre class with 15-metre span and flaps
- ✓ Standard class with span of max. 15 meters and without flaps
- ✓ Club Class
- ✓ Two-seater class

Traveling motor gliders (TMG) have a fixed engine and propeller that cannot be retracted into the body. However, such aircraft are also built to the CS-22 and are thus by definition a glider.

Structures

The aircraft structure is characterised by the fact that it must be both strong and light. This is reflected in the materials and structures chosen. The aircraft structure consists of the following vital main parts:

- ✓ Wings that provide lift (as long as the airflow is correct)
- ✓ The control surfaces (tailplane, fin), which ensure that the wings always have the right direction in relation to the airflow (like the control feathers on a willow)
- ✓ The body that holds all the parts together, creating an aerodynamic enclosure for the pilot.

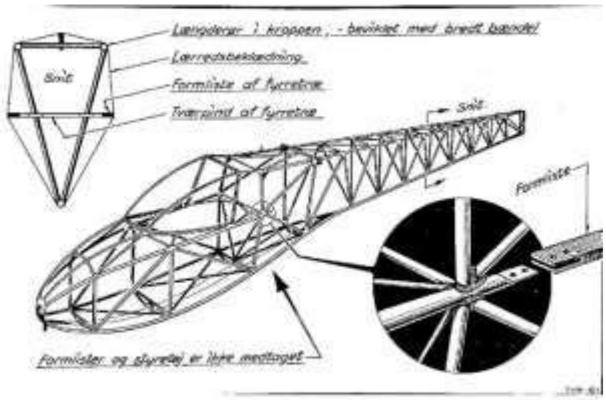


Figur 1-27. Hoveddelene på et svævefly.

Bodies:

The body must be a rigid link between the wing and the control surfaces.

This can be done by building it as a 'lattice body' of thin tubes. This gives a light and strong construction. However, it is not very aerodynamic and will therefore be 'clad' to give it a smooth surface. The roominess of the body (height/width) is controlled by 'trusses' which usually get smaller and smaller towards the tail of the aircraft



Another option is to make the body like a 'tube'. This is called a shell body and it is strong against bending as well as twisting. The weakness of this construction is that it is sensitive to 'point loads'. It therefore needs to be reinforced where there are large point loads (e.g. attachment of landing gear and wings). The shape of the body can also be controlled in this case by means of the trusses, which are also used to fix the steering lines, and the push-pieces to the rudders. A special way of making the 'shell' is to build it as a sandwich of two thin strong layers, with a rigid filling material in between.

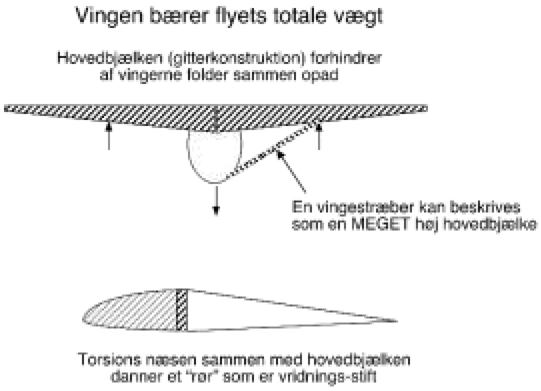
The Wings

The wing itself is curved in the direction of flow in order to form the buoyancy. To prevent the wings from collapsing over the pilot's head, a strong beam is needed to prevent the wing from bending upwards. This can be done as a 'lattice' construction, as described in section 8.2. This forms either an 'I-beam', or a 'box beam'. Both constructions are used for the main beam of an aircraft.

However, it is not 'torsionally rigid' and the wing will therefore twist as the speed changes and the lift on the wing moves forward or back. To ensure that the wing is torsionally stiff, the main beam must be combined with some form of 'tube construction'. This is done by having the leading edge of the wing form a tube with the main beam. Twisting of an object is called torsion, so this construction is called a torsion nose.

If you use the barbell principle, you can see that the thinner/lower you make the main beam, the greater the forces in the main beam. That is why it was not possible to make very thin wings when wooden planes were made. Now you have access to carbon fibre, and when you use this material, you can make quite thin wings, even if they have 29 m span.

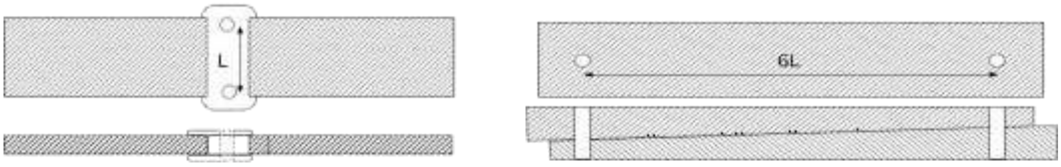
The aspect ratio is the ratio between the mean chord (the average wing chord) and the span. A glider has a large aspect ratio because the wingspan is large compared to the mean chord, while a powered aircraft has a small aspect ratio because the wings have a small span while the mean chord is larger (the wing is wide).



The shape of the wing is controlled by "ribs" that give the wing the right aerodynamic shape. However, in several modern aircraft they have been replaced by a partially self-supporting wing shell (sandwich construction) which ensures the correct shape of the wing surface. A trailing edge is fitted to the trailing edge of the wing to provide a solid mounting for the ailerons.

In order to disassemble the aircraft, the wings can be divided into 2 or more parts. This means that the assembly must be able to withstand the large forces of the main beam.

This is done either with a very solid bracket attached to the end of the main beam, or by allowing the two main beams to 'overlap' so that the forces are significantly reduced.



Main beam with centre bracketOverlapped main beam

If the distance in the overlapped main beam is 6 * the distance in the assembly bracket, then the forces for the main bolts will be 6* less in the overlapped main beam.

The main beam is normally NOT clamped to the body, but only 'clamped together', and then the body hangs in some brackets between the body and the wing. The really big forces are in the main beam itself and the associated joint and NOT between body and wing.

The different control surfaces

To secure the position of the wing in the airstream, the aircraft must be equipped with rudders. The tail fin ensures that the wing does not turn sideways (the pitch axis), and the 'tail plane' ensures the up-down direction (the cross axis). The single control surface is constructed as a 'mini-wing' with main beam, torsion nose etc. to maintain its shape under load. The 3rd direction in which the aircraft must be steered is about the longitudinal axis. Movement around this is controlled by the ailerons, which are located at the tip of the wings.

There are also secondary control surfaces, which are used to adjust the aerodynamic performance of the aircraft. The detailed function and structure of the control surfaces is described in the section "Flight Control" (primary and secondary control surfaces).

8.2 System design, forces and loads

There are high requirements for an aircraft to be approved. This is almost self-evident, as the consequence of a lack of strength in the aircraft would be an accident and, in the worst case, injury to people. The requirements can be summarised as follows:

- ✓ The design must be tested/verified and type certified.
- ✓ The structure must have sufficient 'reserve' to withstand critical conditions.
- ✓ Nuts must be secured (locking nut/locking split, etc.).
- ✓ Main bolts must be secured.
- ✓ Rudder connections must be secured.
- ✓ Critical springs must be made as 'double springs' so that the spring function is maintained even if a single part of the spring should break.
- ✓ The aircraft must be checked by a daily inspection before use, including "Positive rudder check"
- ✓ Checklists must be used before and during flight.

To ensure that the material quality of the aircraft is 'maintained', there are formal maintenance requirements:

- ✓ The aircraft must be maintained at fixed intervals and for special situations.
- ✓ There are requirements for overhaul/replacement of critical parts on calendar time, by number of operations or by operating time. When the aircraft or parts reach this limitation, it shall not be used until the required maintenance has been performed.

Safety conditions

Colours of operating handles:

As part of safety, all vital controls are colour-coded in all gliders:

✓ Driver screen	**Red**	Emergency release of driver's screen
	White	Opening/closing the driver's screen
✓ Clutch	**Yellow**	Nose and bottom couplings
✓ Air brake	**Blue**	Operation of air brakes
✓ Trim	**Green**	Trimming of the aircraft

None of the other controls may have these colours.

Forces and loads

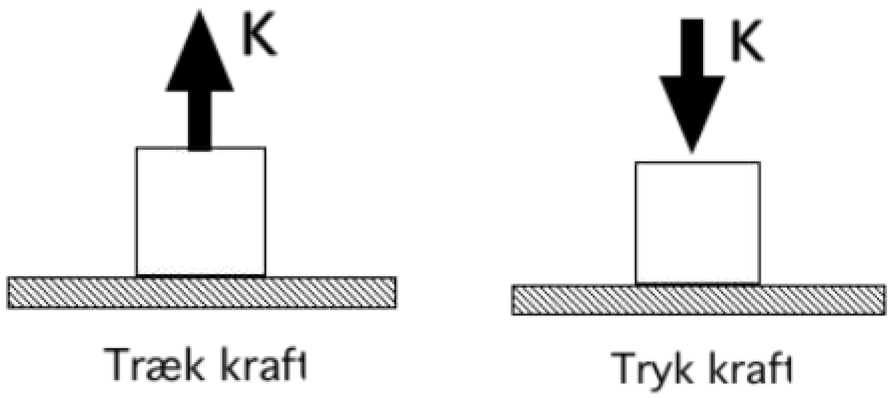
General requirements for 'strong' constructions

Aircraft must be light and strong, otherwise they cannot lift off the ground. That means both choosing the right materials and making the structure itself light and strong.

- ✓ Lightweight materials such as wood, aluminium, carbon fibre, fibreglass and others are used in aircraft.
- ✓ The construction is made to provide the maximum strength for the same weight of material.

Power:

When we push something or pull something, we affect it with a force that is measured in Newtons (N). Force is usually denoted by the letter "F" (Force), or "K" (Force). It is illustrated by an arrow, where the length illustrates the magnitude and the direction of the arrow the direction of the force.

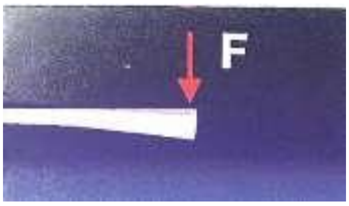


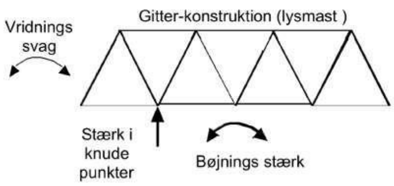
Some materials are strong in compression but weak in tension (e.g. concrete and cast iron), while others are stronger in tension (steel wire, etc.). It is therefore important to choose the right material for the job. But this is not enough when you have a structure where the force will affect the structure differently - depending on where it is subjected to the load.

When a structure is loaded, a deformation of the structure occurs. This will usually take the form of:

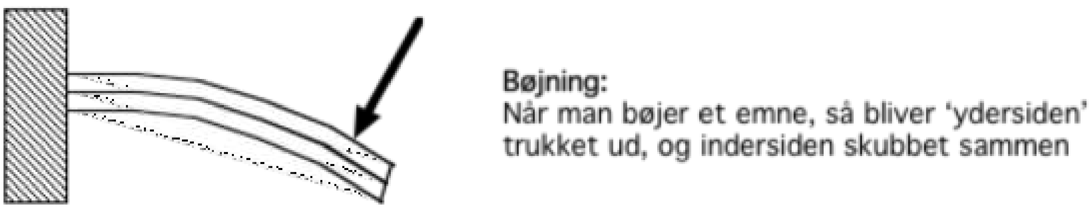
- ✓ Bending
- ✓ Twisting
- ✓ Deflection

Bending of a beam



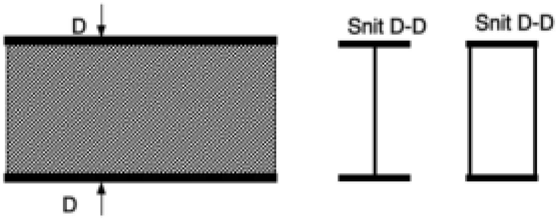


Bending stretches the material on the 'top' side while compressing it on the underside. By using the law of weights, we can show that the 'higher' the beam, the stiffer it becomes and the greater the forces it can withstand (a board on edge is stiffer than a board lying along).



A board on edge - or even better a lattice construction made of triangles - provides a very light and strong construction. The lattice structure is therefore one of the preferred structures in aircraft.

If you 'refine' the lattice construction to many staggered triangles you can show that it corresponds to an I-beam i.e. a strong beam on top, with a 'spacer' and a corresponding beam underneath. This is illustrated below, where 'Section' shows a cross-section of the structure.



It ends with either an "I-beam", or a 'Box-beam" as shown in Section D-D. Both designs are used for main beams in aircraft.

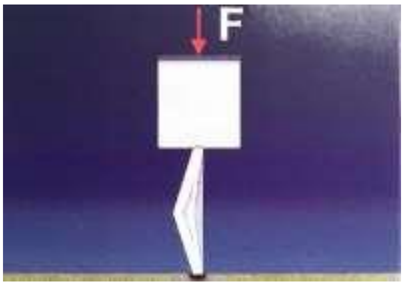
Twisting a rod

Twisting is also a load that occurs in aircraft. It may not be so obvious, but it occurs in many places. Here there is no difference whether the 'board' is on edge or lying down. The best structure is a 'tube' and so this principle is used everywhere in the aircraft where torsional stiffness is required.

You can make a torsionally rigid construction using a 'tube'. It is also partly flexurally rigid, as parts of the wall can be seen as 'a board on edge'. The weakness of a tube is that it cannot withstand large 'point loads', and that it must therefore be provided with local reinforcements where there are point loads. Also, it is more difficult/expensive to make a tube than to make a solid bar or beam.

Bending that occurs when pressure is applied to the end of a rod

A thin rod bends out when you press the end of it. This is independent of the material used. It is only the 'shape' that matters.



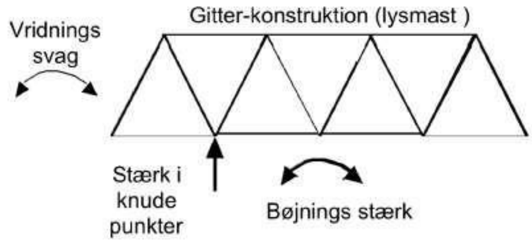
The bending can only be prevented by making the bar stiffer (with the same material usage) so that it does not bend out.

