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GFA Basic Sailplane Engineering

PART 3

Airworthiness

UNCONTROLLED WHEN PRINTED

Revision 24.1

REVISION RECORD

Prepared	Approved	Version	Date
Various	CAD	24.1	24/05/23
Précis of changes Correction of minor errors throughout. Additions to Chapter 20 Electrical Systems and Chapter 11 Flutter. Inclusion of Chapter 27 Radios, Antennae and Avionics and Chapter 28 L'Hottelier Connectors. Mandatory policy of release springs moved to MOSP 3 Section 13.3 and 23.			
Various	CAD	24	08/09/17
Précis of changes Correction of minor errors throughout. Many chapters have been extensively updated. Mainly with a view to incorporating AD and AN requirements and referencing MOSP 3 V7.			
Sean Jorgensen-Day	Vice-President	23	10/4/16
Précis of changes Create electronic version and modernisation of all sections to cover current practices.			

TABLE OF CONTENT

1. INTRODUCTION

This manual sets down some of the technical standards and procedures and is the book of knowledge for GFA authorised Annual Inspectors when studying, inspecting, repairing and weighing sailplanes. It also serves as a standard reference of technical standards and procedures for all persons involved in the maintenance of GFA registered sailplanes so as to ensure a consistent, correct, high standard is achieved.

The GFA Manual of Standard Procedures (MOSP) Part 3 - Airworthiness sets down the GFA procedures such as; the GFA Maintenance system which fills the place of CAR Part 4 and 4A to which GFA hold an exemption, sailplane registration and certification, minimum equipment and placarding, inspection and repair requirements and the authorisation of inspectors and their responsibilities. It also details the requirements for amateur built sailplanes. It is intended to be a simpler and clearer guide to the airworthiness rules/ regulations that apply to gliding than the Australian Regulations and is mandatory to all GFA members.

All gliding inspectors and persons interested in airworthiness work should reference the latest version of the Manual of Standard Procedures Part 3 - Airworthiness. But read the simpler and plain English guide; MOSP Part 3 Registered Operator's Handbook, to get the basics of being a sailplane owner. And they must use this Basic Sailplane Engineering (BSE) manual as the primary reference on how to perform the GFA Standard System of Maintenance.

BSE provides background and guidance as well as procedures on how to carry out inspections and the work required to maintain sailplanes. Note that for LSA gliders you must use the manufacturer's procedures and documentation but you can use MOSP and BSE for guidance. There are Chapters of BSE which now have the status of ADs and take precedence.

1.1 ACKOWLEDGEMENT

We acknowledge the few hard working GFA Inspectors who have helped review and update this version. You know who you are and you can be proud. Thank you for all the enthusiastic volunteer work.

1.2 AMENDMENTS TO THIS MANUAL

It is GFA policy to amend this manual annually in November to ensure that the latest knowledge and experience is available to all inspectors. This 2023 version has two new sections covering L'hottelier connectors, and radios and avionics.

As part of the ongoing need to maintain quality and standards, a process that enables GFA members to make recommendations for improvements and inclusions has been included. A document change proposal form is outlined in this chapter. This form should be forwarded to the GFA office, where it will be added to the review documentation and forwarded to the person conducting the review at the start of November each year. Due to the high workload of our volunteers and staff, it is essential that suggestions have strong detail and reasoning or they may not be acted upon.

Amendments will be completed by reissuing the entire affected section and renumbering it to a different version. These will be notified in the Soaring Australia magazine and on the GFA webpage. It is the responsibility of each sailplane inspector to ensure he or she is working from the latest version of this manual.

1.3 PRIORITY OF PROCEDURES

These standards and procedures are to be followed when the manufacturer's manuals are lacking on the subject. The information contained herein is also intended to provide additional information and knowledge to assist inspectors in learning and performing the required tasks in an efficient manner.

The sailplane manufacturer's documentation remains the overriding authoritative data in any case where they differ from any information in this manual. There are Chapters of BSE which have replaced ADs. The mandatory component of the AD will be added to MOSP 3 and the informative component is in this manual.

A lot of this manual was originally taken from FAA AC43.13. The latest version, 1B/2B or later available online, should be referred to for more information. In case of conflicting data BSE takes precedent or you should ask the CTO for advice. It is possible that BSE provides differing advice to suit Australian gliding.

1.4 DEFINITIONS

Throughout this manual every attempt has been made to be consistent with respect to common terms and abbreviations. However, over time the usage of some terms has changed and inspectors should attempt to assess the context of any abbreviations as to their meanings.

There is a specific chapter in this manual which defines the terminology used. However, the terms ‘glider’, ‘powered sailplane’ and ‘sailplane’ are often used interchangeably. Strictly in Australian regulations LSA are defined as gliders whereas sailplane is used for all others. BSE is being converted to use the term sailplane instead of glider where possible.

The specific terminology may differ from the common glider pilot usage, but an airworthiness inspector needs to be able to relate technical names to common glider pilot jargon.

1.5 DOCUMENT CHANGE PROPOSAL

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GFA Basic Sailplane Engineering</td><td colspan="2">Tracking Details (Office use only)</td></tr>
<tr><td>Number:</td><td>Date Received:</td></tr>
<tr><td colspan="3">Name of person submitting change:</td></tr>
<tr><td>Email Address:</td><td>Phone:</td><td>GFA Number:</td></tr>
<tr><td colspan="3">Affected Section(s):</td></tr>
<tr><td colspan="3">Reason for Change:</td></tr>
<tr><td colspan="3">Source for supporting data or details that may assist the review:</td></tr>
<tr><td colspan="3">Suggested change (please add extra pages if it is substantial):</td></tr>
<tr><td colspan="3">NB: In order to take appropriate action on a change request please ensure a:
• clear description of the issue has been given;
• supporting data, if available, has be identified; and
• suggested change has been provided.
This form may be sent to the GFA by any of the following means:
Email: returns@glidingaustralia.org
Fax: (03)9359 9865
Mail: The Gliding Federation of Australia
C4/1-13 The Gateway,
Broadmeadows, Vic.,3047</td></tr>
</table>

2. TERMINOLOGY

Inspecting and repairing of sailplanes is highly technical and the ability to communicate with other inspectors is vital. Throughout this manual, specific terms will be defined as needed however it is important that inspectors are familiar with some of the more general terms.

2.1 SAILPLANE COMPONENTS

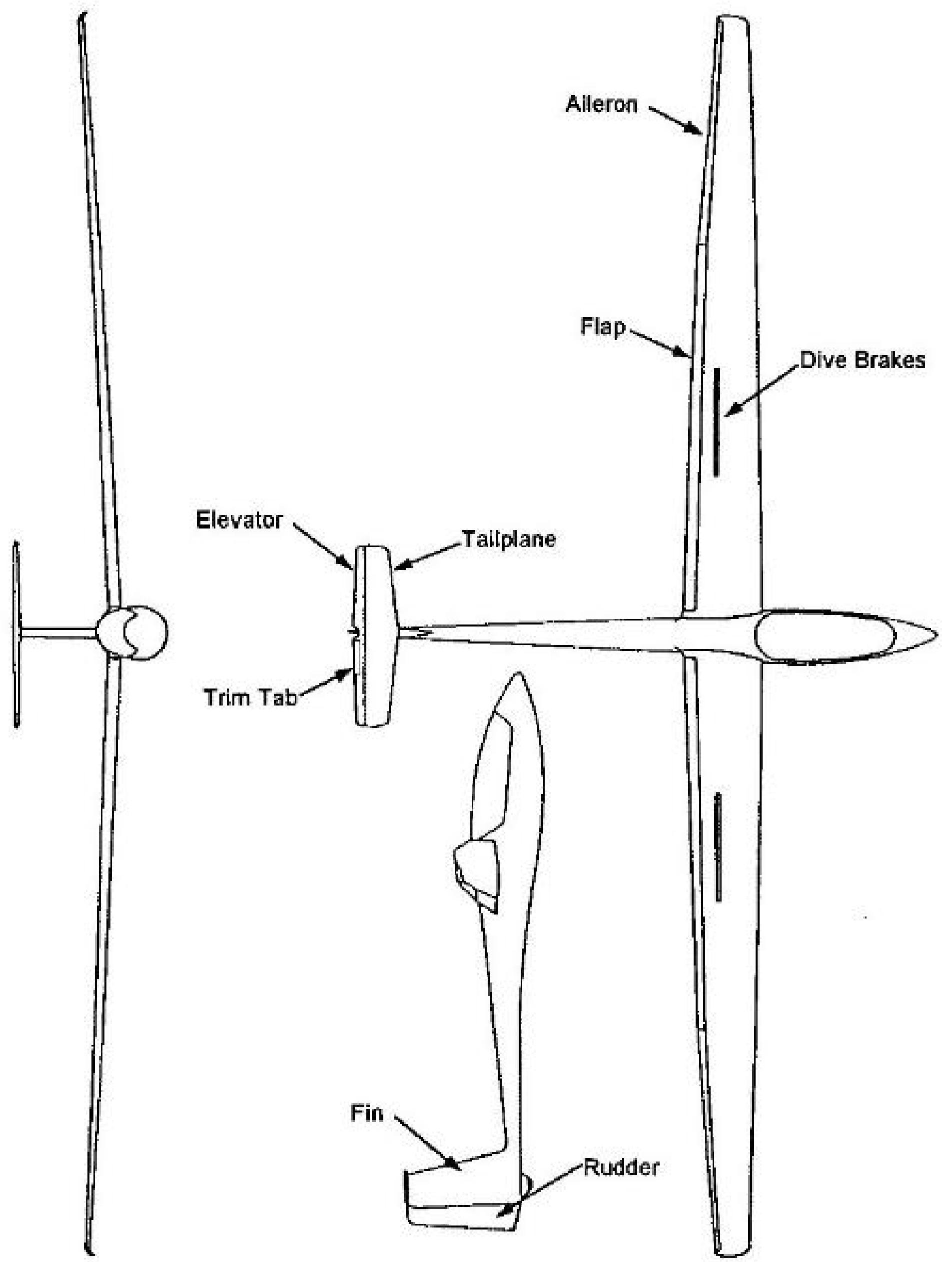


Figure 2-1 Component names

2.2 SAILPLANE GEOMETRY

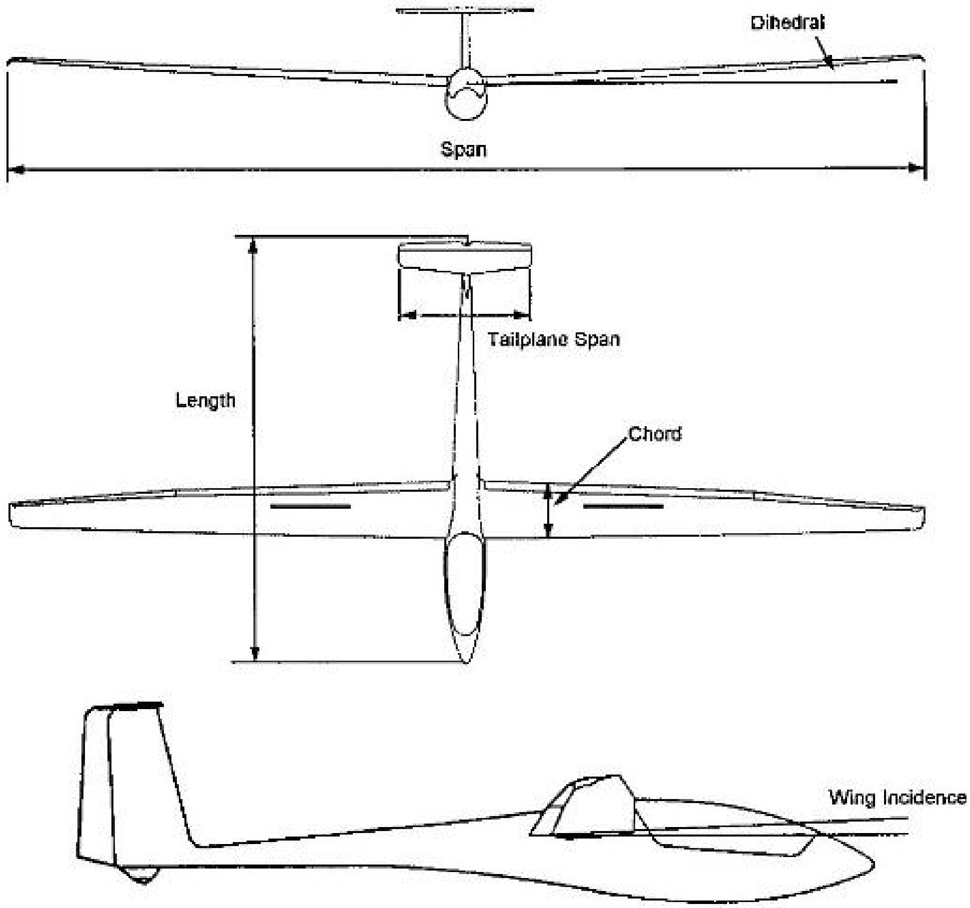


Figure 2-2 Geometry

2.3 HORIZONTAL STABILISER.

There are five basic horizontal stabiliser configurations. They are the conventional tail such as found on the Blanik, the cruciform tail such as on the Libelle, the T tail, the V tail such as on the Salto and the canard where the stabiliser is mounted forward of the wings.

Each configuration will consist of either an all moving control surface or a fixed tailplane and elevator.

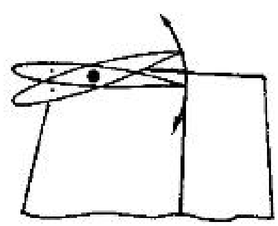


Figure 2-3 All moving tail

2.4 WOODEN STRUCTURES.

Wooden structures are usually constructed with a structural skin supported by internal structure (semi-monocoque). Individual components are glued together as this provides that highest possible strength for a given weight. Almost all modern repairs are done using epoxy glues. The front of the wings are usually covered with sheet plywood and the rear of the wings are covered with fabric which is shrunk onto the structure to make it taut.

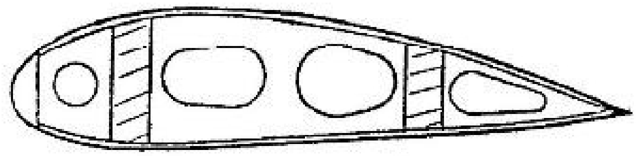


Figure 2-4 Plywood rib with lightening holes

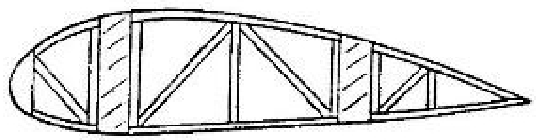


Figure 2-5 Pratt Truss rib with tension diagonals

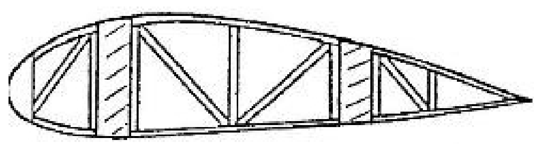


Figure 2-6 Pratt Truss rib with compression diagonals

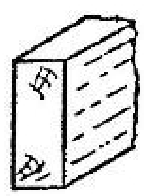


Figure 2-7 Solid Spar

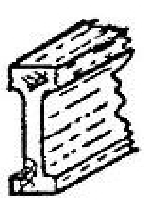


Figure 2-8 Routed Spar

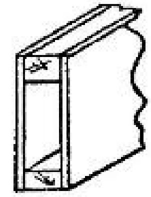


Figure 2-9 Box Spar

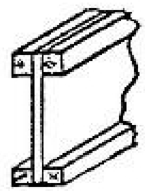


Figure 2-10 I Spar

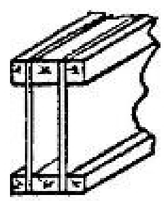


Figure 2-11 Double I Spar

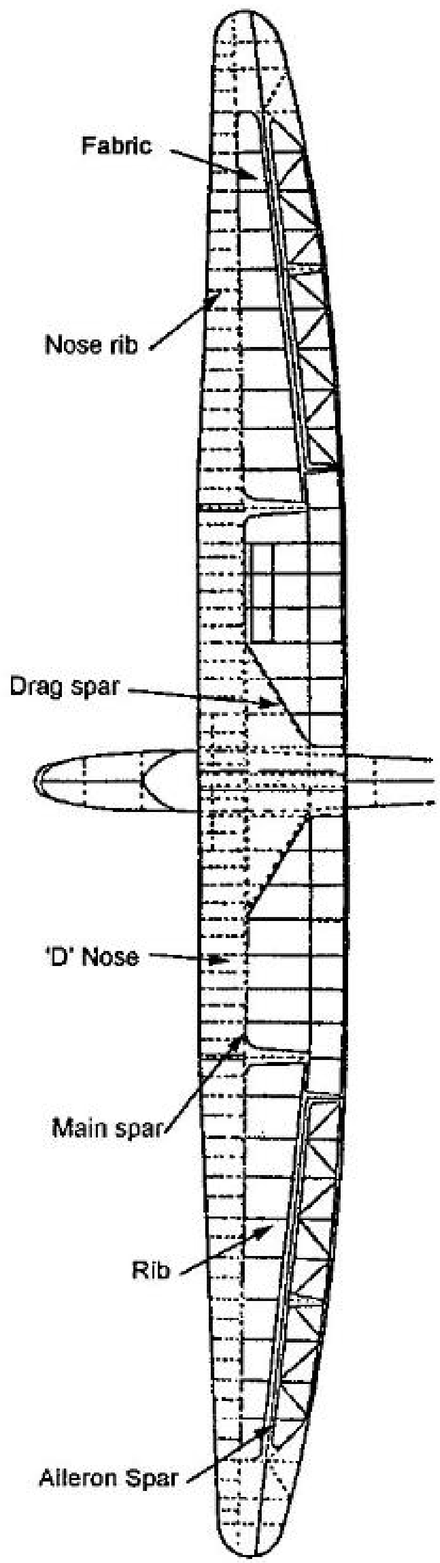


Figure 2-12 **Wooden Wing Structure**

2.5 METAL STRUCTURES.

Metal structures are usually semi-monocoque, however some types are constructed so that the skin carries all of the loads (such as the rear fuselage of the IS-28B2). Most of the metal components are constructed from sheet metal by cutting the metal to shape and then bending it to produce the necessary flanges.

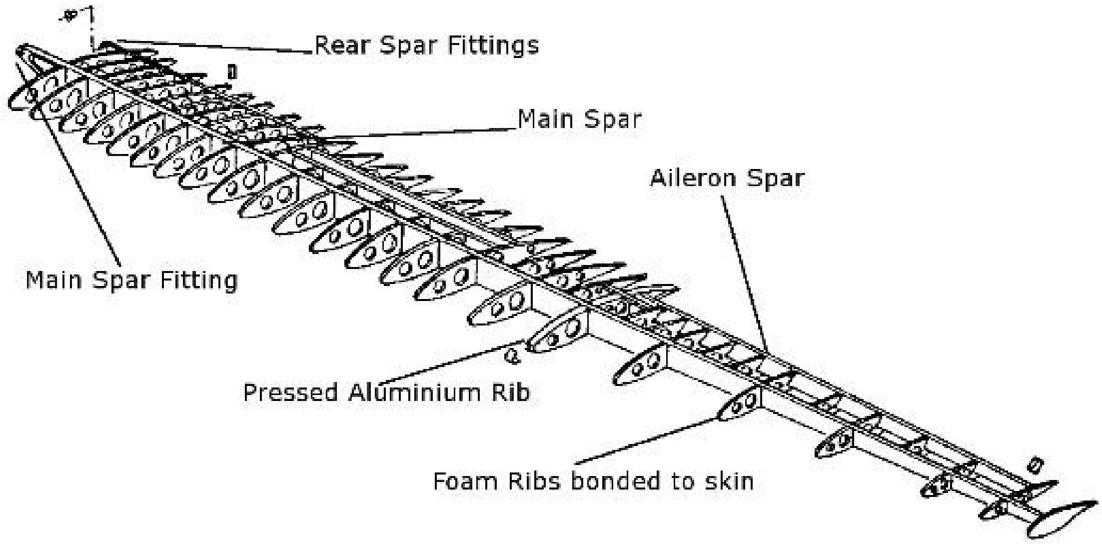


Figure 2-13 Metal Wing Components

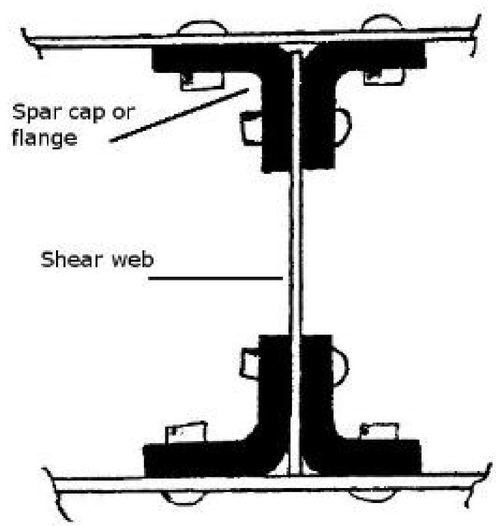


Figure 2-14 Main Spar

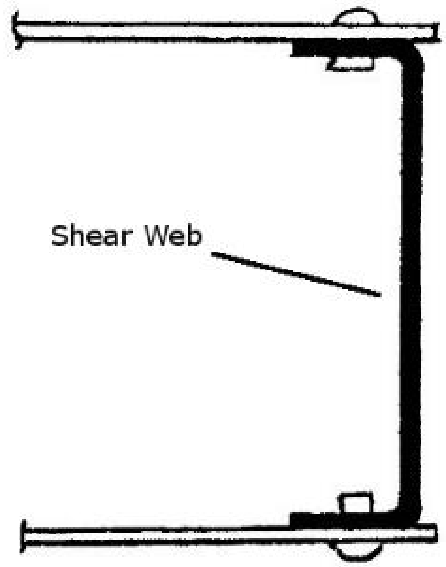


Figure 2-15 Pressed Aluminium Rib

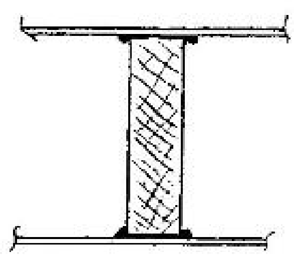


Figure 2-16 Foam Rib

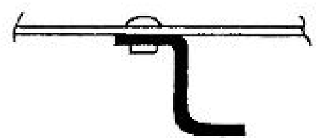


Figure 2-17 Stiffener

Most metal structures are held together by rivets. These come in many types some of which are shown below:

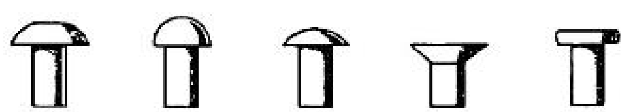


Figure 2-18 Rivet Types

2.6 FIBRE REINFORCED PLASTIC (FRP) CONSTRUCTION.

FRP structures (also known as composites) are manufactured by embedding fibres in a matrix material. In sailplanes the fibres may be woven together as a cloth or grouped in unidirectional bundles called rovings. The fibres may be manufactured from glass, carbon fibre or aramid (trade name - Kevlar). The matrix used is an epoxy resin.

A composite laminate which is strong enough for many sailplane applications is actually quite thin and therefore flexible. To improve the stiffness of the laminate it is often ‘sandwiched’ around a layer of foam or, on older types, balsa wood. Sandwich construction increases the stiffness considerably for only a small increase in weight.

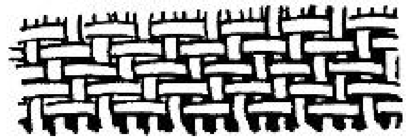


Figure 2-19 Typical Twill Cloth (two over, one under)

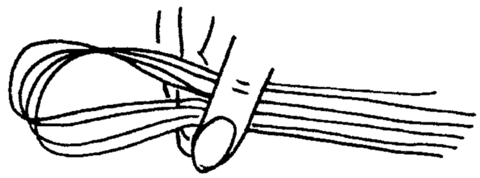


Figure 2-20 Roving

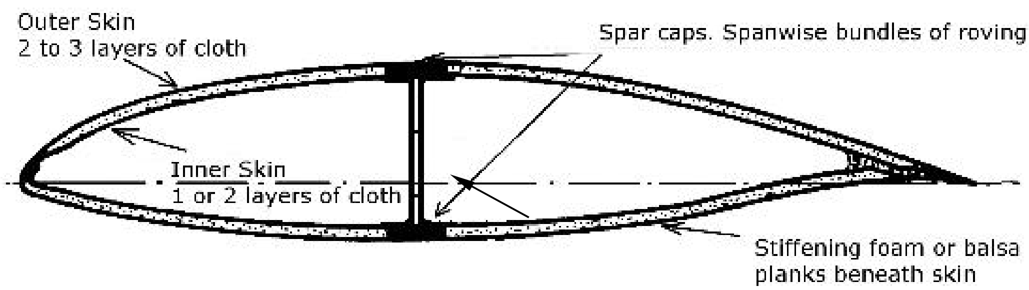


Figure 2-21 Composite Wing

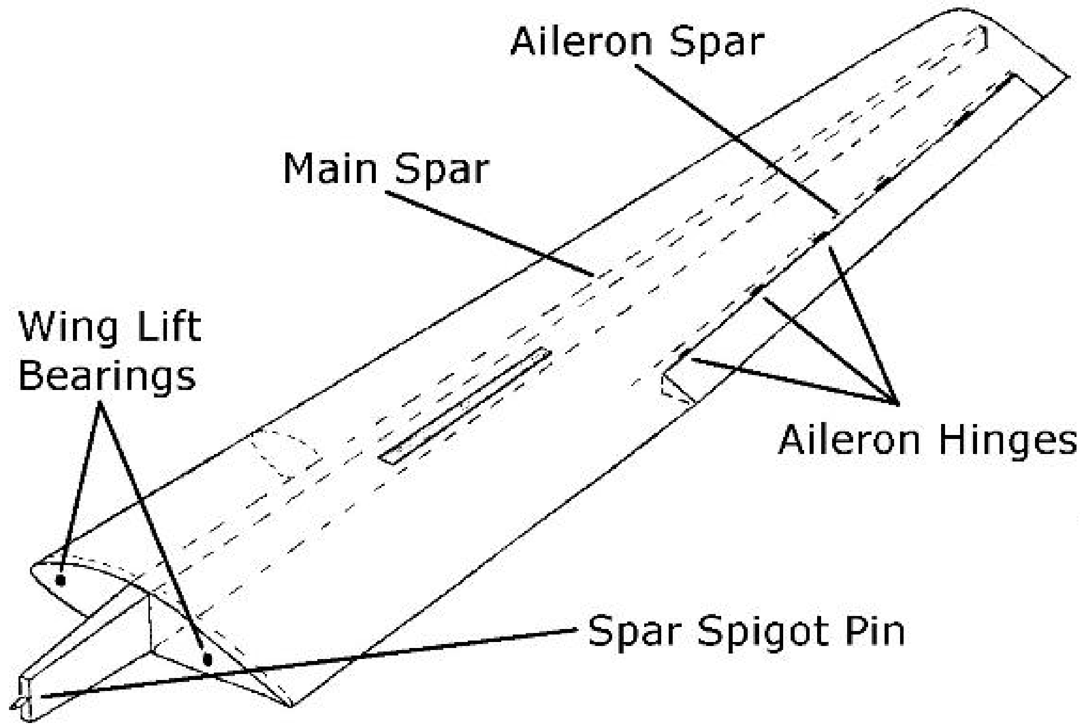


Figure 2-22 Composite Wing Components

2.7 STEEL TUBE CONSTRUCTION.

Some older sailplanes use a frame work of steel tubes as the fuselage structure. These tubes are joined into a truss by welding.

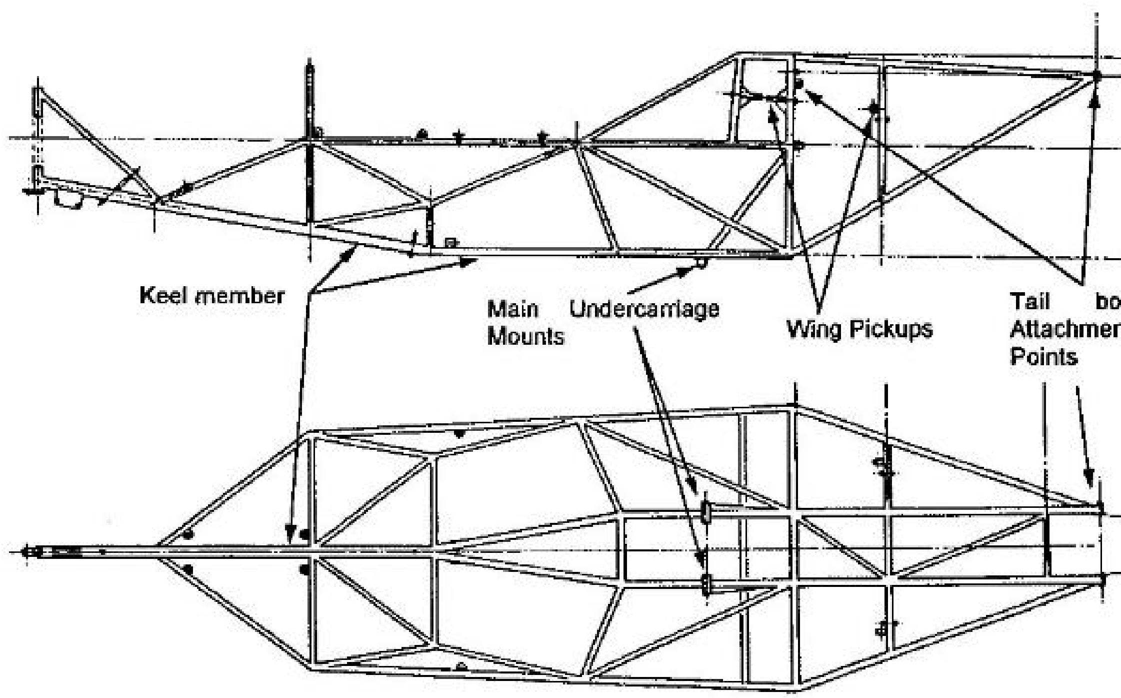


Figure 2-23 Typical Steel Tube Structure (forward fuselage only - the TAIL BOOM is a SEPARATE aluminium tube which bolts into place)

3. INSPECTIONS

Sailplanes are subjected to a comprehensive regime of inspection designed to ensure the sailplane is airworthy and thus safe to fly. In this chapter, an overview of the regime is provided and then the methodology for Annual Inspections is explained.

Depending on how your aircraft is certificated (CoA, EC, amateur built, LSA) varies how you may maintain your aircraft and the Registration Holder may elect some variations. A Logbook Statement is the method of conveying the system and the owners decisions to the Inspectors, refer to MOSP 3 and various advisory documents. A major difference of LSA is that you must follow the manufacturer's maintenance directions, you may not do the GFA Form 2 as an alternative.

For every sailplane you must submit a Form 2 return for every Maintenance Release you issue.

3.1 THE INSPECTION REGIME

The airworthiness of a sailplane is assured through the regime of inspections as follows:

Type of inspection	Purpose	When	Who
Daily Inspection	To establish that the sailplane is fit for flight for that day's flying operations and certify that in the Maintenance Release.	Before the first flight each day	DI Note 1
Independent control check	A double check that all controls have been correctly reconnected.	Following reconnection of controls eg after a Form 2 or re-rig	DI Note 1
Annual Inspection (Form 2)	To ensure that the sailplane is in a sound condition and that, provided it can still pass a daily inspection, it will remain airworthy for 1 year.	Annually, survey, or following a major repair or modification	AI Note 2
First inspection	Brings the sailplane into the GFA airworthiness system	On import or local construction of a sailplane	AI Note 2
Periodic inspections	To ensure the airworthiness of sailplanes, or components of, which may be subject to time (usually hours flown) based deterioration factors.	As required by the manufacturer or a specific AD for the sailplane type or component (eg TOST release).	AI Note 2
Post incident inspections	To ensure no damage has occurred that renders the sailplane un-airworthy.	Following any abnormal incident which may have damaged the sailplane eg heavy landing or ground loop	AI Note 2
Life Inspections	To extend the life beyond a time-bounded age (eg 10 years) or number of hours limit.	As required by the TC holder or a specific AD for the type. Many sailplanes are subject to these.	AI Note 3
Surveys	A detailed inspection, including parts of the sailplane which are not normally or may not have been recently inspected.	As required by the TC holder or directed by MOSP 3 Chapter 14. Same purpose as life extension and covers all sailplanes.	AI Note 3
Weight & Balance	To ensure the sailplanes centre of gravity and empty weight are within the Type Certification.	After major repairs/ modifications. If equipment causing significant mass or moment is added or removed. At least at time of surveys.	AI Note 4

Table 3.1 The Inspection Regime

Notes:
1. DI authorisation is by classification FRP, Wood, Metal
2. AI authorisation is by classification FRP, Wood, Metal
3. Surveys and Life Extensions may only be certified by specially authorised AIs
4. Weight and balance may only be conducted by specially authorised AIs

Details of who can perform which inspection are shown in MOSP 3.

Information regarding the conduct of Daily Inspections is shown in the GFA Gliding DI Handbooks. Details regarding training and examining AI candidates are in a later chapter of BSE.

The order of precedence of documents is confusing and more so now because some parts of MOSP 3 and BSE have taken over from ADs and have the status of an AD. GFA make it clear which have the status of an AD and take precedence over manufacturer's documents. Refer to MOSP 3 for details.

3.2 SYSTEMIC AND HUMAN FACTORS

Before describing the inspection process, it is important to consider the systemic (ie organisational) and people related problems that may affect the quality of an Annual Inspectors work.

3.2.1 CLUB STRUCTURE

In modern accident investigation, increasing emphasis is being placed on the overall responsibility of the organisation to provide a working environment which is conducive to safety. If an inspector fails to tighten a bolt because he or she is under pressure to have the aircraft finished then the club officer who has set an unreasonable work schedule or failed to provide adequate facilities for the job must bear some of the responsibility.

3.2.2 FINANCE

Airworthiness standards cannot be compromised for any reason. An inspector cannot stand up in court and say "we couldn't afford to put a new one in so I let it go". If the money is not available and the problem is serious enough, the sailplane should be grounded.

3.2.3 WORKLOAD

Overloaded inspectors are more likely to rush and may make mistakes. Inspectors should make a point of having as many helpers as is necessary (but not so many that the inspector loses track of what they are doing). This has a double advantage as there is someone to help lift heavy objects and you may be training someone who can ease the workload in the future.

Teaching potential new inspectors and the spreading of airworthiness knowledge are very important. Inspectors who lock themselves away alone, deny themselves the chance of a second opinion.

Club management must also bear some responsibility for the workload of its inspectors.

3.2.4 COMPETENCY OF HELPERS

As well as dealing with the technical aspects of inspecting sailplanes, inspectors must deal with helpers and "experts". When working with helpers it is important to keep a close eye on their work. The word of unknown experts must be treated with caution. If technical assistance is required, seek out a recognised source of information. Be prepared to ask a disruptive person to leave the workshop. After all, it is the inspector's final signature that says a sailplane is safe to fly.

3.2.5 INSPECTOR SUITABILITY

The person who is to inspect and signoff the sailplane must be fit to perform the task. This fitness includes having the relevant approvals, knowledge of the sailplane (or the ability to find and use information) and the ability to physically perform the inspection tasks.

The following attributes of physical ability are required:

a. Good vision. If glasses are required then they must be used. Good lighting is important. To assist in this area there are various scoping devices that are useful and relatively cheap, they can assist in the visual assessment of dark and hard to get to areas.

b. Good hearing. Movement of damaged or poorly supported parts usually results in sound and the ability to hear this is important. A workshop with low ambient noise levels often assists with these types of assessments.

c. Sufficient movement so that access to the relevant parts can be gained. Removal of parts such as releases often requires considerable dexterity. It is often the case that specialist tools can be made/adjusted to minimise physical load.

3.2.6 LACK OF TECHNICAL INFORMATION

Inspectors are often faced with inadequate manufacturers' manuals when inspecting sailplanes, especially for older types. BSE is intended to fill in the gaps; however sometimes an inspector will encounter a problem which is not covered by any documentation and which they have not experienced before.

Inspectors who cannot solve a problem on their own should seek the advice of a more experienced inspector. We don't have to know everything but we do need to make certain we use the correct approved data. If the problem still cannot be solved the inspector should contact their RTO-A or the CTO. Inspectors should never "guess" the solution to a problem.

Be self regulating. If you don't know enough about a task, get help or learn how. Just because you have a rating does not mean you can, have to or should do everything.

3.3 THE ANNUAL INSPECTION PROCESS

Conducting an annual inspection of a sailplane is an involved and complex task. If it is not handled in a clear, systematic, logical way it is possible for faults to be missed and for sailplanes to be reassembled incorrectly. There are eight main steps for performing an inspection:

a. Preparations

b. Pre-inspection review of documentation

c. Aircraft overview

d. Functional checks

e. Rectify and Inspect

f. Checks after rigging

g. Documenting the inspection outcome

h. Evaluation flight

3.3.1 PREPARATIONS

In good time before the planned inspection action the following:

a. Request an Annual Inspection Kit from the GFA in good time.

b. Determine the best dates to conduct the inspection.

c. Arrange for access to a suitable workshop or hangar.

d. Arrange for suitable helpers.

e. Arrange any expert help needed for repairs or particular elements of the inspection.

f. Acquire any necessary special tools and consumables.

g. Or instead of c. to f. send it to a GFA Approved Maintenance Organisation (AMO). You can greatly reduce their charges by having your paperwork in order.

3.3.1.1 DETERMINING WHEN TO CONDUCT THE INSPECTION

A sailplane must not fly once the Maintenance Release (MR) has expired. An Annual Inspection may be conducted before expiry of the MR. Therefore, when determining the date of the inspection, consider:

a. How long will the annual inspection take? This depends on the sailplane, the inspector's experience, availability of help? Is there a repair that needs to be sent away or a part required and if so what is the lead time?

b. When will expert help be available for a repair or planned modification (eg installation of oxygen)?

c. Is the sailplane required to be available for use up to the date of expiry of the MR? Plan an inspection period after this date.

d. Is the sailplane required for a special event (eg competition or wave camp)? Will the MR expire before or during the required period? In which case plan the annual inspection to commence at a date that will comfortably ensure it is completed before the special event.

3.3.1.2 LEVEL OF INSPECTION

The level of inspection required varies with a number of factors. These factors include:

a. The sailplane's usage in the past 12 months. High usage may have caused more wear or deterioration. Low hours may mean underlying issues have not yet become apparent.

b. Storage or operational conditions. An inspector may need to be more cautious if the sailplane has been stored in a damp or leaking trailer, compared with if it has been stored in a dry hangar. Or flown near the sea.

c. The Inspector's familiarity with the specific aircraft. If an inspector has never seen a particular sailplane before, the level of inspection will obviously be more in depth than if the inspector has worked on that particular sailplane over the past few years and knows the history. For example, if the Inspector lubricated the elevator circuit last year, then he might decide a visual inspection will be adequate this year.

d. It is wise that every few years the sailplane is inspected by another AI. This will apply another perspective and set of expertise.