If we use our previous knowledge about bending stiffness, we see that you can prevent 'bending' of a rod by either making it as a tube, or as an angle, so that it becomes bending stiff in both directions. Therefore, a lattice body is not made of steel bars, but of steel tubes, as these have a significantly higher bending and torsional stiffness than a steel bar of the same weight.

By the way, notice that when you 'pull' the structure, a tube or a rod is equally good. It is only against compressive forces that you can risk deflection.

Summary: When a structure is loaded, it can deform due to:

- ✓ Bending (Greatest strength with a beam on edge, or a lattice construction)
- ✓ Twisting (Greatest strength with a tube)
- ✓ Deflection (Greatest strength by using a tube construction)



When building a lattice structure, there are both compressive and tensile forces in the structure, and here it is important to keep in mind that a 'flat bar' / 'a string' can only absorb tensile forces (due to the tendency to deflect, while an angle bar / tube can more easily handle compressive forces.

As an example, look at an ordinary tent. Here, it is clear that the compression forces are absorbed by the tent poles, while the traction forces can be handled by the battens. The reverse is NOT possible !

8.3. Chassis, wheels, tyres and brakes

The undercarriage of a traditional glider has no function when the aircraft is flying, but provides support when the aircraft is stationary or on the ground. In particular, when the aircraft 'bumps' over the ground during take-off and landing, or on a less-than-pristine landing, there are large forces to be transferred from the wings to the wheels.

The forces on the undercarriage must be transferred from the whole aircraft and especially the heavy part i.e. the wings. There must therefore be a solid connection between the undercarriage and the wings. On aircraft with a 'grid body' this is achieved by attaching both the undercarriage and the wings to the 'nodes' in the grid body, while the shell body must have the necessary reinforcements on the shell where the wings and undercarriage are attached.

Almost mead

The solid mead was dominant as the undercarriage of the very early gliders. The mead could carry the weight of the aircraft, and was good for 'gliding over the bumps' at gliding sites. On most types there was some form of suspension to protect the pilot from excessive blows to the back when the aircraft landed. Today it is only found on older aircraft and 'veteran' aircraft.

Fixed main wheel

The fixed main wheel is a simple and robust design. In its basic design, the wheel itself provides the suspension. The tail section is supported by a tail slider, which is resilient to protect the side and elevator hinges from impact during take-off and landing. The advantage of a fixed wheel is that you can't 'forget' to put it out, so you avoid landing on the belly of your body.

Retractable main wheel

A fixed wheel sticking out of the body will cause some wind resistance. By making the wheel retractable you can avoid both wind resistance and the noise from the turbulence around the wheel. However, the retraction mechanism is rather complex, and it also means that you have to remember to "put the wheel out" when you go in for a landing.

Additional undercarriage

Nose wheel:

On some aircraft - particularly two-seater aircraft - the main wheel is positioned so that the aircraft 'almost' balances on the main wheel when empty. This makes it very easy to handle the aircraft on the ground, but it does mean that the aircraft 'goes on its nose' when the pilot sits down in the aircraft. The aircraft is therefore fitted with a 'nose wheel' to support the front of the body until the aircraft is airborne.

Tail lips/tail wheel:

The purpose of the tailwheel/slider is to protect the rear body itself from impact/strike/wear as the aircraft travels over the ground. It must therefore be spring-loaded, and in order for the tail slider to do this, it is often manufactured as a spring, or by mounting the 'wear block' on a suitable piece of rubber. If you have a tailwheel, do NOT be tempted to fit a solid tailwheel as it will not spring as well and therefore will not protect the aircraft structure from impact. There are aircraft today where the tail wheel is also retractable.

On some aircraft - particularly self-launching gliders (SLGs) - the rudder is connected to the tailwheel, allowing the pilot to control the tailwheel using the rudder pedals.

Tires:

The tyre of an aircraft is only used for rolling/braking and therefore has no 'pattern'. Tyres with longitudinal grooves are best for braking with water on the runway, and longitudinal grooves cannot 'fish up' a take-off wire. You must therefore NOT use tyres with a different pattern on an aircraft.

Wheel brakes:

All modern aircraft have some form of wheel brake, unless the aircraft has a mead that can brake the aircraft. For a normal landing, a wheel brake is not necessary, but for an out landing / aborted take off, a very short roll distance may be appropriate and the wheel brake is important.

If the brake is made to activate when the air brakes are fully applied, a cockpit check should check that the air brake lever 'springs' when activating the wheel brake, and does not go hard to a stop (indicating that the brake is defective).

The wheel brake can be made in many different ways

- ✓ with a metal plate pressed against the deck.
- ✓ like a normal drum brake
- ✓ as a conventional disc brake.
- ✓ by other means.

On many aircraft, the wheel brake is connected to the air brake mechanism so that the wheel brake is applied when the air brake is fully extended. On other aircraft, the wheel brake is activated by a "brake lever" located on the control stick. The advantage of this location is that the wheel brake can be activated without activating the air brake (e.g. in the case of a drag start). On the other hand, you have limited forces to brake with.

8.4 Mass and balance (Weight and centre of gravity):

There are two aspects of weight and balance that are critical to an aircraft:

- ✓ The weight of the aircraft
- ✓ Position of the centre of gravity

Weight of the aircraft:

If the aircraft is too heavy, it cannot withstand the loads for which it is otherwise designed. It is not so much how much the undercarriage can carry, but much more how much the wings (and main beam) can carry. This is specified as the total weight of the aircraft. When you then subtract the 'empty weight' of the aircraft (without 'cargo'), you get the aircraft's payload, which is the load you can afford to put on the aircraft (pilot's weight + baggage).

However, this is not the whole truth, as it does not matter whether the weight is in the wings (water ballast) or in the body (a heavy pilot). If the weight is in the body, then it will contribute to trying to bend/break the main beam, whereas water ballast is in the wings, and therefore the same place where the lift is made. This will not bend the main beam to the same extent, and you can therefore afford a higher ballast weight in the wings.

Therefore, all gliders have listed a maximum weight of "non-load bearing parts" (IBD), and this is the maximum weight that the main beam of the wings can carry (including the weight of the pilot + luggage). The weight limit is stated in the aircraft handbook AND on a placard in the cockpit, and for all modern aircraft is usually determined by "non-load bearing parts" (IBD), and thus it can NOT be increased by reducing the water ballast that you carry. As for maximum water ballast, it is the empty weight of the aircraft + the pilot + baggage + water ballast = total weight that sets the limit.

In terms of weight, there is no 'minimum weight' requirement, but there is indirectly a requirement for the location of the centre of gravity.

Position of the centre of gravity:

The aircraft's centre of gravity must be within certain fixed limits. Once you know the empty weight of the aircraft, you can calculate how heavy/light the pilot must be for the aircraft to maintain its centre of gravity within the limits and therefore be airworthy.

Please refer to the calculations in the course "Principles of Flight" pages 23 - 25:

However, for gliders, it will normally be either the total weight or the weight of the IBD that sets the maximum allowable weight in the cockpit. As a glider pilot you do not need to be able to calculate where the centre of gravity is, but you should be able to use the information given in the aircraft handbook and on the cockpit placards.

8.5 Rorflader

Primary and secondary control surfaces:

The primary control surfaces:

To ensure the position of the wing in the airstream, the aircraft must be fitted with rudders. The tail fin ensures that the wing does not turn sideways (the pitch axis), and the 'tail plane' ensures the up-down direction (the cross axis). The single control surface is built as a 'mini-wing' with main beam, torsion nose, etc. to maintain its shape under
load. The 3rd direction in which the aircraft must be steered is about the longitudinal axis. Movement around this is controlled by the ailerons, which are located at the tip of the wings.

The effective direction of all positions can be adjusted. For the tail fin, the rudder behind the fin can adjust the effective direction of the fin, while the elevator can similarly adjust the effective direction of the tail plane.

Crane gates:

To turn the aircraft, a force must be applied to push the aircraft towards the centre. This force can only be provided by the wings, and it is therefore necessary to bank the aircraft to get a partial component of lift from the wings to provide the force for a turn. The deflections of the ailerons are opposite to each other. When the right side goes up, the left side goes down and vice versa. Of course, the ailerons can also be used to return the aircraft to a level position. The use of ailerons is fundamental to steering an aircraft.

When the joystick is moved to the left, the left wing will be lowered and the right raised. Conversely, the stick towards the right will lower the right wing and raise the left wing.

Hall plan + Heights:

The tailplane and elevator steer and stabilise the aircraft around the transverse axis, thereby regulating the angle of incidence of the air on the wing. The 'effective direction' of the tailplane can be adjusted using the elevator, which is a flap at the rear of the tailplane. Alternatively, the whole tailplane can move as a rudder, and is then called a pendulum rudder.

The elevator is used to control speed, and it is usually connected to the joystick by a rigid link. When the stick is pushed forward, the tail of the aircraft is lifted and the speed increases. When the stick is pulled back, the tail is lowered and the speed decreases.

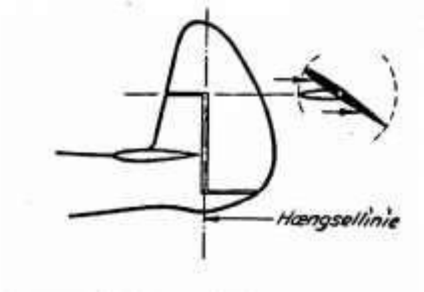
Tail fin + side fins:

The tail fin and rudder stabilise and steer the aircraft around the yaw axis, ensuring that the aircraft points straight into the airstream. The rudder can 'adjust' the direction in the same way as the elevator. The rudder is used in normal flight both to turn with, but also to compensate for, the yaw caused by the secondary action of the ailerons (more on this later). The rudder is controlled by the pedals, which are normally connected to the rudder by two steel wires. When the left pedal is activated, it pulls on one wire, which pulls the rudder to the left, causing the tail to swing to the right and thus the nose to the left. And similarly, the right pedal will turn the nose to the right.

Rudder balancing:

Aerodynamic balancing

To reduce the forces on the rudders, some of the rudder area can be placed in front of the hinge line and this will reduce the forces required to operate the rudder. This type of balancing is called *aerodynamic balancing as it is* due to the aerodynamic forces on the rudders.



Aerodynamic balancing on Ka-6Cr

Mass balancing:

If you 'just' mount ailerons on the back of the wing, the centre of gravity of the rudder will be significantly behind the hinge line. If there is turbulence (thermals) lifting the wing upwards, the centre of gravity of the aileron will try to 'stay where it was' and therefore push the aileron downwards. This results in the wing being lifted up even more - and thus 'self-reinforcing'. This will cause the wing to bend upwards until the wing can 'hold', and now the wing will start to fall downwards, but as the centre of gravity is still trying to 'stay where it was', the movement is also 'self-reinforcing' the other way. Therefore, if we do nothing, the wing will stand and flap up/down, and this can destroy both wing and rudder.

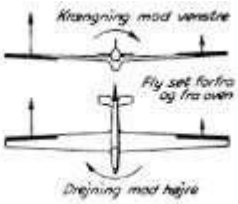
This phenomenon is called 'flutter' and it occurs at high speed. It is in fact the condition that usually sets the limit for the maximum velocity (VNE).

To limit/eliminate this, make sure the centre of gravity of the rudder is at or near the hinge line by placing an appropriate counterweight in front of the centre of gravity. On many fibreglass aircraft this (not insignificant) counterweight is hidden on the leading edge of the rudder, but on older wooden structures such as the ASK-13 it is clearly visible. It is also clearly visible on the leading edge of the rudder of a DuoDiscus (picture below). If the rudder has a part that provides aerodynamic balance, then you can make sure to place the counterweight in this location (as shown above on the Ka-6Cr).

Secondary effect of the cranes:

When we need to start a turn, for example to the left, we start by banking the aircraft to the left by moving the stick to the left. This causes the left aileron to go up and the right aileron to go down. This means that the lift on the outer part of the wing is less on the left side and more on the right side. But more lift means more wind resistance, so the right wing will brake more than the left wing. Therefore, if we do nothing, the nose will turn out of the turn (instead of into the turn!). This is called the *secondary action of the ailerons*.

This fact was already observed by the Wright Brothers, and they had to add a rudder to their glider to compensate for it.



Secondary effect of the cranes

We compensate by using the rudder (via the pedals) to force the nose into the turn, so the glider flies cleanly. It is this coordinated manoeuvre that many pilots spend a lot of time learning when they first start flying.

However, all rudder deflections have a more or less braking effect, and the effect can be reduced by making the upward rudder deflection significantly larger than the downward one. This reduces the secondary effect of the ailerons. This is called "*differential" rudder deflection* and is found on all aircraft to reduce the secondary effect of ailerons.

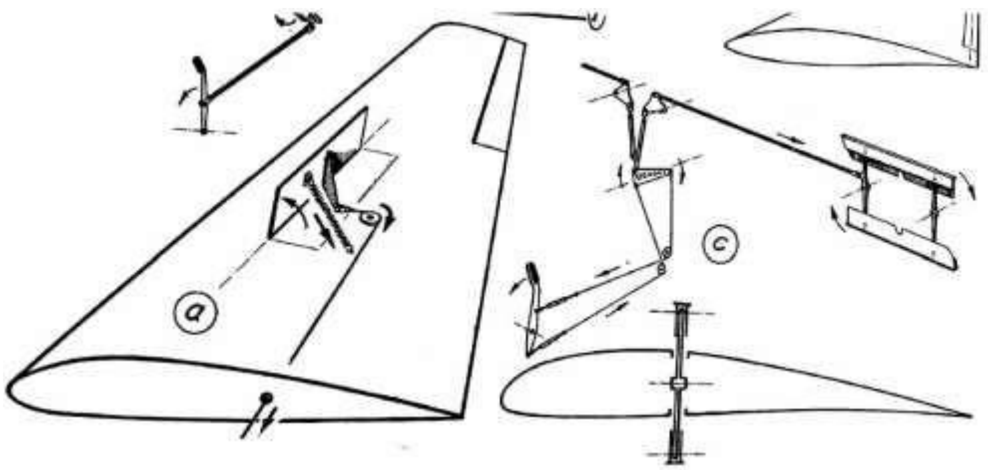
The secondary control surfaces:

In addition to the primary control surfaces used to steer the aircraft, gliders also have several 'secondary control surfaces'. They do not have a direct steering function, but they are used to change the aerodynamic conditions:

Air brakes:

Their function is to increase the wind resistance (drag) of the aircraft so that you can afford to lower the nose (dive) without increasing speed. This means that you can drastically reduce the glide ratio of the aircraft, which is desirable for landing, for example. If the airbrakes are placed relatively far forward on the wing, they will not only act as brakes, but also destroy some of the lift, reducing the glide ratio further.

The most common type is the 'Schempp-Hirth' brake which 'parallel slides' out of the wing, but some older models have a 'spoiler' which is hinged to the leading edge and 'tilts' up when it is needed. Sometimes the use of air brakes is coupled with the use of 'landing flaps'.



(a) - Classic spoiler

c) - Schempp-Hirth brake swings out perpendicular to the airflow

Flaps:

Flaps are parts of the wing (leading edge or trailing edge) that change the aerodynamics of the wing. We will only deal with 'trailing edge flaps', which can change the 'aerodynamic' shape of the wing from being very 'flat', which is good for flying fast, to being curved, which is good for producing extra lift at low speed. The result is a wing that can be optimised for its in-flight function.

The body angle in the air hardly changes when using flaps, as you turn the wing profile (by changing flaps) instead of the whole aircraft when flying fast. The nose of the aircraft is hardly pulled up at low speed, but only increases the effective angle of incidence of the wing when positive flaps are applied during turns and landings. The body will therefore not rotate much about either axis relative to the airflow.

When the flaps move downwards, it is called 'positive flaps' and the wing becomes more curved (slow flight). When the flaps are moved upwards, they are called negative flaps, which give a flatter wing (fast flight). On all newer flaps, the flaps and ailerons are coupled to 'help each other' (flaperon).

Landing flaps, used during landing when the ailerons are NOT attached, prevent the ailerons from stalling when the aircraft is flattened. Flaps mean a more expensive and heavier design, which makes the aircraft more complex to operate. They are therefore only found on the more advanced aircraft.

Trim:

All gliders are equipped with a trim system, which helps the pilot to maintain the correct airspeed. This is done either by influencing the rudder pressure on the elevator or by influencing the elevator itself to hold a certain position by means of a trim tab.
The steering pressure is influenced by the introduction of a spring device between the steering shaft and the elevator push rod. In this way the pilot is helped to maintain the correct pressure on the elevator and thus the correct speed.
Also the elevator can be influenced so that it has just the right setting to get the flight speed right. The trim tab causes the elevator to adopt the setting that gives the right speed.

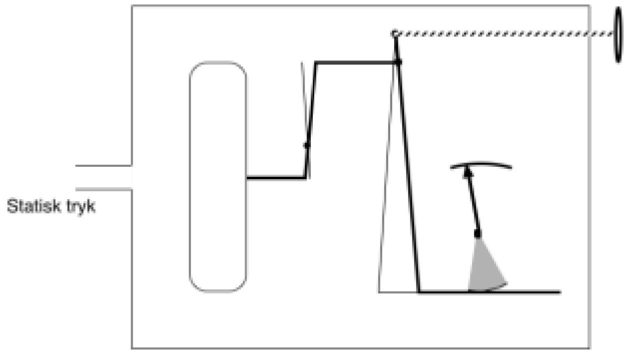
8.6 Instruments:

A glider must at least be equipped with an altimeter and a speedometer. A powered glider must also have a compass. It is also necessary - but not required - to have a variometer, which shows the vertical movements of the aircraft.

- ✓ The altimeter is important to show flight altitudes for e.g. controlled airspace.
- ✓ The speedometer must ensure that the pilot keeps the speed within the permitted limits.
- ✓ The compass is a requirement in powered aircraft - including powered sailplanes.

Altimeter:

The altimeter is a specially calibrated barometer. Like a barometer, it is based on an airless membrane (called aneroid). As the air pressure decreases with altitude, the canister will expand as the altitude increases, and this is then displayed as "altitude" on the instrument.



The altimeter basically measures the static pressure outside or inside the aircraft and displays it as an altitude. As the pressure at the surface of the earth can vary, it is necessary to be able to 'reset' the altimeter so that its display corresponds to the actual pressure. The altimeter is connected to the 'static orifice', which is a place on the aircraft where the pressure is almost the same as if the aircraft were standing perfectly still.

The altimeter is set to either the airfield pressure (QFE) or the sea surface pressure (QNH).
At 'QFE' the altimeter shows "0", and at 'QNH' it shows the airfield altitude above sea level.
The unit of measurement is hPa (Hectopascal), which can typically be seen in a small window on the altimeter.

Altimeters are based on the "ICAO standard atmosphere" of 1013.2 hPa, and therefore do not show the "real" altitude, as the pressure rarely corresponds to the "standard atmosphere". Since all altimeters are calibrated against the same standard atmosphere, two aircraft having the same display on the altimeters will be at the same altitude if the same pressure is set on the pressure scale.

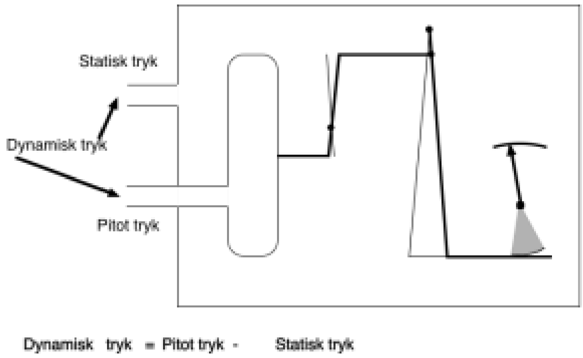
If by mistake the instruments are not connected to the aircraft instrument hoses, the altimeter will be the only instrument still working and showing the correct altitude, unless the aircraft has a pressurised cabin.

Speedometer:

The airspeed indicator measures the pressure inside the pitot tube (pitot pressure) in ***relation to the*** pressure outside the aircraft (static pressure). This means that dynamic pressure = 0 when the aircraft is stationary (i.e. Pitot pressure = Static pressure), unless the aircraft is affected by wind while on the ground.
If the airspeed indicator is by mistake not connected to the Pitot tube, it will not give any reading.

The dynamic pressure depends on the airspeed, if the aircraft is flying, or on the wind speed, if the aircraft is on the ground and the air is moving in the form of wind.

The dynamic pressure also depends on the height. The higher the aircraft is, the lower the indicated airspeed on the airspeed indicator will be. This means that the real airspeed at high altitude will be higher than at low altitude, but the speedometer shows the same. For this reason, the aircraft should not be flown at a higher indicated airspeed at high altitude than at a lower altitude.



Like the altimeter, the speedometer is based on an aneroid, but here one side is connected to the pitot pressure and the other to static pressure. The airspeed indicator measures the "dynamic pressure" as it is based on the aircraft's movement through the air. There is normally no 'reset' as the airspeed indicator should read "0" when the aircraft is stationary.

The speedometer shall be colour-coded as follows:

- ✓ Green area (full rudders allowed)
- ✓ Yellow area (limited rudder deflection - max 1/3 rudder deflection)
- ✓ Red line = Vne (max speed)
- ✓ Yellow triangle (Recommended approach speed at full weight in calm weather)
- ✓ White marking for restriction of use of flaps

As can be seen from four different speedometers, the position of the "yellow triangle" can vary a lot. Please read the aircraft manual (above are from ASW-19B, Discus-b, ASW-24, ASW-20C)

Wool cord

One of the most important and cheapest instruments in a glider is the woollen cord on the pilot's canopy. It immediately shows whether the aircraft is flying cleanly - i.e. whether the wings are level in a straight flight, or whether the aircraft has the correct bank for the turn it is making. When the flight is clean, the wool cord points straight back.

Ball level (heeling pointer)

The ball bubble has the same purpose as the wool cord - to show if the plane is flying clean. If the ball is in the middle, the wings are horizontal in a straight flight, and if it is in the middle in a turn, the aircraft has the correct bank for the turn the aircraft is making.

Thermometer

When the glider is equipped with water tanks, it must also have a thermometer that shows the temperature outside the aircraft. If the temperature approaches freezing, the water ballast must be shut off so that the water does not freeze in the wings. If this happens, the wing will usually be seriously damaged.

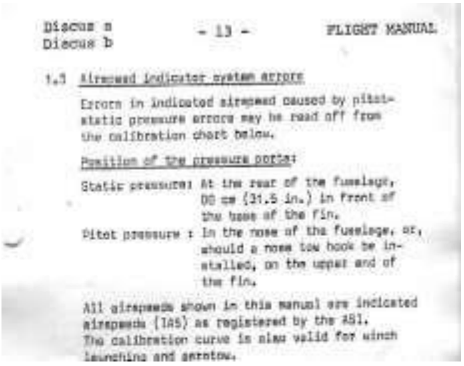
Pressure systems in gliders:

The static pressure:

- ✓ is the pressure that affects the aircraft when it is stationary
- ✓ is the pressure existing in the free air around the glider at the same altitude as the glider. This pressure can be used for the altimeter, but not for the speedometer.

Errors due to the location of the pitot static system:

It is almost impossible to position the pitot tube and static intakes 100% optimally under all speed conditions. For this reason, a graph is often included in the aircraft handbook to show what errors may occur at different speeds.



Discus a
Discus b

- 13 -

FLIGHT MANUAL

1.3 Airspeed indicator system errors

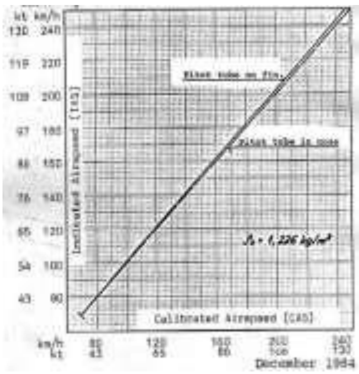
Errors in indicated airspeed caused by pitot-static pressure errors may be read off from the calibration chart below.

Position of the pressure ports:

Static pressure: At the rear of the fuselage, 80 cm (31.5 in.) in front of the base of the fin.

Pitot pressure : In the nose of the fuselage, or, should a nose tow hook be installed, on the upper end of the fin.

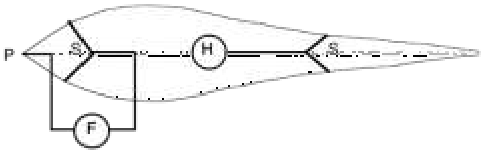
All airspeeds shown in this manual are indicated airspeeds (IAS) as registered by the ASI. The calibration curve is also valid for winch launching and aerotow.



As can be seen from the above description, there may be a small error in the measurement of static pressure and thus also in the speedometer reading. BUT all markings and limits found in the aircraft and aircraft manual have this error factored in. Thus, the pilot should NOT correct for this deviation, but simply use the airspeed indicator display.

Since even small pressure differences can cause an error in the speedometer, we have to "take the mean" between the right and left sides. Static orifices are therefore always made as 'pairs', so they sit opposite each other, on either side of the body.

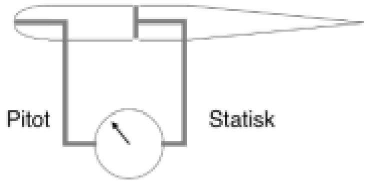
Connections of the speedometer (F), altimeter (H) are called the Pitot-Static system. Pitot opening(P) and several different static intakes (S) are shown in the illustration where the aircraft is seen from above.



Pitot printing:

This pressure is usually measured in the nose of the aircraft. If this is not possible, it can be measured on the leading edge of the fin. On some aircraft with a turbo engine and nose clutch, you have both, and then you can switch between them depending on the situation.

On powered aircraft or powered sailplanes, where there is a propeller in front, which blows the air down along the body, you can NOT measure Pitot or Static pressure close to the body. They therefore have a pitot tube (with associated static orifice), located outside the slipstream from the propeller. Typically it is located under the wing.



The variometer:

The variometer is probably second only to the 'wool string' as the most important instrument in a glider. It is characterised by:

- ✓ It is a prerequisite for 'thermal flight'
- ✓ Measures how fast we rise/sink.

We already know that the pressure will drop when we rise, while it will rise when we sink. So how can we measure whether we are rising or sinking?

The secret lies in a thermos flask with a small hole (kappilar opening) connected to the static pressure, it will show what the pressure was "a little while ago". It will follow when the pressure changes, but will always be "a little behind".

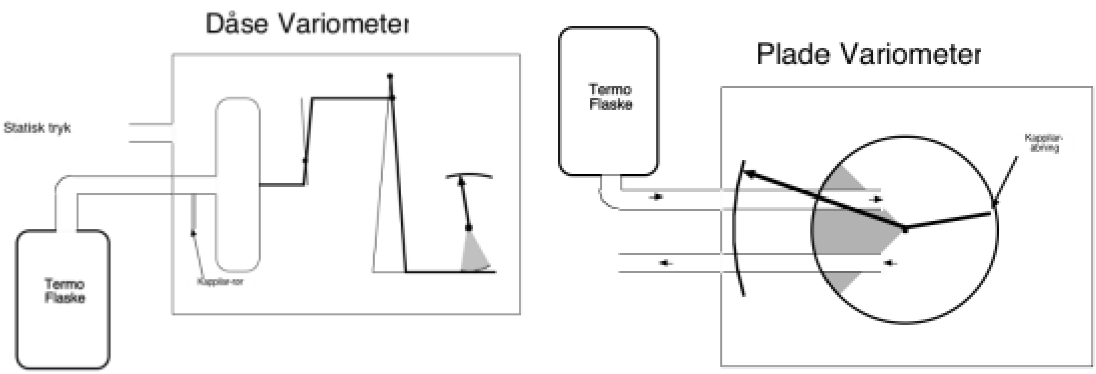
If we compare the pressure inside the bottle with the static pressure outside, we have a measure of whether the plane is rising or sinking:

- ✓ As we rise, the pressure will fall, and so the pressure in the bottle will always be slightly higher than the static pressure.
- ✓ When we sink, the pressure will rise, and so the pressure in the bottle will always be slightly lower than the static pressure.