Ultimately, the inspector must conduct a level of inspection that will satisfy them that all ADs have been complied with and the aircraft is airworthy.

3.3.2 PRE-INSPECTION REVIEW OF DOCUMENTATION

The documentation trail of a sailplane will usually show areas that need to be reviewed, specific actions that need rectification, and historical problems that keep arising and therefore require further understanding.

The documents that should be assembled and consulted include the following:

a. GFA Annual Inspection Kit for the specific sailplane. This is provided by GFA Secretariat on request and payment of a fee. The kit provides a wealth of information intended to help the Annual Inspector perform his duty fully.

b. Aircraft logbook. This will give a complete history of the sailplane, and is very useful for understanding previous work undertaken on the sailplane. It is also required for the recording of the results of the current inspection.

c. Previous Maintenance Release. This will show the amount of flying, any Major or Minor defects and any periodic maintenance activities undertaken in the last year. All minor defects except Permissible Unserviceabilities must be corrected at an annual inspection.

d. Certificate of Airworthiness and Certificate of Registration will show the current legal situation of the sailplane. Note, if the registered operator or his email recorded on the Certificate of Registration is not correct then Airworthiness Directives will not be sent to the person(s) who need them. These must be checked annually for validity and currency.

e. Current flight and service manuals from the manufacturer or equipment/parts supplier (eg a radio manual), will often give advice on servicing cycles and replacement schedules.

f. Airworthiness Directives (ADs), technical notes and Airworthiness Advice Notices (ANs) will all assist the understanding of the current and future needs of the sailplane. Airworthiness Alerts will provide updates and warnings.

A good understanding of these matters prior to commencing the inspection should allow a plan of actions and requirements to be created.

3.3.2.1 ADS, ANS, AND AWAS

The Form 2 kit will include a list of known general and type specific ADs and ANs for sailplane to be inspected. This can be used as the basis of a checklist of applicable ADs and ANs, but must not be regarded as definitive. An example is shown in the following figure:

This Schedule was printed from information current on
22-April-2016

Type: Astir CS

FOR NON-MANDATORY AIRWORTHINESS INFORMATION SEE ANs for General or Specific Types

	ADs DUE AT THESE PERIODS MUST BE RECORDED ON PART 1 OF THE MAINTENANCE RELEASE					
AD Number and Issue	**Within Specified Time**	**Before Next Flight**	**At Daily Inspection**	**Recurring at Specific Intervals**	**Each Annual Inspection**	**Details of Directive**
EASA AD 2010-0053R1 Issue 1	Yes	No	No	Yes	Yes	Waterballast - Hose-Fuselage connections of the Waterballast Dumping System - Inspection/ Repair
GFA AD 0088 Issue 1	By 15.9.77	NO	NO	NO	NO	Aileron Stop (Astir CS Only)
GFA AD 0093 Issue 1	As Soon As Possible	NO	NO	NO	NO	Flight Manual Amendment (Astir CS Only)
GFA AD 0100 Issue 1	By 30.4.78	NO	NO	NO	NO	Rudder Bellcrank Replacement
GFA AD 0121 Issue 1	By 30.6.79	NO	NO	NO	NO	Pilot ballast
GFA AD 0140 Issue 1	By 31.12.79	NO	NO	NO	NO	Extension of time for GFA AD 120 and 121
GFA AD 0161 Issue 1	By 31.12.79	NO	NO	NO	NO	Fitment of mandatory ballast boxes
GFA AD 0167 Issue 1	NO	YES	NO	NO	NO	Amendment to Flight Manual
GFA AD 0170 Issue 1	NO	YES	NO	NO	NO	Placards for Trim box installation

Figure 3-1 Example of a Form 2 Kit Type Specific AD List

It is the Registered Operator and Annual Inspector's role to find all applicable ADs and technical notes. GFA will help with the above registers of what we know may be applicable to your aircraft.

An inspector can also check the GFA General Registers of ADs and ANs on the GFA website where a searchable list is provided. This is required if the Form 2 kit is old and the registers may have been updated.

Be aware that the complexity of modern sailplanes has made it almost impossible for GFA to find all ADs. A motor glider for example may have ADs on the airframe, various instruments, propeller, generators and many other items. The other factor that adds complexity to the AD situation is that many different organisations issue ADs, eg CASA, EASA, FAA, and other state-of-design authorities as well as GFA.

If you find an AD that has not been identified by GFA, please advise the GFA which will then put it in the registers where applicable. Manufacturer's Technical Notes (TN) or Service Bulletins(SB) are not on their own mandatory but they are good advice and usually provide the background to an AD that makes them mandatory if necessary.

We have moved a number of ADs into MOSP 3 and BSE so in future just refer to those sections, they are mandatory. We will cancel the ADs and list the MOSP sections in the Registers. Generally no change is caused by this but the reason is ADs are not meant to provide the standard system of maintenance but are rather there to address risks to flight. It is the modern way.

3.3.3 AIRCRAFT OVERVIEW

When inspecting a sailplane the next step, regardless of the type of inspection, is to assess the entire aircraft. This overview should include an assessment of the overall condition of the sailplane, is it tatty, clean etc. Obvious damage will be easily spotted but if you have never seen a particular sailplane before you have to start by identifying all obvious damage.

Items which should be identified in the overview inspection include, but are not limited to: Damaged skin, cracked canopies, flat tyres, badly aligned controls, controls working in the incorrect sense etc. Every inspection of a sailplane, including the pre-flight walk around, should detect these items.

If a sailplane appears to be complete and undamaged then the inspection should progress to the function stage. If there is damage, then obviously it must be repaired before the functional check can be conducted.

Up to here and even the Functional Checks should be done weeks before you take it out the air so you know what needs doing and thereby allowing some pre-planning to be done. Obviously it is better to know before you start that the ASI needs overhauling, rather than finding out after the rest of the inspection is completed and the sailplane is about to be put back in service. Or to get a few bearings so you can replace them.

3.3.4 FUNCTIONAL CHECKS

During this part of the inspection each part should be examined to ensure it is in a suitable condition to perform the task it was designed for. The inspector should use the GFA Form 2 as the basic checklist together with any additional inspection requirements from the manufacturer's manuals. Alternatively the owner can elect (in a logbook statement) to follow the manufacturer's or another approved maintenance system. Inspectors should also ensure that all ADs have been complied with by checking the logbook entries.

It is best to start with a rigged sailplane so that all faults can be found as follows. The function check should ensure that the structure is undamaged, has no unacceptable cracks and is assembled correctly. The control systems should be checked for correct operation, damaged parts, free-play, attachment to the structure, cleanliness, adequate lubrication etc.

As a general rule this is the best time to conduct deflection and wing frequency checks (see below). A wing frequency check may also indicate if there have been structural changes since the last sailplane inspection.

This philosophy of inspecting for correct function and condition of each sub-system should be continued until the entire sailplane has been inspected. If defects are found or it is necessary to dissemble the system to complete the inspection, the operation of the system should be re-inspected after re-assembly.

Details of the inspections required for the tow release mechanism are contained in a separate dedicated chapter of this manual.

Details of the inspections required for oxygen systems, if fitted, are contained in a separate dedicated chapter of this manual.

3.3.4.1 WING FREQUENCY CHECK

A wing frequency check is conducted as follows:

a. The aircraft documentation will have the wing frequency, both initial and historical; this is the natural vibration of the wings. It is generally conducted on the main undercarriage, with the tire at the correct pressure, but each manufacturer has their own ideas and you must follow the manufacturer's instructions.

b. A drinking glass will 'ring' when tapped, but if it is cracked it will be 'dead'. Similarly a sailplane structure will respond to internal damage, loose wing fittings, etc by changing the frequency at which it wants to naturally vibrate.

c. Therefore it is important to know the frequency and monitor it to ensure any sudden changes are known and the reason investigated.

d. The manner of conducting a wing frequency check is to set the aircraft up as described above, on a solid surface with the wings level, gently shake the wings up and down until the wings flex at a steady rate. Maintain the gentle shaking and, using a suitable watch or someone else counting, determine the total number of wing flexes in a period (up and down is a count of one). Confirm the rate is comparable with previous checks and the sailplane specification.

3.3.4.2 CONTROL SURFACE FREEPLAY CHECK

Free play in excess of the maker's (or BSE) limits may indicate bearing wear, loose control horns, or other control system defects that may not be readily found once the sailplane is de-rigged.

3.3.4.3 CONTROL SURFACE DEFLECTION CHECK

Incorrect control surface deflection may indicate control system damage, incorrect pushrod/ cable adjustment or control stop problems and could explain adverse handling characteristics.

3.3.4.4 FLIGHT CONTROL SYSTEM STOPS

Incorrectly adjusted or damaged control stops can lead to system damage (bent pushrods, damaged bellcranks and control surface hinges etc.

3.3.4.5 ASI AND ALTIMETER CALIBRATION

If the ASI or Altimeter calibration is out, the instrument will need to be sent away for overhaul and this takes time. Check any colour coding against the cockpit placard; differences could indicate that the instrument may have been swapped from another aircraft. The ASI need not be colour coded unless the Flight Manual requires it but if there is colour coding on an instrument it must accurately reflect the limits for the particular sailplane.

3.3.4.6 HARNESS INSPECTION

Is there an Airworthiness Directive out on the harness? How old is it? Webbing damage or age deterioration may require the harness to be replaced or re-webbed. It is common to find harnesses still in service well beyond their approved service life. Re-web or replace such harnesses and if the harness is of the “pull down to tighten” variety, take the opportunity to convert it to “pull up to tighten”.

3.3.4.7 FATIGUE LIFE

As time goes by sailplanes may be kept flying by cannibalising parts. Many of these parts will have fatigue life limits. Check for components that may have exceeded their life limit or will do so during the next 12 months (exchanged component life must be listed in the Logbook). The whole airframe may also be close to its certified fatigue life limit.

3.3.4.8 LOAN EQUIPMENT

GFA and the State Associations have a number of specialised tools available for loan to inspectors. If you will need to borrow any of these items, book them in advance through your RTO-A or State Association.

Loan equipment includes:

a. Electronic weighing scales

b. Tow release testing tool

c. Endoscope (Boroscope)

d. Cable swaging tools (not all states)

e. Fluoro crack detection equipment (not all states)

f. Altimeter and ASI tester (new equipment coming soon)

3.3.4.9 INSPECT AND RECTIFY

The above functional checks before you derig tell you what needs addressing. You now derig and resolve all these issues.

The inspector then carries out the inspection using the Form 2 (or a manufacturer’s schedule) as a checklist. It is good policy to inspect the sailplane together with all ancillary equipment such as radio, oxygen system, tie-down, battery etc. The Inspector should review these items for function, security and their influence on weight and balance.

To complete each area ensure that all parts have the correct safety locking. Since a sailplane cannot “pull over to the side of the road”, all nuts and bolts, turnbuckles, pins etc. must have two factors which prevent them from undoing. The primary securing method for nuts and bolts is the friction generated when the bolt is tightened. The secondary securing method, referred to as “safetying”, may be the elasticity of a Nyloc nut or mechanical securing such as split pins, safety wiring etc.

The inspection schedule is designed to be used as a checklist. At the end of each major component group there is provision for recording a dual inspection by an independent inspector of DI or higher authorisation (See items 16, 20 and 45). This is to verify the integrity of critical internal items & controls which would not be visible once the structure is closed up.

The Form 2 is setup so that the inspector can sign it out before re-rigging and independent control checks. He only does this if he knows he has done the rigged checks already and he made no changes. The Independent check and rerig can then be done later at the airfield by a DI inspector.

Otherwise it is re-rigged so control surface deflections can be re-measured to ensure they are within the specified tolerances. If extensive fabric replacement, painting or repairs have been done or extensive changes made to the aircraft equipment or ballast, then the sailplane must be reweighed.

Once he has completed the Logbook certification (see Section 3.4.1 below), the Annual Inspector signs & dates the "Inspectors Certification" on the bottom of Form 2 Page 2 and fills out the Maintenance Release. The MR can be issued for any period up to a maximum of 12 months, at the inspector's discretion, but not beyond due Survey or life extension programs. Any scheduled maintenance required by the manufacturer, the GFA, or the inspector which may fall due before the next Annual Inspection must be entered in Part 1 of the MR. The date of issue of the MR is on or prior to the evaluation flight.

For powered sailplanes; the main Annual Inspector may not have an engine rating. The AI arranges an engine rated inspector signs off the engine and then he can sign out the whole aircraft.

The Inspector completes the Inspection Report (and a copy of Appendix A/ Manufacturer's schedule if the aircraft is a powered sailplane) and forwards it to the GFA secretariat.

3.3.5 CHECKS AFTER RIGGING THE SAILPLANE

The sailplane may now be rigged in preparation for the evaluation flight. At this point the Independent Control Check must be performed. Check the pitot system is working. Once the inspection is completed an Independent Control Check is performed by the holder of a Daily Inspection or higher airworthiness authorisation. This person must check that all parts are correctly attached, that all controls are correctly connected and safety locks in place, that there is full and free movement and that the controls move in the correct sense. Concealed controls, which have already been checked and signed out at Form 2 items 16, 20 & 45 in the inspection schedule, need not be re-inspected for safety locking.

Check the documentation is complete:

a. The Maintenance Release has been issued.

b. The Logbook certified.

c. A Daily Inspection and independent inspection has been performed and recorded in the DI section of the MR and signed off on the bottom of the Form 2.

The sailplane may now undergo an Evaluation Flight in accordance with the procedures in Section 3.5. Please submit your Form 2c return with hours and landings to date to the GFA office every time you issue a MR.

3.4 DOCUMENTING THE INSPECTION OUTCOME

3.4.1 THE LOGBOOK ENTRY

No inspection is complete without a logbook entry to show that the inspection has been completed and to record all rectifications which were necessary. A short and concise entry must be made in the Maintenance Log (white pages) of the logbook of everything that was done during the inspection. Write your entries so the person reading it in the future understands exactly what has been done. Make sure you record everything that you did so it is clear. The most common fault is to say "All ADs complied with" this does not tell anyone which or what you did.

The RO may fill in lists and hours in the Logbook, neatly, but only an Annual Inspector may make a certification entry in the front part of the Logbook certifying the maintenance was correctly performed and the Logbook is correct.

The following is an example of a logbook entry and should be used as a guide:

> At TTIS = xxx hours, Landings = xxx an annual inspection in accordance with GFA Form 2 and the Maintenance Manual was completed during which the following rectifications were carried out:
>
> a. New left front rudder cable fitted.
>
> b. New nose release spring fitted.
>
> c. New bearings fitted to right hand aileron wing root bell crank.
>
> d. GFA ADs XX issue 1, ZZ issue 3 complied with.
>
> Wing frequency = xxx.
>
> Maintenance Release No 0001 issued.
>
> Name: ________________ Signed: ________________ M________ Date: ________

Please do similar for engine and propellers. Some of these have their own logbook so if they are changed it goes with them – keep it up to date as well as the airframe logbook.

3.4.2 OTHER SECTIONS OF THE LOGBOOK

There are some differences in logbooks dependent on their age. Please amend your logbook to make it compatible. This helps ensure entries and format for all types are similar, makes it clearer, and easier to ensure the continued maintenance of your sailplane and makes the next inspector's job easier. It is worth getting the above right now and then it will be correct and easier thereafter.

Please see MOSP 3 for requirements on Logbooks.

What is essential in a logbook is as follows;

3.4.2.1 WHITE PAGES

White pages:

a. Annual updates are permissible but monthly totals of hours and landings are transferred from the maintenance release (Form 1) at the Annual. Except where a maintenance activity has been performed requiring a logbook entry during the year; in which case hours and landings must be updated at that date. It is worth double checking all MR records and arithmetic as errors are very common after a day flying.

b. The Maintenance Log is exactly that, it is the only legal record and must contain a certification (signature, name, GFA number (new M-xxxxx) and date for each entry, bulk entries at an Inspection may have one certification). Maintenance activities that require a logbook entry are; each AD when first performed or a listing for recurring ADs each year, ANs, repairs, modifications, test results, lifed component changes, scheduled maintenance and any other significant activity. (Cleaning and polishing are not significant but installing a new radio is.)

c. Inspection entries in the Maintenance Log should be opposite the corresponding years, hours and landing record. Pages should be ruled off at the annual so that it is very clear where the entry starts and finishes for that year, do not leave blank lines/spaces in your certification statement.

3.4.2.2 GREEN AND YELLOW PAGES

Green and yellow pages:

a. The Modification Record is a complete list of authorised modifications and the date of incorporation {*}

b. The Repair Record contains records of all (significant, usually structural) repairs carried out {*}

c. The AD Record is a complete list of ADs and the incorporation date. For convenience this can be separated into General and Specific ADs and into non-recurring and recurring ADs, ie a number of pages but easier to check off. {*}

d. The Lifed Structural Component Record is a complete list of any component that requires changing at a defined interval (if any) and details of the life limit and date of changes. Look in the Maintenance Manuals and ADs to complete this list of lifed components. {*}

e. Weight and Balance Record records the weight and balance data and any changes since the last weight and balance.

Note: Green and Yellow pages are not certifications, all work must be certified in the Maintenance Log, i.e. the front part of the logbook; therefore all ADs will have two entries; one in the AD Record and one in the Maintenance Log. The neatest way to tie all of these together is to record the page number of the certification against the record entry e.g. (P14). Make sure the certification is there or an Annual Inspector adds one once he has confirmed the AD was completed. Then complete the AD Record so you don't have to search for all of them every year.

The Lists marked {*} above will make your life easier next year. Please add them if your Logbook does not have them.

Remember you are responsible for all work you certify even after you sell the aircraft. An honest mistake is one thing but if it kills someone be sure you did your work properly at all times. You have liability insurance under GFA if you are a paid up member at the time of the certification and the sailplane is GFA registered and you have followed the regulations and GFA procedures.

3.4.3 OTHER GUIDANCE

If you type up certification statements then glue and staple them into the logbook. And make a short summary statement that you certify in pen in the logbook in case the page goes missing. Make sure you write everything you did. And be clear, "All ADs complied with" tells the coroner nothing. Whereas "The following ADs were checked and complied with; GFA AD 123, EASA AD 231, CASA AD/Eng/2." says exactly.

a. The Weight and Balance sheet must be recorded as an entry on the W&B pages then put in the pocket in the back of the logbook.

b. All other entries must be neatly handwritten in pen or printed.

c. Errors are to be neatly crossed out and the correct entry made adjacent to it; liquid paper or white out is not to be used.

The logbook is a valuable and legal part of the sailplane. Without it or poorly completed and the future owner should realise he is taking a chance and expect a large reduction in price. Look after the logbook; store it so it is safe from fire or accidents.

3.5 EVALUATION FLYING

The annual inspection is completed when the sailplane logbook is signed. The evaluation flight is not part of the annual inspection. However, an evaluation flight must be performed to ensure that the sailplane's handling characteristics are normal for the type. The inspector should provide the evaluation pilot with the information in this section. The completion of a satisfactory evaluation flight may require multiple launches.

Any defects found are to be recorded under Major or Minor Defects in the Maintenance Release as appropriate. Any Major Defect will mean that the sailplane cannot be flown again until the defect is rectified and signed out by an Annual Inspector. Minor Defects mean the sailplane may continue to be flown but the defect must be checked at each Daily Inspection or interval as listed in the MR.

If the flight is satisfactory the Evaluation Flight Report in the Maintenance Release is signed by the pilot and the sailplane can be returned to service. If you do a run to V_{NE} then tick the box. Otherwise write the speed you went to so that future pilots know.

3.5.1 EVALUATION PILOT AUTHORISATION.

Pilots must be experienced and authorised in accordance with the GFA Manual of Standard Procedures Part 2-Operations.

3.5.2 PREFLIGHT PROCEDURES

Once the annual inspection is completed and the maintenance release has been issued, a daily inspection should be performed and certified in the new maintenance release. The DI will normally be performed by the evaluation pilot (would you let anyone else do it for you?).

The sailplane will potentially have had control systems disconnected and reconnected, it is a requirement to conduct and document an independent control system check prior to flight.

An airworthy parachute must be worn.

The pilot should visually check that the canopy jettison system appears to be operational.

The pilot must also be aware of things which can go wrong on the flight. A pilot who is prepared for an emergency has a much greater chance of dealing with it. Things which have gone wrong during evaluation flights include:

a. Control system reversal.

b. A primary flight control not connected.

c. Premature release due to incorrect release maintenance.

d. Vibration and or flutter caused by slack cable control systems, loose hinges, loose bolts, incorrect control surface balance etc.

e. Poor control effectiveness due to incorrect control deflections or missing gap tapes or loose cables.

f. No ASI indication due to covers left on, plumbing incorrectly fitted, holes drilled through plumbing etc.,

g. No altimeter readings due to covers or plugs.

h. The sailplane does not fly straight due to miss-rigged controls, bad repairs (twisted tailplane or wings) etc.

i. Lack of stability due to errors in the weight and balance calculations (CG too far aft).

j. Inability to flare due to errors in the weight and balance calculations (CG too far forward).

k. Structural failure due to defects missed during the inspection.

3.5.3 FLIGHT PROCEDURES

The following procedures should be followed during evaluation flights. The order of these tests is important as discovering a flutter problem part way through a spin recovery would be very unpleasant. The pilot should assess that the sailplane is functioning correctly, especially the ASI, before attempting the V_{NE} run.

Multiple launches may be required to complete the entire programme.

3.5.4 LAUNCH

Under some circumstances, depending on the work done on the sailplane, an aero tow is the only way to gain enough altitude. In most cases winch launching is satisfactory however two or three flights may be necessary to fully check the sailplane.

3.5.5 FUNCTIONAL CHECK

Once airborne, the first step is to ensure that the sailplane is functioning correctly. The following items should be checked:

a. You can even abort before takeoff. In a motorglider make sure you achieve static or normal RPM, you achieve the normal acceleration, etc. Check braking before moving.

b. Aircraft controllable.

c. Instruments operating correctly.

d. Undercarriage operation.

e. Flap operation (if fitted).

f. Spoilers or dive brake operation.

3.5.6 GENERAL HANDLING

Examine the handling characteristics by flying straight and observing for:

a. Slip or skid.

b. Uncommanded roll or turn.

Gently turn in both directions paying attention to control coordination and controllability.

3.5.7 RUN TO V_{NE}

Increase the speed in 10 knot intervals up to the manoeuvring speed, then in 5 knot intervals up to $V_{NE.}$ At each speed check the handling. If turbulence (thunderstorms, rotor) is evident do not exceed the maximum rough airspeed limit. Do **NOT use full controls** above maximum rough airspeed limit, this can overstress the aircraft.

Observe the following:

a. Vibration or snatching of controls.

b. Excessive control movements or forces.

c. Oscillations in yaw or pitch.

d. Any abnormal structural deformation or movement

If any problems are encountered, slow down immediately. Flutter becomes worse with increasing speed.

If unable/ unwilling to complete the run to V_{NE}, write the speed attained next to the high speed tick box in Part 1 of the Maintenance Release.

3.5.8 STALL - STRAIGHT AND LEVEL

The sailplane should be flown at its minimum sink speed with the wings level and no slip. The control column is pulled back gently to lower the speed by 1 knot per second until either a minimum speed or stall is produced. Recover in the normal way.

Observe the following:

a. The indicated minimum or stall speed

b. Aileron control through the stall

c. Stall buffet

d. Wing drop and tendency to spin

e. Difficulty recovering

f. Height lost

3.5.9 STALL - TURNING

Only perform this manoeuvre on sailplanes approved for intentional spinning.

For an effective way to enter a spin (having first done a pre-aerobatic check of course):

a. Enter a turn at normal circling speed but stop the bank at about 10º.

b. Smoothly apply an increasing amount of rudder, at the same time maintaining a constant nose attitude by progressive back stick movement.

c. Allow the bank to increase due to secondary effect of rudder - do not “hold off bank” by crossing the controls.

d. The spin will occur from about 40º bank angle.

Provided the sailplane is capable of spinning (i.e. it is correctly rigged and within its CG limits), the above method is always successful. Crossing controls at spin entry will usually cause unpleasant effects, such as pitch oscillations, and will often inhibit spin development when it would otherwise be possible.

Recover from the incipient spin after ¼ of a turn using the standard procedure.

Observe the following:

e. The motion of the sailplane during entry and recovery

f. The maximum speed during recovery

g. The height lost (estimate)

3.5.10 PITCH STABILITY

Trim the sailplane at 1.4 times the stall speed. If there is no trimmer fitted note the trim speed. Gently increase this speed by 20% and slowly relax the pressure on the control column. Note the speed the sailplane returns to. Repeat only this time decrease the speed by 20%.

Function the trimmer to achieve the maximum and minimum trim speeds.

On easing the pressure on the control column the speed should immediately return towards the trim speed. On some types the speed will oscillate around the trim speed pitching nose up and nose down every 20 - 30 seconds. Provided this can be easily controlled, it is not a problem.

3.5.11 TURN STABILITY

Fly the sailplane in both left and right hand turns at 30° angle of bank. Reduce the speed gently until the minimum flying speed is reached. Complete several full orbits.

Observe the following:

a. Minimum speed for a steady turn.

b. Any control difficulty

c. Any abnormal control forces, particularly reversal

d. Position of controls during the turn

e. Response to small control movements

4. PITOT-STATIC SYSTEMS

4.1 GENERAL

The pitot-static system is a combined system that uses the static air pressure, and the dynamic pressure due to the motion of the aircraft through the air. These combined pressures are used for the operation of the Air Speed Indicator (ASI), altimeters, Vertical Speed Indicator (VSI) and gliding computers.

The correct operation of this system is of vital importance to the safe operation of the sailplane. Leaks in the system may cause errors in Indicated Airspeed reading of 10 knots or more. Errors may result in incorrect reporting to other aircraft and ATC infringements can be a danger to other aircraft.

WARNING

A GFA Annual Inspector or a CASA approved instrumentation technician is required to check and certify in the logbook after any work on the Pitot- Static system.

4.2 INSPECTION AND TESTING REQUIREMENTS

MOSP 3 Section 13.6 defines the mandatory GFA procedures for the Pitot-Static system. BSE Chapter 4 provides the GFA System of Maintenance for Pitot-Static systems replacing the regulations to which GFA has exemptions, ie CAO 100.5. This chapter provides training and guidance on how to perform the required testing and is to be followed unless manufacturer's data dictates otherwise. Refer to Section 4.7 below for details.

AN 169 has been incorporated into this chapter of BSE, the standard GFA system of maintenance, and so is cancelled.

4.3 DEFINITION OF TERMS

Static Pressure	The static pressure is the ambient air pressure surrounding the sailplane. This pressure reduces with increasing height. Most instruments use it as a reference pressure.
Dynamic Pressure	The dynamic pressure is the pressure that the air flow exerts due to its kinetic energy impacting a surface.
Total Pressure (Ram Air or stagnation P)	The total pressure of an airflow is the pressure that would be generated if the flow were brought to a complete stop against a flat wall or a pitot tube.
Position Error	The static ports are affected by the airflow around the sailplane. If the altitude is constant and the angle of attack changes, the flow over the static port changes and the static pressure measured will be different even though the air pressure has not changed. Flight manuals often have a position error correction chart to allow calculation of Calibrated Airspeed (CAS).
True Airspeed (TAS) (knots = kn)	This is the speed of a sailplane relative to the airmass in which it is flying (only equals the speed over the ground in nil wind conditions).
Indicated Airspeed (IAS)	This is the speed shown on the airspeed indicator. IAS only shows true airspeed at standard sea level pressure and temperature.
Calibrated Airspeed (CAS)	This is the speed of the aeroplane after density and temperature affects have been allowed for. Calibrated airspeed equals Indicated Airspeed when instrument error and position error are zero. See below.
Cabin pressure	In sailplanes this is usually below static pressure. Sailplane cockpits usually leak air out around the top of the canopy where the pressure is reduced. This lowers the pressure in the cockpit slightly. In a very well sealed sailplane, it may be possible to have slightly higher pressure in the cockpit if the air vent is open forcing

	air into the cockpit. Cabin pressure is not to be used as a source of static pressure for ASI, VSI or gliding computers. Altimeters are not significantly affected and can use cabin pressure as a source of static pressure.
hPa = mbars	The units of hPa and millibars are the same. The sub-scale of altimeters must be in the unit of hPa and mbars.
QNH	The aviation Q code for the sub-scale setting, ie the barometric pressure scale, so the altimeter reads height above sea level. The standard barometric pressure is 1013mBar which should be used above 10,000ft to report altitude in flight levels. It is reset to QNH on decent below 10,000ft. The sub-scale is important to be correct if flying above 10,000ft.

Table 4-1 Definitions of Terms

4.4 PITOT-STATIC SYSTEM COMPONENTS

4.4.1 MINIMUM EQUIPMENT AND UNITS

MOSP 3 v7.3 states in Section 8.1.1; Each sailplane must have certain minimum equipment, and that equipment must meet appropriate standards. The minimum equipment for all Australian registered sailplanes, except LSA, is:

a. One Air Speed Indicator (ASI). The instrument must be able to indicate at least 5% above the manufacturer's Maximum Allowable Speed in Smooth Air (VNE). The ASI must be in full view of the pilot in command.

b. One altimeter, displaying height in feet and with its sub-scale calibrated in Hectopascals (same as millibars)

c. Magnetic compass

d. A time piece (This requirement may be met by a pilot wearing a watch)

For LSA the minimum equipment is specified by the manufacturer and only the manufacturer may authorise other equipment.

The placards must be in the same units as the instruments.

4.4.2 GENERAL SYSTEM LAYOUTS

There are three basic layouts of pitot-static systems found in sailplanes:

a. Separate pitot and static ports (the most common type).

b. Separate pitot and static probes found on many older sailplanes.

c. Combined pitot/static probes. These probes are usually mounted on the tailfin or nose of the sailplane attempting to measure undisturbed airflow.

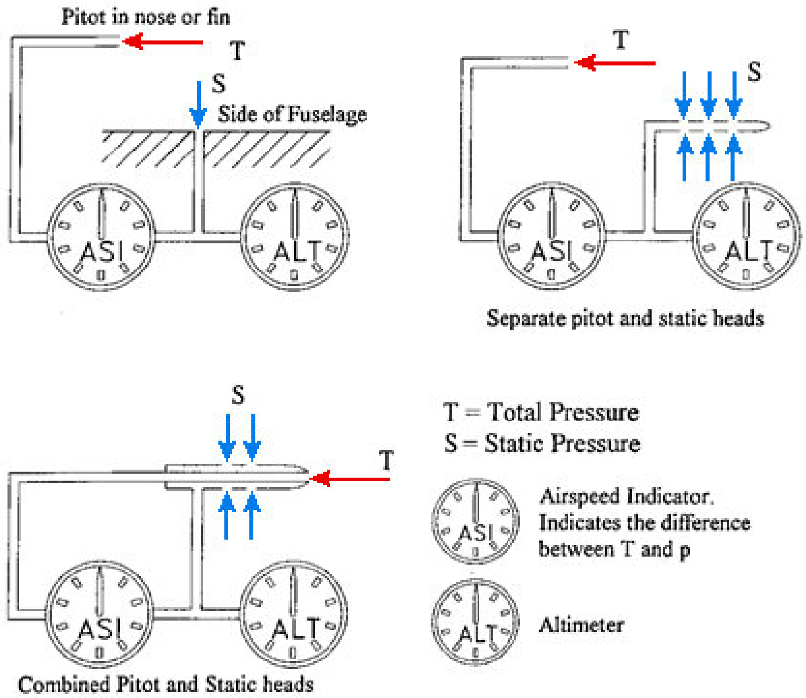


Figure 4-1 Typical pitot-static system layouts

4.4.3 PORTS OR VENTS

The ports or vents are special holes in the sailplane connected to the pressure tubing which are used to measure the Total and Static Pressures.

The Total Pressure, also known as “ram air” (i.e. air that is stopped against a moving aperture), is measured through a pitot tube which is an open tube facing directly into the airflow.

The Static Pressure is measured through a “static port” which is a hole usually in the side of the fuselage at a point where the manufacturer has determined that the pressure over the fuselage at that point is as close as possible to the true static pressure. There are usually static ports on both sides of the fuselage to reduce sensitivity to yaw. They don’t measure the pressure due to movement and attempt to measure the airmass pressure as if the sailplane was not there. Many Flight Manuals will have Pressure Error Correction Chart to correct for static errors due to the location of the static ports.

It is very important that the correct static ports are connected to the ASI. Many sailplanes have 2 sets of ports; one for the ASI and one for the variometer (vertical speed) system. It is vital that the correct ports are used or the ASI may read incorrectly.

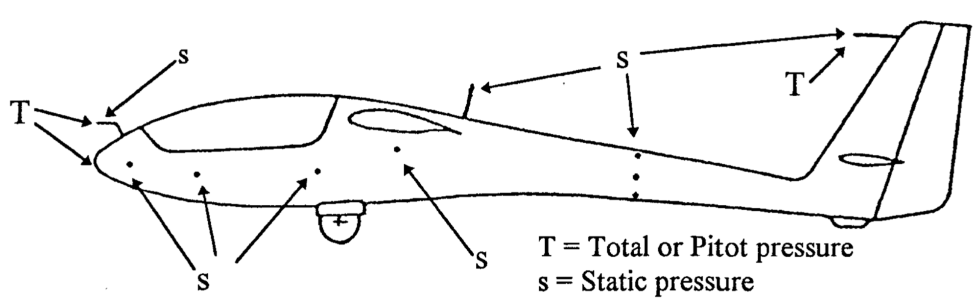


Figure 4-2 Typical Vent Locations

4.4.4 TUBING

Each port is connected to a length of tubing which transmits the pressure to the instruments. This tubing is usually 5mm PVC tubing although the softer, more expensive silicone tubing is sometimes used. PVC tubing hardens over time and it is recommended that the tube is replaced every few years and connections checked annually and trimmed if they leak. Once the tubing has gone hard it is very likely to leak if reinstalled.

Throughout the pitot-static system there will be a number of connectors and T-junctions necessary to provide the correct system layout. Wherever a junction exists, there is the possibility of a leak and so they should be kept to a minimum.

A correctly installed junction should need no extra sealing other than the fit of the tube onto the barbed fitting. The need to install elastic castrator rings or cable ties to remove leaks indicates that the tubing is faulty and should either have the hardened end removed or a new piece of tubing fitted.

4.5 AIRSPEED

In line with the International Civil Aviation Organisation (ICAO) agreement, the airspeed of all Australian civil aviation aircraft, including sailplanes, is usually measured in knots.

A knot is defined as 1 nautical mile per hour. This is slightly faster than a mile per hour and not quite 2 kilometres per hour. Table 4-2 gives the conversion of knots to the most common speed units.

1 knot (kn)	1.688 ft/s	1.1508 mph	1.852 km/h	0.5144 m/s

Table 4-2 Speed Conversion Factors

4.5.1 AIRSPEED INDICATOR (ASI)

The ASI is a primary flight instrument which displays Indicated Air Speed to the pilot(s). It is a mandatory item specified in MOSP 3 Section 8.1.1. For certified sailplanes, the ASI must be certified to a standard eg FAA TSO-C2d or ETSO C2d.

All ASI's are essentially a differential pressure gauge. Airspeed is derived from the difference between the ram air pressure from the pitot tube, or stagnation pressure, and the static pressure. The dynamic air pressure is a function of airspeed and air density. As altitude increases the air density decreases, this causes the ram pressure in the diaphragm to be lower and the resultant indicated airspeed to be lower than true airspeed.

Traditional analogue ASIs have ram air pressure from the aircraft's pitot tube directed into a diaphragm in an instrument case. Static air pressure from the aircraft static vent(s) is directed into the case surrounding the diaphragm. As the speed of the aircraft varies, the ram air pressure varies, expanding or contracting the diaphragm. Linkages attached to the diaphragm cause a pointer to move over the instrument face, which is calibrated in knots.

There are other factors that must be considered in measuring airspeed throughout all phases of flight. These can cause inaccurate readings or indications that are not useful to the pilot in a particular situation. In analogue airspeed indicators, the factors are often compensated for with ingenious mechanisms inside the case and on the instrument dial face.

Analogue ASIs can have a calibration chart to correct for instrument errors found when it is calibrated.

Sailplanes will often have a position error chart in the Flight Manual that allows correction of indicated airspeed to calibrated airspeed.

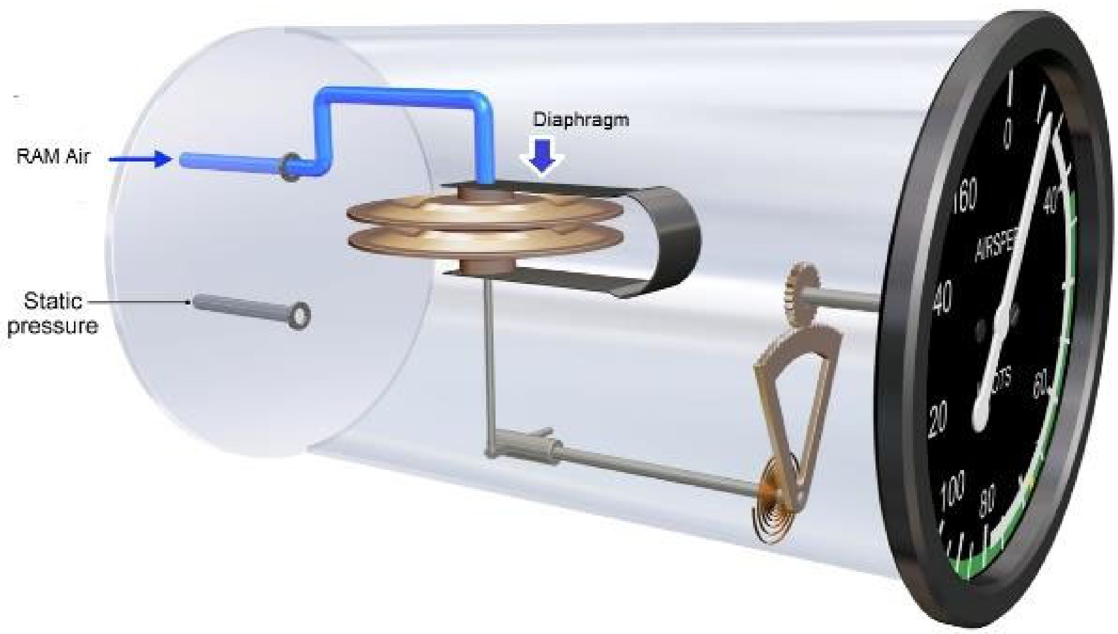


Figure 4-3 Airspeed Indicator Cutaway

Digital ASIs have ram air pressure from the aircraft's pitot tube being measured by a pressure transducer. Similarly, the static air pressure from the aircraft static vent(s) is measured by another pressure transducer and the airspeed is digitally calculated. Some digital ASIs may have a position error correction table built into the firmware for the sailplane type it is fitted to and be able to display Calibrated Airspeed. Some digital ASIs can also calculate True Airspeed and, if connected to a GPS, ground speed and wind speed as well. Whilst this is an advantage, digital ASIs rely on battery power and may not function if there is an electrical problem, whereas analogue ASIs would continue to function. At present, many digital ASIs available on the market are not certified.