You can therefore measure whether we are rising or sinking by:

- ✓ Measuring whether the pressure in the bottle is higher (rising), or lower (sinking) - This principle is used in the can variometer.
- ✓ Measuring whether the air flows out of the bottle (rises), or flows into the bottle (sinks) - This principle is used in the plate variometer, which is the 'normal' mechanical variometer in a glider.

To check whether a mechanical variometer is correctly connected to its thermobottle, the hose connecting the variometer to the thermobottle can be squeezed. If you do this, the variometer will show the stig.

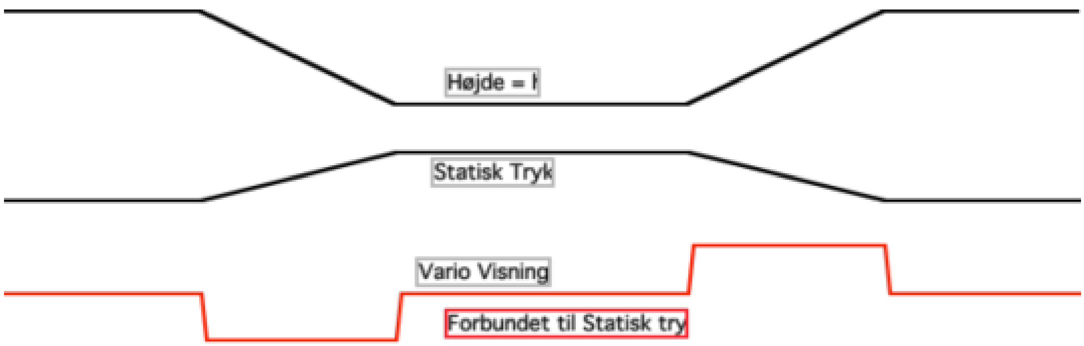


The variometer is a very sensitive instrument and the thermos should NOT be placed where the sun is shining, e.g. on top of the dashboard. It should be stored well down in the aircraft where there is shade at all times. If the temperature in the "bottle" only changes by 1 °C/minute, this will result in an error of 0.5 m/s. It is precisely to avoid temperature errors that you use a thermos flask and not just an ordinary bottle.

Summary:

- ✓ The variometer in a glider is usually a plate variometer.
- ✓ The variometer measures whether air flows out of or into a container (thermos flask).
- ✓ The container and the air inside the container must not change temperature, and the container is therefore made as a thermos flask.
- ✓ The variometer is connected to a pressure port (static), and to a thermos flask. There are therefore 2 connections on a variometer.

When the variometer is connected to static pressure, it will show whether the aircraft is rising or sinking, as illustrated here:



But the variometer does NOT always show whether it is the thermals that are causing the aircraft to climb. Therefore, if we want an indication of the 'thermals', we should not measure the altitude, but the energy.

Variometer compensation (Total energy):

As described above, the variometer shows whether the plane is rising or sinking, but not whether the rise is due to thermals, or whether it is just because we are "slowing the plane down" and thus rising. The rise that the variometer shows when the stick is pulled back is called 'stick thermal', and is not what we want. Instead, we want to see if it is the thermals that are causing the plane to rise.

If we think of a bicycle going down a hill and up the other side, the bicycle has the same energy all the time (if we forget about air resistance):

- ✓ at the top it has not much speed, but a lot of height.
- ✓ down at the bottom it has high speed but lower height.
- ✓ on the other side of the valley it has regained height, but in return the speed has decreased.
- ✓ it has the same total energy all the time.

You can move energy back and forth between height and speed, this is called potential (height) energy and kinetic (motion) energy.

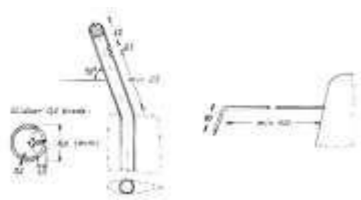
We want a variometer that shows the energy change instead of the altitude change. If we dive the plane, we lose altitude, and since pressure increases with decreasing altitude, static pressure will increase, and an uncompensated variometer will show sink. And during the dive, the pitot pressure will increase as we gain more speed and the static pressure increases as we descend.

To compensate for the higher velocity, we need to generate a pressure that corresponds to the pressure increase that occurs with the decreasing altitude. In other words, we need a pressure drop due to the increased velocity, but increased velocity also produces increased Pitot pressure.

So for the "speed correction" to work properly, the 'compensated' altitude must increase as the speed increases which means the pressure must decrease, but on the contrary, the pitot pressure increases and thus the altitude decreases. So we need **"*a negative pitot tube*"** where the pressure decreases when the velocity increases.

It actually exists on the upper side of the wing where there is negative pressure, but this pressure depends on many other different conditions, so it is not suitable for use in the compensation. But if you use the principle and make a tube with a 'local' constriction, you get the same effect. A tube with a constriction is called a *venturi*, which gives the desired effect.

The same effect can be obtained by making a small opening in the back of an (almost) vertical tube. This is often called the Lundtofte nozzle.



Irving -VenturiLundtofte Nozzle

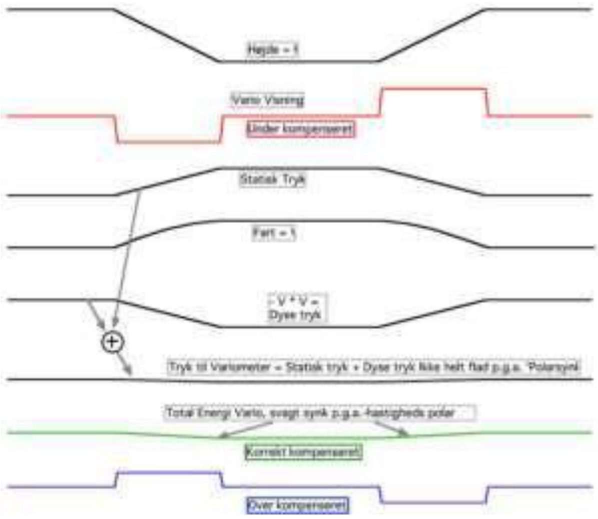
In the venturi there will be a pressure drop in the constriction when the velocity increases. Similarly, in the Lundtofte nozzle, there will be a pressure drop at the back of the pipe when the speed increases, and it is these pressure drops that are exploited to compensate for the pressure increase due to the aircraft coming down, and vice versa when the speed decreases. Then the pressure will increase in the venturi and Lundtoft nozzle, while the pressure decreases due to the aircraft moving upwards.

Total Energy Compensation

Description of Total-Energy compensation (see curves below):

1. When we dive the plane, the altitude will decrease (upper black curve)
2. When we use a (normally) uncompensated/undercompensated variometer (red curve) - i.e. connected to static pressure - it will show decreases throughout the dive and increases as we ascend, since static pressure increases as we dive and decreases as we ascend.
3. The speed will increase, but not linearly, as the height corresponds to the square of the speed

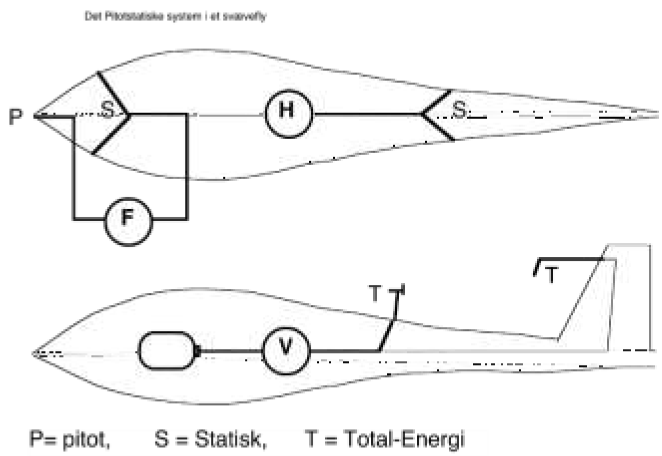
4. The nozzle pressure, which depends on the square of the speed, will decrease linearly as the speed increases. The dynamic pressure (i.e. it = 0 when we are standing still).
5. Since the nozzle is in the ambient air, the pressure will refer to the static pressure.
6. The sum of static pressure + nozzle pressure will give a pressure equal to the energy. The pressure will not be completely constant, as the aircraft will have a greater intrinsic (polar) sinking at high speed (as seen by the aircraft polar)
7. If the variometer is connected to the nozzle (Green curve), the variometer will show a slightly increasing sink rate as the airspeed increases, corresponding to the sink rate that can be read by the aircraft's polar. However, the variometer reading will not be dependent on whether we are climbing or sinking. In neutral air, it will always show the "polar sink rate" i.e. the sink rate that can be read from the aircraft's polar.
8. However, if the compensation is too strong (blue curve, "overcompensated"), the variometer will show pitch when diving and sink when pulling up. This error situation does not normally occur on a nozzle-compensated variometer, but on electronic variometers where the degree of compensation can be adjusted. An overcompensated variometer will therefore show pitch when the aircraft is diving.



Pitot static system with variometer and "nozzle":

Now when we add a variometer connected to a nozzle, the "pitot static system" looks like this:

(P) Pitot opening/port (S) Static opening/port (T) Total energy nozzle/port



The altimeter (H), is connected to the static aperture which (often) sits on the rear body. The altimeter is connected to only one hose.

The speedometer (F) is connected to the pitot tube at the front of the aircraft, and static opening which can be located at the front of the body. The airspeed indicator is therefore connected to two hoses.

The variometer (V) is connected to a thermocouple, and to a "Total Energy Nozzle" (T), which is either on the upper side of the hindbody or in front of the fin. The variometer is connected to the "thermos flask" and to the "nozzle". It is therefore connected to 2 hoses, but only to one orifice on the aircraft.

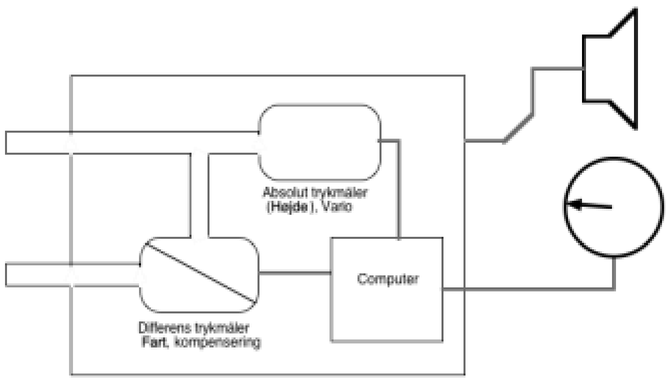
The dynamic pressure (Q), = (P) - (S), and it depends on the speed i.e. = 0 when the speed is = 0, it is always >=0

The total energy pressure (T) comes from either a venturi or a nozzle. It is always =<(S), i.e. (T)-(S) =< 0 .

You can use (S) - (T) to measure the speed. If you do so, the (P) port on the speedometer must be connected to (S) and the (S) port of the speedometer is connected to (T), the dynamic pressure that the speedometer then senses will be
Q = (S) - (T).

Electronic Variometer:

Almost all aircraft today have an electronic variometer. It is usually connected to the static and pitot orifices, and can therefore calculate both altitude and speed.



Det elektroniske variometer har en trykføler til at måle det statiske tryk og beregne højden , og en trykføler til at måle det dynamiske tryk og beregne farten.

Derefter beregner en computer alle de følgende funtioner:
- Variometer, McCready, højdereserve m.m.

Measuring pressure is usually done not with an aneroid but with pressure sensors, and once the signal is converted into an electronic signal, all necessary calculations can be done (today digitally).

One of the great advantages of an electronic variometer is that it includes an audio output, so it can indicate to the pilot whether it is rising or sinking, without him having to look down at the instrument. This is a flight-safety essential, that he can look out all the time.

Since the information is available in electronic form, it can be used with other instruments, and it is common for it to be built with a GPS to calculate glide slope, final glide height, etc.

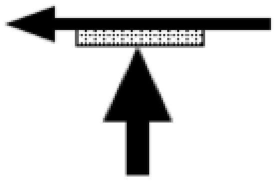
A major drawback of all electronic instruments is that they need power, and if the battery fails, you have no instrument.

Summary of electronic variometer:

- ✓ Uses same principle as mechanical variometer
- ✓ Does NOT need a nozzle to do energy compensation
- ✓ Has the possibility of audio indication
- ✓ Can be interfaced with GPS for navigation
- ✓ Uses power (requires a battery)

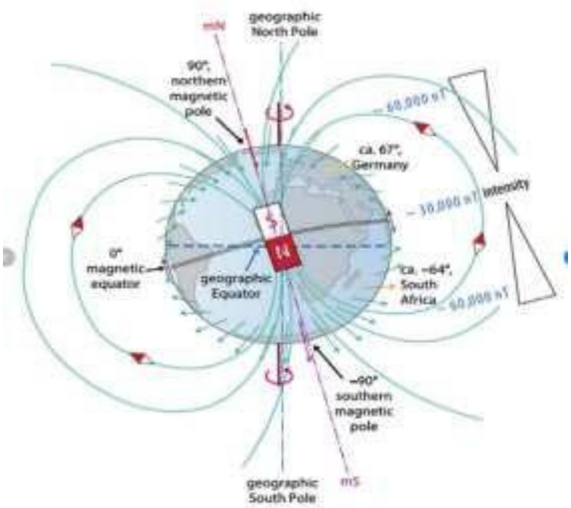
Compass:

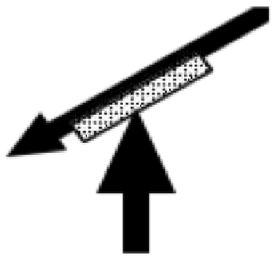
Most people know a compass as a small magnet suspended from the point of a needle, always pointing north. As it balances and is horizontal, it looks like this:



Ideelt Kompas

But this is not the whole truth, because the magnetic field lines from the Earth's magnetic field do not run neatly straight across the Earth's surface. The Earth's magnetic field looks a lot different:

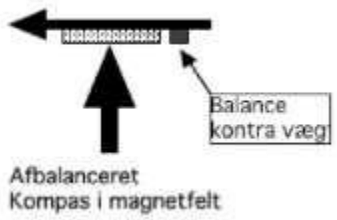




Kompas i magnetfelt

Since the field lines go down quite steeply through the Earth's surface, the magnetic needle will be skewed, and this will give false readings. To compensate for this, a small counterweight is attached to the magnetic needle, as shown in the figure below.