Figure 4-4 Example Digital Airspeed Indicator Display

4.5.2 LIMITING AIRSPEEDS

Every sailplane has speeds which must not be exceeded in given circumstances. These are referred to by standard "V" designations as follows:

V_{NE}	Never Exceed Speed. This is the maximum speed the aircraft may be flown at. At this speed only 1/3 of the maximum control deflection may be used. The aircraft can be overstressed by the pilot using excessive control deflections.
V_{RA}	Rough Air Speed. In most modern sailplanes this is the speed at which the aircraft will withstand gusts of ± 15 m/s. Some older aircraft such as the Standard Libelle and the Hornet were designed to an earlier standard which had no rough airspeed. Instead they were required to withstand a gust of ± 10 m/s at V_{NE}.
V_A	Manoeuvring Speed. This is the maximum speed at which full control surface deflections cannot cause overstress. Below this speed the wing stalls before maximum "g" is reached. Above this speed the structure can be overloaded before the wing stalls ie the pilot can overstress the aircraft.
V_{FE}	Maximum Flap Extended Speed . The maximum speed for each flap setting. Each type may have several flap speeds.
V_W	Maximum Winch Launching Speed.
V_T	Maximum Aerotow Speed.
V_{LO}	Maximum Landing gear operating speed. This is the maximum speed at which the landing gear may be extended or retracted.
V_Y	The Best Rate of Climb Speed for powered sailplanes.
V_{S1}	The Stall Speed of the sailplane at maximum weight with wing flaps neutral and air brakes retracted.
V_{S0}	The Stall Speed at maximum weight with landing gear extended, wing flaps in the landing position and the air brakes in the position which gives the lowest stall speed.

Table 4-3 Air Speed Definitions

4.5.3 POSITION ERROR

The pressure distribution over the sailplane is very complex and changes with factors such as speed, flap position and airbrake deployment. As a consequence it is not possible to find a point on the aircraft which gives true Static Pressure at all speeds and configurations.

When a sailplane type is certified the position error is determined at each speed and a chart of this error is prepared. When the placarded limits are prepared for a sailplane this error is taken into account.

4.5.4 INSTRUMENT ERROR

This is the error inherent in the instrument either due to its design or because a defect has developed. This must be within given limits to ensure that the sailplane is being flown within its design limits and at the altitude displayed.

4.5.5 REDUCING V_{NE} WITH ALTITUDE

As we fly higher, the density of the surrounding air decreases. This means that for a wing to produce the same amount of lift at a constant angle of attack and balance the sailplane's weight, the wing must move through the air at a faster true airspeed. For example, if a sailplane is at the stalling angle of attack at 35kn TAS at sea level then the same sailplane at the same weight will stall at 40.7kn TAS at 10,000 feet.

Fortunately the reduction in air density which reduces the ability of the wing to produce lift also reduces the ability of the airflow to deflect the needle in the ASI in exactly the same proportion and so the stall speed shown on the ASI is constant regardless of height.

The structural loads on the sailplane are also proportional to the Calibrated Airspeed, which with a few small adjustments translates to Indicated Air Speed. So flying at at height with the IAS kept within the placarded IAS limits does lead to the True Airspeed being higher, but you cannot overstress the sailplane from manoeuvre or gust loads. Unfortunately flutter is dependent on True Airspeed and not Calibrated Airspeed and as you fly higher V_{NE} in IAS is closer to the critical flutter speed of the sailplane.

During the certification of each new type, the manufacturer tests the saiplane to V_{NE} at the maximum height for which V_{NE} will be valid. This gives a V_{NE} as a single figure limit for lower level flying. Above this height V_{NE} must be reduced to prevent flutter.

MOSP3 Section 8.3.11 states whenever a sailplane is fitted with an oxygen system a placard of reducing V_{NE} with altitude must be fitted. This placard is normally available from the flight manual. A typical placard showing the reduction of V_{NE} with altitude is as below.

Some older types don't have this placard in the flight manual and if they are fitted with an oxygen system then a placard must be determined by calculating the True Airspeed for V_{NE} at 10,000 ft and then using that value as the maximum True Air Speed above 10,000 ft leading to the corresponding IAS reducing with height. This calculation can be done by the CTOA on request.

Altitude (ft)	V_{NE} IAS (kn)
0	135
5,000	135
10,000	135
12,000	130
14,000	126
16,000	122
18,000	118
20,000	110
24,000	106
26,000	103
28,000	99
30,000	95

Table 4-4 Example V_{NE} Reduction Placard

4.6 ALTIMETER

An altimeter is an instrument that is used to indicate the height of the aircraft above a predetermined level, such as sea level or the terrain beneath the aircraft.

Altimeters that measure the aircraft's altitude by measuring the pressure of the atmospheric air are known as pressure altimeters. A pressure altimeter is made to measure the ambient air pressure at any given location and altitude. In aircraft, it is often connected to the static vent(s) via tubing in the pitot-static system. The relationship between the measured pressure and the altitude is indicated on the instrument face, which is calibrated in feet. These devices are direct-reading instruments that measure absolute pressure.

A sealed diaphragm (the aneroid) is at the core of the pressure altimeter's inner workings. Attached to this diaphragm are the linkages and gears that connect it to the indicating pointer.

Static air pressure enters the airtight instrument case and surrounds the diaphragm. At sea level, the altimeter indicates zero when this pressure is exerted by the ambient air on the aneroid. As air pressure is reduced by moving the altimeter higher in the atmosphere, the diaphragm expands and displays altitude on the instrument by rotating the pointer. As the altimeter is lowered in the atmosphere, the air pressure around the diaphragm increases and the pointer moves in the opposite direction.

The face, or dial, of an analogue altimeter is read similarly to a clock. As the longest pointer moves around the dial, it is registering the altitude in hundreds of feet. One complete revolution of this pointer indicates 1,000 feet of altitude.

The second-longest pointer moves more slowly. Each time it reaches a numeral, it indicates 1,000 feet of altitude. Once around the dial for this pointer is equal to 10,000 feet. When the longest pointer travels completely around the dial one time, the second-longest point moves only the distance between two numerals—indicating 1,000 feet of altitude has been climbed. If so equipped, a third, shortest or thinnest pointer registers altitude in 10,000 foot increments. When this pointer reaches a numeral, 10,000 feet of altitude has been attained. Sometimes a black-and-white or red-and-white cross-hatched area is shown on the face on the instrument until the 10,000 foot level has been reached.

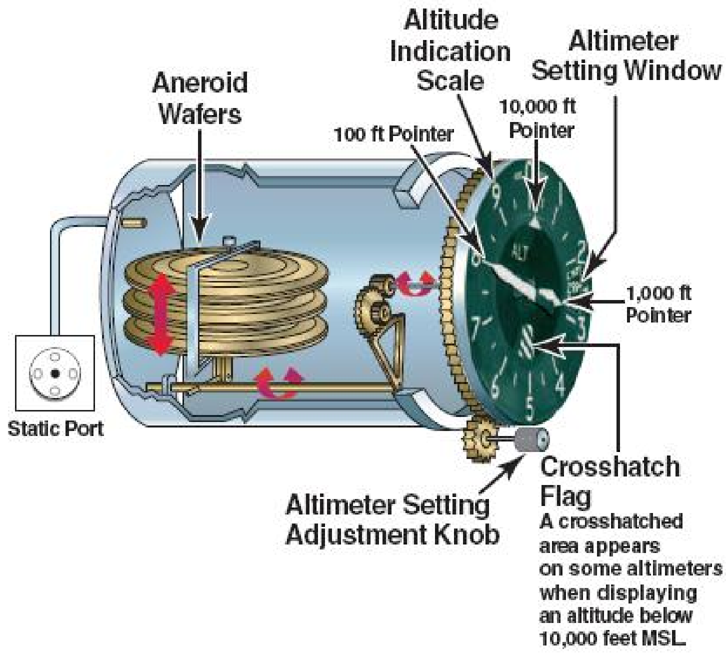


Figure 4-5 Altimeter Mechanism

The altimeter setting knob sets the sub-scale or barometric pressure scale (labelled the Altimeter setting window above).

4.6.1 ALTIMETER ERRORS

There are several sources of error in an altimeter. The two main errors are Instrument Error (IE) and Position Error (PE).

Instrument error mainly arises from wear in the internal gearing or distortion of the capsule (the capsule that inflates and deflates as air pressure changes). In addition, an altimeter may become sticky; in other words, changing pressure does not result in a corresponding movement of the pointers on the instrument's face. This problem is more prevalent on altimeters fitted to sailplanes that are not frequently flown. Usually, a good few hours flying will resolve stickiness and the problem will go away. However, if it persists, servicing the altimeter by a certified instrument repairer may be required. Do not attempt this repair yourself.

Position Error derives from the location of the static ports and from disturbance the aircraft introduces to the air that it is sensing. PE changes with speed and selection of flaps, airbrakes, or yaw of the aircraft. The job of a sailplane design engineer is to find a position on the airframe to place the static ports, such that the PE is minimised over the whole flight envelope. The PE is then measured during prototype test flying to ensure that the PE is within acceptable limits.

In sailplanes the altimeter can be simply left vented to cockpit pressure, with no plumbing connected. While this arrangement will work, it is not good engineering practice as it introduces unwanted PE. Further, there will be minor pressure differences between the pressure caused by the mass flow of air though the cockpit (open vents, etc.) and that measured at the static ports. To minimise these errors, the altimeter should be connected to the static plumbing.

However, in sailplanes the cabin pressure should not cause a significant error and because blockages in tubes and leaks in altimeter cases are more likely to cause significant error, altimeters are best left connected to cabin air and not the static. Ask the pilot to check and connect to static if required. If not connected to static, then leaks do not matter except to the calibration process and the test procedure can accommodate some leakage, but beware.

4.6.2 ALTIMETER ADJUSTMENT

The altimeter barometric pressure scale setting occasionally needs to be adjusted so that the relationship between the indicated altitude and the barometric pressure scale is correct. With the altimeter pointers displaying the correct ground elevation at the location, the value indicated on the barometric pressure scale shall be adjusted to correctly match the current value of the QNH for that location.

> **CAUTION**
>
> Altimeters are complex delicate instruments built like a mechanical watch. They are easily damaged by rough handling and even by putting them down roughly on a hard surface. Be careful or it will require expensive repair. Altimeters are safer remaining in the aircraft. Be careful taking them out and transport in a padded box.
>
> **IF YOU DROP IT – RECALIBRATE IT!**

Altimeter model specific information is provided at Appendix B . If the specific model is not detailed in this Appendix, it may point to possible ways adjustment may be achieved with that particular altimeter design.

Before proceeding to testing the altimeter scale accuracy across low, medium and high altitudes, the barometric pressure scale setting is checked for correct adjustment. With the known elevation at the test location displayed on the altimeter pointers to within +/- 20ft, the barometric pressure scale indicated value shall match the current local QNH value in hectopascals. Current QNH information for a locality may be obtained from the Bureau of Meteorology (BOM) website www.bom.gov.au looking at the observation pages listing data either state-wide or for the state capital city and immediate surrounds. The automated weather stations supply information to the BOM every ten minutes or half-hour depending on location. Airport weather stations are particularly useful sources. Be aware that in changeable weather circumstances the local QNH may vary quickly such that testing the altimeter during a slower moving pressure system should be considered.

The adjustments are more easily performed with the altimeter on a soft bench top and away from the instrument panel. Putting an altimeter down on a hard surface jolts the fine internal bearings (jewels) and can cause impact damage (dents) on the bearing surface. Adjustments are made using small "jewelers" screwdrivers which are typically flat bladed.

4.7 INSPECTION PROCEDURES

4.7.1 ANNUAL INSPECTION REQUIREMENTS

The current requirements for sailplane maintenance are given in MOSP 3 Section 13.6 and must be performed by a trained annual inspector or CASA authorised technician. And this work must be certified by them in the logbook.

4.7.1.1 ANNUAL INSPECTION REQUIREMENTS:

a. Check each pneumatic system for leaks and rectify leaks

b. Ensure that the ASI is connected to the correct static source

c. Check the ASI colour coding is correct

d. Check for V_{NE} reduction with altitude placard if an oxygen system may be used

(The above is simple and quicker than before.)

4.7.1.2 BIENNIAL (EVERY SECOND YEAR) INSPECTION REQUIREMENTS:

a. Calibrate the ASI.

b. Calibrate each altimeter. An accurate altimeter is required to advise other aircraft of your altitude. If not calibrated you may use a permissible unserviceability if you remain out of controlled airspace. Make sure they all read the same at the same barometric pressure scale, including the transponder (if it gives a readout) or placard the calibration errors for the pilot's information.

c. The transponder and its altitude encoder must be calibrated by a CASA authorised technician. If not calibrated within 24 months you may not turn it on (as ruled by CASA). The reason given is it may mislead other aircraft.

4.7.2 PITOT-STATIC SYSTEMS

4.7.2.1 PITOT-STATIC SYSTEM INSTALLATION AND MAINTENANCE

When replacing the tubing of a pitot-static system (or installing a new system in an amateur built sailplane), there are certain aspects of the installation which will protect the instruments from the effects of both water and dust.

All plumbing must be installed so that water tends to run out of the ports. The best way to achieve this is to install the tubing so that the first direction the tubing runs is up.

Some sailplanes also have purpose designed water traps in their pitot-static systems. These water traps have a drain tap which allows them to be periodically drained.

To prevent dust and other foreign objects reaching the instruments it is good policy to install filters in the system. The best filters are small automotive or motorcycle fuel filters which can be installed in the lines.

Whenever a sailplane is not being flown covers should be fitted to all pitot and static vents to prevent the ingress of dust and to prevent wasps building nests in the holes. This is particularly important as wasps in Australia have been known to build a nest sufficient to block the standard vents within a few hours.

4.7.2.2 PITOT-STATIC SYSTEM LEAK TESTING

One of the most important aspects of a correctly maintained pitot-static system is that any leaks are within specification. A leak in the pitot and to a lesser extent the static can influence the pressures in the tubing and result in significant errors. Eg. A likely serious error is in the ASI near Vne – the pitot pressure is highest, it will leak the most, the flow rate in the small pitot entry and through a filter reduces pressure which makes the ASI under-read Vne. This is serious when you are doing Vne IAS as actually you will exceed Vne and **you risk flutter**!

When testing pitot-static systems, the following points should be noted:

a. **The instruments can be damaged** and you must not cause pressures in them that will cause damage. If you are unskilled do not do this testing – it requires care and finesse – get someone who is prepared to take the time to do it carefully.

CAUTION

Ensure that all instruments are disconnected before commencing to purge.

b. If purging is necessary, use compressed air or blowing to remove foreign matter which may have accumulated in the tubing.

c. Purge disconnected Pitot and Static lines outwards, from the instrument panel end towards the pitot tube and static vents.

d. Many systems have multiple vents, and it is necessary to seal all vents.

e. It is best to connect to the pitot and the static vents without disturbing the tubing. This is not always possible and care with reconnection is required.

f. Be aware of any capillary leaks through the variometer or stall warning system. Static systems which are connected to a capillary type variometer should be separate from those connected to the ASI.

g. Do not use silicon sealers to fix leaks in pitot-static systems. Many silicon sealers produce acetic acid as they cure and this acid can cause damage to the instrument's internal mechanisms. While there are silicones which do not produce acetic acid, they should not be used as future inspectors cannot tell which type of silicon has been used.

h. The best way to prevent leaks is to use fresh tubing over the correct sized barbed fitting. The need to use elastrator rings or lock wire wrapped around the fitting is a sign that either the tubing should be replaced or the connection is of a poor design. Where an installation, such as a plain tube, is permanently installed in the sailplane then the best way of sealing the system is to wrap locking wire twice around the joint and twist the ends together to form a clamp.

i. A good way to apply a small vacuum to the static or pressure to the pitot systems is with a 20ml syringe. **WITH CARE.**

j. Test as below. Fix the leaks.

k. Ensure all temporary seals are removed after testing.

4.7.2.3 LEAKAGE TOLERANCES IN GFA AIRCRAFT

Leakage tolerances in GFA aircraft:

a. Static system; evacuate the static system to a pressure differential of approximately 1,000ft on the altimeter, above the aircraft's elevation. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 100 feet on the altimeter.

b. The pitot system is tested for leaks by applying pressure at the pitot head sufficient to cause the airspeed indicator to read about 120 knots.

c. There must be no discernible lag in the movement of the airspeed indicator pointer with the application of the pressure, as such a lag indicates restrictions in the piping.

d. There must be no decrease in the reading when the system is sealed for at least 10 seconds.

The above is tighter than before and is the same as required by CAO 100.5. Our previously wide tolerances may have resulted in sailplanes unknowingly exceeding Vne.

4.7.3 AIRSPEED INDICATOR

4.7.3.1 THE WATER-TUBE MANOMETER

In order to calibrate an ASI, it is necessary to have an accurate and controllable source of low-pressure air. The most practical way of providing this air pressure is with a water-tube manometer. You can construct this as below, and it can be accurate enough. You do not require this for testing for leaks as above.

GFA is arranging an electronic calibrated test kit you may borrow from the regional equipment officer mainly for altimeters, but it will also test ASI.

A suitable water-tube manometer is shown in Figure 4-6**Error! Reference source not found.**. However, any manometer is suitable, provided it has the following characteristics:

a. The manometer must be vertical when in operation unless it has been designed to operate at a set angle. If the manometer is designed to operate other than vertical, then it must be at the design angle, and the scale will have to be altered (during manufacture) so that the vertical heights are as per Table 4-5.

b. The scale must be adjustable up and down to allow for changes in water level. There must be a means of locking the scale while the manometer is in use.

c. The manometer should be mounted to provide a degree of robustness.

d. Both tubes must have identical internal diameters. This is particularly important should a tube need to be replaced. Glass tubes are best, but a uniform plastic tube can work if held straight over the test length.

e. The manometer must be checked for leaks before it is used.

f. The water must be clean. It can have a very small amount of dishwashing soap added to reduce the viscosity and colourant to make it visible. But these must be slight as they affect the readings. There must be no air bubbles.

g. The markings on the scale must be as per Table 4-5. The figures shown are the full height of the water column (from meniscus to meniscus), so the distance from the zero (ambient pressure) is half the height as shown in the figure below:

Speed (kn)	mm of water
30	15.0
40	26.5
50	41.5
60	59.5
70	81.5
80	106.0
90	134.0
100	165.5
110	200.5
120	239.0
130	280.0
140	325.0
150	373.0
160	424.5

Table 4-5 Scale Dimensions

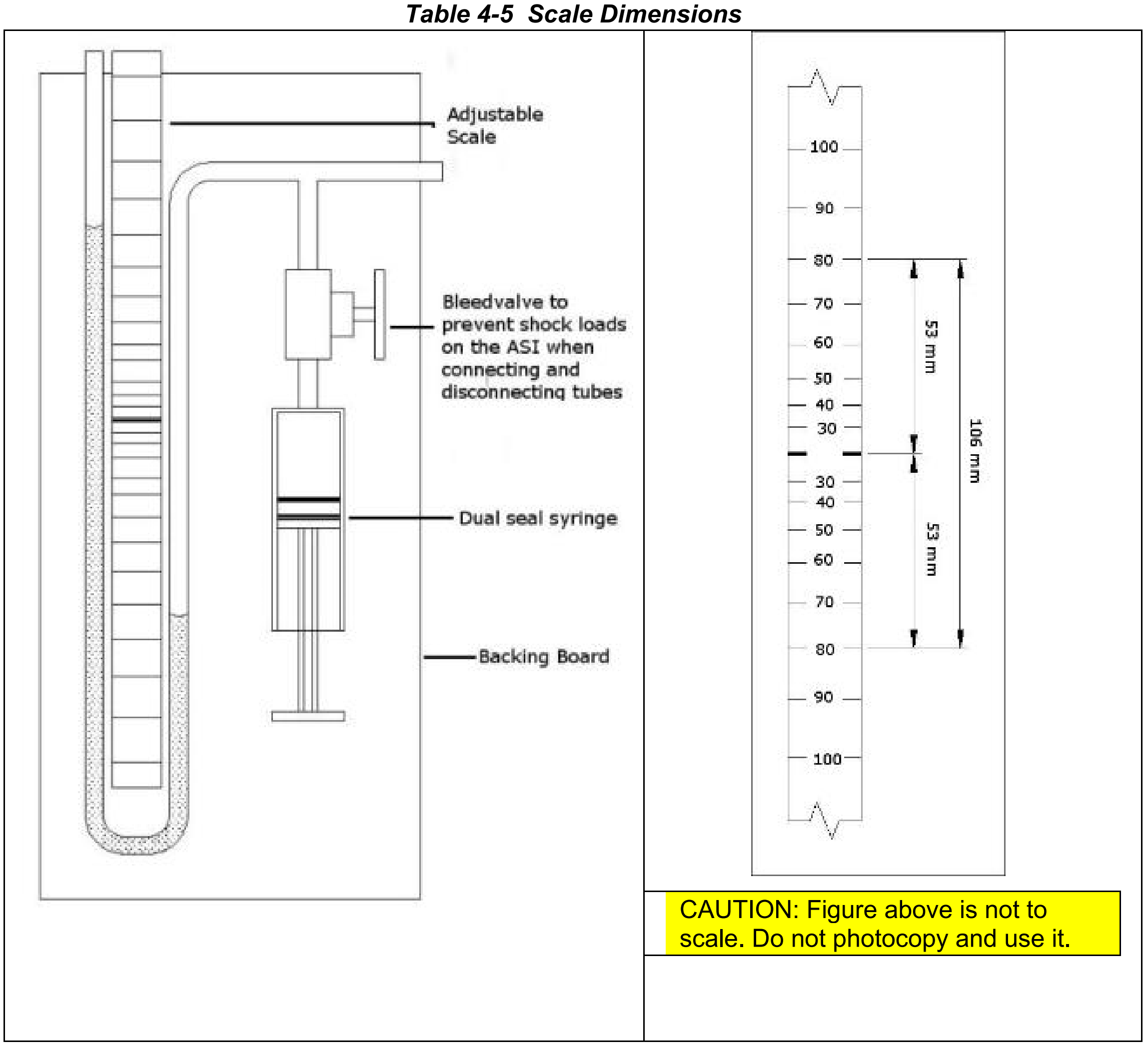


Figure 4-6 The Water-Tube Manometer

4.7.3.2 TESTING AN ASI

The basic procedure for testing an ASI is as follows:

a. Open the bleed valve and move the syringe plunger to the most extended position.

b. Connect the free tube from the manometer or calibration gauge to the pitot connection of the ASI (normally the connection in the centre of the instrument. But it is best to connect to the pitot as you then check the whole system).

c. Close the bleed valve. At this point both the menisci should be level with one another.

d. Adjust the scale until the zero coincides with the menisci.

e. Gently push the plunger in until the manometer reads 30kn. Record the ASI reading in a calibration table as shown in Table 4-6 below.

f. Continue to increase the manometer readings in 10kn intervals recording the ASI readings at each interval until a speed about 10kn above V_{NE} is reached. If a stop is missed (the manometer over reads), do <u>not</u> reverse the movement to obtain the intended manometer reading.

g. Once V_{NE} is reached, reduce the pressure in 10kn intervals back to zero recording the ASI readings as you go. Again do not reverse the direction of movement, record the manometer reading and the error from it.

h. Using the recorded readings, for each 10kn interval, determine the instrument error by subtracting the manometer reading from the ASI indication.

i. The allowable error is 4knots at all readings. (We used to require better accuracy near the stall but there is no good reason for this.)

j. Open the bleed valve before disconnecting the ASI.

Notes:

1. The ASI is extremely sensitive and can be easily damaged.
2. Do not apply negative pressure with the ASI at zero.
3. Apply the pressure very carefully as sudden movements can damage the ASI mechanism.
4. Don't apply vibration or tap the ASI. It must read correctly when gliding and we don't tap it then.
5. The manometer has water in it and ASIs do not like water. Keep the ASI above the manometer and ensure the tubing from the manometer to the ASI is dry and at least 1 m long.
6. Calibration is best done with two people. One operating the manometer valve and calling out the manometer steps; the other reading the ASI and writing down the reading in the calibration table.
7. Obviously, calibration with the new GFA tester is preferred, but you may use the manometer if you are sure it is correct.

4.7.3.3 CALIBRATION CHART

PRESSURE INCREASING			PRESSURE DECREASING		
Manometer (kn)	ASI (kn)	Error (kn)	Manometer (kn)	ASI (kn)	Error (kn)
30			30		
40			40		
50			50		
60			60		
70			70		
80			80		

90			90		
100			100		
110			110		
120			120		
130			130		
140			140		
150			150		
160			160		

Table 4-6 Calibration Table

4.7.4 ALTIMETER CALIBRATION

Calibration means recording the error over a suitable range relative to an accurate instrument and determining if this is acceptable.

GFA has in the past not required altimeter testing other than checking sub-scale on the basis that sailplanes bob up and down with the thermals and we cannot maintain altitude. To fit in safely with other aircraft this is not entirely satisfactory although it has not been a contributing factor in incidents. But these days we need to be more responsive to the expectations of others, and we have to avoid incursions into controlled airspace. So we now require calibration of altimeters, but we provide a reasonable alternative; you can use a permissible unserviceability as long as you will stay well clear of controlled airspace to allow for errors. Obviously, when you report to other aircraft, you must be suitably clear that your altitude will vary, eg. ”currently at about 3,000ft AGL, descending”. If the sailplane is used competitively or is a motorglider, then you should calibrate the altimeters if you may go near controlled airspace.

We are exempt to CAO 100.5 which details the testing required in other aircraft. We need to be reasonably similar. So we have developed a test rig and procedures that are somewhat easier for GFA to apply ourselves. The principle is as follows:

a. It is a risk to remove instruments and transport them for testing. It is better, quicker and easier to test them in place. It is a big cost to the whole fleet to test most altimeters every other year. So it is better that we test them ourselves, installed.

b. Contrary to past practices of testing in a vacuum box it is quite safe to test the altimeters by applying a vacuum to the instrument. But then the instrument must not leak . It is, therefore an easy procedure to connect a calibration instrument to the altimeter static connection with a plastic tube and test it in situ. Testing has shown we can actually test to 30,000ft this way although for most 20,000ft or even 10,000ft may be satisfactory. You only have to test to the expected maximum operating altitude.

c. We must test against a calibrated and reliable calibration instrument. To do this we must have quality control on it. We have therefore developed and tested a kit which we will make available to all regions to buy. Or they can make their own or clubs or AMOs have or can make their own.

d. Whatever instrument is used must be check calibrated each year and proven to be accurate. If the regions hold the kits, then the Regional Equipment Officer (REO) must check them annually, and control on which sailplane it is used and contact the owner if it may be in error when the calibration is found to be out. In reality, the first person to use a faulty calibration instrument will find out, and it will be corrected.

e. The plan is the REO will mail them out to each club once a year. Each club has two trained inspectors who then test half the sailplanes over two weekends. Then mail it back to the REO. The equipment is robust enough to mail. Large clubs may wish to have their own.

f. The clubs must choose suitably minded inspectors to be trained. When the equipment is first shipped to them, they will be given a manual and training by phone. It is not hard – it only requires care, patience and understanding. This will mean we are compliant. ,and will save each sailplane owner about $100 pa and it works easier and safer. It will take longer initially, but the altimeter can be tested in 30 minutes. And the ASI can also be tested in about 20 minutes with the same kit.

g. If an instrument is faulty, it will have to be sent for repair to a professional instrument workshop. But they are hardly ever faulty. The risk is that initially, we may find many that are as we have old instruments that have hardly been checked. We are generally not capable or qualified to correct errors except the sub-scale setting. If your club has a trained instrument technician (there are many Airforce and commercial people in GFA who are capable), it is permissible for them to fix instruments.

h. Obviously, this is a hassle and extra work. If you do not need to go near controlled airspace, then we have put in place permissible unserviceability to allow you to continue easily as you have in the past. See AIRW-M15 Schedule of Permissible Unserviceabilities.

4.7.5 ALTIMETER TESTING PROCEDURE

4.7.5.1 COMPARISON

The kit manual is attached as Appendix 1. In summary:

a. The altimeter sub-scale is tested and reset if necessary. This is easy and safe if you have been trained.

b. The calibration instrument is connected via flexible tubing to the altimeter under test. The air pressure is gradually lowered by hand vacuum pump on tubing connected to both altimeters. The altimeter usually remains in the sailplane but is disconnected from the static system.

c. The altimeter's reading at each specified altitude is compared against the reading on the calibration instrument, and the error noted. There is a hand vacuum pump to apply vacuum. The calibration instrument is very accurate however ignore slight variations that can be caused by temperature. It is also robust and so should not get damaged but look after it, it is costly to replace or repair.

d. It is necessary to test the altimeters readings on the way up (increasing altitude) and down (decreasing altitude). The altimeter should be tested to an altitude of at least 20,000 ft. But the owner may specify less and it can then be placarded to that height.

e. You may tap alongside the altimeter as sailplane pilots tend to do this to reduce stickiness. (Especially in weak thermals it helps to climb!)

f. On the way down, stickiness and hysteresis is also calibrated.

g. The procedure defines the acceptable errors.

h. The altimeter is reconnected to the static system if it needs to be and the system is checked for leaks as above.

4.7.5.2 SUB-SCALE TESTING

The altimeter sub-scale is probably best corrected using the new calibration instrument.

To otherwise perform a sub-scale test, it is necessary to obtain an accurate QNH at your location. This can be easily obtained by either using a recently calibrated altimeter, or by reference to the Bureau of Meteorology (BoM). In this latter case, wait until there is a large pressure system over your location; that is, the pressure system shows isobars (lines of equal pressure) wide apart over your area. Then lookup the QNH for your location on the BoM website. If you are at an airfield for which a Terminal Area Forecast (TAF) is issued, the QNH shown on the TAF is considered sufficiently accurate.

Set the QNH obtained above on the sub-scale of the altimeter. Then compare the altimeter's indicated altitude with the known altitude of your location. If the error is greater than 50 ft, the altimeter should be considered out-of-tolerance and a trained person can reset it.

Check each altimeter in use in the sailplane, including readouts on the transponder are within 100ft when at the same QNH setting, usually the standard 1013mbars. Note errors and have the offending instruments repaired.

Appendix A GFA ALTIMETER & ASI TEST KIT INSTRUCTIONS

A.1 ALTIMETER & ASI TEST KIT INSTRUCTIONS

General Notes:

a. The objective of this kit was to enable compliance testing in a quick, simple, lower risk method. Instruments can be tested outside the aircraft system but the system will require a separate leak test after re-installation. Instruments are at risk of being dropped etc. If removed they need to be transported safely to a workshop and back. If they can be calibrated without removal this testing takes 30 minutes for an altimeter and saves you hundreds of dollars every 2 years. If the altimeter leaks you will have to remove it, test it in a vacuum chamber or send it for repair. This kit can work with a vacuum chamber, but it is not supplied. We may add this if it becomes necessary.

b. It is likely that initially we are going to find many leaky or faulty altimeters but they usually go for decades once overhauled and are then quick and cheap to test.

c. Tests required are laid out in BSE Chapter 4 “Pitot Static Systems”. This replaces the CASA CAO 100.5 appendix 1 requirements for GA aircraft. These procedures form part of the GFA standard system of maintenance as required by MOSP 3 Section 13.6.

d. The test kit consists of a Meriam M203 Altimeter/ ASI Calibrator, a fine control mechanical pump, test fittings and hoses all packed in a padded carry case

e. The Meriam calibrator, in particular, is a precision instrument and needs to be treated as such. However, it was chosen as an electronic robust calibration unit that can survive postage in its padded box. But it will be used by many in an important function and must be treated with care and itself calibrated biennially.

f. The Meriam calibrator can measure in many different units and functions; however, for our purposes, it has been locked by pin number to only Altimeter/ ASI calibration and leak testing.

g. The kit is not required for leak testing and ASI calibration can be done by manometer to save using the kit excessively, eg if it is too busy

h. These tests may all be done by an annual inspector but only if trained and capable in this testing. Care is required in all this testing and instruments can be damaged and caused to read incorrectly.

This is mainly a risk for infringing airspace or exceeding Vne, ie serious risks.

i. Problems, damage or missing components should be reported to the Regional Equipment Officer or the RTO in your region as soon as possible as it could mean the previous sailplanes were incorrectly calibrated.

j. Please fill in the kits logbook of altimeters tested so you may be contacted if calibrator errors arise.

k. Please ensure all kit items are returned promptly and safely to the equipment officer.

A.2 CALIBRATION TESTING

Pitot and Static system tests required by MOSP 3 are as follows:

a. Pitot/Static system leak test, annually and whenever the plumbing is disturbed. Can be done using only a 20ml disposable syringe and the aircraft instruments as given in BSE.

b. Full altimeter calibration, biennially using this test kit or another calibrated calibration system and includes the following sub-tests:

c. First; Altimeter barometric scale. Set sub-scale, see BSE and this manual

   i. On rising altitude:

      1. Friction

      2. Scale error

      3. Case leak

   ii. On falling altitude:

      1. Hysteresis

      2. After effect

      3. Sub-scale readings – check range of settings.

      4. Refer to the Altimeter Test Results sheet that summarises and is used to record results.

d. Full ASI calibration, biennially. Can be done at any time using a manometer as in the past or with this kit.

A.3 UNPACKING AND SETUP

Unpack and setup as per the attached photograph

Wherever possible the calibration test needs to be conducted on the installed system however if a mechanical variometer or a flask are fitted to the static system then they will need to be disconnected or isolated.

Instruments can be tested outside the aircraft system, but the system will require a separate leak test after re-installation.

Keep the test equipment tubing as short as possible, do not use silicon tubing.

A.4 ALTIMETER TESTING

You may test all altimeters including the transponder altitude encoder with this kit. However, you are only required to test the primary altimeter and to list the others as un-calibrated in the minor defects of the Maintenance Release. eg a gliding computer need not be calibrated. Although you can check the transponder, it has to be calibrated anyway by a qualified technician who checks signals and other factors important to reliable data communications.

The Meriam calibrator operation is:

a. The default startup screen is “Altimeter” other startup defaults are possible but have been locked out to prevent inadvertent or other adjustments

b. To change from "Altimeter" to "ASI" calibration press "Tare"; to change back press "Tare" again

c. It has been locked at sub-scale setting = 1013hPa. i.e. the whole altimeter calibration is done at 1013hPa

Test and set Sub-scale; Set the aircraft altimeter sub-scale to 1013hPa. (all testing is done with reference to 1013hPa not QNH or QFE). Ensure that the shut-off needle valve is open. The altimeter should read the same altitude as the Meriam; if not you have a sub-scale error that needs adjusting (see separate instruction on adjusting the sub-scale for your type of altimeter, there are differences in each type)

If you do the tests in the order suggested by the test sheet and below you will save time going up and down. ie you can with practice calibrate an altimeter in 30 minutes by going up to 20,000ft and back down once. On the way up you do a leak test and the friction and scale error tests, on the way down you do the hysteresis test in comparison to Test 2 and an after effect test once complete. Then you adjust the sub-scale to each value given and record the error from the altitude it should read at that sub-scale.

Although in unpressurized aircraft such as sailplanes the altimeter can be left disconnected from the static and so avoid the influence of case leaks, it is not possible to do the tests this simple way if the case leaks significantly. Often it is the sub-scale knob that leaks. But it should be quite cheap and simple to get the leak fixed for many years of simpler testing. Alternatively, you must use a vacuum chamber and must not connect the altimeter to the static. Then the altimeter does not have to pass the leak test.

If there are any errors, then you will have to have a qualified technician overhaul it.

A.4.1 ALTIMETER SCALE ERROR AND FRICTION TEST

Proceed as follows:

a. Ensure that the shut off needle valve is open

b. Wind the coarse pump handle fully in

c. Close the shut off needle valve to start testing

d. The Meriam calibrator and the Altimeter must read the same within 20ft or set the sub-scale again as above

e. Wind out the coarse adjusting handle stopping at the test points specified in the attached Altimeter Test Results sheet. Try to only go up in altitude, ie decrease vacuum, because allowing the vacuum to oscillate at the reading will induce errors. This is hard to do.

f. Test 1 is the Friction test; record the <u>change on the altimeter caused by tapping</u> as soon as you get to each altitude on the Meriam.

g. Test 2 is the actual scale error test; record the <u>altitude error of the altimeter from the Meriam</u> after holding the vacuum and tapping the altimeter case to get rid of friction. If the altimeter drops in altitude then allow it to drop a few hundred feet and try again to pause at the required altitude on the Meriam or close to it. A bit of practice will allow you to do this well enough. The important point is to estimate the error to within 10ft caused by friction and scale. Do not get distracted by the precision of the Meriam – it is super sensitive and will show variations and is therefore influenced by temperature changes and small leaks.

h. If the case or the plumbing is leaking, you will find it hard to carry out the test procedure accurately. Fix the leaks.

i. GFA have set wider tolerances than GA aircraft as it is usually impossible to maintain accurate altitude in a sailplane and the important factor is to have an altimeter that is accurate to about 100ft so that you can advise other aircraft of your altitude and avoid infringing airspace.

A.4.2 ALTIMETER CASE LEAK TEST

Proceed as follows:

a. At 1,000ft and any other altitude you desire perform a case leak test by;

b. Stop pumping and isolate the altimeter using the shutoff valve.

c. It should not reduce in altitude by more than 100ft in 1 minute. This is much more onerous than previously specified by GFA but is the norm. As per the note above strictly, this may not matter to unpressurized aircraft, but it would make this calibration hard to do. And if connected to your static system it could induce errors in variometers and gliding computers.

d. In other aircraft, CASA specify the test is carried out at 18,000ft. In un-pressurized aircraft, this does not make sense, and so we do the test at 1,000ft AGL.

A.4.3 TESTING TO HIGHER ALTITUDE

You must test to an altitude above that at which the aircraft may be flown. Usually, GFA calibrates to 20,000ft but if the pilot plans wave flying then 25,000 or even 30,000ft is possible using this kit. Record the limiting altitude in the logbook and maintenance release. It will save time and may avoid workshop repair if you test to 10,000ft or even 5,000ft and that is sufficient.

The vacuum pump may not have sufficient capacity to reach a high altitude in one go. This varies with leaks and case volume. To continue testing above this altitude, you must:

a. Close the isolating valve on the altimeter to lock in the altitude gained

b. Open the hand pump shut off valve

c. Wind the coarse adjusting handle fully in

d. Operate the hand pump to climb back to the previous altitude. This pumps the crank pump and the Meriam back to the altitude

e. Close the hand pump isolation valve and open the valve to the altimeter

f. Continue testing as previously

g. Repeat to get higher and higher. But leaks will get worse and may prevent accurate testing at some point. Placard the altimeter to limit altitude or get it repaired.

A.4.4 HYSTERESIS TEST, TEST 4

This is done at 2 altitudes on the way down.

It is the error from the altitude on the way up. ie the difference between the altitude when rising and falling.

A.4.5 AFTER EFFECT TEST, TEST 5

This is the error from when you started.

A.4.6 SUB-SCALE ERROR TEST, TEST 6

Set the Meriam to 0ft by applying slight pressure with the pump.

You adjust the sub-scale on the altimeter to each value given and record the error of thealtitude reading while maintaining the Meriam at 0ft.

A.5 ASI CALIBRATION

You may calibrate the ASI using this kit but a manometer can be as accurate. See BSE Chapter 4 for details.

A.5.1 ASI SCALE ERROR TEST

Proceed as follows:

a. Connect the ASI pitot, in place of the altimeter static, to the kit

b. Ensure that the bleed needle valve is open

c. Wind the coarse adjustment handle fully out

d. Close the bleed needle valve

e. Change the screen from “Altimeter” to “Airspeed” by pressing “Tare”

f. Wind the coarse adjusting handle in stopping at the primary scale markings up to the aircraft VNE. Record each ASI error

g. Wind the coarse adjusting handle out stopping at the primary scale markings down to below stall speed, record each error

h. Tolerance required is ± 4 kn. (We have increased this as it is not practical or useful to have an ASI more accurate near stall. ie the pilot should not be fixated on the ASI at that point. In any case the stall speed varies with load.)

Altimeter Test Results Ref: MOSP 3 & BSE Ch 4 14/09/2017

Aircraft Registration: Altimeter Sno: Test Kit Sno: Calibration Due:

Test Date: Tested By: Signature: Membership No:

Altitude	1. Friction	Tol +/-	2. Scale Test, After tap	Tol+/-	3. Case Leak	Tol +/-	4. Hysteresis	Tol +/-	5. A/Effect	Tol +/-	6. S/scale	Alt Diff	Altitude	Error
0AGL	Set Subscale	20								50	Easiest is to hold Meriam at 0ft.			
0		70		50							952	-1727		
1,000		70		50		100					965	-1340		
2,000		70		50							982	-863		
5,000		70		50							999	-392		
8,000		70		60				75			1013	0		
10,000		80		80				75			1033	531		
15,000		90		110							1046	893		
20,000		100		130							1049	974		

Tests: A. Static systems leak test. Fix all to give less than 100ft over 1 minute at 1000ft AGL. Tap the case.

B. Pitot system leak test. Fix all to give no discernable drop over 10 seconds at 120kn. Don't tap

C. Altimeter Test. Don't do the greyed cells. Approach the test value on the reference altimeter carefully, try not to overshoot.
Write down the error or movement in ft at the given altitude while holding the reference altimeter constant with the pump.

Up	1. Friction test: Measure change due to tapping case.	Note before and after tapping
Up	2. Up Scale test: Measure error after tapping case.	
Up	3. Case Leak: Leak in 1 minute at 1,000ft AGL.	Always tap the case for each reading.
Down	4. Hysteresis: Measure difference between up and down reading.	Always tap the case for each reading.
Down	5. After effect of up and down. Error after returning to AGL.	Always tap the case for each reading.
	6. Subscale test. Alt diff is the altitude you should get at constant pressure. Error can be +/- 50 ft. Fill in 'Altitude' reading.	

Airspeed Indicator Test Results Ref: BSE, Ch 4

Aircraft Registration: **Altimeter S.no:** **Test Kit S.no:** **Calibration Due:**

Test Date: **Tested By:** **Signature:** **Membership No:**

Airspeed	Tolerance+/-	Measured Rising	Measured Falling	Complies Y/N	
0	4 Kt.				Don't tap the case.
10	4 Kt.				Write down the error
20	4 Kt.				
30	4 Kt.				
40	4 Kt.				
50	4 Kt.				
60	4 Kt.				
70	4 Kt.				
80	4 Kt.				
90	4 Kt.				
100	4 Kt.				
110	4 Kt.				
120	4 Kt.				
130	4 Kt.				
140	4 Kt.				
150	4 Kt.				
160	4 Kt.				
170	4 Kt.				
180	4 Kt.				
190	4 Kt.				
200	4 Kt.				

Appendix B ALTIMETER CALIBRATION INSTRUCTIONS

B.1 KOLLSMAN SENSITIVE ALTIMETERS

MODEL: Late Model Kollsman Altimeter Variant with Screws Front and Side Facilitating Barometric Pressure Scale Adjustment.

Source: www.mrkent.com/flying/altimeter/

1. Before starting, obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment**.** Set the altimeter to the exact altitude of your location.
2. You will find a small screw (Screw #1) near the main adjusting knob, just to the left and a little above, on the instrument bezel (see Figure A1 below). Remove this screw. Its purpose is to lock another "apparent" screw (Screw #2) in position.

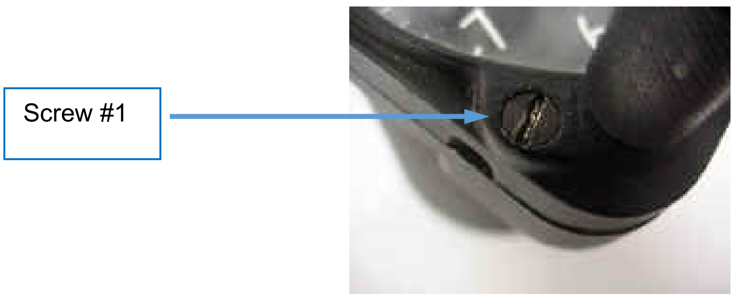


Figure B-1: Locking Screw #1

3. You may not be able to see the "apparent" screw (screw #2) as it is positioned on the side of the bezel rather than on the front. Although it has a screw head, it has no threads. It simply slides in and out of the hole it occupies. By removing screw #1, located on the front of the bezel, you will release the "fixed" condition of this side screw (screw #2).

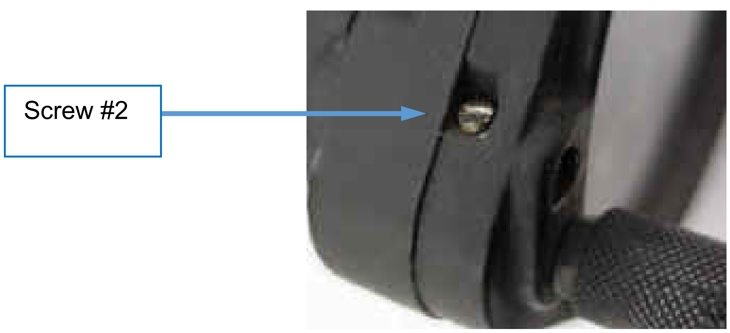


Figure B-2: Apparent Screw #2

4. Once you have removed screw #1, you will be able to see what is shown in Figure A3. It displays the threaded hole through the shaft of screw #2. Use a paper clip or piece of safety wire to slide the screw #2 slightly "up", or out of it's hole (only 1.5 mm or so).

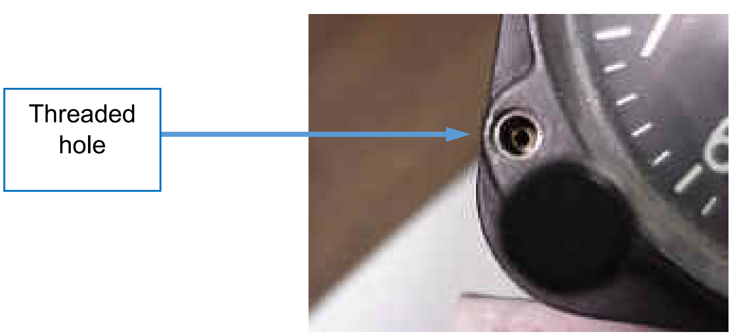


Figure B-3: Threaded hole through Screw #2

5. Once screw #2 has been moved up as shown in Figure A4, the altitude mechanism is disengaged from the adjusting knob. Pull the adjusting knob out and turn it to change the barometric reading in the window without changing the altitude setting.

Figure B-4: Screw #2 moved outwards to disengage altitude mechanism

6. Determine the current barometric pressure reading from the BOM observations website or other reputable source.
7. Pull out on the adjusting knob and set the barometric pressure to the correct amount in the window. You may have to try this a couple of times because when you release the adjusting knob it must mesh with the gears. As it snaps into place it may move the setting slightly.
8. Once the adjustment has been completed, use safety wire or paper clip to slide screw #2 back into its original position. You may have to re-align it with the viewing hole in order to re-position screw #1.
9. Replace screw #1 and tighten.

MODEL: Early Model Kollsman Altimeter Variants with Central Adjusting Knob and Separate Plate.

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment**.** Set the altimeter to the exact altitude of your location.
2. The barometric pressure scale adjusting knob is at the 6 o'clock position. The small plate underneath the knob is secured with a small screw left and right of the knob. Remove the screws on the left and right of the plate.

Figure B-5: Early Kollsman Altimeter with Removable Plate

3. Pull the adjustment knob out gently to disengage the altimeter mechanism.
4. Determine the current barometric pressure reading from the BOM observations website or other reputable source. Reset the barometric pressure scale s to the current local QNH without disturbing the altimeter hands.
5. Gently push the adjustment knob in to mesh the gear teeth again and secure the plate in position using the two screws.

MODEL: Early Model Kollsman Altimeter Variants with Central Adjusting Knob and Integral Plate.

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment. Set the altimeter to the exact altitude of your location.

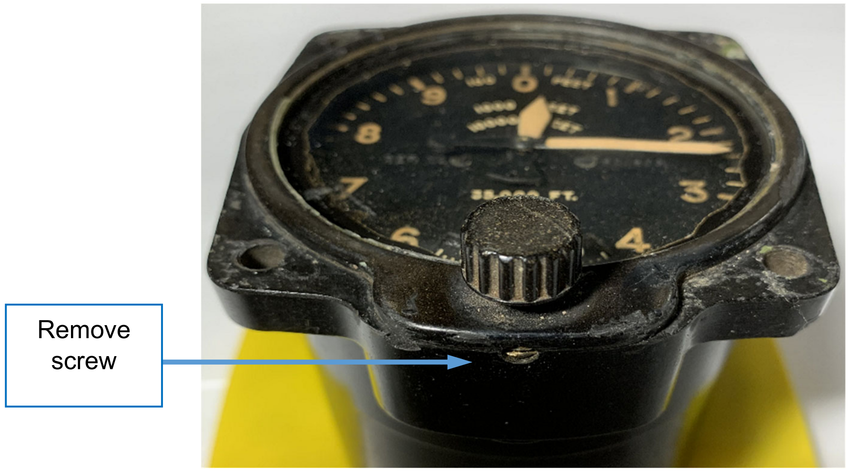


Figure B-6: Early Kollsman altimeter with integral plate

2. Remove the small screw underneath the adjusting knob.
3. Determine the current barometric pressure reading from the BOM observations website or other reputable source.
4. Pull out the adjusting knob to disengage the altimeter mechanism.
5. Hold the knob out and adjust the barometric pressure scale.
6. Once satisfactory gently push the adjusting knob in.
7. Replace the small screw and tighten.

B.2 WINTER ALTIMETERS

MODEL: 4 FGH 20 Article Numbers 4220 and 4440, and 4 FGH 10 Article Number 4110

Source: Winter website 2020

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment. Set the altimeter to the exact altitude of your location.
2. Remove the adjusting knob.

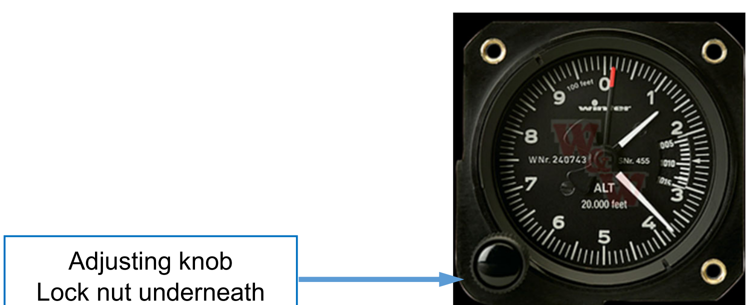


Figure B-7: Winter Altimeter

3. Using the special tool, unwind the locking nut for 1.5 to 2 turns.
4. Reinstall the adjusting knob.
5. Determine the current barometric pressure reading from the BOM observations website or other reputable source.

6. Lift up the adjusting knob and turn to adjust the barometric pressure scale.
7. Once adjustment complete, remove the adjusting knob and tighten the locking nut using the special tool. Pay attention to the torque of the lock nut.
8. Reinstall the adjusting knob.

MODEL: 4 FGH 40 Article Number 4550, and 4 FGH 10 Article Number 4320

Source: Winter website 2020

1. Before starting, obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment**.** Set the altimeter to the exact altitude of your location.
2. Remove sealing compound and wind out 'special screw no.1' shown in Figure B-8 for 3 turns.

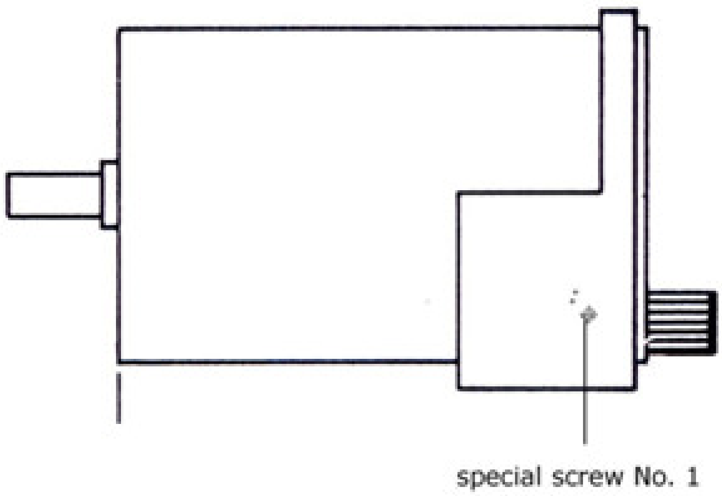


Figure B-8: Winter Altimeter 4 FGH 10 Article Number 4110

3. Determine the current barometric pressure reading from the BOM observations website or other reputable source.
4. Lift up adjusting knob 2 to 3 mm higher than normal to disconnect altimeter mechanism and turn the subscale.
5. Once adjustment is complete, lower the adjusting knob. Return 'special screw no.1' to its original location. Do not over tighten this screw.
6. Replace sealing compound over 'special screw no.1'.

B.3 FALCON GAUGE ALTIMETERS

MODEL:

Source: Wultrad Inc website

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment**.** Set the altimeter to the exact altitude of your location.
2. Locate the screw near the main adjusting knob, just to the left and a little above on the adjustment knob as shown in Figure C1. Remove the screw using a screwdriver.

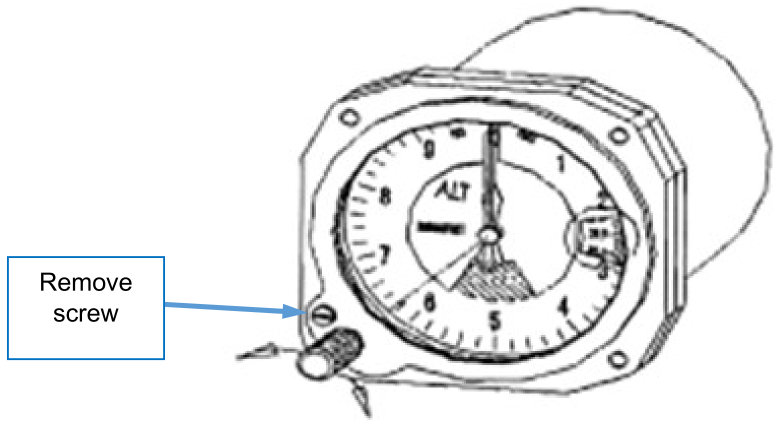


Figure B-9: Falcon Gauge Altimeter

3. If in the aircraft: Separate the gear Part No.1 shown at Figure B-10 from the shaft by using a small tweezers or screwdriver (care needs to be taken, only use the tool smallenough to get into the screw hole).

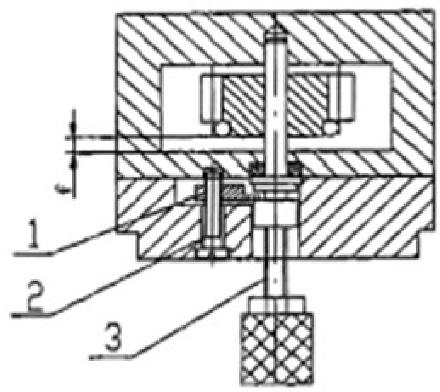


Figure B-10: Cross Section of Adjusting Mechanism

1. If out of the aircraft: Hold the altimeter in your hand and turn 90 degrees to the left. Pat the back area of the instrument to have part no. 1 shown at Figure B-10 separate from the main gear.

4. Determine the current barometric pressure reading from the BOM observations website or other reputable source.

5. Pull out on the adjustment knob and turn it to change the barometric reading in the window without changing the altitude setting. You may have totry this a couple of times because when you release the adjusting knob it must fit between some gears as it snaps into place it may move the settingslightly.

6. If in the aircraft: Use the small tweezers or screwdriver to slide part no. 1 back into its original position. You may have to re-align it with the viewing hole, in order to reposition the screw.

2. If out of the aircraft: Turn the altimeter 180 degrees so that it is now 90 degrees to the right and pat the back of the altimeter to let part No. 1 move back to its original position.

7. Replace and tighten the screw.

MODEL: UI MODEL 5934 SERIES

Source: United Instruments Maintenance Manual TM-5934, 2017

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment. While gently tapping the altimeter with a finger, set the altimeter to the exact altitude of your location.

2. Remove the locking stud screw beside the adjustment knob using a screwdriver as shown in Figure D1.

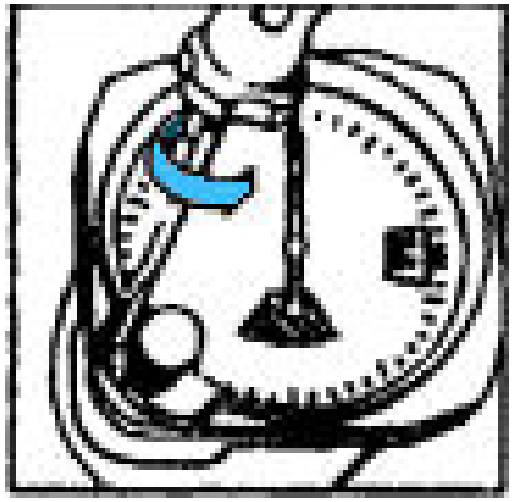


Figure B-11: Locking Stud Screw Removal

3. Slide the locking stud away from the knob to unlock the knob shaft as shown in Figure B-12.

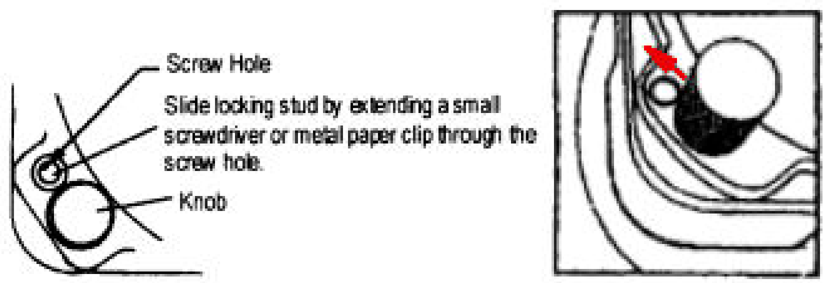


Figure B-12: Unlocking The Adjustment Knob

4. Determine the current barometric pressure reading from the BOM observations website or other reputable source.
5. Pull the knob out gently until it stops and has disengaged the knob shaft from the altimeter mechanism. Turn the knob to move the barometric pressure scale independently from the pointers and set the local QNH.
6. Keeping the local indicated altitude matched to the local QNH on the barometric pressure scale, push in the knob and turn slightly so that all gears engage.
7. Slide the locking stud back towards the knob shaft, and tighten the locking stud screw. Ensure that the screw is perpendicular in the hole when tightening. As it is tightened, the turning force (torque) required will increase if it is properly aligned. When properly aligned and tightened, the screw will not move to either side when pressed.
8. Check security of the locking screw by pulling on the knob while turning it. The pointers and the barometric dial shall rotate simultaneously.

MODEL:

Source: Sloley and Coulthard “Aircraft Engineer’s Handbook No. 4 Instruments” 5th edition 1953

1. Before starting obtain an accurate barometric pressure reading from a local weather service, and know what your exact altitude is as you make the adjustment. Set the altimeter to the exact altitude of your location.
2. Locate the screw to the left of the adjusting knob, as shown in Figure B-13. Remove the screw using a screwdriver. The adjusting knob may need to be removed first.

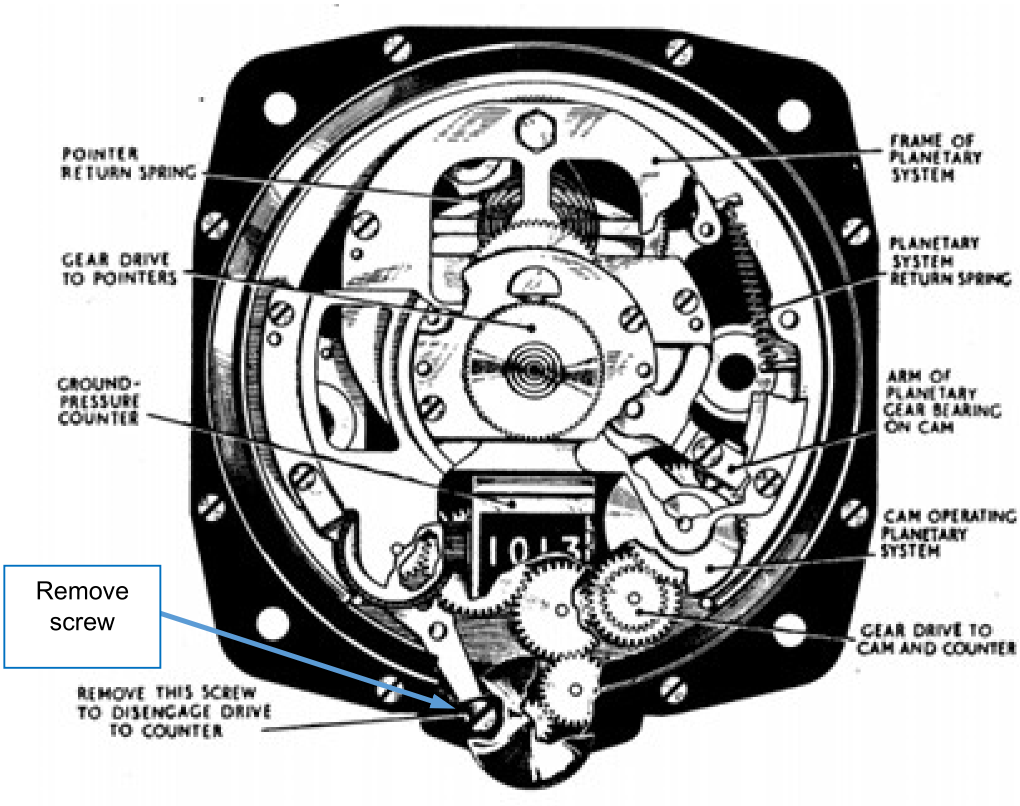


Figure B-13: Smith altimeter with drum counter style barometric pressure scale

3. Determine the current barometric pressure reading from the BOM observations website or other reputable source.
4. Rotate the adjustment knob to change the barometric reading in the window without changing the altitude setting.
5. Replace and tighten the screw.

MODEL:

Source: From G.E.Irvin "Aircraft Instruments" 1st Edition 1941 McGraw-Hill page 321

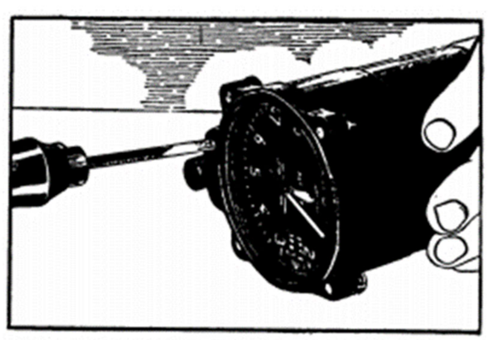


Fig. 438.

Directions for Changing Barometric-scale Adjustment.—Take out the locking screw far enough so it may be pushed sideways (Fig. 438). Put tweezers or a fingernail in the screw slot, pulling the screw to the left (away from the knob) (Fig. 439). With the

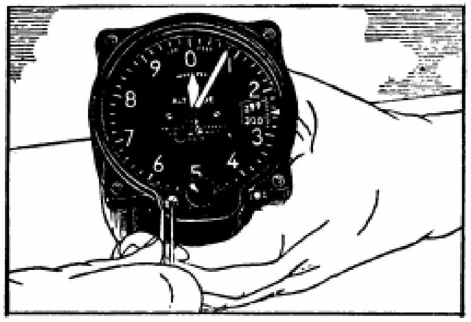


Fig. 439.

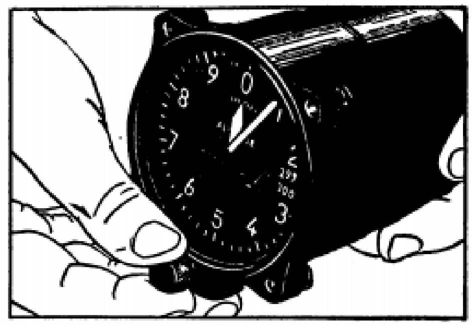


Fig. 440.

screw in this position, the knob may be pulled out part way (Fig. 440). By turning the knob while in this position, the barometric scale is turned without turning the hands of the altimeter.

5. NUTS, BOLTS AND HARDWARE

5.1 INTRODUCTION

The correct installation of the general hardware found in sailplanes is vital to the safe operation of the sailplane and also to a long life for the sailplane. The use of an incorrect bolt may result in an under-strength joint, excessive wear or a joint which is liable to undo.

Nuts and bolts primary function is to hold components together.

A bolt is always used with a nut; sometimes these are ‘captive’ nuts which are fixed in the aircraft and not placed on the bolt by the operator. Nuts and bolts serve as a fundamental component in many structures as they provide strong bonds that do not break even under great amounts of pressure. Nuts and bolts can have several different styles and types, each suited to match the needs of a particular application or need of the job.

Many steel structures, including buildings, are designed to be simply bolted together. The Eiffel Tower in Paris, for example was originally a temporary structure and after twenty years it was to be dismantled. As a result it was built with bolts, and has lasted a long time.

The nut is always used opposite a mating bolt and features a threaded hole which is the same as the thread on the bolt. When secured, the nut and the bolt are able to stay together without dropping apart due to the friction that is generated by their thread, compression of the parts, and a slight stretch of the bolt.

There can be application where vibrations and rotation may cause the nut and bolt to come loose, in this circumstance a locking system using the nut itself (self-locking nuts), or a separate locking system such as lock washers, split pin or lockwire are used.

5.2 TYPES OF BOLTS

Because different sailplane manufacturers use different types of nuts and bolts it is very important to be able to identify each type to avoid mixing bolt types with the possibility of damage to the fastener and loss of strength of the assembly. It is important to note that some types of bolts are metric and others are imperial. A screw pitch gauge and a micrometer are useful for this task especially with bolts of similar size e.g. 3/16" BSF, 10-32 AN and 2 BA.

5.2.1 DIN STANDARD

The DIN standard are a metric bolt. DIN stands for Deutsche Industrie-Norm which basically translates as German Industrial Standard. All German and some other European sailplanes use bolts which have been manufactured to a DIN specification. Table 9 shows the specifications for the most common bolt DIN 931. DIN specifications are used for almost everything in Germany including split pins and spanners!

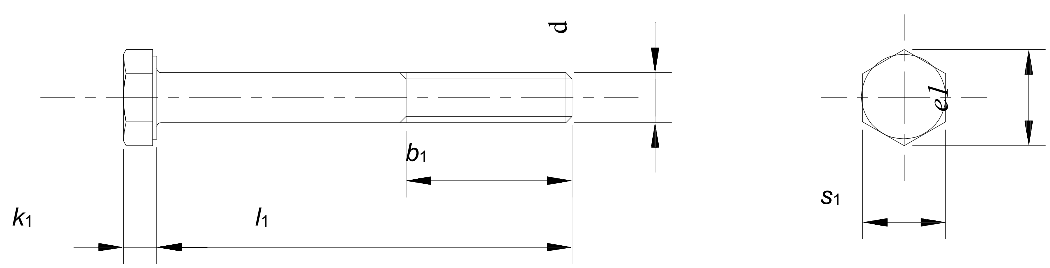


Figure 5-1 Bolt Specifications

d	b_1 From	To	e_1	k_1	s_1	l_1 Availab le in lengths from	to
M4	14		7.74	2.8	7	22	70
M5	16	22	8.87	3.5	8	30	80
M 6	18	24	11.05	4	10	30	90
M 8	22	28	14.38	5.3	13	35	110
M 10	26	32	18.9	6.4	17	40	150
M 12	30	36	21.1	7.5	19	45	180
M 16	38	44	26.75	10	24	55	200
M 20	46	52	33.53	12.5	30	65	220
M 24	54	60	39.98	15	36	75	220

Table 5-1 DIN 931 Bolt Specifications

Each type of DIN specification bolt is available in a number of strength grades and the grade is usually embossed on the head of the bolt.

Typical grades and the strength they represent are shown in Table 5-2. As can be seen from the table, DIN bolts are very strong compared to the typical loads in a sailplane control system however whenever a bolt is replaced it should be replaced with one of the same grade or higher. DIN specification bolts are available from most specialist bolt suppliers.

Property class	3.6	4.6	4.8	5.6	5.8	6.8	8.8	10.9	12.9
Minimum Tensile strength N/mm^2	330	400	420	500	520	600	800	1040	1220
Tensile load to break an M 6 bolt (kgf)	676	819	860	1024	1065	1229	1639	2130	2500

Table 5-2 Property Classes

There are 4 basic types of DIN nuts: the normal nut DIN 934, the thin check nut (about 60% of the thickness of the normal nut) DIN 439, the self-locking nut (nyloc) DIN 985 and the castellated nut DIN 935.

The advantage of the DIN standard bolts is that they are readily available and cheap. The disadvantages are that they will have a slightly looser fit in a hole or bearing (which may allow a small amount of free play in control connections), have a relatively long threaded section of the bolt (which may need to cut down to size) and tend to come in length increments of 5mm. The 5mm increments in length may result in one bolt having a shank that is 1mm too short and the next length of bolt having a shank 4mm too long resulting in excess washers being needed.

5.2.2 ONL STANDARD (FITTED TO BLANIKS)

The ONL standard are a metric bolt. The ONL standard originated in Czechoslovakia (now the Czech Republic) and is used on the Blanik L13 and any other aircraft originating from that country. Because these bolts have metric dimensions, they have often been used as replacements when DIN bolts have not been available. However care must be taken to ensure that understrength bolts are not installed and they must not be loaded in tension due to the small size of the head.

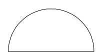
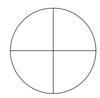
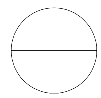
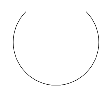
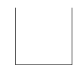
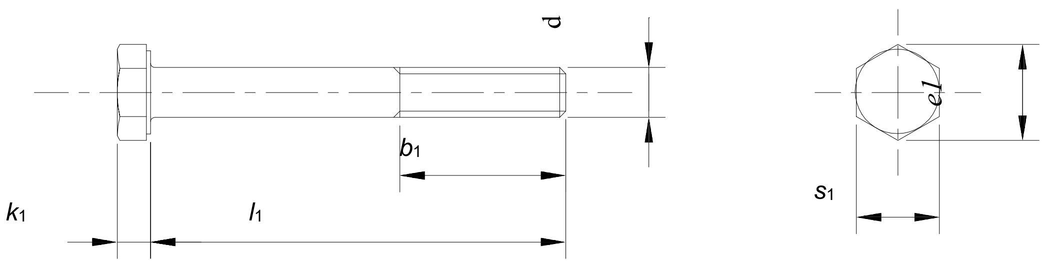
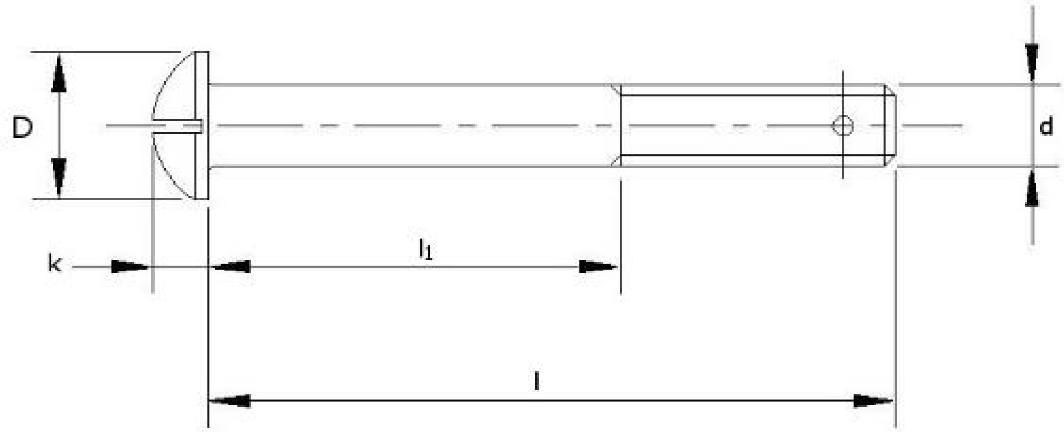
Grade	8E	8G	10G	10K	12K
Tensile Strength N/mm^2	800-950	800-100	1100-1300	1000-1200	1200-1400
Shear Strength N/mm^2	65	64	90	90	108
Identification marking					

Table 5-3 ONL bolt identification



d	e	k	s	Split pin size
M 5	9.2	2.5	8	1.2 x 10
M 6	10.4	2.5	9	1.6 x 12
M 8	13.8	2.5	12	2.0 x 16
M 10	16.2	3	14	2.5 x 18

Table 5-4 ONL 3120 calibrated bolts with hexagonal head (Standard 10G material)



d	D	k	Split pin size
M 5	9	3	1.2 x 10
M 6	11	4	1.6 x 12
M 8	14	5	2.0 x 16
M 10	17	6	2.5 x 18

Table 5-5 ONL 3125 Calibrated Bolts With Slotted Head (Standard 8e Material)

5.2.3 EUROPEAN AIRCRAFT STANDARD BOLT

Similar to the DIN and ONL standards, these are a metric bolt. There are a wide variety of specially approved aircraft bolts available from Europe eg LN 9037 or EN 2859 and have many similarities with the AN and MS bolts described below. They are available in a variety of strengths, head styles and are available with drilled heads or threads for lock wire or split pins.

All European aircraft approved bolts will have the standard number either stamped or embossed on the head of the bolt. The head of the bolt will also have a number for its diameter and a number for the length of the bolt e.g. 9037 06 044 on the head of the bolt will be a LN9037 bolt with a 6mm diameter and a 44mm length. Note that some older standards will have the ‘length’ as the total length of the bolt, while newer standards will have the ‘length’ as the length of the shank.

The advantages of European aircraft approved bolts are that the fit of the bolt is slightly tighter (close tolerance) than the DIN standard (resulting in reduced free play) and the lengths come in 1mm or 2mm increments meaning that you can almost always get the exact shank length you need without needing excess washers. The disadvantage is that they are not widely available in Australia and can be costly.

5.2.4 AN (ARMY NAVY) OR MS (MILITARY SPECIFICATION)

The AN specification bolts are imperial sizes. They are the preferred fasteners for all general aviation aircraft manufactured in the US and are also used extensively on airliners. Because these are specially approved aircraft bolts, their quality is assured and they come cadmium plated for excellent corrosion prevention. The cadmium plating give the bolts a yellow or silver colour depending on the process used to plate the bolts.

WARNING

AN hardware should not be welded as the cadmium plating gives off highly toxic fumes.

AN bolts are certified to a minimum tensile strength of 125000 psi (≈860 N/mm^2).

AN fasteners are only available in imperial sizes and can be purchased from your local LAME in small quantities or from an aircraft parts supplier

Sailplane inspectors will find AN fasteners on American built sailplanes as well as the Pilatus. AN fasteners are the preferred choice for amateur built sailplanes and are often used as replacements for BSF on British and Australian sailplanes.

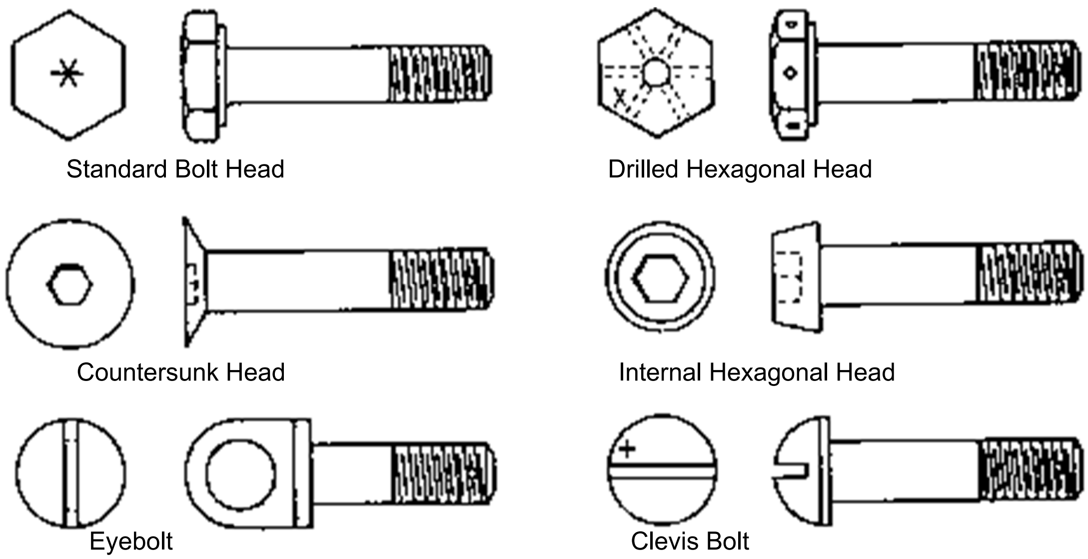


Figure 5-2 Some AN Bolt Types

To aid the identification of AN bolts, the head of each bolt has an embossed symbol which represents the type of bolt and the material it is manufactured from. Because these bolts are manufactured by a number of sources, the exact markings can vary between manufacturers. However, all AN standard steel bolts will have standard markings as per

Figure 5-3 and may also have markings identifying the manufacturer.