The compass is affected by misalignment due to two factors: the Earth's magnetic north pole is in a different location from the geographic north pole (variation), and the effects of metal or electricity in the aircraft (deviation).



This means that the magnetic needle is in equilibrium, but ONLY when exposed to 1g - i.e. during straight ahead flight at constant speed, or in other words: It does not display correctly when turning, increasing speed or reducing speed! Also, remember that the magnetic field's "dip angle" and fluctuations vary depending on where you are on the ground.

So an ordinary "scout compass" only works correctly here in the northern hemisphere. In addition to this, the compass will also be affected by the magnetic field from magnetic sources in the aircraft. The errors that occur due to magnetic fields in the aircraft are called the compass deviation. This can be partially compensated for by some adjustable magnets in the compass. Any residual error is documented by means of a deviation table.

The compass is required in all powered aircraft, including gliders with homing engines, self-launchers and TMGs. The compass shall be sighted and the associated deviation table shall be located in close proximity to the compass.

GPS:

GPS stands for "Global Positioning System", which is based on satellites launched by the US military. Today the correct name is GNSS, (Global Navigation Satellite System), which includes satellites from the US, EU, and Russia, but in "common parlance" it is still called GPS.

A GPS receiver finds its position by measuring the distance to at least 4 different satellites. It should be enough to have 3 satellites, but since a very accurate clock is required, you need to have 4 satellites. The satellites know their position very accurately and send it down to the GPS receiver, which can then calculate its position. In an aircraft, it also needs to calculate altitude.

The Earth is not round like a sphere, but slightly flattened with several deviations. All this is known by the satellites and the GPS receiver, and it can still determine the position. However, the signal from the GPS satellite is very weak, so the GPS antenna must be located as freely as possible in the aircraft and NOT covered by conductive material such as metal or carbon fibre.

A GPS navigator originally took up 50 * 50 * 20 cm, but today it can be built into a wristwatch and has become widely used - even in gliding.

Modern GPS receivers calculate the position from the signals of up to 12 different satellites. It can NOT calculate the aircraft's heading, but it can calculate the aircraft's track and is therefore an excellent navigation aid as it typically also includes a map.

Benefits :

- ✓ Can calculate aircraft position with less than 10m accuracy
- ✓ Can calculate the track of the aircraft,
- ✓ May contain 'Moving Map'
- ✓ Can be downloaded as an App for a "SmartPhone"
- ✓ Can be equipped with an additional "altimeter", and can then be used as an official logger.
- ✓ Can be very easy to use.

Disadvantages:

- ✓ Runs on battery that can 'run out' of power.
- ✓ Do not always have updated maps.
- ✓ Takes 30 - 120 seconds to boot up.
- ✓ Can be so advanced that it is difficult to use.
- ✓ Is not very accurate in altitude calculation, and therefore often has a pressure sensor to measure barometric altitude.

Other:

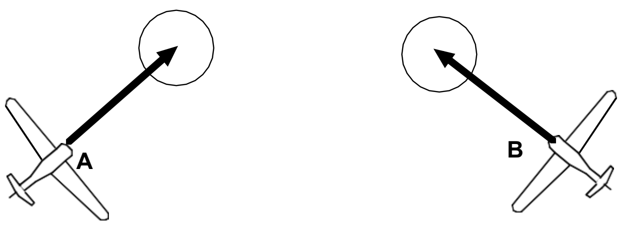
- ✓ Cannot designate "heading". A compass can.
- ✓ Cannot be used to find "horizontal".

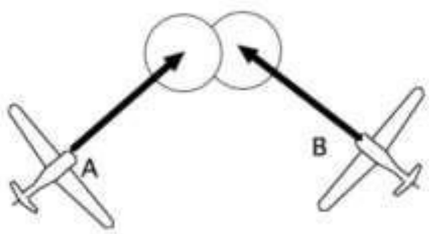
FLARM:

FLARM is a 'collision warning system' first developed for gliders, but it is NOT a mandatory system required for aircraft minimum equipment.

The system is based on a GPS receiver that determines the aircraft's position and direction of movement. It broadcasts this information on a separate antenna and then listens for other FLARM devices. Since it does not need to be able to receive the signal from FLARMs far away, the transmitter does not need to be very powerful.

It then calculates its own movement and compares it with the data of all the FLARMs it can hear. By comparing its own heading + speed, with the heading + speed of the other aircraft, it can calculate whether there is a risk of collision. If so, it will sound an alarm starting 18 seconds before the collision.





Large distance no alarm Collision hazard (<18 sec), ALARM

It will simultaneously show direction and altitude on a small display, so you can see where the other aircraft should be. When there is no alarm, it will show the direction to the other FLARM which is closest to activate an alarm (i.e. NOT the closest aircraft, but the 'most dangerous' one).

Simple display . 1 aircraft onlyAdvanced display to view multiple aircraft

The simple display gives a warning, but the advanced display gives a good overview of the situation, so you can see a plane behind you, for example.

Since several FLARMs include a GPS + pressure sensor, it would be obvious to use them as loggers as well, so they can log time, position and altitude. They are good enough to be used as official IGC approved loggers if kept calibrated. Data from the logger is read out after the flight via an SD card

8.7 Assembly of a glider and its rudder connections

A glider is built so that it can be disassembled and reassembled relatively easily. This is necessary as landing on a field or airfield is part of the sport. When this happens, the aircraft must be able to be disassembled and transported back to its home airfield. When maintenance work has to be done outside the flying season, the aircraft must also be able to be disassembled for putting into the workshop.

The aircraft handbook describes the procedure for disassembling and reassembling the glider, and learning how to disassemble and reassemble the aircraft is part of the type retraining.

Usually the glider is stored in its transport cart when separated, and the vast majority of transport carts are designed to assist in reassembling the aircraft by cradling the body of the aircraft so that the wings can be attached without further holding of the body. Before starting assembly, make sure the brackets are greased to make assembly a little easier, and always start by putting the wings on first.

The reason for this is that should the body tip over during assembly, nothing is likely to happen, unlike if the tailplane was fitted first. In this case it would probably be damaged. The wing that is mounted first must be held in position by a man or supported by a wing yoke. The second wing is then fitted and the main bolts of the aircraft are inserted and secured.

Securing the main bolts is crucial to safety and can be done either by putting a safety pin through the main bolts so they cannot slip out again, or by having the bolt handles locked by a safety device in the aircraft.

After mounting the wings, the tailplane must be mounted and secured. There are several ways of securing the tailplane depending on the type of aircraft, but the common feature is that there must be no doubt that the tailplane is correctly fitted and fully seated.

On modern aircraft, connections to elevators, ailerons, flaps and air brakes are self-connecting, so they are automatically connected when the wings and tailplane are fitted, but on older aircraft the rudder connections must be manually connected and secured so they cannot come off again. In the case of a manually assembled rudder linkage, the securing can be done by safety pins or, in the case of l'Hotellier couplings, by a split or spring-loaded "Wedekind" fuses.

On some aircraft, the joints of the rudder assemblies are difficult to see. Here a mirror can be of great help, and one must
never think that you can just "feel" if the connections are assembled correctly.

Once the aircraft is assembled, "Daily Post-Assembly Supervision" and "Positive Rudder Control" are required, where you have someone else hold the rudder and air brakes in the outboard positions while you operate the joystick and other cockpit controls. This ensures that the rudder and control surfaces are connected.

Even if DT has been performed on the aircraft earlier in the flight day, it must be acknowledged in the aircraft logbook when it has been performed.

<u>Daily supervision after assembly necessary:</u>

In August 2018, a solo student crashed a Ka-6 in Braunschweig, Germany. The German Accident Investigation Board found that the metal rod connecting one of the ailerons to the control rails had slipped out because the safety pin, which was supposed to prevent such a thing, had been fitted so that it slid alongside the metal rod instead of down through the hole in the rod that was supposed to be secured by the pin. The pilot died after jumping out of the aircraft.

https://www.news38.de/braunschweig/article216400297/Absturz-Segelflugzeug-Unfall-Braunschweig-BFU-Waggum-Flugschueler.html

Positive rudder control after assembly:

Some years ago an AstirCS was assembled and made ready for take-off. The pilot checked that the rudders were connected to the control lines and found, among other things, that the elevator went up when he pulled the control stick. Everything looked normal. During the take-off, the pilot realised that the elevator was not responding to his movements with the control stick and he had to assume that the elevator was not correctly connected. The pilot was astute enough to complete the game start to gain sufficient altitude. When the wire was released, he released the harness, deployed the emergency chute and parachuted out of the glider. He was not injured in the ejection. If someone else had held on to the elevator while the pilot operated the stick, they would have found that the elevator was not connected.

8.8 Manuals, handbooks and documents

Handbooks:

Aircraft Flight Manual - AFM:

The aircraft manufacturer is obliged to publish an Aircraft Flight Manual (AFM) which, among other things, tells how the aircraft should be flown and what the operational limitations of the aircraft are - including the aircraft's:

- ✓ Maximum weight
- ✓ Minimum weight in seat(s)
- ✓ Water ballast
- ✓ G influences
- ✓ Blasting pieces for the couplings
- ✓ Which manoeuvres are allowed
- ✓ Maximum speed
- ✓ Speed in turbulent air
- ✓ Daily supervision

To make it easier for pilots to find the essentials of this information, there are signs in the aircraft indicating speeds, weights, etc., and controls have a pictogram showing what they are intended for, as well as most having a color indicating what they are intended for. The handbook will also list the pictograms and what they mean.

Aircraft Maintenance Manual - AMM:

Aircraft manufacturers are obliged to publish an AMM on the aircraft, which provides information on the maintenance of various parts of the aircraft. There is a detailed description of what to look for and how often it should be done as well as who is qualified to do it. Some things can be done by an owner pilot, while others need to be done by a material inspector.

Repair Manual

A repair manual contains repair instructions for various parts of the aircraft, and the manual is usually produced by the aircraft manufacturer or design holder. The instructions must of course be followed. If a regulation is not available in the repair manual, a regulation approved by the aviation authorities of the country responsible for the type or approved by the Danish aviation authorities may be used.

There are also often references to the type of material used, e.g. the type of glass or carbon fibre used for the various structural parts or the size of the tyres, etc. However, there is rarely a parts catalogue, so if you need spare parts for an aircraft, you usually have to contact the manufacturer and give the aircraft type, serial number and describe which part you need. The serial number is important because there are often variations over a long production run.

Documents:

Certificate of Airworthiness:

When the aircraft is registered on the Danish register, it is issued with a Certificate of Airworthiness (LDB). The airworthiness certificate is a proof that the aircraft is airworthy at the time of issue. It does not normally have an expiry date attached. In the DSvU CAMO (maintenance organisation), an Airworthiness Review Certificate (ARC) must be issued each year.

CERTIFICATE OF AIRWORTHINESS
LUFTDYGTIGHEDSBEVIS

Trafikstyrelsen

	Denmark / *Danmark* Danish Transport Authority / Trafikstyrelsen	Document number E2357 *Dokument nummer*
1. Nationality and registration marks *Nationalitets- og registreringsmærker* OY-HXH	2. Manufacturer and manufacturer's designation of aircraft *Fabrikant og fabrikantens typebetegnelse* **Schempp-Hirth Ventus 2cT**	3. Aircraft serial number *Luftfartøjets serienummer* **99**

4. Categories
Kategorier
Utility Category Powered Sailplane

5. This Certificate of Airworthiness is issued pursuant to the Convention on International Civil Aviation dated 7th December 1944 and Regulations (EC) No 216/2008, Article 5(2)(c) in respect of the abovementioned aircraft which is considered to be airworthy when maintained and operated in accordance with the foregoing and the pertinent operating limitations.
Dette luftdygtighedsbevis er udstedt i medfør af konventionen angående civil luftfart af 7. december 1944 og forordning (EF) nr. 216/2008, artikel 5(2)(c), for ovennævnte luftfartøj, der anses for at være luftdygtigt, når det vedligeholdes og opereres i overensstemmelse med de ovenstående og relevante operationelle begrænsninger.

Limitations/Remark
Begrænsninger/Bemærkning: **None**

Date of issue: **28 March 2014**
Udstedelsesdato:

Signature: Tom Kjeldsen
Underskrift:

6. This Certificate of Airworthiness is valid unless revoked by the Danish Transport Authority.
A current Airworthiness Review Certificate shall be attached to this certificate.
Dette luftdygtighedsbevis er gyldigt, med mindre det tilbagekaldes af Trafikstyrelsen.
Et gældende luftdygtighedseftersynsbevis skal vedlægges dette bevis.

EASA Form 25 Issue 2

This certificate shall be carried on board during all flights
Dette bevis skal medbringes ombord under alle flyvninger

Airworthiness Review Certificate - ARC

Before an ARC can be issued, the aircraft must be airworthy and the aircraft maintenance programme (AMP) must be up to date. It is an ARS that issues an ARC and approves the update of an AMP. The issuance of an ARC is thus independent of when the aircraft has maintenance and annual inspection performed. For example, the inspection may be performed in the spring and the ARC may be performed in the fall. In this way the work can be spread over the year, which is a relief for all parties. An ARC is thus a piece of paper which documents that the aircraft's airworthiness documentation is in order.

The set of rules behind the initial and continuing air depth is described on pages 8 - 11 of the DSvU the compendium on aviation law, to which reference is made.

Radio certificate

A radio certificate is a document TBST issues as proof that the aircraft is equipped with a radio approved for use in the aircraft with the specific call sign.