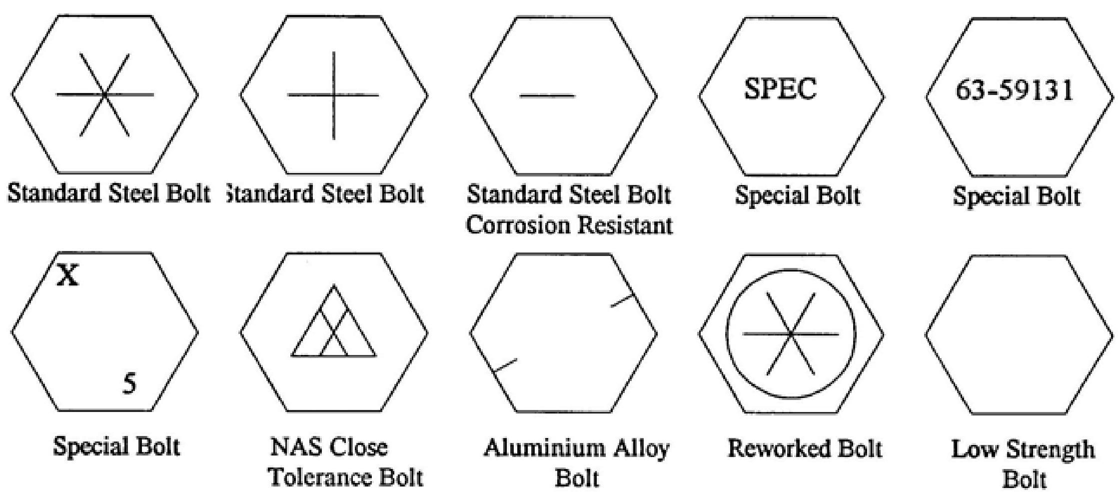


Figure 5-3 AN bolt identification

To fully Identify an AN bolt, it is necessary to know its nominal diameter in 1/16” and its length. An AN 4 bolt is 4/16” in diameter = 0.25”. Likewise an AN 5 bolt is 5/16” in diameter = 0.3125”.

The length of the bolt from under the head of the bolt to the end of the shank and is expressed as a dash number. An AN 4-10 bolt is 0.25” diameter and is 1.03” long. Each dash number specifies a different length for different bolt diameters. You must refer to a size chart or AN bolt gauge to find the correct dash number. If AN bolts are being purchased, a catalogue should be consulted to ensure that the correct bolts are ordered.

AN No	Diameter	Thread	Spanner size A/F
AN 3	3/16”	10-32 UNF-3A	3/8”
AN 4	1/4”	1/4-28 UNF-3A	7/16”
AN 5	5/16”	5/16-24 UNF-3A	1/2”
AN 6	3/8”	3/8-24 UNF-3A	9/16”
AN 7	7/16”	7/16-20 UNF-3A	5/8”
AN 8	1/2”	1/2-20 UNF-3A	3/4”

Table 5-6 AN Bolt Specification

5.2.5 BSF (BRITISH STANDARD FINE)

BSF are an imperial bolt. They are the standard fastener on older British and Australian production sailplanes although care must be taken with Australian sailplanes as bolt installation was heavily driven by supply of WWII surplus bolts. The best way to tell if BSF fasteners are fitted to a sailplane is by trying to fit a normal spanner. BSF bolts larger than 1/4” require special spanners such as 17/32 A/F.

Because BSF hardware is no longer readily available in Australia whenever a bolt becomes unserviceable it should be replaced with an AN specification bolt.

Nominal Size	Threads per inch	Spanner size A/F
1/4”	26	7/16”
5/16	22	17/32”
3/8	20	39/64”
7/16	18	91/128”

Table 5-7 BSF Specifications

5.2.6 BA (BRITISH ASSOCIATED)

The BA standard are an imperial bolt. As the BSF series of bolts only goes down to 1/4” nominal diameter, a second standard exists for smaller sized bolts. As for BSF, BA is the standard fastener on older British and Australian sailplanes for 3/16” and smaller.

The usual sizes for BA fasteners are 2BA and 4BA (said “Four B A”) and like gauge sizes the higher the number the smaller the bolt. Other sizes from 0BA to 10BA are available although, like BSF, they are very difficult to find in Australia. BA fasteners also use special spanner and drill sizes.

BA Number	Shank Diameter	Width across flats	Threads per inch
2BA	0.185” = 3/16”	41/128”	31.4
4BA	0.142” = 9/16”	1/4”	38.5

Table 5-8 BA Specifications

5.2.7 AUSTRALIAN COMMERCIAL BOLTS

When bolts are no longer serviceable it is sometimes possible to use commercial bolts in lieu of the original specification bolts. Whenever a bolt is replaced the inspector must be sure that the replacement part is of equivalent or higher strength than the original and if a close tolerance bolt has been used then the new bolt must be of an equivalent tolerance. Replacement bolts should be purchased from a reputable supplier who is able to provide traceability of the bolt. This traceability should include the bolt manufacturer, the bolt batch number and the heat treatment that has been applied to the bolt. Bunnings will not be able to provide this information. However, suppliers like Konnect (Coventry Fasteners) or United Fasteners should be able to supply this information when you request it for your records.

When replacing DIN specification bolts, equivalent grade bolts may be used as most Australian metric hardware standards are based on DIN specifications.

If replacing a bolt that is directly in contact with aluminium structure, only cadmium plated bolts are to be used as the cadmium plating will corrode in preference to the aluminium.

Where AN bolts were originally fitted then only AN bolts may be used as a replacement.

When replacing BSF bolts, AN bolts should be used. However, if commercial imperial bolts can be shown to have equivalent strength then they may be used provided they have a UNF thread. Bolts with UNC of Whitworth thread may <u>not</u> be used as replacement bolts in sailplanes.

5.3 INSPECTION OF BOLTS

Whenever a bolt is removed it should be inspected for general condition and should be replaced if it has any of the following faults:

a. Corrosion. Only bolts with light corrosion may be re-used and the corrosion should be removed and steps taken to prevent it recurring.

b. Cracks. Any sign of a crack is cause for immediate replacement and investigation into why the crack occurred.

c. Rounded head. If the head of the bolt is at all rounded due to slipping spanners (the spanner used was too big) the bolt must be replaced. Even if it is possible to reinstall the bolt to the correct torque, you may never remove it again!

d. Worn threads. Normal threads are not designed to be undone and done up forever. Each time the nut is torqued the thread wears and the nut becomes looser on the thread. A bolt which is twenty years old and has been removed at each annual inspection may have threads worn beyond acceptable limits.

5.4 BOLTING PRACTICE

Generally, bolts which carry any significant load in sailplane structures or control circuits are loaded in shear. Consequently the plain "shank" of the bolt carries the load and the thread is used only to clamp the components together. Bolts should be selected to ensure that only the shank is within the components. Because only a limited number of bolt lengths are available, a bolt will sometimes have to be used which is slightly too long in the shank and washers will be needed to stop the nut becoming "thread bound" i.e. being tightened on the thread run out rather than clamping the components together. The washers should be added to the threaded end of the bolt to ensure that the shank is fully in contact with the bearing surface.

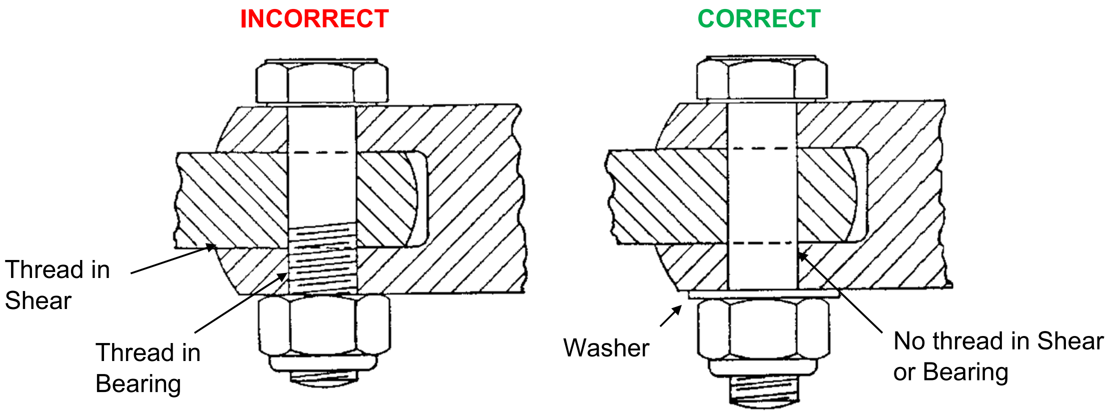


Figure 5-4 The Right and Wrong Way to Assemble a Bolt - Non-moving Parts.

Whenever a bolt has excess thread length, the end of the bolt should be shortened so that no more than 3 threads protrude beyond the end of the nut to prevent the bolt catching on other parts of the sailplane or if the bolt is external, the possibility of a tow rope catching the bolt. If the bolt is plated, the cut end of the bolt should be painted with primer to prevent corrosion.

In a push rod assembly joint or a bearing assembly the nut should always be tightened so that the movement takes place in the bearing rather than between the bolt and the mounting hole.

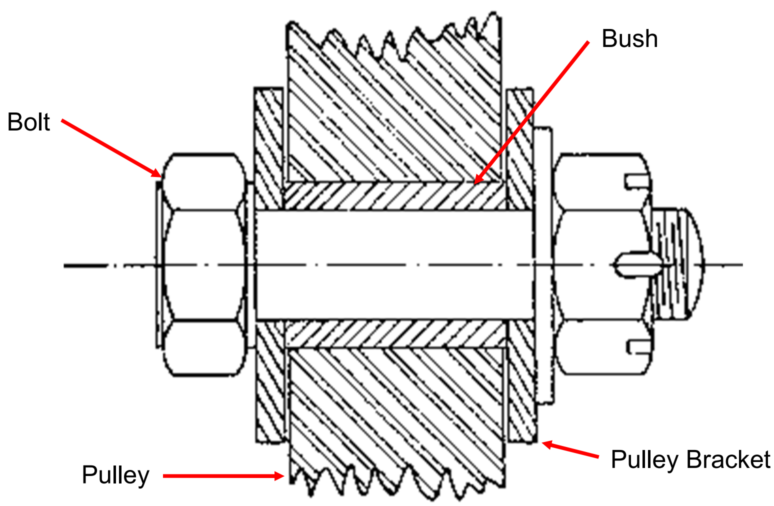


Figure 5-5 Correct Bush Assembly

5.4.1 BOLTING WOODEN STRUCTURES

Correct bolting practice when installing bolts in wooden structures is vital to ensure the joint is strong enough and that it will not degrade over time. Because timber changes size with varying moisture content, if the bolt is installed in the middle of winter the moisture content of the timber is likely to be high, six months later in summer the timber may have dried out and shrunk therefor allowing the bolt to be loose. If the bolt is tightened at this point then as the timber swells again next time it is wet the fibres may be crushed and damaged.

In this situation the inspector has a difficult decision in deciding the correct tightening of the bolt as the bolt cannot be loose or it will work and damage the timber but over torqueing can easily cause fibre damage in the timber. In general bolts should be tightened until they are just snug. About 1/2 a washer depth of fibre crushing seems to be about right.

To alleviate this problem, most designers place a “penny washer” at both ends of the bolt (one under the head and another under the nut) to spread the load over a much larger area and thus reduce the problem of damaging the timber and the bolt periodically loosening. Penny washers should be used wherever a bolt bears on wood, provided there is room.

5.4.2 BOLT TORQUES

Whenever a bolt is installed it is important that the tightening torque is correct.

Because the spanner length increases in proportion to bolt size it is usually possible for an experienced inspector to tension a normal steel bolt by applying a firm torque with the correct sized spanner until the bolt is snug. Where a bolt is unusual or the inspector is inexperienced, the manufacturer’s recommended torque should be obtained and a torque wrench used.

Wherever possible, the nut should be rotated and the bolt held still as the friction of the bolt rotating in the hole will significantly affect the torque of the assembly.

5.5 SAFETYING OF BOLTS

The primary forces which prevent the nut unscrewing from the bolt is the friction force developed between the thread of the bolt and the thread of the nut and, as experience on many types of machines has shown, if the bolt is correctly torqued the nut is very unlikely to come undone. It is for this reason that all threads should be free from oil or grease before being assembled unless the manufacturer explicitly says to lubricate the thread.

Because of the consequences of a bolt coming undone in flight every bolt in a sailplane (in every aircraft for that matter) must have a second method of preventing the nut from coming undone.

5.5.1 ELASTIC LOCK NUTS

The most common method of safetying bolts in sailplanes is to use an elastic lock nut. These nuts have a plastic or fibre insert in one end which is cut into by the bolt thread as the nut is wound onto the bolt. Because of the elastic nature of the insert, it provides a high friction force on the thread which is independent of the tightening torque and so is acceptable as a safetying device.

When using elastic lock nuts the following points should be noted:

a. The bolt is in safety when one full thread is showing through the elastic insert.

b. The nuts may be reused until they can be wound on with the fingers. The nut may not be salvaged by tapping the end of the nut with a hammer to tighten insert.

c. The nuts may be used over bolts which have been drilled to accept split pins provided there are no burrs on the bolt.

d. The nuts may be used over bolts which have had the excess thread removed provided the thread at the cut end of the bolt has been filed to prevent the sharp edge from cutting the plastic insert.

e. The nuts must be torqued sufficiently to prevent the bolt rotating in the joint. In some designs it is not possible to tighten a rotating joint and maintain movement and in these installations elastic stop nuts must not be used

f. Most elastic lock nuts are not heat resistant and so should not be used in the engine compartments of powered sailplanes.

g. Elastic lock nuts must not be used on rotating components like rudder hinges as the frequent rotation may cause it to loosen. Split pins must be used for such application and castellated nuts must not be replaced by elastic nuts.

5.5.2 OTHER LOCK NUTS

When an elastic stop nut cannot be used because of the possibility of fire an all metal lock nut must be used. These nuts come in a number of varieties and have generally been deformed in some way so they provide a metal to metal interference fit. Whenever an all metal locknut is disassembled both the bolt and nut must be replaced as the threads are permanently damaged when the nut is wound onto the bolt.

5.5.3 REDUCED HEIGHT LOCK NUTS

In some applications where there is limited clearance eg air brake blades, some release installations, reduced height lock nuts are sometimes used. As these nuts are thinner than the full size nuts, they will have reduced tensile strength as their load transfer to the bolt thread is reduced. These must only be used where the bolt is loaded in shear.

Figure 5-6 Reduced Height Lock Nut

Bossard Australia have BN19175 reduced height lock nuts in a range of styles available at their online store: https://uat9.bossard.com/au-en/. **The maximum torque for M6 BN19175 is 4 Nm.**

5.5.4 CASTELLATED NUTS

On older types constructed before elastic stop nuts became readily available the primary means of safetying bolts is to install a castellated nut and a split pin through a hole in the bolt. This method of safetying may be used where it is not possible to correctly torque the bolt because the required rotation will be lost.

When installing castellated nuts the nut should be torqued until the slot in the nut aligns with the hole in the bolt. If it is not possible to align the hole and the slot using a reasonable torque then different thicknesses of washers should be used so the correct alignment can be obtained.

5.5.4.1 SPLIT PINS

The usual way to safety the castellated nut is using a split pin. It is important that the pin be the correct size as if a pin the wrong size is used it may not be strong enough to adequately retain the nut. As shown in Figure 5-5-7 there are two possible ways to install a split pin.

Optional Preferred

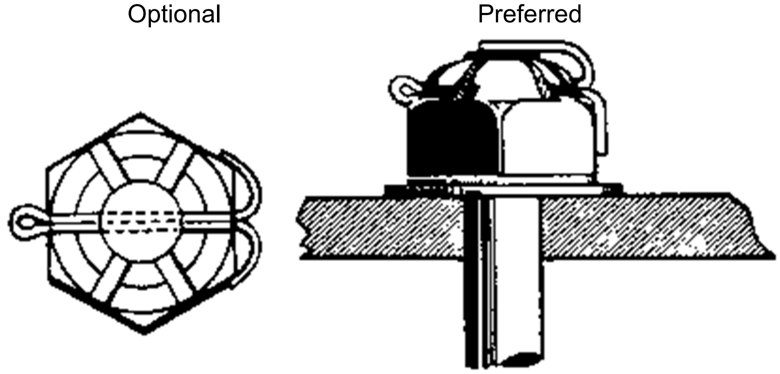


Figure 5-5-7 Split Pin Installation

When installing a split pin the following rules should apply:

a. The prong over the end of the bolt should be trimmed so that it doesn’t extend beyond the bolt diameter.

b. The prong bent down should be trimmed so that it doesn’t touch the washer.

c. If the optional wrap around method is used the prongs should be trimmed so they do not extend past the nut.

d. Reasonable bend radii should be used as tight bends are prone to breakage.

e. Split pins should never be reused.

5.5.5 SAFETY WIRING

Whenever a bolt is installed in a captive nut or where a number of bolts form a cluster, it is usual to safety these bolts using lock wire.

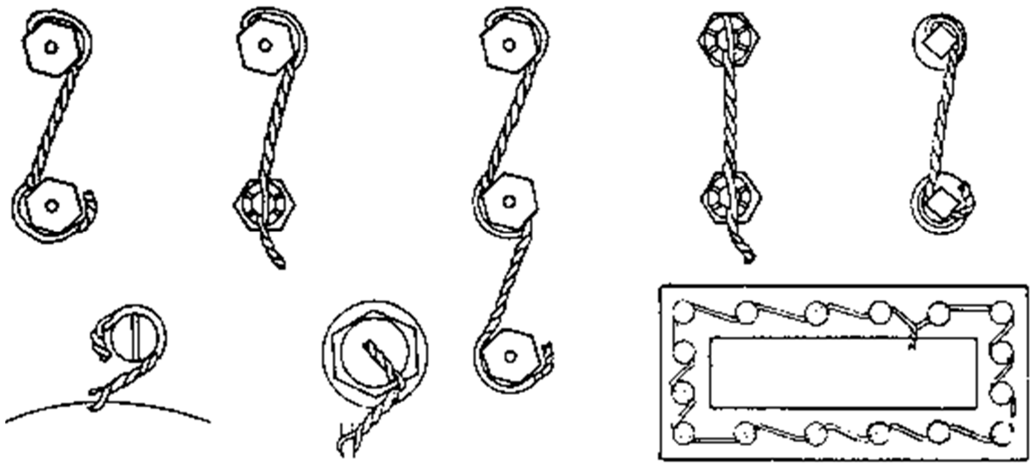


Figure 5-8 Safety Wiring

When safety wiring is used the following points should be noted:

a. Only use aircraft grade safety wire. It is cheap and readily available with a little planning.

b. All lock wiring must be installed so that the tension in the wires tends to tighten the bolts.

c. Proper aircraft lock wire pliers make the task of lock wiring much easier. See Figure 5.8.

Figure 5-9 Lock Wire Twisters

5.5.6 JAM NUTS

The use of jam nuts on ordinary nut and bolt installation is not recommended on sailplanes because the method is poorly understood. When the outer nut is tightened against the inner nut it experiences much higher loads than the inner nut and so the thick nut should be to the outside.

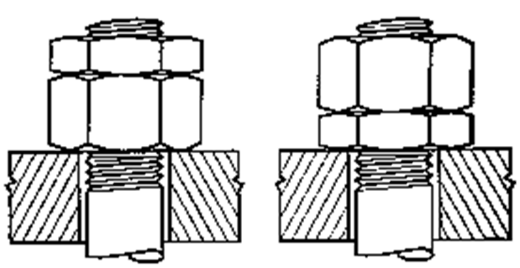


Figure 5-10 Jam Nut Assembly

The only place on a sailplane that jam nuts are commonly used is to secure the rod ends into the pushrods.

5.5.7 PUNCH LOCKING

Sailplane manufacturers sometimes use punch locking to secure a nut when there is not enough space for a self-locking nut or castellated nut. This method has been used in the past for reasons of economy where it was intended that the nut would be seldom, if ever undone.

To remove the bolt, the deformed end must first be filed or ground back to the nut. The nut may now be unscrewed but any remaining burrs on the end of the bolt should be removed before an attempt is made to remove the bolt from its hole.

A new bolt must be fitted each time a bolt secured by punch marking is removed. The new bolt must have the correct length of shank with the thread trimmed off to allow approximately half a millimetre to extend beyond the nut.

After the nut has been tightened, the bolt head should be supported with a dolly while the punch marks are made.

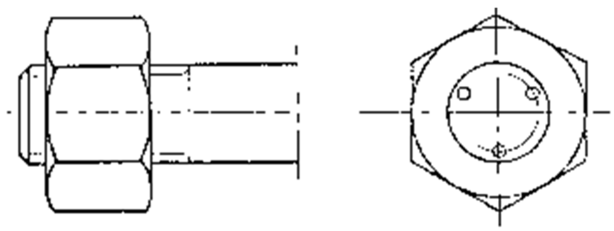


Figure 5-11 Punch Locking

5.5.8 LOCTITE

Sometimes, especially when vibration is high such as in powered sailplanes, Loctite or a similar product is used to secure the bolt. These products set in the absence of oxygen and so only harden between the threads. The advantage of the Loctite is that all other products are excluded and so the chances of corrosion are greatly reduced.

Special care must be taken to select the correct Loctite grade. Most manufacturers specify the grade to use and this must be adhered to. Where the manufacturer hasn't specified the grade then the Loctite published guides should be used when selecting the correct grade to use.

5.5.9 TAB WASHERS

A tab washer is a special washer which is bent up after the nut has been tightened and provides a mechanical safetying of the fastener.

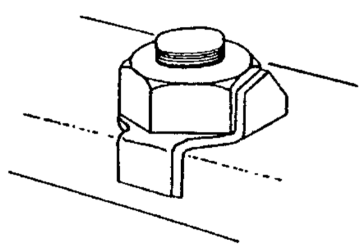


Figure 5-12 Typical Tab Washer

Any tab washer which has been used should not be used again.

5.6 WASHERS

Whenever a nut and bolt is used, a washer should be installed between the nut and the fitting to adjust the position of the nut to prevent thread binding. When bolting steel, the washer may be omitted so the nut is within safety.

If aluminium or magnesium structures are being bolted then a cadmium plated steel washer should be used as the cadmium will corrode rather than the alloy structure.

As noted in Section 5.4.1, “penny” washers should be used wherever wooden structures are bolted.

5.7 CLEVIS PINS

Clevis pins are used in cable systems and in secondary control systems. They consist of a steel pin with a head at one end and a hole drilled at the other end to accept a split pin.

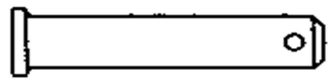


Figure 5-13 Typical Clevis Pin

Whenever a clevis pin is installed, a washer should be placed between the split pin and the parts to prevent the part being worn by the split pin.

5.8 ROLL PINS

Roll pins are a convenient method for sailplane manufactures to use for securing parts, especially the pins used as hinges of control surfaces on some Grob and Schempp-Hirth sailplanes.

During maintenance, roll pins can cause a few problems. They rely on expansion to provide the friction which locks them in place. Because of the likelihood of damage to the roll pin during fitting and removal, they should be only used once.

The end of the roll pin should be checked for burrs before any attempt is made to remove it. If there are burrs or the pin has been flared out during installation, it is necessary to file the end of the pin flat so it will pass through the hole.

Removal should be done using some form of extractor or pressing tool to avoid damage to the sailplane structure. If the use of a hammer and punch cannot be avoided, the structure should be supported with a dolly. The punch used must be slightly smaller than the hole and have a flat end.

Components are usually drilled by hand at assembly e.g. aileron hinge pins on Grob Astirs’. The parts will only go together with the original pin in the original hinge so care must be taken not to mix the pins.

5.9 TORQUE

Nuts are tightened onto a bolt by applying a twisting force (torque) to the nut. Torque is measured as Force (kg, N or pounds) times a lever length. Typically, Newton-meters or foot-pounds are used, but sometimes an unusual unit such as a kg-cm is used.

It is very important that the correct torque be applied. In particular, over-torqueing must be avoided because it can cause failure of the bolt. Under-torqueing can cause wear by allowing movement where none should exist.

A correctly torqued bolt will have the correct amount of tensile stress and the correct amount of bolt stretch, thus allowing the bolt to exert the proper clamping force.

For example, a 6mm diameter bolt carrying 288 kg of tensile load has a tensile stress of 99.8 n/mm2 and has stretched .057mm. (See below for details of this calculation)

For most sailplane work, it is not necessary to use a torque wrench, but it is necessary that the sailplane engineer calibrate themselves to find out how much force they need to apply with the spanners they are using. Where the torque is critical for particular bolts, the bolt torque will be specified in the aircraft maintenance manual.

Below is a table of the correct torques for commonly-used bolts. The figures are based on turning the NUT and not rotating the whole bolt while holding the nut still.

Bolt type	Size	Correct Torque
Cadmium plated unlubricated AN (Army-Navy) aircraft bolts	1/4" 5/16" 3/8" 1/4", into wood with penny washers	11 N-m 34 N-m 40 N-m 9.5 N-m
Metric DIN (Deutsche Industrie-Norm , as used on most German sailplanes) Property Class 12.9 (this is the highest property class and equivalent in strength to AN bolts).	M5 M6 M8 M12	8 N-m maximum 14 N-m maximum 35 N-m maximum 121 N-m maximum

Table 5-9 Recommended Bolt Torques

A cautionary case example: On a Jabiru undercarriage, a high-tensile bolt from a hardware shop was substituted for an AN bolt. The person doing this substitution thought he was doing a good thing. Well the bolt failed very early from fatigue, luckily as the aircraft was being wheeled out the hangar. In this case, the hardware shop bolt was defective in toughness, as measured by "elongation to failure" in comparison to the AN bolt. It may well have had other property defects too.

5.9.1 NUT FRICTION AND TORQUE

In order to apply the correct tensile stress to a bolt by means of tightening a nut, it is important that the friction between the nut and bolt be known. It has been estimated that only 10% of the applied torque goes into tensile stress in the bolt. 50% is spent overcoming nut friction and 40% overcoming thread friction. So the nature of the surfaces involved in producing this friction becomes important. Lubricated nuts require less torque than dry nuts.

A cautionary case study: An automotive manufacturer changed to a different bolt supplier, with no other changes intended. Suddenly the factory suffered a spate of bolt tensile failures. It turned out that the new bolts had a lower coefficient of friction and applying the same torque was overloading them.

On some torque wrenches, you will see that an alternative method of achieving the correct tensile stress is catered for... the nut is turned a calculated amount after contacting the surface to be clamped.

Thus in the 6mm example bolt referred to previously, where 0.057 mm of stretch is to be applied to achieve the stress of 99.8 N/mm2 , this corresponds to 20.5 degrees of rotation of a 1 mm thread pitch nut. (This calculation uses 210,000 N/mm^2 as the Young's Modulus for steel)

5.9.2 SPANNER LENGTH

Remembering that Torque = Force x Distance, it follows that doubling the length of your spanner will double the torque applied by a given hand force.

This fact has caused some manufacturers to deliberately cut down the length of spanners used in production so that nuts are less likely to be over-torqued.

5.10 REPLACING HARDWARE

If you cannot obtain the correct replacement and you are not sure of the correct replacement based on the above guidelines then you must apply for engineering help from the GFA. We can arrange an engineering order to specify a replacement.

5.11 REFERENCE AND FURTHER READING

1) EA-AC 65-9A Airframe & Power plant Mechanics General Handbook. IAP Inc. Casper, Wyoming.
2) AC 43.13-1A Change 3. Acceptable Methods, Techniques and Practices. IAP Inc. Casper, Wyoming.
3) Ajax Fasteners. Fastener Handbook, Bolt Products. Ajax Fasteners, Richmond, Victoria, 1985.
4) Machinery's Handbook, 24th Edition. Industrial Press Inc., New York, 1992.
5) Ray C. Stafford-Allen. Glider Maintenance Manual. British Gliding Association, London, 1959.
6) Sailplane Overhaul Manual (Wooden Construction) General Part. Warsaw, 1967

6. CABLE SYSTEMS

6.1 INTRODUCTION

Steel cables are used extensively in sailplanes as part of the control system and in some vintage sailplanes as external bracing as part of the structure. Each cable assembly consists of the cable itself and some form of end terminal. The terminal is usually a looped end which is held in shape by a thimble and a sleeve which is swaged into place. The cable assembly may also contain a turnbuckle for adjusting cable tension and may pass around a number of pulleys and through fairleads (a device to guide a cable around an object).

Some older sailplanes may contain hand woven splices rather than swaged endings. Teaching of hand woven cable splicing is beyond the scope of this book and the local club expert (if there is one) should be consulted before attempting a woven splice. The expert may be identified by his great age and gnarled fingers! All hand woven cables must be in accordance with the procedures in AC 43.13 1B Chapter 7.

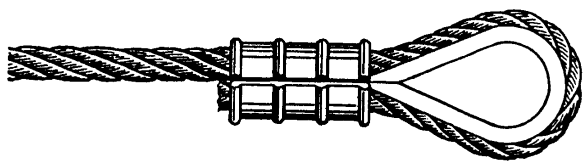


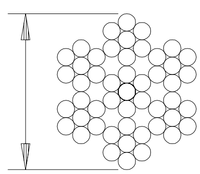
Figure 6-1 Typical Cable End

The steel cable used in aircraft is available in galvanised steel or in stainless steel. The stainless steel cable is more expensive than the galvanised cable and in most applications wears more quickly. Only in environments where corrosion is a real problem should the use of stainless steel cable be considered.

6.2 CABLE TYPES

All cables consist of a series of wires which are wound together to produce a strand. The strands are then wound together around a central strand to form the cable. Cable designation is set down as: Number of strands x Number of wires per strand. Most cables used in Australia are either:

7 x 7 flexible cable or



7 x 19 extra flexible

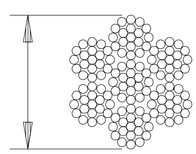


Figure 6-2 Cable construction

6.2.1 AMERICAN CABLES

The main cable type is the American system which designates its cables by the outside diameter of the cable. This is the cable system used on almost all GA aircraft and is readily available, at a price, from any LAME workshop in the country.

Almost all cables found in sailplanes in Australia will be either 3/32" or 1/8" with a small amount of 5/32" cable.

CAUTION

You cannot mix imperial and metric cable components even if they look right.

Available cable sizes are:

Diameter (Inches)	Construction	Breaking Strength (lb.)	Approx. weight per 100' (lb)
1/16"	7 x 7	480	0.75
3/32"	7 x 7	920	1.60
3/32"	7 x 19	1000	1.70
1/8"	7 x 19	2000	2.90
5/32"	7 x 19	2800	4.50
3/16"	7 x 19	4200	6.50
1/4"	7 x 19	7000	11.00

Table 6-1 Available American cables sizes

6.2.1.1 NICOPRESS SWAGE

American cables must be terminated with a Nicopress swage. The process must be done using the correct sleeve and the correct thimble in the special Nicopress tool, the finished joint is then stronger than the cable itself. There are two types of tool, a hand squeezer which resembles a set of bolt cutters or the less expensive clamp squeezer both of which are genuine Nicopress tools and the only tools which may be used to swage American aircraft cables.

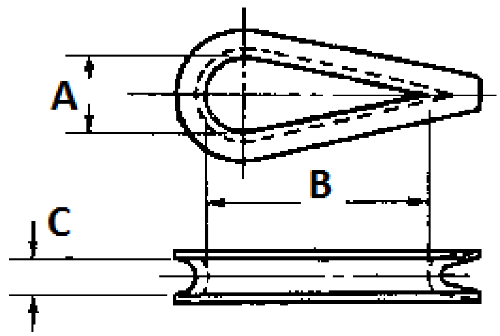


Figure 6-3 AN 100 Thimble

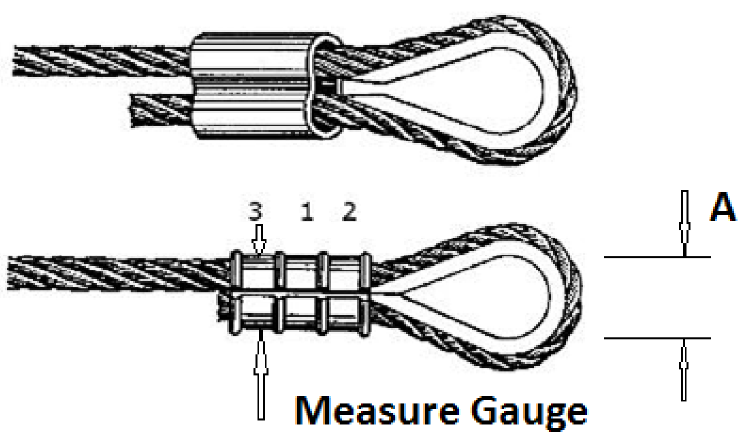


Figure 6-4 Swaging Sequence for 1/8" Cable

Cable	Sleeve	AN 100 Thimble	Thimble dimensions		
Size	**Stock No.**	**Dash No.**	**A**	**B**	**C**
1/16"	18-1-C	-3	0.35	0.7	3/32
3/32"	18-2-G	-4	0.35	0.7	9/64
1/8"	18-3-M	-4	0.35	0.7	9/64
5/32"	18-4-P	-5	0.4	0.8	11/64
3/16"	10-6-X	-6	0.5	1.0	13/64

Table 6-2 Sleeve and Thimble Dimensions for American Cable

After the Nicopress splice is completed, it must be inspected to the following criteria:

a. Sufficient "tail" extending from the sleeve (2 to 3 mm).

b. Thimble gripped firmly but with tips not distorted or buried in the sleeve.

c. On the 1/8 inch cable splice, the three compressions must be evenly spaced with no overlap or bending of the sleeve.

d. Check each compression for size with the appropriate gauge.

e. Proof load to 60% of cable breaking strength (or proof load sample).

6.2.2 BRITISH CABLES

The British system is found in a number of older designs and the cables are designated by the minimum breaking strain which the cable should sustain in hundredweight (cwt.) (one hundredweight is equal to 112 lb. or 50.8 kg). The most common sized cable used in sailplanes is the 10 cwt.

6.2.2.1 TALURIT SWAGE

Manufacturing of a Talurit swage is similar to producing a Nicopress swage. When using the Talurit system, only genuine Talurit ferrules, thimbles and compressing tools may be used. After the Talurit swage has been completed, the flash may be removed carefully with a file provided the diameter of the ferule is not reduced. Inspection must include:

a. Check for correct diameter of ferrule after compression.

b. Sufficient "tail" extending from the sleeve (2 to 3 mm).

c. Thimble gripped firmly but with tips not distorted or buried in the sleeve.

d. Check ferrule for cracks with 5X magnifier

e. Proof load to 60% of cable breaking strength (or proof load sample).

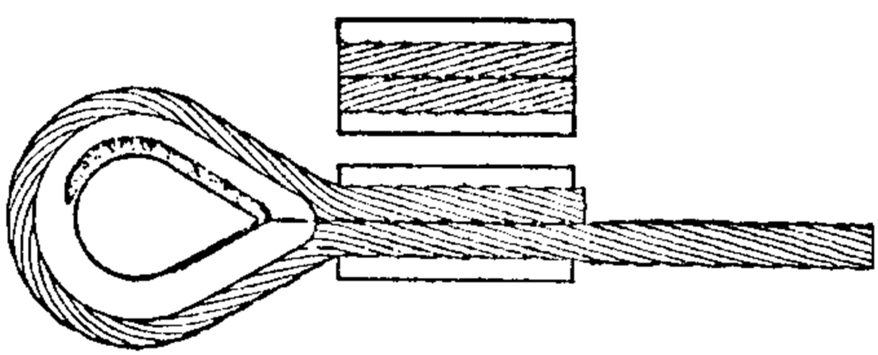


Figure 6-5 Sectioned Talurit Sleeve

6.2.3 OTHER CABLE SYSTEMS

The other systems which may be encountered are:

a. Metric DIN specification cable. The metric system is a direct equivalent for the American system as the sizes of the cable have been chosen to match the American system. The most common size cable is 3.2 mm diameter. But you cannot use a metric swage on a very similar imperial cable, etc, they may slip, and it would be illegal.

b. Hemp cored cable. This was used in eastern European countries but has been banned from sailplanes in Australia for many years.

As well as the Nicopress swages some sailplanes use cable terminal ends. Installation of these terminal ends is a specialist job and requires the use of a rotary swaging tool. If you have to replace a cable which uses these type of terminals the job should be entrusted to your local LAME. Note if stainless steel then follow CASA AD/GEN/87 (must be replaced every 15 years.)

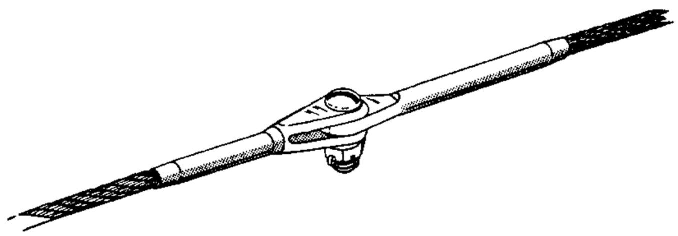


Figure 6-6 Typical Cable Terminals

6.3 CABLE INSPECTION

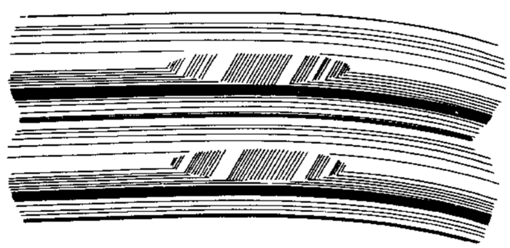


Figure 6-7 Individual Outer Wires Worn Less Than 40% (Worn Areas Individually Distinguishable)

The most common reason for replacing a control cable is wear, which will occur at every point at which the cable makes contact with any other part of the sailplane. Worn cable will show itself by bright areas on the cable (provided the cable has been in recent service) and the individual strands of the cable must be inspected under magnification for excessive wear. Cable wear patterns should be compared to the diagrams. Cables as per Figure 6-7 may continue in service. Cables in which the outer strands are more than half worn must be replaced.

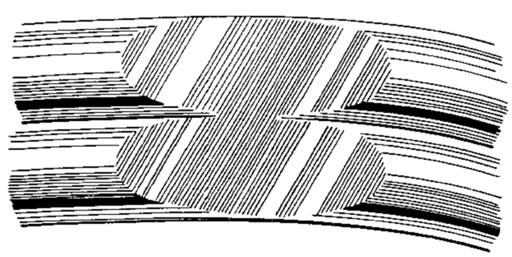


Figure 6-8 Individual Wires Worn 40 - 50 % (Note Blending Of Worn Areas)

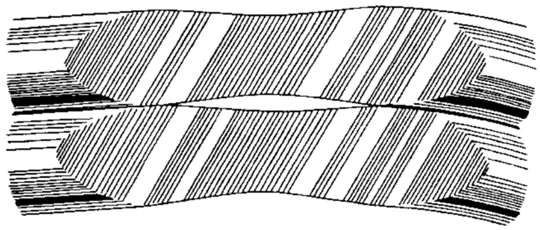


Figure 6-9 Individual Wires Worn More Than 50 %

Fatigue will show itself in the form of broken wires at any point where the cable changes direction. Small diameter pulleys and fairleads which force a change of direction are likely areas to look. Running a rag along the cable should detect any broken wires or the cable can be bent and any broken wires will stand out.