AIRCRAFT RADIO LICENCE
RADIOBEVIS - LUFTFARTØJ

Trafikstyrelsen

	Denmark / *Danmark* Danish Transport Authority / Trafikstyrelsen	
1. Nationality and registration marks *Nationalitets- og registreringsmærker* OY-HXH	2. Manufacturer and manufacturer's designation of aircraft *Fabrikant og fabrikantens typebetegnelse* **Schempp-Hirth Ventus 2cT**	3. Aircraft serial number *Luftfartøjets serienummer* **99**
4. Call sign OY-HXH *Kaldesignal*	5. Aircraft ICAO 24 bit address (hex) *Luftfartøjets ICAO 24 bit adresse (hex)* [illegible]	

6. Installed radio equipment must be approved and included in the continuing airworthiness of the aircraft.
Only radio frequencies dedicated to aircraft may be used.
[illegible]

Date of issue: **28 March 2014**
Udstedelsesdato

Signature: Tom Kjeldsen
Underskrift

7. This aircraft radio licence is issued in accordance with Order no. 885 of 23/06/2011 on call signs and identification numbers for aeronautical radio services in Danish registered aircraft or ground stations. A call sign or identification number is annulled if the aircraft is no longer entered in the Register of Danish Aircraft.
[illegible]

Manuals / journals

Aircraft maintenance status log

At the front of the glider's logbook is a "Maintenance Status" where it is easy to get an overview of airworthiness decay. It is a table where a material controller or owner-pilot has released the aircraft to either a tacho time, a take-off number, an hour or a date. The aircraft is airworthy until one of the numbers/date is reached - whichever occurs first.

An example of the maintenance status and its content is shown in the DSvU compendium for the subject Aviation Law page 10. When the maintenance status is updated, one or more new numbers must be entered in the table and the date on which the condition was renewed and by whom.

If you want to see where the due date/number comes from, this can be seen in the Follow-Up table, which is pictured on page 10 of the DSvU compendium in the subject Aviation Law.

Motor Journal

For powered sailplanes, an engine logbook must be kept to document engine maintenance and repairs, and propeller run time must be recorded when any work is performed on the propeller. The log shall follow the engine, which on powered aircraft is considered a replaceable component. Repair or replacement of an engine must be carried out at the manufacturer's premises or at an approved workshop. As for all other maintenance work on gliders, a work order must be made before the repair and must describe what has been done on the engine.

Propeljournal

The propeller, like the engine, is also considered a component that can be replaced or sent for repair/overhaul. Therefore, the propeller also has a separate record documenting maintenance and repairs of the propeller, just as the running time of the propeller is entered in the record when something is done to the propeller. The propeller log accompanies the propeller if, for example, a replacement propeller is purchased. In principle, the new owner must then either have the log or the manufacturer must issue a certificate stating the running times etc.

Component cards

Some components on the engine have component cards, as they can be exchanged with an equivalent new or overhauled component. Component cards are typically on fuel pumps, solenoids and fuel injection systems. It will mostly be on TMG aircraft that you will find these components.

Equipment list

The equipment list is part of the technical log, see below, and describes the instruments and other equipment that are part of the aircraft. It can be instruments, radio, transponder, GPS etc. and the equipment listed in the equipment list is part of the aircraft when it was weighed.

When determining the empty weight of the aircraft, all the equipment listed in the equipment list is included.

Technical journal

The technical file is a folder/ring binder where all the aircraft documents are collected and organised in a clear manner. It is all the documents that can document the airworthiness and maintenance of the aircraft and its components.

1. Inspection reports
2. Maintenance Follow-up, Aircraft Maintenance Program - AMP
3. Registration and airworthiness certificate and ARC, noise certificate, flight manual approval
4. Equipment list, measurement report
5. Weather report,

6. Status of AD/LDD/TM, overview of handbook updates
7. Work orders
8. EASA Type Certificate, Form One or FAA 8130
9. Instruments
10. Insurance
11. Radio certificate - aircraft
12. Engine and propeller manuals, component cards

The technical file does not have to be carried in flight, but must be available to the "technical maintenance service" as stated in BL 1-12.

8.9. Airworthiness and maintenance

When is a glider airworthy ?

To ensure that an aircraft is safe and meets international requirements, common rules have been established for the design of aircraft and the documentation of their airworthiness, manuals, etc. Any new aircraft design must be approved by the aviation authorities. In Europe, the European Commission, through EASA, has issued a set of rules that all manufacturers must follow for design and approval.

An aircraft is not airworthy and may not be used for flight until it has been approved by an aviation authority. Similarly, the aircraft must be maintained at all times in accordance with the regulations in order to remain airworthy. If this is not done, the aircraft will not be airworthy.

Airworthiness is therefore divided into two categories:

1. The initial airworthiness
2. The continued airworthiness

The initial airworthiness:

When a new aircraft is placed on the Danish register, the manufacturer must vouch for its airworthiness. In Europe, EASA supervises manufacturers and conducts regular audits to ensure that manufacturers are continuously complying with their procedures and documentation for standards and quality.

When registering, the manufacturer must provide a number of documents:

- A test flight report
- A weather report
- A declaration of conformity on the plane
- A type certificate
- An Aircraft Maintenance Manual (AMM)
- An Aircraft Flight Manual (AFM)
- A noise certificate if it is a glider with engine
- Documentation on "components" such as engine, propeller, clutches, etc.

If it is a used aircraft, the above documents and all papers describing the aircraft's repairs and maintenance must be included. The aircraft's records must also be included so that flight times etc. can be documented. In other words, you must have documentation for the entire life of the aircraft.

An acceptance inspection shall be made by a material inspector who shall examine the aircraft in a manner similar to an annual inspection. There shall be a sign in the aircraft with the Danish registration of the aircraft. The sign must be made of a non-combustible material, e.g. metal. This is so that it may be possible to find the plate after the aircraft has been burned and thus identify which aircraft it is.

The material controller issues an inspection report of the reception survey and possibly a new weighing report if, for example, instruments are installed or removed from the aircraft. The weight report is the basis for calculating the empty weight of the aircraft, the aircraft's centre of gravity and the minimum weight in the front seat. An Aircraft Maintenance Program (AMP) must also be established, describing the maintenance of the aircraft and its components.

Once the Danish aviation authorities have approved the application, they will issue the following documents:

1. Registration certificate - see "Aviation law" page 12
2. Certificate of Airworthiness (typically without expiry date, but must be renewed in the form of an ARC) see page 34
3. Radio certificate - aircraft if equipped with radio - see page 35
4. Approval of the Flight Manual.

The aircraft must also join a Continuing Airworthiness Maintenance Organization (CAMO), which takes care of its continued airworthiness.

The continued airworthiness:

Maintenance of gliders and powered sailplanes

The rulebook

The rules for continuing airworthiness in Europe are issued by the European Commission through EASA. The rulebook is based on the framework established by ICAO.

The maintenance is described in EASA Part M supplemented with some Danish regulations (BL - Bestemmelse for Luftfart). The EASA rules apply if there is a discrepancy with the Danish rules. The rules for which flight documents must be present for gliding are found in EASA Part SAO.

The Danish Aviation Authorities have published BL 1-2, BL 1-3 and BL 1-12 concerning the maintenance of aircraft - including gliders. BL 1-3 concerns only Annex I aircraft, which are nationally regulated and which we will not discuss further in this subject. Annex I aircraft are typically old aircraft. In the past they were called Annex II aircraft.

Commitments:

The owner and operator of an aircraft are responsible for the continued airworthiness of the aircraft and must ensure that the aircraft is not used with less:

1. The aircraft is maintained in an airworthy condition; and
2. That any operational or emergency equipment is properly located and in serviceable condition, or clearly marked as unserviceable; and
3. the certificate of airworthiness is valid, and
4. The Airworthiness Review Certificate (ARC) is valid and
5. The maintenance of the aircraft has been carried out in accordance with an approved Airworthiness Maintenance Program (AMP).

CAMO:

To meet the conditions above, the owner of the aircraft may:

1. choose to contract the continuing airworthiness obligations with a Continuing Airworthiness Maintenance Organisation - CAMO (controlled environment).
2. undertake continuing airworthiness itself without a contract to a CAMO, but rather associated with a CAMO (uncontrolled environment).

To be able to maintain aircraft, the aircraft must therefore be assigned to a CAMO. This can be in a controlled or uncontrolled environment:

Controlled environment:

In the controlled environment, the CAMO has obligations that provide relief regarding inspection and renewal of ARC - Airworthiness Review Certificate.

The benefits of a controlled environment are:

- The CAMO keeps track of aircraft airworthiness messages
- Only physical inspection of an ARS every 3 years
- The ARC can be administratively renewed for 2 years after review of the documentation
- It is the CAMO's responsibility to ensure that both periodic maintenance work and the manufacturer's and EASA's current broadcasts are carried out in accordance with the applicable regulations.

The disadvantages are:

- There must be a contract between the aircraft owner and the CAMO, which probably also means a payment for
  the performance of the CAMO.
- Hours and starts as well as inspections and checks carried out must be reported on a regular basis.

Uncontrolled environment:

In the uncontrolled environment, aircraft owners and pilots are more responsible for ensuring that the aircraft remains airworthy.

Advantages of an uncontrolled environment are:

- There is no contractual obligation to CAMO, e.g. payment of fees.
- There is no continuous reporting on hours and starts and inspections carried out

The disadvantages are:

- There is a risk that aircraft airworthiness messages are not always tracked
- There must be a physical inspection of the aircraft every year, but it must still be done according to the aircraft maintenance programme (AMP).
- The ARC must be renewed every year.

DSvU has been approved as a CAMO via TBST. And DSvU has chosen to operate in an uncontrolled environment. In order to be approved as a CAMO, DSvU has had to build and describe in detail a maintenance organisation. This is described in DSvU's documents "Maintenance Organization Manual" - MOM and "Continuing Airworthiness Management Exposition" - CAME, which are available on DSvU's website.

DSvU maintenance organisation:

The clubs' workshops are in principle subdivisions of the DSvU workshop, and must therefore follow the guidelines laid down by the DSvU. There are special requirements for the layout of the workshop, and all tools used for servicing aircraft must be marked and kept separate from other tools used, for example, for winch maintenance or the wire hanger. In addition, certain types of tools must have a documented calibration certificate traceable to an approved calibration facility.

In principle, all DSvU members are part of the maintenance organisation, but there are major differences in what each member is allowed to do in terms of maintenance work. Some tasks require people with a special background:

- ✓ Material inspectors
- ✓ Workshop Manager
- ✓ Technical Manager
- ✓ Head of Control
- ✓ Accountable Manager (Head of the CAMO)

Maintenance and repair of gliders:

All maintenance and repair of aircraft shall be carried out by persons approved to do so (material controllers), and the aircraft AMP and repair instructions shall be followed. The AMP usually refers to to the aircraft maintenance manual, which contains instructions for various repairs and maintenance.

If not specified in the manual, the general repair method is used. In practice, it is usually the owner/user who carries out inspections and maintenance to the extent that they are qualified to do so, and then the material inspector inspects that the work has been carried out correctly.

Two different types of maintenance are distinguished:

1. **Planned maintenance:**
   These are things that are checked/changed regularly:
   - Date stamp (calendar)
   - Operational (number of hours)
   - Operational (number of starts)

   All this is controlled by
   - Manufacturers' instructions
     => Enrolled in Aircraft Maintenance Program (AMP)
     => kept up to date in the "Follow-Up" form.

2. **Unplanned maintenance**
   These are things that come suddenly:
   - ADs from EASA, Technical Notices and Service Bulletins from the manufacturer and other 'stuff that to be done'
   - Repairs/inspections due to damage/incidents
   - Circumstances giving a "Yes" in remarks in the aircraft Journal

It always starts with a "Work Order" and ends with a "Release" (CRS - Certificate of Release to Service).

Owner-pilots
As part of the maintenance, *preventive maintenance* to be performed without disassembling or removing structural parts, control systems, rudder surfaces, high-pressure hydraulic hoses, propellers/rotor blades, motors or undercarriages, and the special tools and procedures specified by the manufacturer shall be used. This is described in Part-M.

Preventive maintenance can be carried out by SPL pilots (owner pilots), who must then write their licence number in place of the M stamp in the maintenance status and on the WO and Follow-up form with the times of the next check. The WO and Follow-up form must be uploaded in the DSvU archive system by a material controller.

In general, all maintenance that does not require the use of tools of any kind can be carried out by an owner pilot. In all other cases, an equipment inspector must be involved.

Aircraft Maintenance Program - AMP
An AMP is a detailed description of the aircraft's Maintenance Programme. The AMP prescribes the maintenance to be carried out on the aircraft and its components to maintain continued airworthiness. The AMP refers to the aircraft and component maintenance manuals. or as appropriate.
instructions that go beyond the instructions in the maintenance manuals. An example of this is the Danish AIC B 16/12, which prescribes that the aircraft should only be weighed at change of ownership and that the compass should be checked every year.

AD-notes from EASA
When EASA issues an AD (Airworthiness Directive), it must be followed and if the work is not completed within the specified period, the aircraft shall no longer be airworthy. On the EASA website there is a complete list of all AD-notes that have been issued, as well as a search function where you can search for an aircraft type or manufacturer or other information.

Link: https://ad.easa.europa.eu/

Technical messages (TM) from the aircraft manufacturer

Normally, it is the aircraft manufacturer who issues technical notices of works and modifications to be carried out on an aircraft. These technical notices may be mandatory or voluntary. In general, they are mandatory if EASA is involved and issues the technical notice as an Airworthiness Directive (AD-note).

If EASA has not issued an AD in conjunction with a TM, this TM is not mandatory. Both AD Notes and Technical Messages must describe who may acknowledge their execution. In some cases, pilots retrained for the aircraft may sign for the execution, while other messages require a material controller to sign for the execution.

Link: https://www.dg-flugzeugbau.de/service-wartung/technische

Service Bulletins (SB)

The manufacturer of the aircraft or components may issue Service Bulletins recommending, for example, an upgrade or similar. A Service Bulletin is not mandatory, but a suggestion for improvement.

Work Order (WO):

Before any maintenance or repair can take place, a Work Order must be drawn up describing what is to be done. Work Orders must be numbered consecutively in each calendar year, and before the number itself, the aircraft registration is indicated. The number has the format 2019/1, 2019/2, and next year 2020/1 etc. The original Work Order is inserted in the aircraft technical log and a copy must be sent to DSvU when the work is completed. This is done electronically as DSvU has set up an electronic filing system.