Figure 6-10 Cable Inspection Technique

Corrosion should be looked for anywhere the cable is likely to get wet, either from water, sweat or battery fumes. Hemp cored control cable, which was banned in Australia many years ago, was very susceptible to corrosion. To check for the presence of a hemp core, twist the cable against its direction of "lay" and observe the core strand. If the Inspector does not have the strength to execute the foregoing method, a two-inch nail can be inserted between the strands without damage to the cable and the core inspected.

Note: Some cables may have a thin coloured cotton thread, which is acceptable, as distinct from a hemp core which will be brown in colour.

6.4 CABLE LIFE

Cable life may be limited by 3 factors:

a. The requirements of an Airworthiness Directive.

b. There may be specific instructions contained in the sailplane's maintenance manual.

c. Where cable life is not limited by a) or b) above, the cables must be replaced on condition.

6.5 CABLE CARE

In order to obtain maximum cable life the cable should be protected by a light coating of graphite grease or general purpose low temperature oil. If over time a heavy accumulation of the corrosion preventative compounds occurs then it should be removed and fresh protector applied. When cleaning the cable do not use MEK or other solvents as this will remove the internal lubricant in the cable.

Special care should be taken when handling cables to prevent kinking. Once a cable is kinked it is ruined and must not be used in aircraft.

6.6 PULLEYS

Pulleys should be checked for any roughness of operation and condition of bearings. These pulleys are also known to seize and instead of rotating the cable slides over the pulley. This causes excessive control circuit friction and wear to both pulley and cable.

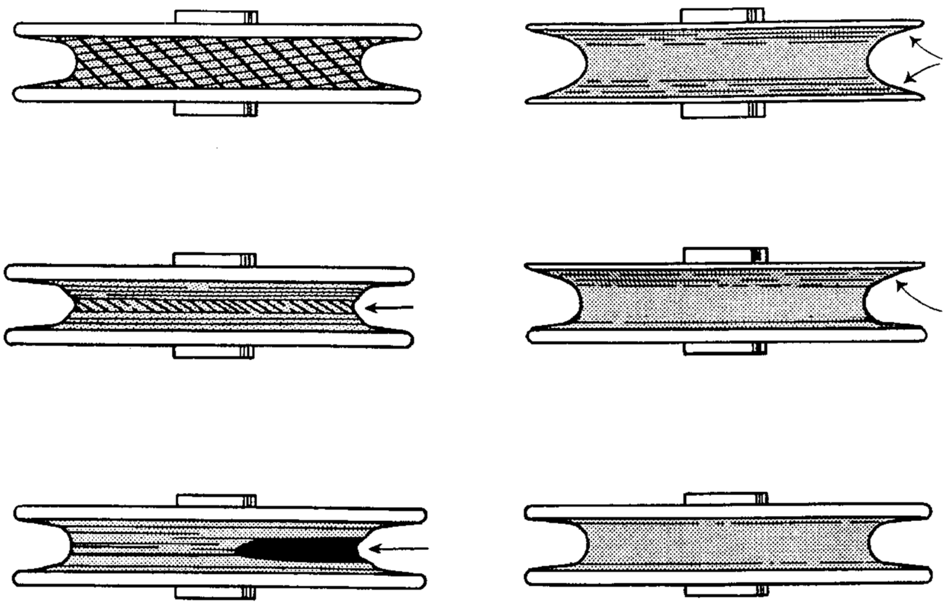


Figure 6-11 Pulley Wear Patterns

The wear pattern which appears on the pulley can be a good guide to the health of the cable system.

6.7 CABLE TENSION

The turnbuckle is used to alter the length of the control cable for the purpose of adjusting the control position and adjusting cable tension.

On sailplanes with closed type control cable systems, the cable tension determines the amount of control free play and control circuit stiffness. It is critical the correct cable tension is maintained and this can be checked with a cable tensiometer. The correct tension for a closed circuit control cable should be provided in the aircraft's Maintenance Manual.

Figure 6-12 Typical Tensiometer

6.8 TURNBUCKLE LOCK WIRING SCHEMES

When locking a turnbuckle, it must meet the following specifications:

a. The terminal end threads on MS or AN type turnbuckles must not protrude from the barrel by more than three turns (the turnbuckle barrel will be labelled). All other turnbuckles must have no threads showing.

b. Safety wiring should be done neatly with no loose ends which can catch on adjacent structure or another turnbuckle.

c. Safety wire must not be reused. The minimum size of the safety wire and the minimum strength of the lock wire material varies depending on the size of the cable (the correct sized turnbuckle must also be used) and is shown in the following table:

Cable Size	Type of wrap	Diameter of safety wire	Material (annealed condition)
1/16”	Single	0.040	Copper, Brass.[1]
3/32”	Single	0.040	Copper, Brass.[1]
1/8”	Single	0.040	Stainless Steel, Monel and “K” Monel.
1/8”	Double	0.040	Copper, Brass.[1]
1/8”	Single	0.057 min.	Copper, Brass.[1]
5/32” and greater	Double	0.040	Stainless Steel, Monel and “K” Monel.
5/32” and greater	Single	0.057 min.	Stainless Steel, Monel and “K” Monel.
5/32” and greater	Double	0.051[2]	Copper, Brass.[1]

[1] Galvanised or tinned steel or soft iron wires are also acceptable.

[2] The safety wire holes in 5/32” diameter and larger turnbuckles may be drilled sufficiently to accommodate the double 0.051” copper or brass wires when used.

d. Turnbuckles must not be lubricated.

e. There are 4 ways of lock wiring a turnbuckle however only two of these commonly are used on sailplanes. They are the single wrap and the double wrap as shown in shown below. Both methods are acceptable.

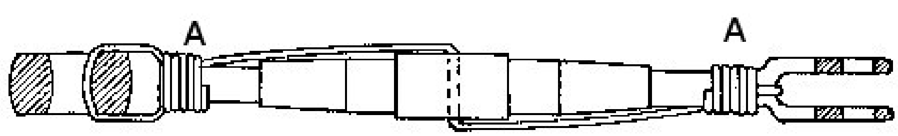


Figure 6-13 Single Wrap

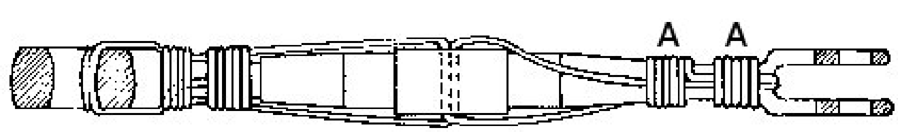


Figure 6-14 Double Wrap

f. Whenever the safety wire is wrapped around the turnbuckle (position A in Figure 6-13 and Figure 6-14), it must pass around at least 4 times.

6.9 MAKING A NEW CABLE

The most important part of making and installing new cables is to ensure the length of the cable is correct. Incorrect cable lengths can cause uneven rudder pedals and loss of full control movement. Most FRP sailplanes which use cables in the rudder system have no turnbuckles to adjust out the slight inaccuracies of cable construction and so special care must be taken to ensure correct cable length.

If an old cable is being copied it is important to check the operation of the control in all positions prior to beginning. Available turnbuckle adjustment should also be checked.

Cables stretch when loaded for the first time as the cables bed in. It is therefore advisable the cables be preloaded to 50% of their breaking load prior to being fabricated into cable assemblies. When stretching the cables special care must be taken by placing a guard over cable to prevent injury in the event of a cable break.

If it is not possible to manufacture the cable and then install it in the sailplane then the cable must be made up in situ. One end of the cable (the end which is most difficult to access in the sailplane) should be made up and cable then fitted to the sailplane. The length of the cable should be adjusted and the second end swaged. Construction of the cable may be made easier by the use of a splicing clamp as shown in Figure 6-15.

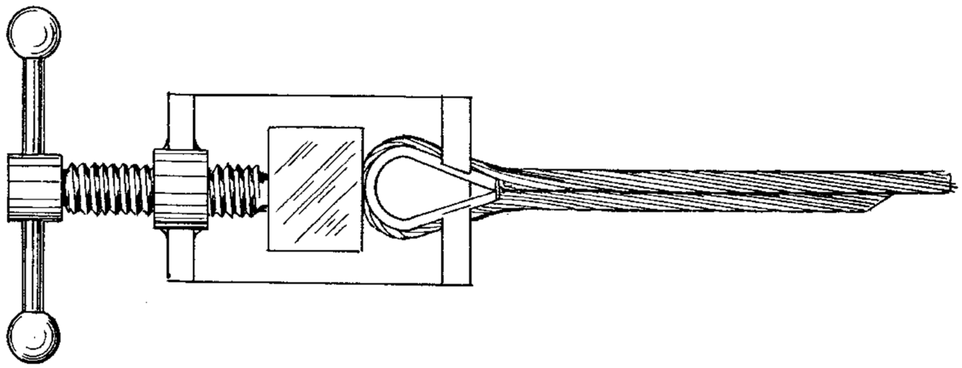


Figure 6-15 Cable Swaging Clamp

6.9.1 PROOF TESTING

Each cable manufactured must be proof tested to 60% of its breaking strain where the cable can be removed from the sailplane. If it is not practical to proof load the finished cable in the sailplanes a sample cable may be tested provided it is made using the same materials and process as the ones fitted to the sailplane.

Testing the cables can be performed by using a leverage assembly, say 10 to 1, and a spring balance to measure the load. When loading the cable precautions, such as guards over the cable, must be taken to prevent injury if the cable should fail.

Sample calculation:

Assume testing in a rig with 10:1 leverage and 1/8 cable.

Load on Lever = $\frac{(\boldsymbol{Breaking\ Strain\ x}\ \mathbf{0.6})}{\mathbf{10}} = \frac{\mathbf{2000*0.6}}{\mathbf{10}} = 120\ lb \approx 54\ kg$

7. CANOPIES

7.1 INTRODUCTION

The canopy is one of the most expensive and vulnerable parts of the sailplane with some canopy bubbles costing over $8000. The condition of the canopy also has several significant airworthiness considerations.

Most canopies are made of Polymethyl methacrylate (PMMA), also known as acrylic or acrylic glass as well as by the trade names Plexiglas, Acrylite, Lucite, and Perspex. In the rest of this chapter "Perspex" (a trademark belonging to ICI) is used to generically describe the canopy material.

If Perspex is not cared for properly it will, over time, develop cracks, pitting and discolouration which significantly reduce the optical qualities of the canopy. This leads to a significant reduction in safety especially when the sun is low on the horizon and when conditions are hazy. If the pilot's vision through the canopy is significantly impaired then it must be considered un-airworthy.

As the canopy also doubles as the point of entry and exit on almost all sailplanes, the correct operation of the opening mechanism and the canopy jettison system are also vital.

7.2 ROUTINE CARE

7.2.1 DAILY CARE

Cleaning of the canopy should be performed at each Daily Inspection to ensure that the pilot can see through it. Clean the plastic by washing it with plenty of clean water and mild soap, using a clean, soft, grit-free cloth, sponge, or bare hands. It is important to thoroughly dry the canopy with a clean chamois as any small beads of water will leave a dirt mark when they dry.

The canopy can be polished using a specific Perspex polish. The regular use of a Perspex polish will reduce the build-up of a static electricity charge.

Do not use gasoline, alcohol, benzene, acetone, carbon tetrachloride, fire extinguisher or de-icing fluids, lacquer thinners, or window cleaning sprays. These substances can be dangerous to handle and use and may soften the plastic and cause crazing.

Static electricity builds up when the Perspex is rubbed by a dry material. This can be a dry cloth, the air over the canopy or even normal handling. The static electricity causes dust particles to stick to the canopy which can reduce pilot vision.

The use of silicon based cleaners is not recommended on FRP or fabric covered aircraft as the silicon will interfere with the glues and dopes which may be used during any repairs.

7.2.2 PERIODIC CARE

At least annually after removing dirt and grease and if no great amount of scratching is visible, finish the plastic with a good quality grade of commercial Perspex polish such as Maguires or Mothers. Apply the polish as directed on the bottle and bring to a high polish by rubbing lightly with a soft clean cloth.

Friction created by buffing or polishing too long in one spot can generate sufficient heat to soften the surface. This condition produces visual distortion and should be avoided.

These specialised polishes contain chemicals which are designed to rejuvenate the acrylic material and reduce the effects of static electricity.

Annually you are required to test the emergency exit, see MOSP 3 Section 13.8 Emergency Exits. This means ejecting the canopy, carefully, making sure it works and reinstalling it. During the DI you must check the canopy mechanisms are visually correct for hinges, release mechanisms, and that they appear they can be ejected if required.

7.2.3 CANOPY COVERS

The use of a good quality, clean, flannelette lined canopy cover will have a triple benefit by reducing the chances of minor scrapes and scratches, lowering the internal cockpit temperatures and reducing the Ultra Violet light in the cockpit. Reducing the amount of UV light will have a positive effect on harness life and reduce fading of cockpit linings.

A poor quality or dirty cover can reduce the life of a canopy. An ill-fitting cover will rub on the canopy when the wind blows causing a build-up of static electricity. The static electricity then attracts dust which acts as a grinding compound between the canopy and the cover resulting in scratches. Lycra stretch fit covers work well. But grit can get under it and movement then scratches the canopy. Other composite covers work or to different degrees. Take care and care of your cover.

7.2.4 HANDLING OF CANOPIES

The correct handling of canopies is vital to their life span. Canopies must NEVER be lifted by the clear view panel as this places stress on the Perspex in an area where there are significant stress raisers.

Where the manufacturer has not provided obvious handles, it is recommended that these be installed so that pilots and passengers do not have to lift the canopy on the Perspex.

7.3 REPAIR OF PERSPEX

The concept of repairing Perspex is quite straight forward however even simple repairs take a significant amount of time and if the inspector does not take special care at each step then a poor repair will result. If the optical qualities of the repair are not good enough then the canopy will need to be replaced.

7.3.1 CUTTING PERSPEX

Before cutting Perspex it should be warmed to at least 20°C. This will soften it enough to reduce the chance of the Perspex chipping or cracking.

The saw should have at least 14 teeth per inch, finer saws should be used on very thin layers, and the Perspex should be held firmly to prevent vibrations which can cause cracking. The saw should be worked through the material allowing the saw to cut the Perspex at its own pace. Do not try and force the pace by pressing hard.

The cut surface should be polished smooth to remove all notches which may cause cracks.

7.3.2 CRACKS IN PERSPEX

The brittle nature of Perspex makes it very susceptible to cracks. If cracks are left unattended they will grow in a very short time to the point where the canopy will have to be replaced. Once a crack is identified the end of the cracks should be stop drilled immediately.

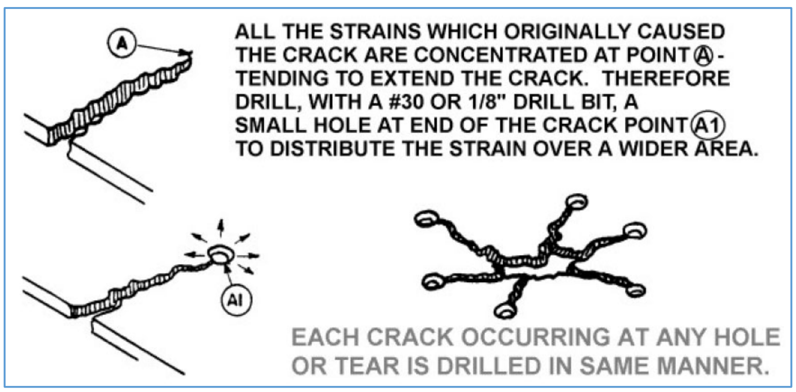


Figure 7-1 Stop Drilling

7.3.3 DRILLING PERSPEX

Stop drilling eliminates the stress concentration effect at the end of the crack and, if done properly, should prevent further crack growth provided the overall strength of the canopy bubble is not compromised. The area just in front of the visible crack will be affected by the crack and so the hole should be drilled just past the end of the crack. For all but the smallest cracks the hole should be about 3mm diameter. The hole must be drilled with a specially sharpened drill or else the drill will chip the hole, creating stress risers which cause more cracks to form, often in several new directions.

Before drilling Perspex the drill must be specially sharpened so that it scrapes away the material rather than cutting it. This achieved by regrinding the tip with a zero rake angle as shown in the picture below. Or an easier way is to dull the sharp cutting edges or use old drills to SCRAPE, not cut.

Before drilling the canopy perform some test drills on scrap Perspex to ensure the correct technique is being used. Like all drilling, a light pressure should be used allowing the drill to do the work. Pushing hard on the drill is likely to result in cracked or broken Perspex.

Refer to: AC 43.13-1B Change 1. Acceptable Methods, Techniques and Practices Aircraft

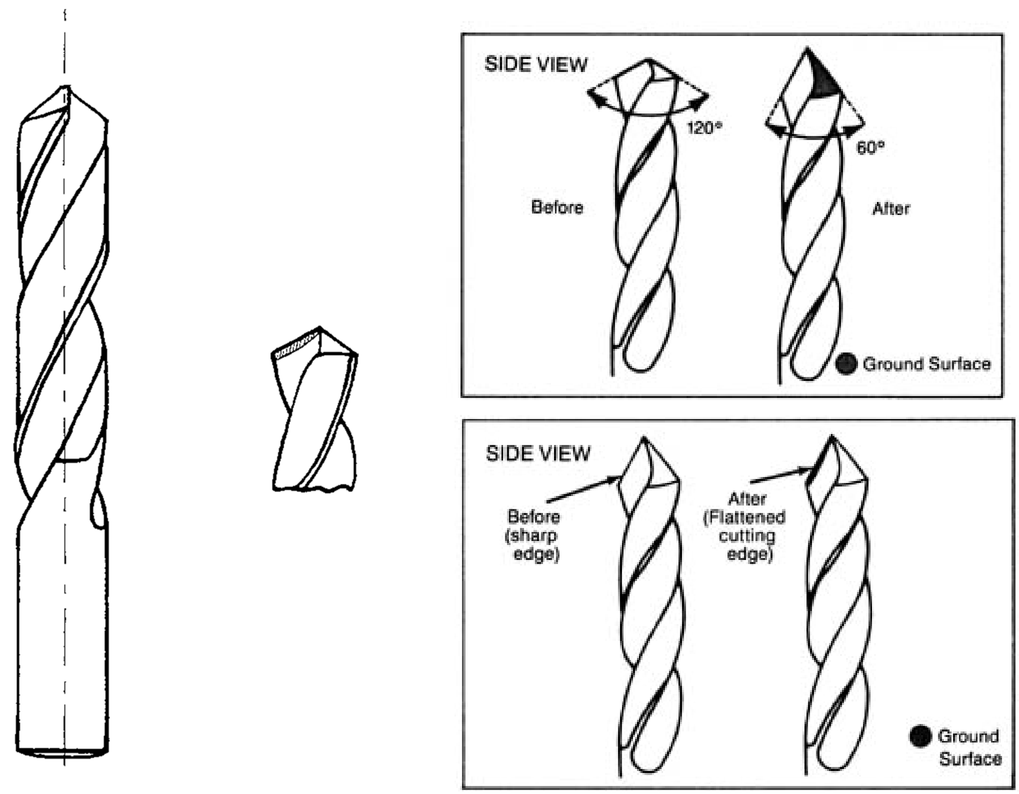


Figure 7-2 Correct Sharpening Of Drill For Perspex

Ref: http://www.plasticsmag.com/features.asp?fIssue=sep/oct-01

Clamping a piece of wood to the Perspex material and drilling through into the wood can eliminate chipping on the backside of drilled holes. Start drilling the warmed Perspex with slow speeds and light pressure. Increase speeds and pressures as you progress. As the drill bit starts to go through the canopy, reduce the speed and pressure so that the drill bit penetrates through slowly. It is important to deburr both sides of the holes lightly with a machine countersink. No hole should have a sharp corner. (source vansaircraft.com)

There are many other views on drill bit sharpening. Consider these but in any case test, practice, and take care. A canopy is a precious item that is hard to repair and is expensive.

7.3.4 PERMANENT REPAIRS

Stop drilling a small crack will stop its growth for a while however if the crack is left for long enough it will inevitable begin to grow again. If the crack is large enough to allow relative movement between the sides then the crack should be repaired immediately as stop drilling will not stop the crack growing.

Regardless of the size of the crack the first step is to drill the end. This will redistribute the stresses and help the repair last longer. The hole should then be plugged. This is done by gluing a small length of Perspex rod into the hole. The hole should be drilled the same size as the stock rod and the end of the rod is then dipped in a Perspex solvent. The rod is then pushed into the hole and left until it sets. The rod is cut to length and blended in during steps g and h of Section 7.3.4.2

7.3.4.1 SOLVENT CEMENTS

As a solvent the following materials should be used or a proprietary Perspex solvent obtained from your Perspex supplier.

CAUTION

Perspex solvents may be toxic and dangerous to use. Follow safety direction on the solvent container. Use only in a well ventilated area and wear gloves and safety glasses as a minimum.

7.3.4.2 REPAIR OF CRACKS

To repair a small fine crack a small amount of solvent should be placed on the crack and allowed to move into the crack by capillary action. Larger cracks should be repaired by using Acrifix 92.

The canopy can be repaired as follows:

a. Cut out a 60° vee in the affected area as shown in the figure below with a chisel or similar tool using a scraping action, leaving a small-gap at the bottom of the vee. Keep your fingers, dirt and grease away from the vee. A wipe with methyl dichloride will help clean the joint.

Figure 7-3 Vee Cut into Perspex

b. Using multiple layers of tape or other suitable damming material, build up each side of the vee to retain the cement.

c. Tape along the underside of the vee covering the gap which need only be 0.5mm, no more.

d. Apply the Acrifix 92 to the vee, filling the vee and dam completely. Be careful to not trap air under the cement as you lay it in.

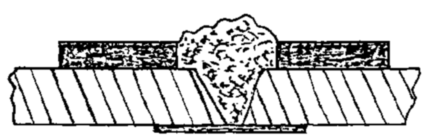


Figure 7-4 Gluing Technique

e. Acrifix 92 cures under UV light so it must be left to cure in sunlight or under a UV light source.

f. If during curing the natural shrinkage reduces the cement to a lower level than the top of the vee, refill with Acrifix 92 to the top of the dam.

g. After 24 hours of curing, using a scraper reduce the build-up to the level of the Perspex.

h. Polish starting with 600 grit paper and ending up with a fine polish. To achieve the best results use the Micro-mesh method to polish the canopy (see the section below Finishing Polishing).

i. Acrifix cures clear, and the only evidence of the repair is usually the bubbles you couldn't get out.

7.3.5 WARNING - DAMAGED CANOPIES

WARNING

Canopies can generate high air loads. If a repair is extensive and its failure in-flight could influence the pilot's safety then a new canopy should be fitted. We have had canopy failure blamed for accidents in the past.

7.4 FINISHING-POLISHING

Canopies which have a small amount of scratching may be rejuvenated by using a canopy scratch remover. This is a slightly abrasive polishing compound which grinds away the surrounding material until the scratches are gone. Special care should be taken when using these polishes as excessive pressure may cause the Perspex to locally overheat and warp out of shape.

Canopies which have significant scratching or which have been repaired require more work. The best method is to use the 'Micro-mesh' system to actually sand the surface to remove deeper scratches. The system begins with 1500 grit paper (sailplane wings are normally finished to 1200 grit) and finishes at 2000 grit.

Mechanical polishing of canopies may be performed by experienced persons however inspectors who have little experience should carefully weigh up the cost of a new canopy with the potential time saved. A mechanical polisher will quickly overheat the Perspex if left in the one place for even a few seconds.

7.5 MECHANICAL ATTACHMENT OF PERSPEX

The fitment of canopy bubbles to the canopy frames is outside the scope of normal inspection work. Fitment of any canopy bubble to a frame (metal or composite) requires a repair authorised person. The sailplane inspector's role is to ensure that the canopy bubble is airworthy and securely attached to its frame.

On metal frames such as IS sailplanes and Blaniks, check that the Perspex is securely attached to the frame. Check for looseness of the securing screws and/or rattling of the Perspex in its frame. Gently tighten any loose screws or bolts being sure not to over-tighten any screws or bolts as the pressure can easily crack the Perspex.

On composite frames, check for cracks in the frame that may indicate that the Perspex is de-bonding from the frame. Check for voids or gaps between the frame and the Perspex that may indicate that the Perspex is de-laminating or separating from the frame

7.6 CANOPY JETTISON MECHANISMS

A correctly functioning canopy jettison mechanism is vital to the airworthiness of the sailplane even if it is intended that the sailplane will never be flown with a parachute. Even in a relatively minor accident the ability to jettison the canopy to access an injured pilot could be vital.

For this reason the jettison mechanism must be functioned at each Annual Inspection. Any moving parts must be lubricated (unless they are designed not to be lubricated) and the mechanism must be rearmed. The maintenance manual for each type should be consulted for specific details.

To reduce the risk of inadvertent operation without precluding intentional operation then a method of using a clear worded placard, a cover, or other protection is permissible. If using a lock-wire then soft wire, such as fuse wire, should be used. The person installing the wire must perform a function test to ensure that the locking wire can be easily broken. Alternatively, a placard that is breakable could be used to seal the control but not prevent easy operation.

7.7 CLEARVIEW PANELS

The clear view panel (it is a lot more than an air vent) is required to be fitted to each sailplane in a response to certain conditions which can cause instant and complete fogging of the canopy during the early stages of the climb. This occurs when the sailplane has sat overnight in very cold air and the airframe has ‘cold soaked’. As the sailplane climbs through the inversion into a warmer and moister layer of air the moisture instantly condenses out and blocks all vision. The only way for the pilot to see is to look through the clear vision panel.

The sailplane inspector must therefore ensure that a clear vision panel is fitted and functions properly.

8. SAILPLANE SEAT HARNESS

8.1 INTRODUCTION

This section presents information on pilot seat harnesses and their applicable inspection procedures. MOSP 3 Section 13.2 defines the mandatory maintenance requirements.

The two main functions of the seat harness are:

a. To firmly restrain the pilot in the sailplane under normal flight loads resulting from both manoeuvring and gusts, and

b. The “once in a lifetime” function to restrain the pilot during ground impact in an accident.

To be able to deliver these functional requirements the harness must:

a. Be readily adjustable by the pilot in flight without excessive hand forces,

b. Not have the harness adjustment slip or the buckle attachments detach under load, and

c. Always be in top condition.

For each seat, safety belt, and harness, its attachment to the structure must be shown, by analysis, tests, or both, to be able to withstand the inertia forces prescribed in the standard that the sailplane is designed to. For CS 22 (CS 22.561) these design loads are:

a. Upward 7.5 g

b. Forward 15.0 g

c. Sideward 6.0 g

d. Downward 9.0 g

This mean that a human body weighing 110 kg loads the webbing and seats to the equivalent of 1650 kg in the forward direction. All components of the harness must withstand these loads. Fittings attaching webbing to structure have additional factors of safety applied. For CS 22 (CS22.625), the design loads are multiplied by a fitting factor of 1.33 and the harness attachments are loaded to the equivalent of 2195 kg in the forward direction.

To ensure this level of strength the inspection procedures on harnesses will need to be adhered to very closely.

Research studies suggest that higher loading is within the capacity of most people to survive and so future requirements may dictate that harnesses should be strong enough to withstand loads up to 25 g such as with aircraft used for agricultural use. To ensure this level of strength the inspection procedures on harnesses will need to be adhered to very closely.

WARNING

The harness is an **essential** part of occupant protection during a sailplane crash event. It must be in good condition and properly maintained so that during a crash it does its job perfectly, otherwise the pilot may be severely injured. Re-webbers are closely controlled by CASA. We must use CASA approved re-webbers who use approved parts, approved procedures, and do the job correctly. Refer Section **Error! Reference source not found.** below for more details.

In recent years, changes in webbing have occurred and this may not be compatible with old fittings. Testing showed some slipped at half the load required. You may be able to use your old buckles but you may need to change the length adjustment fittings. Also sailplane harnesses often require shorter stitch patterns which need special testing. GFA has arranged testing and approval of this. Please contact the CTO for details and approvals that your rewebber can use. Ensure the rewebber knows and follows approved procedures and is not doing you a cheap job!

ADs exist on harnesses, usually buckle defects. You must find these and resolve them.

8.2 HARNESS FUNCTIONAL PERFORMANCE

There are many factors affecting how well people are restrained in a sailplane. These include:

a. The design of the webbing straps (webbing material, stitching patterns etc),

b. The condition of the webbing,

c. The condition and functionality of the buckles, and fittings,

d. The ease in length adjustment and the holding against slippage,

e. The correct installation of the harness in the sailplane, and

f. The type of cushions used.

8.3 HARNESS WEBBING

Like any woven material, harness webbing has threads running along the strap and threads running across the strap, these are called the warp and weft directions respectively. The warp threads provide the strength of the strap and the weft threads hold the strap together.

When webbing is loaded the load tends to concentrate towards the edge of the material as shown in Figure 8-1. This is why frayed edges on the webbing are so detrimental to the strength of the webbing and webbing with frayed edges must be replaced.

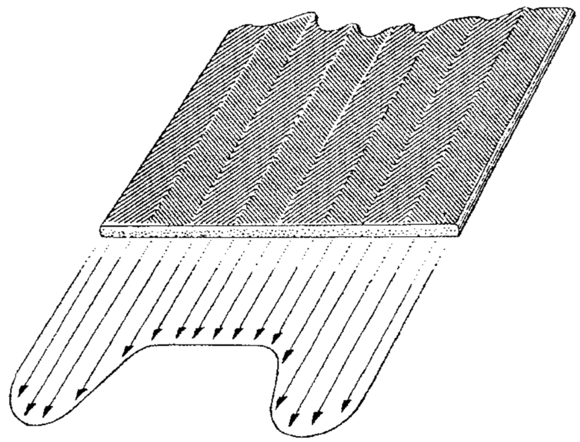


Figure 8-1 Load Distribution in Webbing

The harness must distribute the acceleration loads as evenly as possible on the body. To do this the harness needs the maximum area of contact with the body and to achieve this some manufactures install large abdominal pads on the lap strapss of their harnesses. Where these have been fitted they should be in good condition without losing their stiffness and any worn or soft pads should be replaced.

8.3.1 WEBBING CONDITION:

The condition of the webbing is critical to the performance of the harness.

In contrast to a low total hours per annum private sailplane, a high utilisation training sailplane will have much higher hours and cycles leading to more UV exposure, and webbing surface wear at metal fittings and attachment points.

Chafing on the metal fittings causes surface fibre damage, which decreases the strength of the harness. This should be repaired by rewebbing either immediately,or within a short time according to circumstance. Fraying at the edges is particularly critical. Where the harness chafes on the sailplane's structure, consider fitting sacrificial rubbing sleeves over the straps.

Due to the harsh ultraviolet (UV) light environment and/or high sailplane utilisation, the harness may deteriorate or wear quicker and require more frequent webbing replacement. Webbing life limits must be complied with. Prematurely worn, faded or deteriorated webbing shall be replaced when found.

You must check that the adjustment of the harness length works without high hand forces. As an illustration, one defect report stated the harness webbing had to be scrapped having failed this requirement after 6 years installation. The use of slightly thicker webbing when rewebbing the harness, together with the narrow slot in the webbing length adjuster clip, led to the webbing surface furring up and blocking the slot. The harness adjustment was very difficult and beyond what a crew person could reasonably manage in flight.

Webbing in sailplanes with a rear canopy half which stands erect when open (eg. Hornet, ASK-21) can have the sun's rays concentrated by the erect rear canopy onto a small area such as a shoulder harness strap leading to damage due to excess heating of webbing fibres or even burn marks.

8.3.2 WEBBING CLEANING

Maintain the webbing in good condition by keeping it free of harmful contaminants. Therefore, at each 'Form 2' inspection consider if the harness webbing needs washing to remove contaminants. Refer to the harness manufacturer's instructions regarding safe washing practice. In the absence of such instructions the following advice applies.

Clean the webbing only when there is sound reason to do so, such as to remove excessive dust & dirt, salts from sweating, mould, oils or greases and occasionally vomit (acids). The important protective finish on the surface of webbing fibres can be adversely impacted by excessive washing with inappropriate cleaning products and/or excessive mechanical abrasion. Carelessly conducted washing is counterproductive by reducing strength and harness life, increasing wear, and can adversely impact the way the harness performs under load.

If washing is required, use a sponge together with clean luke-warm water (never hot) and ordinary mild soap so that the water is neutral pH, ie. neither acidic or alkaline. Note that nylon materials respond adversely to any acidic substances, whereas with polyester, alkalis have an adverse effect.

Do not use a bristle brush in order to avoid mechanical damage to fibres. Following washing, rinse with clean water, and leave the webbing to air dry without heat. Avoid exposing metal fittings to water as much as possible. The central buckle must not become wet with cleaning media (water/soap) at any stage. Reinstall only when all parts are completely dry. If the metal fittings need cleaning, then use a cloth with iso-propyl alcohol and apply this ONLY to the metal fittings.

8.4 HARNESS LIFE LIMITS

The life of a harness is specified in MOSP 3 Section 13.2.

8.4.1 AGING OF WEBBING

In the early 1970's experiments began to establish the effect of aging on harnesses. The effect of ultraviolet (UV) light, as well as some other environmental factors was established. Experiments show that the main environmental causes of the decline in the strength of synthetic webbing are UV light, temperature, humidity and the oxygen content of the atmosphere. Of these, UV light is the major factor.

In Australia, harnesses in sailplanes are subjected to high levels of UV light. A case study was carried out at ARL on an 11 year old harness with the following results:

Harness type	Early model Gadringer
Sailplane type	AS-K 13
Time in service	11 years, 2000 hours.
Strap	**Breaking load**
Right shoulder	550 kg
Left shoulder	500 kg
Right lap	1122 kg
Left lap	1428 kg
Original webbing strength	2000 kg

Table 8-1 Harness Breaking Load With Age.

The shoulder straps have a larger reduction in strength due to the high exposure to sunlight compared with the lap straps. Webbing used in light aircraft suffers from UV during long term outside storage, whereas with sailplanes the webbing suffers from UV exposure under bubble canopies. So consider what factors are at work increasing UV exposure in each case and replace webbing when inspection reveals this as necessary .

8.5 BUCKLES AND STRAP END FITTINGS

The strap metal end fittings engaging in the buckles must be stronger than the webbing, be in sound functional condition and be subject to close inspection for wear, corrosion, deformation and loss of surface finish such as chrome plating.

Damage to the chrome plating is particularly dangerous as the flaking chrome is sharp and may cut the webbing. Harness fittings which have been re-plated must be viewed with suspicion unless they have been re-plated by an approved organisation and have a release note stating that the components have been re-plated to an approved procedure. There is the danger of hydrogen embrittlement which cannot be detected using non-destructive techniques and can potentially result in strength loss sufficient to cause metal components to shatter when dropped onto a very hard surface. If faced with plating issues, then it is strongly recommended to replace the fitting(s) with new because this is relatively cheap and certainly effective.

8.5.1 QUICK RELEASE BUCKLE

All harnesses must have a central quick release feature where one action releases at once all the straps end fittings inserted into the central buckle, or as interleaved centrally together in the case of early harnesses.

Quick release buckles shall be checked for correct operation and demonstrate:

a. Positive locking. Of particular importance for some quick release buckles is that the correct webbing end lug is inserted to the corresponding location around the buckle periphery.

b. Immediate and clean release of all the strap end fittings when the control knob or quick release mechanism is activated. However, the quick release should require positive force to activate and not be on a “hair trigger”. At least one accident is suspected to have been caused by a quick release being activated unintentionally by the pilot because it required too little force to open.

c. No inadvertent release of any webbing strap ends.

d. Smoothness of operation without any signs of jamming.

e. Any springs to return the control knob to the closed position.

f. No evidence of significant wear.

g. The release control for separate disengagement of the shoulder straps (if fitted) shall function correctly.

Best practice is to carry out a function test with a person actually sitting in the seat to ensure the quick release unit functions correctly in fastening and unfastening modes.

Failure of the central buckle on any of these points requires that the harness be replaced before further flight with a serviceable harness. Then the buckle can be replaced or repaired before returning the harness to service. Repair, if practical, must be carried out by an approved service organisation or the manufacturer. Please report such defects via an SDR to the CTO because such problems can have broad implications.

Some modern harness quick release buckles have the facility to release the shoulder harness independent of the lap straps. It is highly recommended, particularly for aerobatic sailplanes, that this facility be disabled if the harness release manufacturer or GFA has approved data for this action. For Gadringer-Gurte harnesses, refer instruction 38 dated 9 June 2015, or later edition, on their website.

If the quick release buckle incorporates a separate release control for releasing only the shoulder straps, then that release control must be checked for operation. It **must not** release on a ‘hair trigger’ action but be positive in operation and must not release the lap straps either on shoulder strap disengagement or when the shoulder strap ends are re-engaged.

8.6 LENGTH ADJUSTERS

Length adjusters typically operate by the webbing wrapping over a sliding cross bar (slider). The tension in the webbing pulls down on the slider which then clamps down on the tail / free end of the webbing. Whilst the clamping provides a significant amount of the grip of the length adjuster on the webbing that prevents slippage, a portion comes from friction of the webbing wrapping around the slider under tension. Quite often there is a thin wire spring that provides pressure to the slider to keep it in the clamped position if there is insufficient tension in the webbing.

On occasion, the thin wire spring has become dislodged from the adjuster assembly. This has allowed the webbing to slip in flight. In one case a harness lap strap came loose during a high speed final glide and the pilot struck their head on the canopy during turbulence.

Figure 8-2 Wire Spring on Length Adjuster Slider of a Gadringer Harness. The Two Images on the Right Show Displaced Springs

It has been found that some length adjusters have been disassembled for cleaning and then incorrectly reassembled. In some cases the slider has been installed upside down.

Figure 8-3 Length Adjuster Slider Installed Upside Down in a Gadringer Harness

The slider bar also has a specific cross section which is important for maintaining harness tension. Incorrect orientation can cause “micro-slippage” where the webbing eventually becomes loose over time despite appearing to hold load over a short time. The curved face must be where the webbing wraps around the slider and the sloping face must be towards where the slider clamps onto the webbing.