DA SK SVÆVEFLYVER UNIO

WORK ORDER

Undertegnede flyejer ordrer hermed nedenstående arbejder udført på OY-HXH

Lyngby 17-02-2019

Job nr. / Work Order: OYHXH- 20 19/ 1......

Side 1 af 8 (incl. Work Sheets etc.)

PFG	Ventus 2cT		SOLO	n/a	
Aut. Nr. DK MF 0003 Dansk Svæveflyver Union Fasterholtvej 10 – Arnborg 7400 Herning	OY-HXH	99	546	n/a	
	2012	874	17.17	n/a	

1	Årlig vedligeholdelse og inspektion af fly	Udført iht Bilag 1 udarbejdet på grundlag af Maintenance Manual for Ventus 2cT, Edition June 1996, rev.14, marts 2006	11/3-2019	12.03.2019
2	Årlig vedligeholdelse og inspektion af motor pylon	Udført iht Bilag 2 udarbejdet på grundlag af Maintenance Manual for Ventus 2cT, Edition June 1996, rev.14, marts 2006	11/3-2019	
	Løbe nr.:	Overført til / (Transferred to) Work Order OY- 20 /	(To be rectified not later than)	

Mat. Stempel

den 17/3 2019

SV401.11A

All maintenance and repairs must be carried out in consultation with an equipment inspector, who also approves the work. A Work Order can be expanded by completing one or more Work Sheets, where there are several lines with space for a detailed description of the fault and how it has been rectified. Other relevant documents can also be attached to a WO.

When a new WO is created, it must be described which workshop will perform the work. Most often the club workshop is used. In addition, a representative of the aircraft owner must sign the WO as a

"ordering" of the work. And the aircraft's current flight time and takeoffs, as well as any component running times must
be indicated to show at which flight time/start the work has been ordered and/or carried out.

The basis for the work must be stated and a reference made to the repair specification to be used for the work, e.g. a reference to the section of the AMM to be used.
The repairer writes the date and signature in a field on the WO as a receipt for the work done, and in the field next to it there is space for the inspector to date and sign as a verification of the work done correctly. Although it has been written previously that it is the material inspectors who do the work, it can be physically done by a qualified person in consultation with the inspector doing the actual work while the material inspector does the final inspection and paperwork.

Which materials and tools may be used for maintenance and repairs ?

In general, you should follow the manufacturer's instructions of what materials to use for maintenance and repairs. For certain types of parts, e.g. screws, bolts and nuts, there are European standards (EN, LN, DIN, etc.) which the manufacturer has used in production and these can in principle be bought freely on the market, but this requires they are manufactured by an approved manufacturer and usually also supplied with the manufacturer's CoC - Certificate of Conformity, or bought from the aircraft manufacturer who can certify the parts.

Components such as couplings, instruments and structural parts must be supplied with EASA Form One (or FAA 8130 = US approval), which are airworthiness certificates for the parts, i.e. that the parts are fit for installation in aircraft.

Tools used for repairs and maintenance must be kept separate so that they are not used for purposes other than aircraft maintenance. Tools shall be individually numbered for each aircraft maintenance workshop and shall be stored in such a way that it is easy to see if anything is missing. This can be done with a tool board where a silhouette of the tool is painted, or a tool cabinet where the tool is in milled foam mats. If the board shows a silhouette or there is an empty cut-out in the foam, some tool is missing and could potentially have been left in the aircraft. It must be found so that it cannot cause damage in flight.

Certain types of tools also need to be calibrated periodically to prove that they meet applicable tolerances. This applies, for example, to torque wrenches used to tighten bolts and nuts and the scales used to weigh the planes.

Annual inspection:

When the aircraft has been maintained and/or repaired in accordance with the aircraft's approved AMP or repair instructions, it may be presented for inspection by a material inspector. The inspector shall examine the aircraft and the aircraft records and documentation of the maintenance and any repairs. All this is documented in an Inspection Report. The inspection shall be carried out in accordance with the manufacturer's instructions. If this is not available, the DSvU inspection report is used.

If no deficiencies are found, the inspector may release the aircraft to service - normally for one year, but certain operational or calendar inspections may become current before one year has elapsed. It is important to remember that if the aircraft ARC has an expiry date earlier than one year from the inspection date, the ARC must be renewed before its expiry date for the aircraft to remain airworthy.

Certificate of Release to Service - CRS:

For an aircraft to be airworthy, it must have a valid ARC and a Certificate of Release to Service.
CRS. It is either stamped in the aircraft's logbook or a sticker is inserted in the logbook with the following content:

> It is hereby certified, that the aircraft has been maintained in accordance
>
> with specifications in relevant maintenance data and a Certificate of
>
> Release to Service has been issued under Aut.no. DK MF 0003.
>
> Ref: Work Order Place: Date:
>
> OY- .... 20...../ ..../......
>
> ....
>
> Certifying staff signature and stamp:

It is important that at the same time in the aircraft "Maintenance Status" is updated with which new decay the aircraft will
have In terms of starts/times/date.

Issuance of the aircraft ARC:

As DSvU operates in an uncontrolled environment, an aircraft's ARC - Airworthiness Review Certificate - can only be issued for 12 months at a time. As mentioned above, an ARC can be issued for 12 months at a time if an "Inspection Report for glider inspections" is available that is less than one year old. The renewal of an ARC can only be done by an Airworthiness Review Signatory - ARS.

Once a new ARC has been issued, the Follow-Up form must be updated with a date for the next expiry. This should also be reflected in the maintenance status.

Airworthiness Review Signatory - ARS

An ARS is a highly experienced material controller who checks the paperwork in order to
extend the airworthiness in the form of an ARC. So the ARS reviews both the AMP, the inspection report, the record and other documents to ensure that, for example, the AMP has references to latest versions of manuals and that any current AD or TM for the aircraft has been carried out and acknowledged. In addition, he must inspect the aircraft to see it is as described in the aircraft's paperwork.

The ARS is involved in the drafting of an AMP on a new aircraft, just as updates to an AMP must approved by the ARS.

When is a glider not airworthy ?

Continued airworthiness is dependent on meeting the deadlines and number of operations applicable to aircraft and components. Furthermore, technical messages and AD-notes must be completed within the specified time limits. Failure to comply with these conditions results in loss of airworthiness.
It is therefore crucial that the pilot - and the owner - is aware of the many different deadlines that must be met.

But in addition to continued airworthiness, airworthiness can also be compromised if the aircraft is subjected to extraordinary events. In general, the aircraft loses its airworthiness if it suffers actual damage.
No one is

probably doubt that the airworthiness has been lost if the aircraft's fuselage has broken, but it is immediately more uncertain if, for example, the aircraft has made a very hard landing but has no visible damage.

When an aircraft has been subjected to a heavy load, at least daily inspection of the aircraft should be carried out and the aircraft should also be inspected by a competent person - e.g. a material inspector. There are several examples where damage has only become apparent after the aircraft has been dismantled during the winter overhaul. This would usually mean that the aircraft's hull insurance would not cover the repair, as damage would normally have to be reported some time after an accident.

DSvU requires that all incidents, occurrences and accidents are reported to DSvU using the Safety Management System - SMS, and in addition, accidents and serious incidents must be reported to the Accident Commission - HCLJ. See UHB group 800 series for further information.

SMS can be found at this link: [https://medlem.dsvu.dk/Flysik-udvalg/Safety-Management-System- SMS/menu-id-1313](https://medlem.dsvu.dk/Flysik-udvalg/Safety-Management-System-SMS/menu-id-1313)

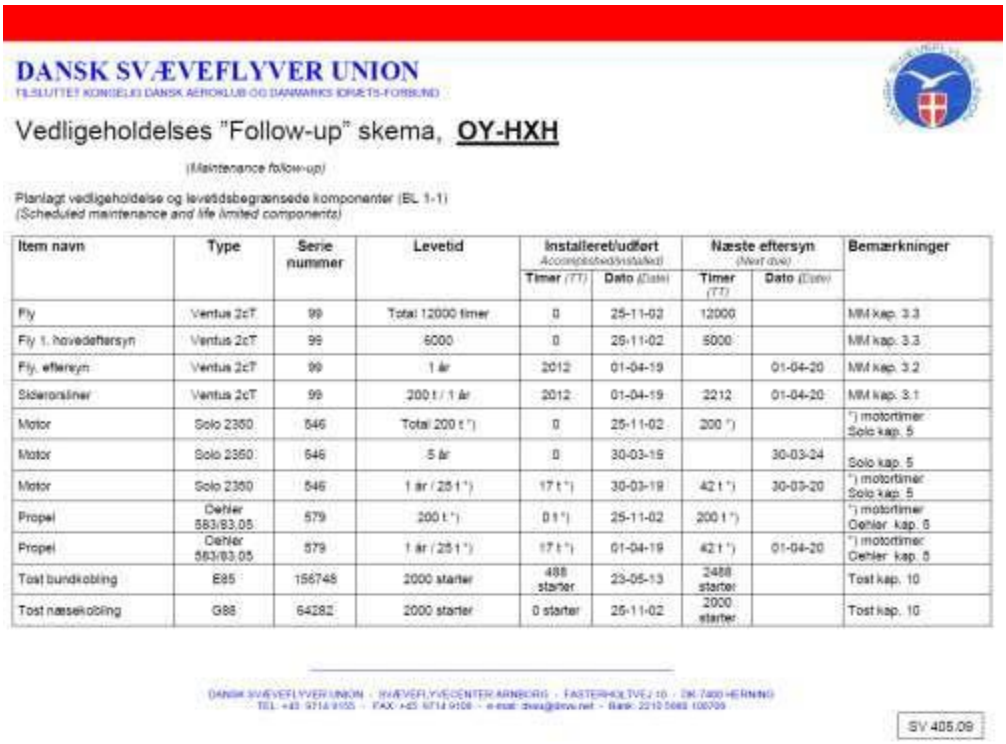
Follow-up form:

It can be difficult to remember when the aircraft, ARC and various components are due for overhaul/maintenance. Therefore, a Follow-up Schedule has been created in which all the conditions described in the aircraft AMP are entered at various intervals. For each component it is described when it was installed, what time/start time it happened and date, and when it is next due for an overhaul. An aircraft can have many reasons for expiry:

- ✓ There is an annual inspection
- ✓ There may be a maximum number of hours between inspections, e.g. 200 hours
- ✓ There may be a major overhaul at 3000 hours
- ✓ There may be a number of starts, e.g. 2000 which are typically the clutches that have this limitation
- ✓ And some aircraft may even have a maximum

number of years Below is an excerpt from an

aircraft's Follow-Up Schedule:



DANSK SVÆVEFLYVER UNION

TILSLUTTET KONGELIG DANSK AEROKLUB OG DANMARKS IDRÆTS-FORBUND

Vedligeholdelses "Follow-up" skema, **OY-HXH**

(Maintenance follow-up)

Planlagt vedligeholdelse og levetidsbegrænsede komponenter (EL 1-1)
(Scheduled maintenance and life limited components)

Item navn	Type	Serie nummer	Levetid	Installeret/udført *Accomplished/installed*		Næste eftersyn *(Next due)*		Bemærkninger
				Timer *(TT)*	Dato *(Date)*	Timer *(TT)*	Dato *(Date)*	
Fly	Ventus 2cT	99	Total 12000 timer	0	25-11-02	12000		MM kap. 3.3
Fly 1. hovedeftersyn	Ventus 2cT	99	6000	0	25-11-02	6000		MM kap. 3.3
Fly, eftersyn	Ventus 2cT	99	1 år	2012	01-04-19		01-04-20	MM kap. 3.2
Siderorsliner	Ventus 2cT	99	200 t / 1 år	2012	01-04-19	2212	01-04-20	MM kap. 3.1
Motor	Solo 2350	546	Total 200 t *)	0	25-11-02	200 *)		*) motortimer Solo kap. 5
Motor	Solo 2350	546	5 år	0	30-03-19		30-03-24	Solo kap. 5
Motor	Solo 2350	546	1 år / 25 t *)	17 t *)	30-03-19	42 t *)	30-03-20	*) motortimer Solo kap. 5
Propel	Oehler 583/83.05	579	200 t *)	0 t *)	25-11-02	200 t *)		*) motortimer Oehler kap. 6
Propel	Oehler 583/83.05	579	1 år / 25 t *)	17 t *)	01-04-19	42 t *)	01-04-20	*) motortimer Oehler kap. 6
Tost bundkobling	E85	156748	2000 starter	488 starter	23-05-13	2488 starter		Tost kap. 10
Tost næsekobling	G88	64282	2000 starter	0 starter	25-11-02	2000 starter		Tost kap. 10

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SV 405.09

Other inspections:

Head check:

If the manufacturer's original limitation on the operational life of the aeroplane is to be extended, a major overhaul shall be carried out in accordance with the manufacturer's instructions.

Reception visibility:

Upon entry into Denmark, the aircraft must undergo a receiving inspection, which is similar in scope to an annual inspection, where both aircraft and papers are thoroughly checked.

Weighing must be performed unless the aircraft has been weighed within the last 5 years. And since many aircraft may be delivered without instruments or have instruments replaced, a weighing may often be necessary. At a minimum, a new CG calculation and minimum seat(s) weight must be performed.

It shall be ensured that all Airworthiness Directives (LDD) previously issued by TBST, as well as Airworthiness Directives (AD) and Technische Mitteilungen (TM) for the type, have been executed and that a record of these and their execution is documented in the aircraft logbook.

20 years of overhaul of wooden aircraft

Wooden aircraft may be subject to a 20-year inspection requirement, which must be repeated every 5 years thereafter. This inspection must ensure that the wood structure is still fresh and that the glues are intact. This inspection must be incorporated into the aircraft AMP if the aircraft is subject to EASA Part-M regulations.

Inspection for abnormal influences:

If an aircraft has been subjected to abnormal influences, it must be inspected by a material inspector before it is put back into service. Before this can be done, a Work Order must be created at the inspection, which the material inspector signs, stamps and uploads to the DSvU electronic filing system.

The material controller acknowledges in the aircraft log (page 206 ->): 'Inspection for abnormal influences. No fault found" and refers to the Work Order on which the inspection was based. The date of the inspection is written, signed and stamped with the inspector's stamp.

Follow-up to accident report:

As a general rule, accident reports must be accompanied by a detailed description of the extent of the damage. This description may be set out in a Work Order.

Inspection after repair:

After any repair or modification, the aeroplane shall be subjected to an overhaul by a material inspector with authority commensurate with the extent and nature of the repair/modification.

The material inspector shall ensure that the repair/modification is fully documented as regards:

- ✓ Repair regulations
- ✓ Repair methods
- ✓ Raw materials
- ✓ Spare parts
- ✓ Standard consumables

Reporting shall be in accordance with the descriptions in the DSvU Maintenance Organization Manual (MOM).

Inspection after assembly:
After assembly, the pilot in charge of the assembly shall check the aircraft and acknowledge the assembly in the aircraft logbook. The check shall be carried out as a daily supervision in accordance with UHB gr. 520.

Daily supervision:
Before the first flight of each day, a daily inspection must be carried out in accordance with UHB gr. 520. As part of the daily inspection, positive control is performed, where the aircraft controls are operated from the flight deck while a person outside holds the various rudders and air brakes one at a time. This allows the pilot to sense from the cockpit if there is a firm connection to the rudder and air brakes. Remember that this is not a test of strength, but simply a light force to establish a firm connection. If too much force is applied, brackets etc. may be damaged.
This also includes checking the maintenance status.

After DT, daily supervision must be acknowledged in the glider's logbook before the first take-off of the day. Only pilots with a licence who have been retrained for the type may acknowledge DT (Daily Supervision).

Minimum equipment for gliders
For VFR operations in gliders, the glider must have at least the following according to BL 1-12, and it must of course be in serviceable condition:

- ✓ A speedometer
- ✓ A pressure gauge
- ✓ One type-approved lumbar and shoulder belt for each seat
- ✓ A compass if it is a powered glider

Additional equipment may be specified in the aircraft handbook, which must of course also be present and in working order.

If the above minimum equipment is not operational, the aircraft must not fly. For example, if a radio does not work, this does not prevent the aircraft from flying, but the aircraft must obviously not fly in airspace where a radio is required to fly.

Deviation
If an aircraft is equipped with a compass, the compass must be checked at least once a year. Most compasses can be adjusted and the error can often be reduced. A deviation table should be provided with the compass to show the error on different courses. A deviation report should also be prepared and uploaded to the DSvU archive system and placed in the technical record. The deviation is due to influences from metal and electrical components, such as radio, electrical variometer and wiring etc.

8.10. Aircraft structure in connection with engine and propeller

As mentioned in section 8.1, powered sailplanes are also built to the CS-22. The specificities of TMG are addressed in the training programmes applicable to TMG training - both the basic training for an SPL licence and the TMG upgrade to an existing SPL licence.

However, there are also other powered sailplanes that licence holders can use with an SPL licence. These are:

- ✓ **SLG = Self Launching Gliders**
- ✓ **SSG = Self Sustaining Gliders -> glider with homing engine**

Therefore, in the course General Knowledge of Aircraft, we shall also touch upon topics related to engine and propeller as far as it has an impact on such categories of aircraft.

The body of the motorglider

For both SLG and SSG, the engine and propeller can be folded into the body, so the aircraft looks like a normal glider when the engine etc. is in. However, the body is built in a different way, as there must be a well in the fuselage to accommodate the engine and propeller.

This well makes the aircraft - all other things being equal - heavier than the corresponding ordinary glider without engine, but it also gets a construction where there can be risks of damages and breaks, which do not exist on gliders without engine. It is therefore important to DT the aircraft in such a way that the structure around the engine well is checked for cracks and damage.

The engine itself, including propeller, can weigh about 50 kg, and when it is mounted in the body, it rests on a stop at the bottom of the aircraft, but the suspension rotates about a point much further forward in the body. This means that a hard landing or an uneven airfield can cause the whole engine installation to move, hitting its stop at the bottom of the body. In very hard impacts, this can cause damage to the bottom of the aircraft, but also to the entire engine foundation. Daily inspection must therefore be extended to this area of the aircraft.

When the engine and propeller are seated in the body of the aircraft, the engine well is closed with flaps flush with the body of the aircraft. These flaps sit on hinges which are screwed into the structure. These hinges and body must be checked for cracking as they are typically screwed into the structure.

The engine is naturally warm after it has run. The aircraft manual typically prescribes how the engine should be cooled before it is re-fitted into the body. The engine well is normally designed so that the structure can absorb some heat, the well being lined internally with heat absorbing material, but if the engine is too hot when run into the body, structural effects on the body can occur. This will typically be seen on the walls of the well during DT, as well as there must be no damage to the heat absorbing lining of the engine well.

Position of propeller when deposited in the body

The propeller must be in a certain position when the engine and propeller are to be folded into the body of the aircraft. If this position is not correct, the engine will not retract and damage will occur to both the propeller and engine flaps. The damage to the propeller may be so severe that it no longer meets the minimum requirements prescribed by the manufacturer and, if this is the case, the glider may no longer be used with the engine.

If this is the case, the possibility of engine precipitation must be completely switched off and the engine flaps must be glued. The propeller must then be returned to the manufacturer or an approved workshop for repair.

Continued use as glider after dismantling of engine and propeller

It may be necessary to remove the engine and propeller from the aircraft in order to send it for repair. If the aircraft manual allows, the aircraft can then be used as a traditional glider without engine, but there will be a need to check the centre of gravity. The aircraft handbook will typically describe what to do in such a situation - including what ballast is needed in the aircraft. The guidelines in the aircraft handbook must be followed, otherwise the aircraft's centre of gravity may, in the worst case, be completely out of the permissible range.

Fuel and oil

Most SLG and SSG powered sailplanes have two-stroke engines. Such engines do not have a bottom tank of lubricating oil, but the oil is mixed into the fuel on which the engine runs. The aircraft handbook typically describes the minimum fuel and oil requirements for the engine. These values must of course be adhered to, but users of such aircraft should be aware that fuel which has been in the aircraft tank for a long time loses some of the additives which the aircraft handbook requires when specifying fuel types. If the aircraft is to remain unused for a long period of time - typically a few months - the fuel should be drained from the aircraft to prevent it from becoming stale.

There are also very specific quality requirements for the oil blended into the petrol. High-quality oils are typically required for high-revving engines. If the correct oil is not used, there is a risk of deposits forming in the engine and of, for example, piston rings sticking and damaging the cylinder walls of the engine.

Engine operating temperature

There must be a certain mixing ratio between the fuel and the oil mixed in. It can be 1:40 or 1:50, but the mixing ratio between fuel and air in the carburettor is also important. If an engine is normally flown in Denmark, where the airfield is typically 50 metres above sea level, the same engine will be far too hot if it is flown in France or Austria at an airfield 700 metres above sea level. In such situations, the carburettor should be set to give a slightly richer mixture than that used in Denmark.

If the engine exhaust temperature becomes too high, the engine rpm must be reduced, and this in itself can be a risk if it requires high engine rpm to pass a mountain ridge or similar in a place where the landscape is somewhat higher than in Denmark. There is thus a real safety issue in this.

Inspection intervals

Both engine and propeller will be subject to certain overhaul intervals and these must be part of the aircraft's AMP and thus the "Follow-Up Schedule", which contains all overhaul schedules for components in the aircraft.

8.11. Water ballast systems

Both this course and the course "Flight Performance and Planning" include the fact that gliders can increase the flight weight with water ballast to give the best performance at a higher speed. However, as this requires the aircraft to be able to jettison the waterballast before landing, there is also a relationship with the engineering and safety of the glider.

The aircraft handbook typically states the maximum weight of the aircraft with and without water ballast. The reason for this is that the weight of water in the wings is not included in the weight of non-load bearing parts. Therefore, the difference between MTOM without water ballast and with water ballast may be different than the weight of the water ballast.

The pilot who wishes to carry water ballast must therefore ensure that the total weight is kept within the limits prescribed in the aircraft handbook.

If it is possible to fill the tail of the aircraft with water in order to pull the centre of gravity well back into the permitted range, the pilot must ensure that this ballast is consistent with the total weight of the aircraft and the position of the centre of gravity.

Flying in low temperatures

The temperature is lower at altitude than it is at ground level. Therefore, a water ballast on the ground can turn into an ice ballast at altitude, and this can be extremely dangerous. Water that freezes into ice will expand and, in the worst case, change the structure of a wing so that the top or bottom of the wing separates from the main beam. If this happens, the structure of the wing is gone and the wing no longer has the strength that the pilot expects it to have.

When the temperature approaches 0, the water ballast must be discarded so as not to risk damaging the structure.

Aircraft water tanks and the technology behind them

In most cases, the water tanks in a glider are long bags that are pulled into the wing by a line. When the bag is full, it is expanded, and when it is empty, it lies flat in the wing. In other aircraft, the tanks are an integral part of the wing structure (integral tanks).

Empty water tanks, which are not integral tanks, can move during flight and driving on the ground, and in extreme cases they can twist, closing the drain from the tanks. This would mean that the glider could only drop the water ballast from one tank while the other remained full. During landing, this would pose a risk that the wing with the remaining water ballast would dive, resulting in a groundloop.

If this situation should occur, the glider should land at an increased speed and if the aircraft has flaps, these should be set in the negative position so that the aileron effect is preserved as long as possible.

8.12 Batteries - performance and limitations

All gliders today have some electronic instruments:

- ✓ Radio
- ✓ Transponder
- ✓ GPS
- ✓ FLARM
- ✓ Electric Variometer

The glider has a battery to power these systems. It is a standard 12V 7.2 Ah battery. This is normally a lead-acid battery, but it can be replaced with NiM, or Li-Ion/Li-Polymer batteries.

The lead-acid battery is relatively heavy, but can use a very simple charger. The other battery types require a fairly sophisticated charger to avoid posing a danger.

However, for all installations:

- ✓ The battery MUST be fitted with a fuse (preferably in the battery box itself). This is to protect against fire in the event of a short circuit.
- ✓ The plug from the battery must be "female" so that you do not inadvertently short-circuit the battery.

The standard "12V 7.2Ah" means that the battery with a voltage of 12 volts can provide a power of 1 ampere for 7.2 hours. This should be enough for most flying days, but the key is how much power the connected instruments draw during use.

A radio listening only on one frequency does not consume much power, but an electric variometer with an attached GPS immediately consumes somewhat more, and if there is a need to use the transponder when flying through airspace with transponder obligation, power consumption can increase quite a lot.

Therefore, it is useful to carry more than one battery. The optimum is the ability to switch from the primary battery to a backup battery. This, in turn, requires that both the main battery and the backup battery are in good condition.

8.13. Parachutes for emergency jumps

During gliding, the occupants usually wear a parachute so that they can - if necessary - leave the aircraft and save themselves in the event of a collision or other accident in the air.

Parachutes in gliders are basically divided into two groups: automatic release and manual release.

Rescue parachutes with automatic release work in the meeting that the parachute has a release line, which is coupled to the glider. If a parachute with automatic release is to be deployed, the parachute will be released via the release line when the pilot leaves the cockpit.

Manual release parachutes are released by the pilot pulling the release handle after leaving the aircraft. This has the advantage that the pilot can get away from the aircraft sufficiently before the parachute is released to avoid the risk of it becoming entangled in the aircraft. On the other hand, there is a risk of delay when jumping out at low altitude and thus a risk that the parachute will not deploy in time.

Parachutes used in gliders for training purposes must be approved as emergency parachutes by the manufacturers and must be repackaged and checked in accordance with the applicable regulations. The DSvU has determined that pilots must wear parachutes during training flights.

The length of time for which an emergency screen is repacked varies from manufacturer to manufacturer, but normally there should never be more than 12 months between repackings. In most cases the validity period of a repack is 120 days = 4 months.

However, the period of use may be extended by a DSvU material inspector in accordance with UHB454, but never beyond 12 months after the last repackaging. The parachutes must therefore be repacked at least every 12 months by a parachute packer/rigger approved to pack parachutes.

Both when the shields are repacked and when the period of use is extended by a DSvU material inspector, the shield's packing card or maintenance certificate must be endorsed, and in this way the user of the shield can always see whether the shield is still approved for use.

Instruction in the use of emergency screens

Student gliders must be instructed in the use of the emergency parachute at the beginning of their training, without this meaning that they must actually try to jump out with a parachute. However, they should be instructed in how to exit the aircraft (see section 8.14.) and how to deploy the parachute once they have exited the aircraft.

Similarly, guests who are given a ride in a glider must be instructed in the use of both a parachute and emergency procedures.

Thankfully, the need to parachute has been very rare in the past, so its use may seem a little violent. But it is necessary to do to ensure that those on board are aware of what to do should such a situation arise.

8.14 Emergency jump aids

In the previous section the use of an emergency parachute was described, but prior to the use of a parachute there are things that the occupants should also be aware of.

The most important thing is how the occupants get out of the plane in an emergency, and here the use of emergency ejection of the driver's screen is the most important. The colour of the emergency chute is ALWAYS red and everyone in a glider must be aware of this - student, instructor, pilot and passenger.

Next, passengers must be aware of how to leave the aircraft. First of all, the harnesses have to be unfastened, and there is a difference between pulling a securing buckle out of the harnesses and turning a buckle or wheel to unfasten the harnesses. All this needs to be instructed before the flight - both for glider pilots and for guests.

When it gets to that point, the occupants need to be aware of where to deploy the parachute once they are free of the aircraft. This means that the hand must be on the release handle before leaving the aircraft. And exiting an emergency glider also requires insight.

Typically, the occupant must sit up on the edge of the cockpit and drop out while keeping their hand on the release handle. And once out, the pilot must wait to release the parachute until he is free of the glider, so that the parachute does not risk becoming entangled in the aircraft.

There are other ways to get out of a glider. There are systems with an air cushion that lifts the pilot out of the cockpit so that the pilot does not have to exert himself. There may also be handles that use arm forces to facilitate egress.

It is important that during training students become familiar with the different situations that can arise during an emergency jump, so that a jump is almost made on the spinal cord.