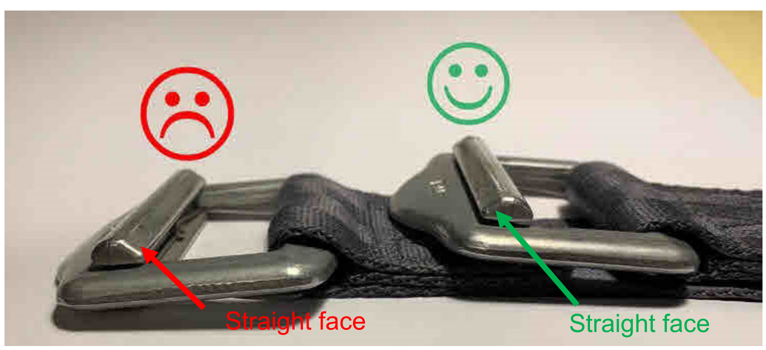


Figure 8-4 Incorrect and Correct Orientation of Slider on Gadringer Harness

8.7 HARNESS INSTALLATION

The installation of the harness can have a significant impact on its ability to function properly, particularly in a crash. Beware of assumptions when inspecting the installation or when installing harnesses. The central buckle always has one lap strap permanently installed in a specific receptacle location around the buckle periphery. While in most cases the harness will be supplied with that lap strap orientated for the port side anchor point, beware as orientation to the starboard side is found occasionally. The buckle has an upright orientation and must not to be installed upside down.

The installer may falsely assume that this fixed lap strap always goes to the port side anchor point. If a fixed lap strap orientated for the starboard anchor point is installed to the port side, then the buckle will be upside down. This can lead to the three remaining belts being fitted by the pilot to the wrong insertion points around the buckle periphery thus reducing or negating safe harness performance.

This is an issue with harnesses with a circular periphery to the buckle, such as with Schroth. If a club fleet has these harnesses widely installed and a mixture of port and starboard attachments, it is recommended to standardise on port side attachment. There is a procedure for changing over starboard to port in the Schroth harness manual.

On some harnesses it is not immediately clear which strap is for the shoulders and which strap is for the lap. However, the fittings that connect to the buckle will differ and may affect the performance of the harness under load if the wrong fitting is inserted into the wrong slot of the buckle. In one example during a Daily Inspection on a club two seat sailplane, it was discovered that the rear seat left hand lap strap would disengage from the rotary buckle under applied load. The shoulder strap end tangs were of a different shape to the lap strap end tangs. The shoulder strap ends will not successfully engage the buckle if used in the lap strap location. Note that the harness manufacturer's manual specifically states a WARNING relating to the positioning requirements. It was clear that the straps from both seats had been shuffled around after cleaning during an annual inspection.

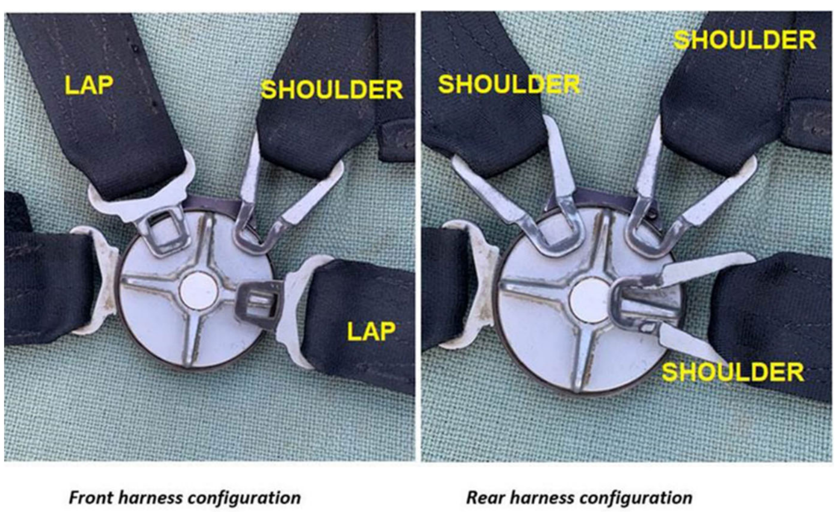


Figure 8-5 A Two Seat Sailplane With Incorrect Harness Installation

8.7.1 HARNESS ATTACHMENT TO FUSELAGE

Correct wrapping of webbing around the fuselage attachment points is critical and the attachments must be serviceable by examination for wear, damage, distortion, delamination or structural cracking.

With some sailplanes it is possible to attach the harness incorrectly such that the attachment might fail in an emergency. Figure 8-6 shows how this is possible with the shoulder straps of an Astir. The correct method is to loop the webbing around the crossbar. The thin wire prevents the webbing sliding along the crossbar, it is not the attachment point! Similarly, Figure 8-7 shows a crotch strap from a 5 point harness fitted to an ASK-21 where the strap has been attached to the thin sheet metal intended to prevent the strap from sliding along the structural tube.

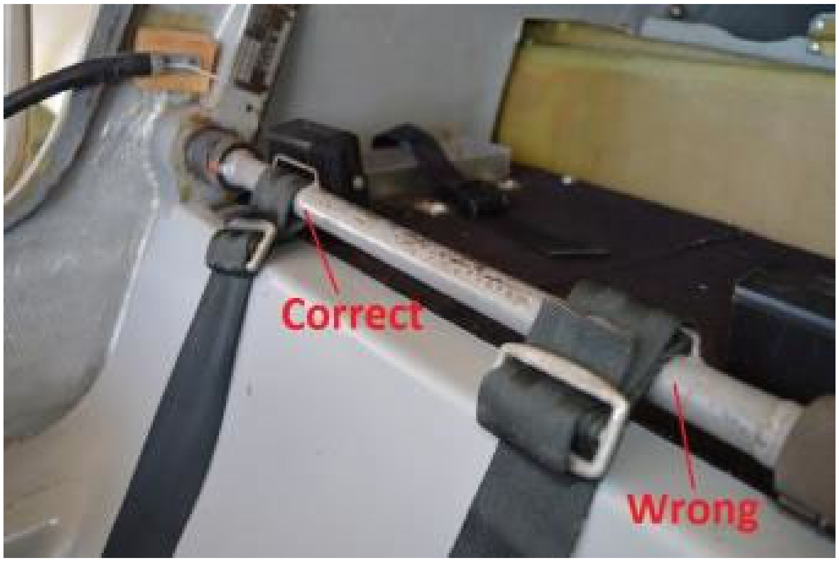


Figure 8-6 Example of Harness Attachment Error

Note in Figure 8-6 that the doubling back of the strap tail through the three-bar clip, if it can be achieved, is an effective way of reducing slippage.

Figure 8-7 ASK-21 Crotch Strap (from 5 point harness) Wrapped Around Locator Rather Than Main Structural Tube

8.8 HARNESS REPLACEMENT AND REWEBBING

Safety harnesses may only be rewebbed in accordance with MOSP 3 Section 13.2. All replacement harnesses, whether rewebbed or new, must have a release note from the approved organisation performing the rewebbing work (CASA Form 1) or, if new, from the manufacturer (usually an EASA Form 1). This release note goes into the sailplane's maintenance records and must be kept with the logbook records folder. The release note reference & number is entered in the logbook entry together with the inspector's certification for harness installation.

It is mandatory that sailplanes manufactured after 30 August 1980 are fitted with 'pull up to tighten' lap straps. It is very strongly recommended that all sailplanes are similarly fitted with 'pull up to tighten' lap straps when the harness is next replaced or rewebbed.

Like new harness webbing, all rewebbed straps must have a label identifying:

a. the company performing the rewebbing or repair work,

b. the part number if there is such identification in their document system,

c. the webbing serial number, job number or rewebbing work order number, and

d. the date of manufacture (DOM) and/or the date of webbing life expiry.

The CASA standard may also be listed, but it is not always found.

This information shall be printed in waterproof ink onto a cloth patch and stitched to the strap in a durable manner, possibly including a clear flexible plastic cover. If the harness does not have this identification and does not have a logbook entry as to when it was fitted, then the webbing should be rejected as it is not possible to know its history.

When putting a harness out to a reweb organisation, it is recommended to make a photo record, and:

a. prior to sending, record the webbing thickness (undamaged), width and lengths, and specify that the new webbing be like for like so that it is compatible with the hardware,

b. ask the reweb organisation if they need to see the whole harness with all its hardware, even if It is only a single shoulder or lap belt needing attention,

c. ensure that the webbing lengths are fit for purpose and communicate the length specifications clearly to the rewebbing organisation or manufacturer. Copying the old harness may be valid but it is very worthwhile considering whether the old harness lengths were indeed suitable, and

d. require the lap straps be sewn with ‘pull up to adjust’ operation if that is not already the case, and

e. specify that the webbing free ends are not simply cut with a hot knife but instead folded back on themselves and sewn so as to make the ends bulky.

Later check the work when the harness is received back and prior to reinstallation:

a. Thin webbing or more slippery material may slip through the fittings and not tighten properly as has been found occasionally with newly rewebbed harnesses.

b. Thicker webbing may be supplied with insufficient consideration of the narrow gap in the length adjuster such as with Schroth harnesses.

c. Other mistakes in rewebbing have occurred such as locking tabs sewed on the wrong side.

Quite a bit of variation, particularly in length can be found between harness used in the same sailplane type. Figure 8-8 shows the differences between harnesses from 2 different Grob Astirs.

Figure 8-8 Variations in Harness Lengths **for the** Same Type of Sailplane

The harness with the red tabs was a newly manufactured harness which had been fitted to an Astir. After a few flights, the lap straps detached from the attachment points during pilot strapping in. Investigation found that the lap strap tails were so short that there was insufficient material to fold the tail back on itself and permanently stitch it. The thin webbing tail was able to slip through the three-bar clip at the attachment to structure.

Also, the shoulder straps had insufficient length to adjust for large pilots such that on strapping in the buckle was pulled up and would not allow the lap straps to sit low on the hips as required. Even for an average size pilot, there was not enough shoulder webbing length to grip to pull down for tightening. When the new straps were compared with those from another Astir, the difference in dimensions was very noticeable.

8.8.1 HARNESS REPLACEMENT AFTER ACCIDENTS

It is not permitted to re-use any harness that has been recovered from a serious accident where it is likely that it has been loaded over the rated strength or the residual strength following years of use. The harness is a fundamental piece of safety equipment, and it must be treated as such. All harnesses recovered from an accident should be destroyed unless it can be established beyond doubt that the harness is serviceable, such that the inspector is completely satisfied that the harness or seat belt was not subject to any abnormal loads. If the sailplane is being rebuilt following an accident, it is strongly recommended that new harness(s) are fitted.

8.9 CUSHIONS

The cushions used with the harness also have a large influence on harness performance. Seats with excessively soft cushions are compressed under acceleration. As the foam is compressed the webbing comes loose and the body "submarines" under the belt. When the acceleration stops, the foam then rebounds as shown in Figure 8-9, resulting in possible injury to the abdomen, internal organs and spine.

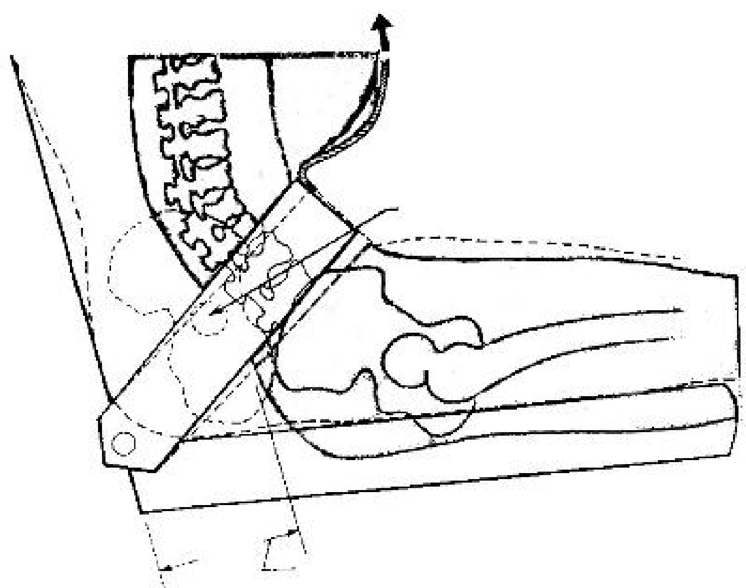


Figure 8-9 Pelvis Rotation and Submarining

Energy-absorbing seats, seat cushions or seat mountings constitute another means of improving safety by reducing the load on the occupants' head and spine in a crash and /or landing with retracted wheels (Refer to CS 22.561(c)). Two commercially available materials which are known to be effective in sailplane cockpits are Confor (CF45/CF47) and Dynafoam.

Tests in England (refer to Doctor A Segal) have indicated that substantial reductions in spinal g loading can be achieved by the use of the correct foam while the g experienced by the spine is actually increased by the use of soft foam compared to a bare seat. The best results were found by combining 25 mm of hard grade low resilience foam with 12 mm of medium grade low resilience foam for comfort. The medium foam is placed above the hard foam and the sandwich is upholstered to prevent damage by UV light and abrasion.

It is recommended that the foam cushion be as thin as possible as this reduces the loosening of the harness under acceleration and therefore reduces submarining.

1.1.0 WEBBING CONDITION:

The condition of the webbing is critical to the performance of the harness. As stated previously, the load in the webbing is concentrated at the edges and so fraying is critical to the strength of the webbing.

Webbing also wears where it chaffs on the metal fittings. Webbing damage decreases the strength of the harness and should be repaired within a short time of being noticed. Where the harness chaffs on the aircraft's structure, rubbing sleeves should be fitted over the straps.

In order to maintain the webbing in good condition it must be kept free of harmful contaminates e.g. dirt, rust, salt and especially grease. It is therefore important to wash the harness webbing at each Form 2 inspection with mild soap and warm water, rinse and then allow to dry completely before re-installing.

1.1.0 FITTINGS

One predominant fact arising from gliding accidents in recent years has been the high proportion of harness fitting failures in comparison to harness webbing failures. The metal fittings must be stronger than the webbing and so the continued inspection of the fittings is important.

The fittings must be inspected for wear, corrosion, deformation and loss of surface finish such as chrome plating. Damage to the chrome plating is particularly dangerous as the flaking chrome is sharp and may cut the webbing. Also, the fittings may in time allow the webbing to slip and therefore prevent the harness from being correctly tightened.

Harness fittings which have been re-plated must be viewed with suspicion unless they have been re-plated in an approved organisation and have a release note saying that the components have been re-plated to an approved procedure. The reason for this is the danger of hydrogen embrittlement. Hydrogen embrittlement cannot be detected using non-destructive techniques and can result in strength loss sufficient to cause components to shatter when dropped onto a hard floor from a height of a few feet.

The release mechanism of the harness must be of the quick release type. If the buckle will not release properly, it is unserviceable and should be replaced or repaired before further flight.

A release that has the ability to release the shoulder harness separately must have that ability disabled.

1.1.0 AGING

In the early 70's experiments began to establish the effect of aging on harnesses. The effect of ultraviolet (UV) radiation, as well as some other environmental factors was established. The experiments show that the main causes of the decline in the strength of synthetic webbing are UV light, temperature, humidity and the oxygen content of the atmosphere. Of these UV light is the major factor.

In Australia, harnesses in sailplanes are subjected to high levels of UV light. A case study was carried out on an 11 year old harness with the following results:

Table 8-1 Harness Breaking Load With Age.

The shoulder straps have a larger reduction in strength due to the high exposure to sunlight compared with the lap straps. Webbing made for aircraft probably was not expected to get the UV exposure we give them in sailplanes. So we need to expect more frequent deterioration and replace them more often.

1.1 LIFE OF A HARNESS:

The life of a harness is specified by the manufacturer or by MOSP 3 Airworthiness, whichever is shorter.

8.10 ANNUAL INSPECTION

At the annual inspection, the harness shall be inspected to determine if it is satisfactory to continue in service ‘on condition’ for the coming 12 months, or if any repair or replacement actions are now necessary:

a. A readable manufacturer’s label shall be present on all webbing components and show that the webbing will continue to be within life limits for the next 12 months. If less than 12 months, but say 3 to 11 months usefully remains, then the required rewebbing action with latest action date must be written into the Maintenance Release Part 1.

b. Assess for significant webbing colour fade caused by ultra-violet light. Compare suspect areas to areas which rarely see sunlight.

c. Fraying. Any frayed webbing will cause a reduction in strength. It may also point to a defect in the harness end fittings, length adjusters or attachment to structure.

d. Consider if the harness webbing has reached the stage where washing is needed to remove contaminants such as mould, grit/dirt, oil, grease, etc. Refer to Section 8.3.2 on cleaning.

e. Stitching condition.

f. Stains on stitching or webbing may indicate chemical contamination and the need for cleaning.

g. Length adjusters. Check for ease of operation, locking facility (incl. springs) and no slippage when under tension. Look for wear, corrosion, contamination and incorrect reassembly.

h. Central buckle. Check for ease of operation, locking facility (incl. springs) and no release when under tension. Look for wear, corrosion, contamination and incorrect reassembly.

i. Installation. Check that the harness is installed securely to the correct structure attachment points. The webbing must not have any possibility of inadvertently coming detached. Check for structural issues at attachment points, such as cracking, FRP delamination, glue failure in timber, etc.

j. Webbing width mismatch. Webbing which is too wide for adjusters and fittings will bunch and not work correctly. Webbing too narrow may allow tilting and slippage of the adjuster.

k. Consider if the webbing lengths are functionally satisfactory for the range of occupants. Do any pairs of straps, lap or shoulder, need lengthening?

l. Pull up straps are present?

m. Seat cushions. They should be made from energy absorbing foam with minimal rebound. They should be anchored so that they cannot move and must not restrict control movement.

Following inspection, test the harness for function on buckling up and releasing with an occupant seated in the sailplane.

8.11 REFERENCES

Flying Safety Information. Harness - Safety through Knowledge. Braunschweig, 27-3-87.

CAA UK Safety Notice SN-2019/003 re Harness Integrity
British Gliding Association, AMP Part 4, Leaflet 4-8

“Is Pilot Insecurity a Problem at Your Club?”, Anthony Smith GFA CAD, Gliding Australia September 2020 via GFA website.

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British Gliding Association booklet, “Why you should fly with an energy absorbing safety cushion” 12 pages, second edition March 2017.
“Safety In The Cockpit, Cushions and Harnesses” by Len Diekman of GFA. - Via GFA website

Amsafe - Webbing Service Life Guidelines - April 2014

The Aircraft Crash Survival Design Guide.

9. OPTIONAL EQUIPMENT

9.1 GENERAL

Most of our sailplanes have equipment fitted and removed at regular intervals and provided care is taken this should not present any problems. Optional equipment is defined to be any item that can be added or removed from the aircraft without the need for tools. In more general terms equipment that you carry with you to the aircraft and place in the cockpit just before flight would fall under the optional category. Examples would be oxygen bottles in special enclosures found on DG aircraft, flight computers or mobile devices fixed with velcro in the cockpit or a tie down kit. Changing of a radio or flight computer that is normally permanently fixed into the instrument panel is not considered optional equipment. However, in some cases oxygen systems are semi-permanently installed and so would be classified as non-optional equipment. Removal of such an item could thus change the weight and balance.

There are no hard and fast rules about when a weight and balance calculation should be performed due to equipment change, so the following guides should be used to inform your decision.

Flight safety can be maintained if the following three areas of concern are given proper consideration:

a. Change in sailplane Weight and Balance.

b. Interference with Flight Control Systems.

c. Pilot Accident Protection

These three topics will be taken one at a time and their implications considered.

We are restricted by law in what and how we can alter an aircraft. Certified aircraft may only be modified with an Engineering Approval, Experimental aircraft may be changed but the GFA may need to be advised, and Light Sport Aircraft (LSA) may only be changed with manufacture's approval. This is obviously restrictive and we need to be sensible. GFA have therefore created some new rules to help you free this up and make sure what you do and how you do it is safe and correct. So refer to MOSP 3 Clause 18.7 "Minor Changes Not Requiring Approval" and related sections on what you can and cannot do. Another set of rules allowing changes are given in MOSP Part 3 AIRW-M15 "Permissible Unserviceabilities". These allow you to do what is sensible and restrict or guide you on what is risky. Be sensible.

If in doubt get an engineer to approve it. GFA has engineers to assist you.

9.2 CHANGE IN WEIGHT AND BALANCE

Fitting of non-optional equipment is a matter for an Annual Inspector, but may require additional signoff from a Weight and Balance certified inspector. Typically these equipment changes will be for instruments. So long as the instrument weight change is kept under the 1kg mark, typical weight and balance should not be affected enough to warrant needing a recalculation of W&B.

When considering changing equipment, the following must be looked for:

a. C.G. movement too far rearward.

b. C.G. movement too far forward.

c. Reduction/increase of maximum allowable pilot weight.

d. Increase/reduction of minimum allowable pilot weight.

e. Decrease/increase of weight of non-flying parts.

See rules in MOSP 3 Clause 20.2.3 –Definition of significant change in weight and balance.

Some sailplanes use batteries and radio equipment mounted either well rearward or well forward as fixed ballast to control the Centre of Gravity travel. Removal of these items can result in a pilot accidentally flying outside of his allowable limits. In cases like this, the sailplane MUST be PLACARDED "Not to be flown without tail battery", etc.

The logbook maintains the history of the weight and balance, and should be consulted and updated each time changes are made. The record will include all the fittings at the time, including instruments etc. When you consider that in some cases over 30kg of additional weight is accumulated between instruments, oxygen systems, tie down kits and so forth, keeping track of equipment fitted and removed plus weighing after re-painting or repairing, is extremely important.

Be absolutely certain you understand the situation. For instance most sailplanes have the pilot forward of the CoG and so a minimum pilot is critical to spin recovery. But in very few the pilot is behind the CoG and so the max pilots are the critical case. Likewise fuel may allow it to take off but as the fuel runs out the CoG changes. Don't chance it.

9.3 EQUIPMENT CHANGES - PLACARDS

Where it is intended to fly with and without particular equipment, for instance oxygen, (a system could be shared by several aircraft) then there must be two sets of placards in the cockpit to cover allowable pilot weights in both cases.

9.4 INTERFERENCE WITH FLIGHT CONTROL SYSTEMS

It is of the utmost importance that optional equipment does not interfere with flight control systems, and two cases must be considered:

a. Simple interference by being fitted into the wrong position.

b. Displacement during loading generated by extreme flight manoeuvres, or ground impact.

A case history -

"A sailplane went through a Certificate of Airworthiness Inspection at the completion of which a dual control inspection was carried out prior to the pilot accepting it for test flying.

As part of the cockpit check the pilot felt the need to check rudder travel with the ADJUSTABLE pedals first fully back, then fully forward. In the fully forward position he applied FULL RIGHT RUDDER and found it impossible to bring the rudder back to the central position.

The rudder pedal was caught on a RADIO installed through the instrument panel".

9.5 PILOT INJURY PREVENTION

When fitting optional equipment, safety of the pilot should be the utmost consideration. Gliding operates in a turbulent atmosphere, by nature, so poorly secured equipment can become internal missiles very quickly. Almost all sailplanes will have something stored behind the pilot's head - batteries, water bottles and tie down kits are typical examples. A hammer and pegs in a tie down kit can be fatal if it breaks loose in flight. Even a rapid shift can temporarily daze the pilot if hit in the wrong place - leading to potentially fatal consequences.

The following section will enable you to calculate the design strength and the test loads of the restraint required.

9.5.1 EQUIPMENT RESTRAINT

Restraint of equipment must be designed such that under maximum flight or emergency landing loads the equipment will not move or break free of its restraints. Consider these cases:

a. Equipment in the front panel and nose ie ahead of the pilot (s): This equipment must be restrained to maximum flight load factor the sailplane is certified to (these flight limit "G" values are shown in the Flight Manual and refer to Section **Error! Reference source not found.** for flight envelope) multiplied by 1.5. For example: if a type is certified as "Aerobatic" under CS-22 then the equipment must be designed to not move under: Positive (downward) = 7G x 1.5 = 10.5G, Negative (upward) = 5G x 1.5 = 7.5G.

h. Equipment behind the pilot(s): This equipment must be restrained as above, but because it could strike the pilot(s) in the event of ground impact it must be designed to be restrained for 15G loading forward.

b. All equipment should be designed to withstand 6G loading sideways and 9G rearward.

9.5.2 JUSTIFYING THE STRENGTH OF A RESTRAINT

The justification of the strength of a restraint for a piece of equipment in many cases can be achieved by design calculations. However, it is often more practical to test the restraint by applying proof loads to the item. The proof loads are 2/3 of the design load.

Direction	Proof Load
UPWARD	5G
DOWNWARD: Utility category Aerobatic category	6G 7G
FORWARD	10G
REARWARD	6G
SIDEWAYS	4G

Table 9-1 Equipment Proof Loads

All proof loads must be applied through the CG of the restrained equipment. The proof loads must be held for at least 3 seconds. The restraints and surrounding structure must be inspected afterwards and must not show any signs of damage or deformation.

Any damage found in the sailplane supporting structure after the proof load must be repaired and is considered a failure of the design. Damage or deformation of the restraint structure is also a failure, and the design needs to be reconsidered.

The REARWARDS load may be difficult to apply in some situations and can be validated by comparison if the FORWARD test was successful and the restraint design is symmetrical in the fore-aft direction ie the design is such that it does not matter if it faces forwards or backward. Similar applies to the SIDEWAYS test. If the design is symmetrical in the port-stbd direction, the SIDEWAYS test only needs to be applied in one direction.

Once the restraint design has been proven, the Annual Inspector shall record and sign for the conduct of the tests, the proof loads applied and the outcome in the sailplane logbook.

Example: An item located behind the seat of a “Utility” category sailplane.

Item = 3kg.

By reference to the above, the item restraint will have to withstand these proof loads -

UP	3 X 5	= 15 kg
DOWN	3 X 6	=18 kg
FORWARD	3 X 10	= 30 kg
BACK	3 X 6	= 18 kg.
SIDE	3 X 4	= 12 kg

Note: If proof loading with the item in situ and the loads are applied to the item, the weight of the item must be considered in the above loads. The UP proof load will be 15 kg + 3 kg = 18 kg. The DOWN proof load will be 18 kg – 3 kg = 15 kg. If the proof load is applied directly to the restraints ie the item is not fitted, the weight of the item does not need to be considered.

By using a 50 kg spring balance (or a digital load cell) with suitable straps, the item can be loaded UP, SIDESWAYS and FORWARD to the PROOF loads determined and held for at least 3 seconds. To verify the DOWNWARD load capacity, 15 kg of ballast blocks can be loaded onto the item (total weight is then 18kg) to press it down.

If the restraint capacity is difficult to determine or it is difficult to apply proof loads, seek the assistance of your RTO-A or CTO.

Any items over 10 kg must be treated as a modification.

9.6 OTHER CONSIDERATIONS

The installed optional equipment must not impede the pilot(s) visibility of the instruments or the controls. An example that happened: a pilot had mounted a PDA on the right hand side of the canopy of a DG-400 with a suction cap mount. This obscured the pilots vision of the air vent knob and the canopy jettison knob on the stbd side of the cockpit. During the flight the pilot tried to open the air vent but inadvertently pulled the canopy jettison knob, despite these knobs being a different shape and feel. The partially jettisoned canopy has held in place by hand and the aircraft landed safely.

The installed optional equipment should not impede the egress of the pilot(s) in an emergency. An example that happened: A pilot had installed a flight computer on the canopy. The thin power wire was routed via the front hinge of the canopy to the instrument panel. When the pilot tried to bail out the thin wire prevented the canopy lifting to jettison. The pilot was found dead in the crash with their parachute ready.

10. FATIGUE

10.1 GENERAL

Like any human or animal, if you work a structure long enough and hard enough, it will become "tired", and loses its ability to carry load, it becomes "fatigued".

It is common to hear the comment "wood doesn't fatigue", or “fibreglass doesn't fatigue". The unfortunate thing is that all aircraft structural materials will fatigue, given the right circumstances.

An Inspector is interested in fatigue from two points of view:

a. Total fatigue life set by the manufacturer, for the complete airframe or major components.

b. In service, individual component fatigue life dealt with on a day to day basis.

Fatigue is primarily controlled by the manufacturer setting life limits on airframes and components. Some of these may be extended “on condition”. For recreational aircraft in Australia some flexibility is allowed but sensible care must be taken. Life limits of airframes and items specified in Airworthiness Directives and some other items may not be exceeded, refer MOSP 3 for the regulations and the sailplane Logbook Statement. But for instance the TBO of an engine or prop may be extended by the Registration Holder. This does take on extra risk and it must be decided sensibly and taking into account the manufacturer’s good advice. Do not just take a chance, increase inspections and know what to look for.

10.2 FATIGUING LOADS

Under normal operations, sailplanes and powered sailplanes experience flight and ground loads that vary with the state of flight:

a. Take-off

b. Landing

c. Winch launch

d. Aero tow

e. Soaring flight

f. Aerobatics

By using a full instrumented sailplane, the range of loads for each of the above areas of flight can be recorded. Then a sample structure can be put into a test rig and the flight loading simulated, continuously, until evidence of structural breakdown occurs.

Recording of this flight load information is difficult and expensive, and the results will vary from country to country, area to area, pilot to pilot, which means that the load values used for fatigue test programmes are usually a compromise to achieve an "average" result.

WARNING

Ground handling can generate loads and vibrations that are quite destructive to tail wheels, tail wheel mounts, rudder hinges, elevator hinges, rear fuselages, etc.

10.3 DAY TO DAY FATIGUE

By far our biggest problem as Inspectors is the deterioration of minor structural and mechanical parts, during the safe life of the primary structure.

We have classic cases of local fatigue damage:

a. Rear Fuselage frames in the Blanik fuselage.

b. Blanik tailplane and fin tip rib cracking

c. Twin Astir undercarriage castings.

d. Slingsby T61 rear spar to fuselage attachment cracks.

e. ES 60 dive brake system bell cranks - cracks.

f. And many more.

Australia has the highest sailplane/powered sailplane utilisation in the world. This means that we are most likely to find a defect before anyone else including the manufacturer, so we must be very careful and must report them so everyone can learn and correct.

Detail design of airframe and system parts can be heavily cost oriented, with the possibility of design mistakes or errors which can develop into problems in service.

Inspection of a Pik 20 D revealed cracks in the bend zone of the lower rudder hinge attached to the fin post. It is suspected that flapping of the rudder in the wind while the sailplane was tied down may have been a contributing factor, but also the fact that in the subject fitting it appears that the bend was made along the "grain" of the material.

10.4 POOR WORKMANSHIP - INDUCING FATIGUE

In the past, a tailplane fell off a Blanik following a ground handling incident. Some 7 years previously the tailplane front attachment plate and channel was damaged and replaced with new parts. The repair riveting standard was such that only half of the rivets put back carried load the way the designer intended. This overloaded the other rivets and the local structure; fatigue cracks started, resulting in total failure under very minor loading conditions.

This incident, and others, points to a requirement for repairs to be periodically checked to ensure that they are sound and the structure around them is sound.

Typical things to look for are:

a. Badly driven or loose rivets, holes oversize.

b. Sharp bend radii

c. Bolts in oversize holes

d. Delamination in FRP - air pockets

e. Incorrect glue mix - in timber

f. Incorrect mating of spliced joints

g. Incorrect materials

h. Original shape not reproduced.

10.5 BEHAVIOR OF MATERIALS

To be able to find premature fatigue the inspector must have some idea of the behaviour of different types of material, subject to fatiguing load cycles.

10.5.1 WOOD

To all intents and purposes, timber has an indefinite fatigue life in sailplane and powered sailplane structures designed to accepted airworthiness standards.

However defects can occur due to reasons discussed in this section, so the Inspector must be aware of:

a. Splitting in solid timber components.

b. Glue failure causing delamination.

c. Attachment of steel and alloy parts, looseness resulting in oversize holes, etc.

d. Plywood splitting, an example being at the top of the fuselage, behind the wing on Kookaburras, resulting from repeated landings on rough ground or one heavy landing.

10.5.2 FIBRE REINFORCED PLASTIC

From testing carried out by Slingsby sailplanes and other European bodies, plus knowledge of the physical build-up of a Fibre Reinforced Plastic (FRP) structural element, the manner in which FRP shows fatigue is clear. Taking a wing as an example:

a. Bending loads are resisted by the wing spar:

b. The critical section is usually at the root end which is built with bundles of rovings at the top and bottom, running span wise

c. On the compression side, the epoxy resists the load, with little support from the thin glass fibres, buckling under load

d. On the tension side the glass strands resist the load, not the epoxy.

e. Signs of fatigue will show up first on the compression side in the form of hairline cracks in the direction of the glass fibres, with the epoxy tending to turn opaque

f. The second stage is marked by cracking at 90 degrees to the glass strands; the structure is becoming unsafe.

g. It has been shown that when this evidence first becomes visible, the structure will still support maximum design load, obviously there must then be a slide in strength as the cracking develops.

Summarising:

FRP structure is fatigue sensitive in those parts of the structure subject to compression loading, with the first visual evidence being breakdown of the epoxy resin. Development of inspection methods should allow FRP. structures to be life extended on the same basis as timber, with "condition" to be established by inspection.

FRP is now a well developed material and has shown very long life resulting in repeated life extensions being allowed. FRP fatigue relates to:

a. Manufacturing techniques such as resin types and cure procedures.

b. Natural ageing.

c. Exposure to UV and extremes of hot and cold.

d. Repairs.

10.5.3 METAL

Experience shows, most if not all of our fatigue and premature fatigue problems have been in metal components, which means that the practical serviceability of wooden and FRP structures is controlled by the behaviour of their metal parts.

We are able to predict with reasonable accuracy the load cycle capability of most metals used in aircraft construction. In turn, if we know the exact load cycle on a component, then the service life of the component can be predicted.

Metals however can be totally unpredictable in their behaviours if:

a. The component is exposed to excessive vibration.

b. The environment causes component corrosion.

c. The component heat treatment is not correct.

d. The machining or fabricating technique is at fault.

e. Incorrect plating procedures

f. Actual loading higher than the designer thought.

g. Installation is incorrect.

h. Notch sensitivity

i. Pre-stressing due to manufacturing process.

The detection of premature failure of components depends on sound inspection techniques and inspector awareness.

11. FLUTTER

Flutter is mentioned in many sections of this manual. Flutter is a complex subject and this section is intended to give a basic overview of what flutter is and the preventative measures.

11.1 WHAT IS FLUTTER

Flutter is, by definition, an aero elastic phenomenon. An aero elastic phenomenon is one in which the aerodynamics and structure of the aircraft combine to cause the structure to oscillate. In many cases this oscillation can cause catastrophic structural failure within one second of onset.

Figure 11-1 Damage to Tail Boom from Suspected Rudder Flutter

When designing a sailplane, it is the designer's responsibility to prove that it is free of flutter at all the speeds below the Design Maximum Speed, a speed well above V_{NE}. To maintain freedom from flutter, the inspector must ensure the sailplane is within the limits for control surface balance and free play. The sailplane structure must be in good condition and free from structural damage.

Flutter is a very important subject that used to kill many sailplane pilots. Over time, flutter prevention knowledge has improved and procedures and practices were implemented to reduce the risks. The number of flutter incidents has reduced until now it is almost unheard of. But it is still possible and even likely if inspections are not performed correctly.

Flutter is caused and influenced by many factors; design, maintenance, various control surface or system aspects, over-speeding (and therefore instruments), and then pilot understanding and operation such as reducing V_{NE} with altitude and how indicated airspeed works, and poor speed control. Be sure you understand and address all the factors involved as it could be caused due to many different factors which are discussed in several Chapters.

The simplest and therefore most likely forms of flutter are control surface flutter: rudder, aileron, flap, elevator and even trim tab. Slightly more complicated is flutter of a control surface driven by a trim tab. More complicated forms are: wing twisting and bending driven by the ailerons, fuselage vertical bending driven by the elevator, and fuselage lateral bending and twisting driven by the rudder.

Flutter requires some sort of input to start, often merely a tap on the controls or a minor bump from the airflow. Once it starts, the flutter will continue until the airspeed is reduced. Even when the airspeed is reduced it may take some seconds for the oscillations to completely die out.

11.2 FACTORS AFFECTING FLUTTER

There are many factors that contribute to the flutter characteristics of a sailplane. The designer controls these factors and through design calculations and testing, proves sufficient safety margins against flutter in normal flight. These design factors are: stiffness of the each structural component eg the wing, or control surface, the mass distribution of each structural component, and stiffness of the control systems. Many very high aspect ratio sailplanes have their structure determined by stiffness requirements to avoid flutter rather than simply strength.

The designer will also put a lot of flutter related information into the flight and maintenance manuals. However, this information is often distributed throughout the manuals and will not be found under a 'flutter avoidance' heading.

Inspectors must pay attention to a wide range of maintenance factors when inspecting a sailplane to ensure that it will remain free of flutter including:

a. Control surface centre of gravity and mass balance. Refer to Section 11.3.

b. Control surface drain holes are clear to prevent a build up of water shifting the centre of gravity.

c. Control surface hinge wear and hinge cracking / debonding.

d. Trim tab freeplay and control stiffness.

e. Control system freeplay from worn control system bearings. Refer to Section **Error! Reference source not found.**.

f. Control system cable tension.

g. Maintenance of control system dampers (if fitted).

h. Structural damage which changes system stiffness eg debonding ribs that support control system hinges. Hidden wing structural damage may be detected with a wing frequency check – refer to Section **Error! Reference source not found.**.

i. ASI calibration. Refer to Section **Error! Reference source not found.**.

j. Pitot-static system integrity and leak checks. Refer to Section **Error! Reference source not found.**.

k. Airspeed placards are installed and readable.

l. Mounting pin and bearing freeplay for wings and tailplanes.

m. Fore-aft wingtip freeplay.

Inspectors teaching or examining Daily Inspector candidates must ensure that the member knows how to carry out control surface freeplay checks, pitot-static system checks and tailplane mounting checks as these are important safeguards against flutter.

Pilots have a critical role in avoiding flutter by:

a. Avoid flying beyond V_{NE} either through inattention to airspeed or poor understanding of V_{NE} reduction with height at higher altitudes,

b. Performing competent daily inspections, and

c. Arranging for inspections after hard landings, ground loops or flight overloads.

11.3 CONTROL SURFACE FLUTTER

With sailplanes the parts most likely to flutter are the control surfaces especially the ailerons, flaps, rudder and elevators or all flying tailplane. The most common form of flutter and the easiest to visualise is flutter of hinged control surfaces.

The following figure shows a typical wing or tailplane with a hinged control surface and the basic sequence of events involved in 1 cycle of flutter. The dotted lines show the original position of the structure.

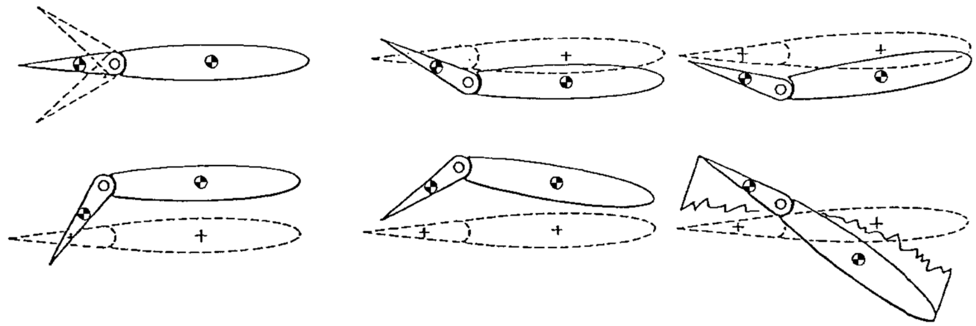


Figure 11-2 Flutter Sequence

The flutter sequence is, from left to right:

a. The initial condition showing the available range of control surface travel and the centre of gravity of the surface behind the hinge line.

i. Deflection "downward" of the structure from its initial position by some factor such as a gust or manoeuvring. Note that the control surface is "left behind" due to its own inertia. The upward deflected control surface causes an increase in the air loads, particularly torsion on the wing / tailplane.

b. This has two effects; deflection of the structure further away from its initial position and rotation of the structure. This is the 'aero' part of aero elastic. The twisting of the structure increases the air loads trying to return the structure to its original position.

c. The structure then springs back to its original position and, because of the energy stored in the structure, it overshoots. This is the 'elastic' part of aero elastic. Note that the control surface now lags in the other direction due to its own inertia.

d. The control surface again rotates from the torsion applied by the control surface and increases the loads trying to deflect the structure.

e. If the process continues and the oscillations increase, the structure risks being deflected too far and it will fail. Alternatively the control surface will repeatedly hit it's deflection limits and it will fail.

11.3.1 INCORRECT CONTROL SURFACE BALANCE

As shown above, the centre of gravity position of a control surface relative to the hinge line has a significant effect on the flutter of a control surface. The further aft the CG is from the hinge line, the more inertia the control surface will build up when moving. The greater inertia causes the control surface to deflect further and cause greater loads on the structure. The easy solution is to design the surface so that its centre of gravity is on or in front of the hinge line by adding mass balance weights. This can take the form of weights attached to the forward portions of the control surface, bob weights which protrude from the control surface (Foka) or weights attached to pushrods etc in the control circuit (G109). This solution adds a considerable mass to the control surface. Often a sailplane designer will validate a compromise where the control surface center of gravity is allowed to be located within a short range of distance behind the hinge line. These limits are published in the maintenance manual, either as a CG position relative to the hingle line, or as a hinge moment.

Every change in the mass of a control surface requires checking of its mass and balance to ensure it is within limits.

Many older types, especially wood and fabric types, have no manufacturer set limits. They fly relatively slowly and the mass and balance of the control surfaces varies only slightly as repairs and re-fabricing should return the surface to its original condition.

Modern sailplanes with high V_{NE} require more care especially as repairs and refinishing can have a significant effect on the balance of the control surfaces. Where the manufacturer has set down limits for the control surface balance, they must remain within those limits.

Best practice is to check the control surface weight and balance before and after repair, refabricing or refinishing. That ensures that there is awareness of potential issues before work commences and reduces risks of a surprise after the work is completed. Common practice on large powered aircraft is to write the weight and balance of the control surface on its leading edge (where it is typically hidden from direct view) along with the date. Again this is done to ensure that there is awareness of potential issues before work commences. It is recommended that the weight and balance and the date is written on the leading edge of the control surface in marker pen as well as recorded separately in the logbook.

11.3.2 EXCESS FREE PLAY

If the freeplay of the control surface is beyond that allowed by the manufacturer or the limits set down in Section 13.5 (in the case that the manufacturer has not set limits), then the control surface may flutter. Under dynamic loading the extra freeplay causes the surface to lag and this increases the possibility of flutter.

11.3.3 REDUCED CONTROL CIRCUIT STIFFNESS

A fault in a control system, such as a damaged bell crank mount, may reduce the stiffness of the system. This will allow the control surface to deflect further under a given disturbance. Obviously the increased control deflections will increase the possibility of flutter.

In sailplanes with control cables the tension in the cables directly affects the stiffness of that control system. It is therefore vital that the tension in the control cables be adjusted to the manufacturer's specifications.

11.3.4 FRICTION

Friction tends to increase the damping of the control system. This absorbs the energy of flutter and reduces its chances. Inspectors need to be careful with any maintenance which reduces control system friction. This will have little impact on push rod systems but may be significant in cable systems.

Like control circuit stiffness, control cable tension has a significant effect on system friction and therefore flutter. There have been numerous instances of loose control cables causing flutter - even at speeds below stall speed and all inspectors should ensure that cable tensions are as per specification.

Inspectors should also be aware that the cable tension varies considerably with temperature due to the differential expansion of steel and timber. For this reason a periodic re-tensioning schedule should be considered to ensure that cable tension is correct in summer (cables too slack causing flutter) and winter (cables too tight causing structural damage).

11.3.5 REDUCED STRUCTURAL STIFFNESS FROM DAMAGE

Damage such as glue failure, delamination, cracks, etc. that reduces the stiffness of the structure will allow the forces that drive flutter to deflect the structure further than would normally occur. In particular, reduced torsion stiffness will lead to increased air loads further deflecting the structure. Any reduction in stiffness of the structure, especially the torsional stiffness, can alter the frequency of the structures natural oscillation and may cause flutter at an airspeed lower than V_{NE}. A change in structural stiffness may also bring the frequency of the structure closer to the frequency of other structural components. This could lead to oscillation of one component setting up an oscillation in a separate component causing a feedback loop with potentially catastrophic consequences.

Ground loops can cause disbonding of interior structure in the lower fin which can lead to reduced structural stiffness and flutter. A video showing this damage is here: https://www.youtube.com/watch?v=ZXjTaGjS3j0&t=97s Inspectors may be assisted by comparing the stiffness of the sailplane to others of the same type. The video demonstrates flexing of the fin and listening for noises from the disbonded structure and watching for bulges in the skin.

11.3.6 WATER BALLAST

The addition of water ballast changes the mass distribution of the wing and this affects the way the wing oscillates. As an experiment perform a wing frequency check on a wing with and without water ballast. The wing will oscillate at a lower frequency with the water ballast. The wing will have a range of resonant frequencies between full and empty of water ballast.

11.3.7 GAP SEALING TAPE

As discussed above, flutter requires some form of initial disturbance to start. The initial disturbance is usually a gust or an input from the pilot. So a sailplane may fly many times before an adverse input appears (or is made) and flutter occurs.

Flutter may also start on a control surface, which would not normally flutter, if a vibrational input is started and maintained. This can occur when a gap tape sticks-up into the airflow. The airflow can form rolling eddies as the flow breaks away behind the tape. These eddies have a low pressure and roll downstream with the airflow. The cascade of fluctuating pressures can excite the control surface causing it to vibrate and may lead to flutter. The gap tape needs to be flush with the surface.

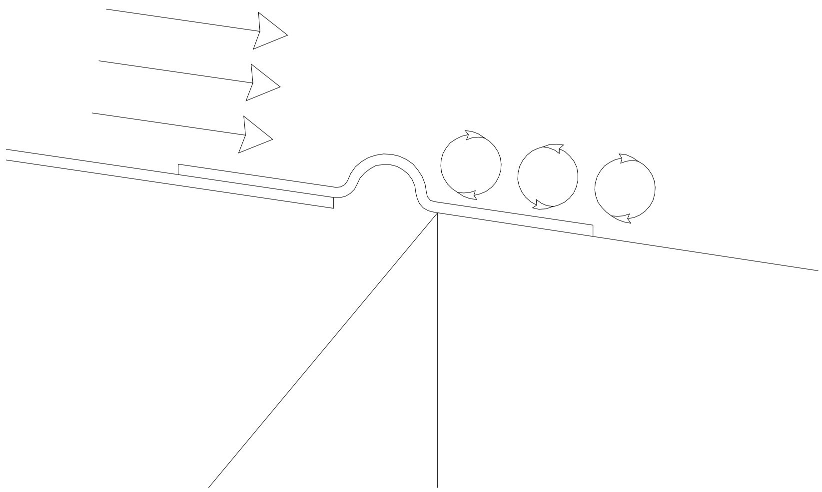


Figure 11-3 Gap Seal Tape

Flutter can also be caused by airflow asymmetry on a symmetrical airfoil. An unusual example occurred on a Twin Astir. During an annual inspection, the gap seal on the rudder was replaced. Unfortunately, the maintainers only had sufficient tape to do one side. They instead used plain gap seal tape to complete one side of the rudder and used combination gap seal tape with built in zig zag turbulator on the other side. By tripping the boundary flow on one side of the rudder and not the other, the sailplane encountered rudder flutter at relatively modest speed. Fortunately it was able to land safely.

11.3.8 SPEED

Any control surface not balanced around its hinge line will flutter if flown fast enough. When the designer sets the $V_{NE,}$ the sailplane is proven to be free of flutter up to that speed with a small safety margin. It therefore follows that exceeding V_{NE} may cause flutter.

If a sailplane's pitot-static system is not functioning correctly then the pilot may exceed VNE unintentionally. Under reading of the ASI may be caused by problems in both the pitot and static systems. A leaking or blocked pitot tube or a kinked line to the instrument may affect the pitot system.

The static system is affected by leaks in the static system. If the static pressure in the cockpit is slightly higher that the surrounding air (normal when the ventilation system is open) and the static system is open to this higher pressure, then instruments connected to the system will under read. Only a small leak in the static system is needed to cause a significant under reading of the ASI. Blocked static ports will cause the ASI to indicate lower airspeed as altitude is increased.

Because the flutter airspeed is strongly dependent on true airspeed (TAS), flying at high altitude brings the sailplane closer to its flutter speed at indicated airspeeds which are less than it's sea level VNE. For this reason, a reducing indicated airspeed V_{NE} with altitude placard is required for sailplanes which have an oxygen system fitted. Refer to Section **Error! Reference source not found.** on oxygen for the full details of this requirement.

It is therefore vital that the pitot-static system is functioning correctly in accordance with Section **Error! Reference source not found.** on the Pitot Static system.

11.4 WING FLUTTER AND WINGLETS

Encountering wing flutter in sailplanes is very rare. If mass is added to the wingtip of a sailplane wing, it will resonate at a noticeably lower frequency. This lower frequency will correspond to a lower wing flutter speed. Adding winglets to older sailplanes will increase the mass at the wingtip and reduce the flutter speed. For this reason, many sailplanes that have had winglets retro-fitted have had their V_{NE} reduced as a result. One fatal in flight breakup in Japan was blamed on the retro-fitting of winglets to an older FRP sailplane.

All fitment of winglets to older FRP sailplanes need to have a modification order or approval from the manufacturer.

11.5 FLUTTER PREVENTION

The large number of factors that affect the flutter characteristics of a particular sailplane requires the inspector to be especially vigilant.

Often flutter is discussed with single modes of flutter in isolation. Whilst this simplifies the discussion, it obscures the fact that the entire sailplane is involved in a flutter event. At annual inspection, the inspector needs to consider all the factors connected to flutter and resist signing out a sailplane with myriad small deficiencies where each is just within the acceptable limit. These multiple factors can combine to produce flutter.

Ongoing preventative maintenance and not letting small deficiencies accumulate over the years is the best practice to avoid flutter.

11.5.1 MEASURING CONTROL SURFACE BALANCE AND MASS

The balance and mass of control surfaces can have a major effect on both the handling characteristics and flutter properties of any sailplane.

When measuring the balance of a control surface, use the following procedure unless there are specific procedures in the Maintenance Manual for the sailplane:

j. Remove the control surface from the sailplane. Unless the control surface is off the sailplane you cannot be sure that there is no friction due to seals, control systems, etc.

k. Mount the control surface so it can rotate freely around its hinge line. The normal procedure is to clamp supports to a work bench and balance the control surface on the supports. Other options include suspending the control surface from overhead supports. The critical aspect in all mounts is that the control surface is free to rotate about its hinge line. Take special care when measuring rudders from Glasflugel types. Support them using part of the gimbals mechanism that mounts in the rudder.

l. Position an accurate set of scales under the trailing edge of the control surface (accurate means within ± 2 g) so that the surface is horizontal. Mark a point on the control surface where the scales are to touch. Ensure that the load on the scales is through a single point and not distributed over an area. Take the reading from the scales and measure the perpendicular distance from the hinge line to the point of contact of the scales.

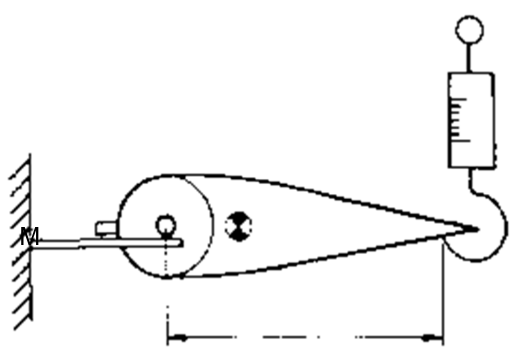


Figure 11-4 Mass Balance Measurement

Determine the balance of the control surface (the residual moment) by multiplying the reading from the scales by the distance from the hinge line to the scales. Take special care with units to ensure that the calculated value is in the correct units.

Measure the mass of the control surface as this can have an effect on the flutter of the surface it is attached to and the loads on the hinges. When measuring the mass of the control surface the scales should be accurate to within 25g and take care to ensure that the surface is not touching any other objects.

Mass balance weights are located in particular positions by the designer and this sometimes reflects complex considerations. For example: the rudders of the Janus, Duo Discus and Arcus all have a large bob weight at the bottom and a small weight towards the top of the rudder The bob weight is close to the fuselage tail boom axis where there is no movement when the fuselage is twisting about the longitudinal axis, but significant movement occurs in large side to side fuselage tail end swinging. As a contrast the weight at the top participates in all the various flutter motions. Respect that the designer knows the underlying reasons.

11.5.2 RECTIFICATION OF CONTROL SURFACES WHICH ARE OUTSIDE THE MANUFACTURER'S LIMITS

If a control surface is outside the manufacturer's limits, it is necessary to bring it back inside those limits before the sailplane flies again. This is because the manufacturer has proven the sailplane is free from flutter provided the surfaces are within balance, the control system is within the freeplay limits and the aircraft is in good condition. Flutter may not occur, even though the surface is out of balance, for many flights because just the right combination of speed and vibration (from atmospheric turbulence) has not occurred. The only way to guarantee that flutter will not occur is for the sailplane to fully meet the manufacturer's specification.

If a surface is out of limits with regard to balance but is under the maximum permitted mass then bring the surface back into balance by adding mass balance in front of the hinge line.

Attach the mass balance in accordance with the Maintenance Manual. If there are no instructions in the Maintenance Manual then inspect the attachment of mass balancing lead elsewhere in the sailplane for details such as type of fastener, spacing, the use of glues, etc. When installing this balance mass take special care to ensure that the new mass does not foul with any other part of the sailplane and attach it securely. Mass balance weight attachment must sustain 24 G due to the potential violence of flutter. If in doubt, seek RTOA advice.

If you cannot balance the surface without exceeding the maximum permitted mass then the only option is to make the surface lighter. This will usually require the removal of finishing coats such as gel coat from the underside and if necessary from the upper side. In severe cases it may be necessary to remove all gel coat and apply a thin layer of paint (probably polyurethane) to protect the surface. In extreme cases seek advice from the RTOA or from the sailplane manufacturer.

If you still cannot bring the surface back into tolerance, then replacing it is the only option.

11.6 DUSTER'S DEMISE - A FLUTTER CASE HISTORY

Saturday, April 24th, was a good soaring day at Orient Airfield in South Africa, and I had been flying my new home built Duster in the vicinity of the airfield for some 4 hours. The time was 17:00 hours and I felt that the air was calm enough to conduct the high speed test to red-line which is 206 km/h . I decided to pass over the airfield at circuit height at right angles to the runway in use to enable me to complete a proper landing approach.

I manoeuvred myself into a position some three kilometres out and radioed my intentions to the tower who gave me the all clear. I started the run from a height of 400 m and was surprised at how rapidly the Duster built up speed. In a very short period I had 200 km/h indicated and eased back on the stick to maintain that speed. I then passed through some mild 'bubbly' turbulence and immediately afterwards felt a violent high frequency vibration from the rear of the fuselage. I have read a lot about flutter and knew straight away what had happened.

The sequence of events thereafter (according to the wreckage recovered) was that the rudder broke away from its spar first, followed shortly afterwards by the fin. The rudder oscillations probably caused the two elevator halves to oscillate in opposite frequency because although they stayed with the aircraft the main spar joining the two halves sheared leaving the sailplane without elevator control.

The Duster began diving and, when I felt no response to the stick, I realised immediately that I would have to bail. I released the canopy and seat belts with remarkable efficiency (having practiced this manoeuvre a few times before), and the negative g from the steepening dive (combined with the slipstream) got me out of the cockpit as effectively as any ejector seat would have done.

The official inquiry into the accident found that it was probably caused by flying the sailplane beyond its VNE which in turn was probably cause by the ASI under-reading due to; a) the pressure altitude on the day being 8000 feet and b) the ASI being connected to cockpit static which may have caused it to under read.

There are several points which should be noted from this report. Firstly, the pilot began the VNE run at 400 m ≈ 1200 ft. This is very low and leaves no margin if something goes wrong. In this case the pilot was lucky as very few pilots who experience difficulties under 1500 ft. are able to bail out in time.

Secondly, the flutter did not occur until the sailplane hit turbulence. Something was required to start the flutter.

11.7 REFERENCES

Basic Glider Criteria Handbook. Federal Aviation Administration, Flight Standards Service, Washington DC, 1962

DG Flugzeugbau website - Flutter resistance of the DG1000

Australian Gliding July – August 1998 p.18-22, “Flutter” by Mike Burns

OSTIV Volume 18 No 4 1994, “Possibilities of Hight Altitude Flutter During Wave Flights", by Walter Stender, Germany, Fritz Kiessling, Germany, Joachim P Kuettner, USA

12. LOADS ON SAILPLANES

12.1 GENERAL

When inspecting a sailplane a good knowledge of the loads it is likely to be subject to is required. The loads which are imposed on the sailplane structure during normal operations fall into four broad categories:
Manoeuvring loads, gust loads, launching loads and landing loads. Additionally, powered sailplanes are subject to engine and propeller loads.

The load cases and numbers presented here apply to sailplanes which have been certified to JAR 22 introduced in 1980. Older sailplanes are certified to earlier standards and the numbers and meanings of some terms when applied to these sailplanes are slightly different. Since 2002, most European sailplanes have been certified to CS22. Other standards may be adopted but the differences are not likely to be so significant that this text, BSE, is made invalid.

When inspecting a specific sailplane, the information contained in the Type Certificate Data Sheet (TCDS) is primary, or a GFA Data Sheet if no TCDS, and the manufacturer's Flight and Maintenance Manual is authoritative. The latest versions apply for the life of the sailplane.

12.2 MANOEUVRING LOADS

Manoeuvring loads are those imposed on the structure when the pilot moves the control column, the rudder pedals, the dive brake handle or the flap lever.

12.2.1 SYMMETRICAL LOADS

Symmetrical loads are primarily generated by moving the elevator although changing flap settings and opening the dive brakes can significantly affect the load distribution over the wings. When the sailplane is designed it must be proven to be strong enough throughout the Manoeuvring Envelope.

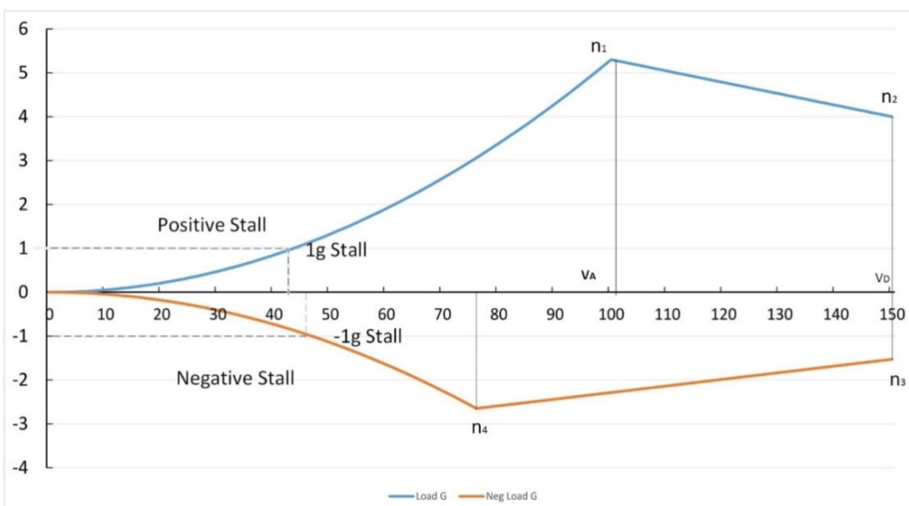


Figure 12-1 Manoeuvring Envelope (JAR 22 Utility Category G Loading)

The manoeuvring envelope is a plot of normal force as a ratio of the normal force necessary for steady level flight (the 'g' loading) versus speed. The sailplane must be able to withstand the forces inside the envelope and it may fail if it is taken outside the envelope.

The region from zero up to the stall speed is only of academic interest as the sailplane cannot maintain steady flight. From the positive stall speed up to the manoeuvring speed (V_A) it is not possible for the sailplane to be flown outside the envelope because the wing stalls. The designer has to prove the sailplane is strong enough to withstand the maximum g loading. Above V_A it is possible for the pilot to damage the sailplane by careless use of the controls.

The negative case is similar (except the g loads are negative of course) and the differences can be explained as follows: The aerofoil is less able to generate negative g load so the -1g stall speed is faster than the +1g stall speed (if the section was symmetrical then the stall speeds would be the same) and the sailplane is not required to be as strong in negative g.

The table below shows the limit g loading for a Utility Category sailplane certified to JAR 22 and CS-22.

n_1	at V_M	+5.3 g
n_2	at V_{NE}	+4.0 g
n_3	at V_{NE}	-1.5 g
n_4	at V_M	-2.65 g

The table below shows the limit g loading for an Aerobatic Category sailplane certified to CS-22.

n_1	at V_M	+7.0 g
n_2	at V_{NE}	+7.0 g
n_3	at V_{NE}	-5.0 g
n_4	at V_M	-5.0 g

12.2.2 LOADS IN THE SAILPLANE (SYMMETRICAL MANOEUVRING)

When a sailplane is manoeuvred, the wings generate the increased lift to accelerate the sailplane. In addition, the tailplane loads change because an increased force is required to rotate the aircraft to increase the angle of attack and hence the wing lift

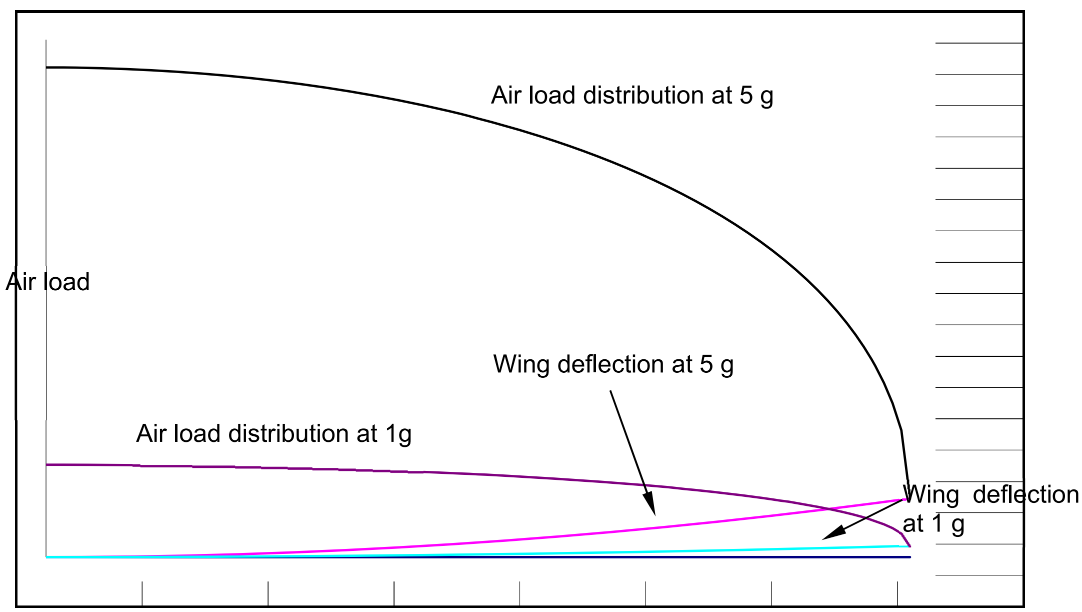


Figure 12-2 Spanwise Load Distribution

This increase in wing lift bends the wing upward as shown above and results in compressive stresses in the top spar cap and tensile stresses in the lower cap. The up load on the wing combined with the tail down load in the fuselage and the increased 'apparent' weight of the pilot(s) results in stresses in the fuselage as shown below

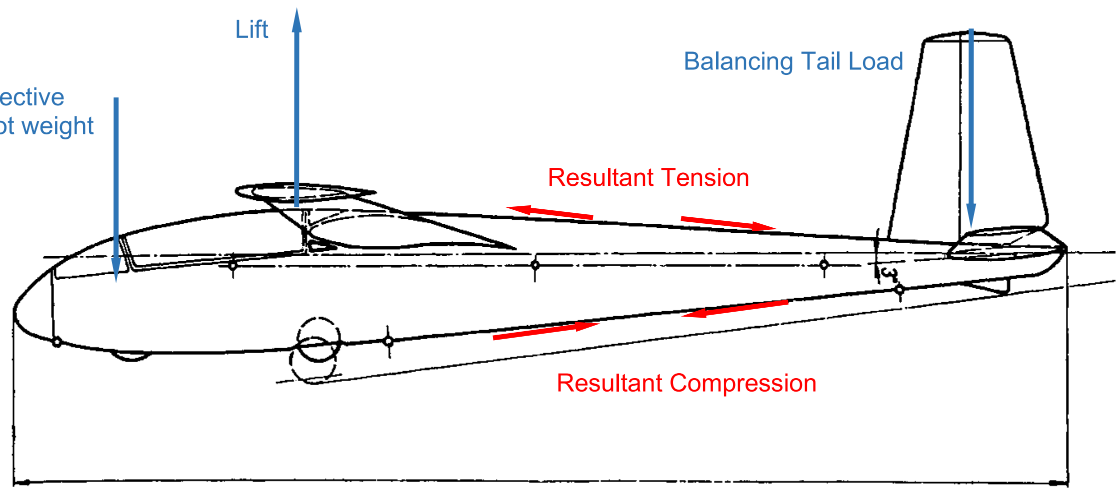


Figure 12-3 Loads in the Fuselage During Positive Manoeuvres

In the positive load case there is also a distributed down load over the tailplane which is of similar shape to the wing loads but reversed. This results in compressive loads on the underside of the tailplane and tensile loads in the top surface.

Because the angle of attack is increased to provide the extra lift the induced drag on the sailplane wings also increases. This extra drag acts on the wings and tends to pull them backwards. This will place the rear wing pick-ups into compression and, depending on their design, will place the forward pick-ups into tension.

During negative manoeuvres the concept of the loads is similar but they are reversed.

12.2.3 ASYMMETRIC LOADS

If a pilot applies aileron or rudder, the resultant loads on one side of the aircraft are different from the other side.

The application of aileron causes an increase in lift on the side with the down going aileron and less lift on the side of the up going aileron. Application of rudder will cause side loads on the fin and the secondary effect of rudder (roll) results in asymmetric loads on the wing. The diagram below gives a conceptual idea of the loads and deflections on a sailplane during a typical asymmetric manoeuvre.

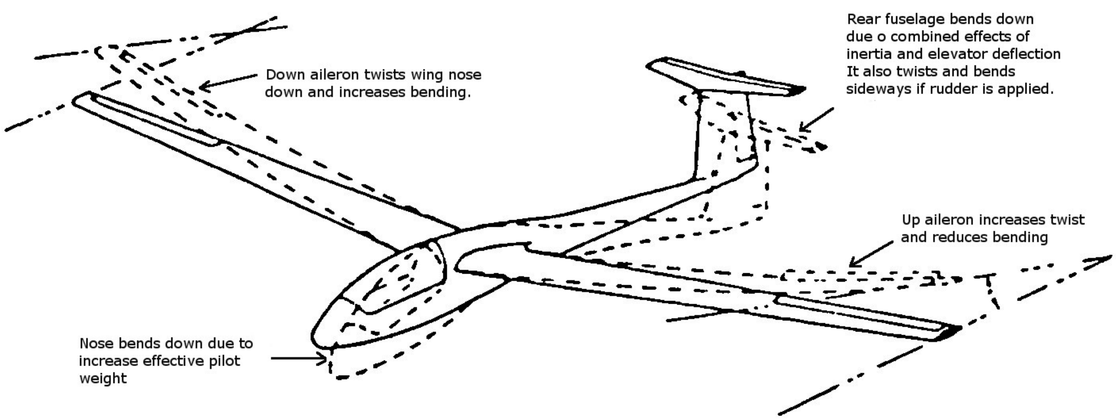


Figure 12-4 Combined Loads During a Rolling Pull Up

12.3 GUST LOADS

When a sailplane flies through air with varying up and down velocities, the angle of attack on the wing changes. This results in changing loads on the sailplane. The designer is required to prove the sailplane is strong enough to withstand the maximum gust strength the sailplane is likely to experience.

Sailplanes which have been certified under JAR 22 are required to be strong enough to withstand a vertical gust of ±15 m/s (≈ 30 kts) at the rough air speed and a gust of ±7.5 m/s (≈ 15 kts) at the design dive speed.

Some older sailplanes are required to withstand a ±10 m/s gust at the design dive speed and so do not have a rough airspeed as such. The actual strength of the wing and fuselage which is required to meet these requirements is similar.

If a sailplane has a Maximum Rough Airspeed and it is being flown below that speed then the wing will stall before the structure is overstressed.

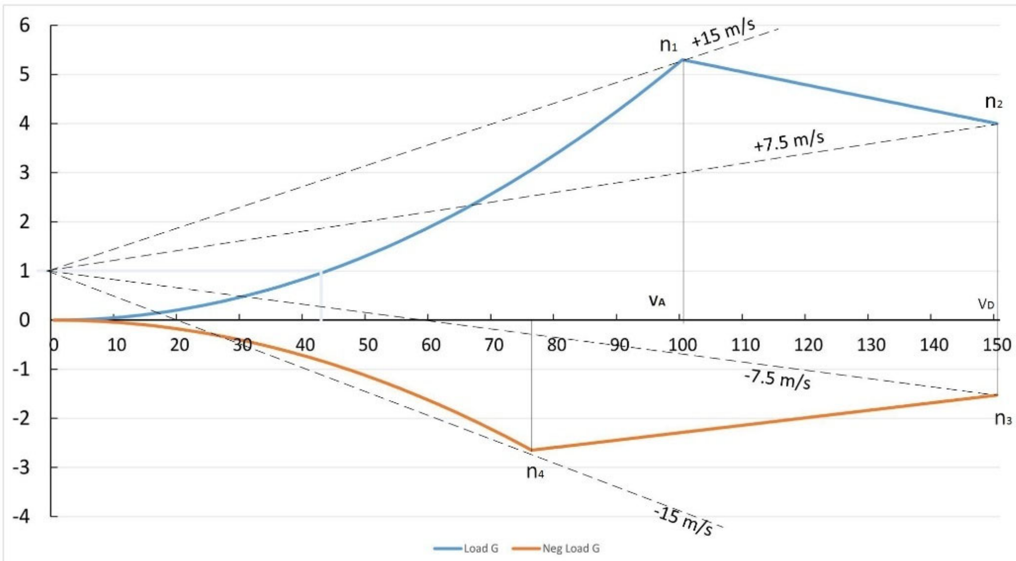


Figure 12-5 Gust Flight Envelope

12.4 LAUNCHING LOADS

During launching additional loads are imposed on the sailplane. These are quite simple during aerotow as the sailplane is flying normally and the only addition is the pull on the aerotow release. This pull is a maximum during the initial acceleration. During the steady climb (with no gusts or pilot inputs) the cable loads are low and may be estimated as per the following example:

$$\frac{L}{D} = 30$$

L = Weight (for steady flight) = 400 kg

D = cable load (or the sailplane would accelerate or decelerate) = 400/30 = 13.3 kg of cable tension.

12.4.1 WINCH LAUNCHING LOADS

When a sailplane is winch launched, the loads imposed on the structure by the launch method are substantial. The pull on the cable can be thought of as extra payload in the fuselage. Because the stresses due to this are high, the wing is not able to withstand the manoeuvring loads (5.3 g) during the launch. For this reason the maximum speed which is permissible during the winch launch is reduced so the wing stalls or the weak link breaks before the sailplane structure is overstressed.

12.5 HEAVY LANDING AND GROUND LOOP LOADS

When a sailplane is subject to a heavy landing or a ground loop the inspector must understand the loads which the sailplane is likely to have been subjected to so that the inspection can cover the likely damage points.

Refer to BSE Chapter 25.

13. CONTROL CIRCUIT RIGGING

13.1 GENERAL

A correctly rigged sailplane has its control system travels, freeplays and their geometry within the manufacturer's specifications. Correct rigging is vital to the handling and operational characteristics of the sailplane.

Check the control systems travels at each annual inspection and after any major repairs that could affect the sailplane's geometry, such as a broken fuselage or a heavy landing. Metal gilders, either aluminium or steel tube, are susceptible to gradual bending of components and therefore the geometry of the sailplane is more likely to change with time and heavy landings. Wood and FRP structures are more likely to fracture when overloaded and so damage to sailplanes constructed of these materials is more noticeable.

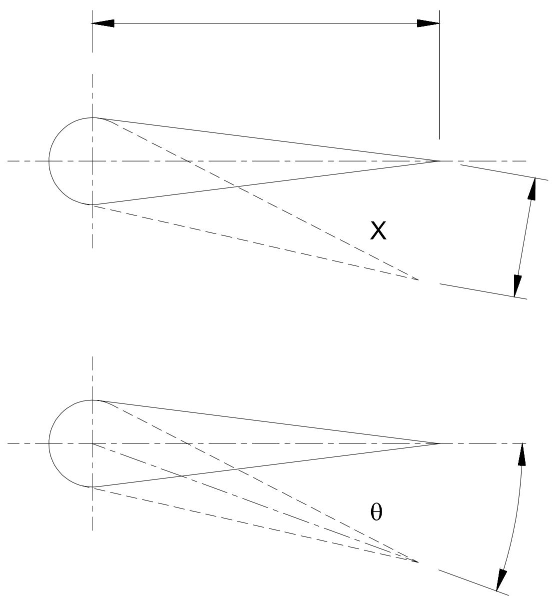
13.2 CONTROL SURFACE TRAVEL

Incorrect control surface travel can result in unsafe flying characteristics, unpleasant handling and unnecessary drag.

13.2.1 CHECKING TRAVEL

The Flight or Maintenance Manual for each type contains the specifications for the control surface deflections. Most manuals give the deflections as either an angular deflection or as a distance from the neutral position at a specified point.

Where deflections are given as an angular deflection it is often helpful to use an inclinometer.



DISTANCE: The deflection X is shown as the distance moved by the trailing edge, at a fixed position along the control surface, from the neutral position.

ANGLE: The deflection θ is shown in degrees of movement from the neutral position.

Figure 13-1 Distance Vs Angle

13.2.2 ELEVATOR TRAVEL

This is the most critical control surface for correct travel as it has a primary influence in the stall and spin entry characteristics of a sailplane:

a. Insufficient up travel: The sailplane may be unable to stall or flare properly during landing.

b. Insufficient down travel: The sailplane may be unable to recover from a spin or the pilot may be unable to prevent nose pitch up at the start of a winch launch or in a towplane upset.

c. Excessive up travel: Sailplanes designed as unspinable, e.g. ASK 21 and Grob 103 Twin II, may stall/spin and the load on the control surface may exceed that allowable.

d. Excessive down travel: The tailplane may stall during launch ground run, particularly all flying tails, and the surface may be overloaded.

13.2.3 RUDDER TRAVEL

The rudder travel can also be critical as the rudder plays an important role in recovering from a spin.

a. Insufficient travel: The sailplane may not recover from a spin and may have reduced turn coordination.

b. Excessive travel: The rudder and fuselage structure may be overloaded or the fin may stall.

13.2.4 AILERON TRAVEL

Incorrect aileron travel may reduce the roll response, reduce turn coordination, increase aileron drag and increase total drag. Increased travel may cause a sailplane to become more susceptible to spinning at low speeds. Incorrect up/ down differential movement can make the handling poor.

13.2.5 TRIM TAB TRAVEL

The minimum and maximum trim speeds will alter handling and speed control of the sailplane. Makes it harder to fly at stable airspeeds.

13.3 SETTING UP A CONTROL SYSTEM

Follow these basic steps when setting up a control system:

a. Set the control column up in the neutral position. This may be with the stick vertical or a distance from a datum as shown in the aircraft's manuals. Clamp the stick in place. Be aware that some sailplanes mix controls e.g. the elevator fore/aft position and aileron droop.

b. Work through the control system from the stick to the control surface ensuring that each component is in safety and set as per the aircraft data. For flaps and ailerons ensure the system is symmetrical from one side to the other. At the end of this step ensure fairing of the control surface with the supporting structure. Note: On some types the correct neutral point is with the controls unfaired. Check the manuals for details.

c. Remove the clamps and check the control surface deflections. Adjust the stops so that the control deflections are correct.

13.4 CONTROL SYSTEM STOPS

Manufacturers design control stops to serve the dual purpose of limiting the force a pilot can apply to the control circuits and also to ensure that the mechanisms of the control circuit themselves cannot be damaged by moving further than they were intended to.

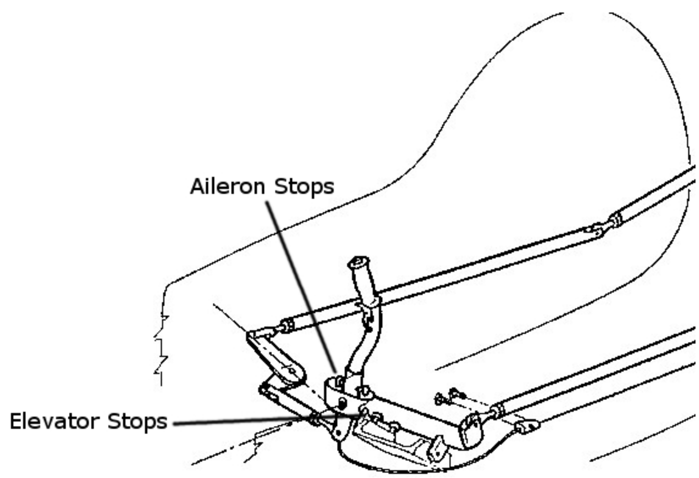


Figure 13-2 Control System Stops

At each annual inspection, check the control stops for correct functioning. If the stops are not operating correctly, the end of travel will be spongy rather than exhibiting a crisp stopping action. The control surface movement must be limited by the stop only and this sponginess indicates the control circuit binding or rubbing somewhere other than at the stops. Long term binding and rubbing in the control circuit will lead to damage. Take care to check that the stops operate properly through the full range of control stick movement, e.g. do the aileron stops work correctly at both full up and full down elevator?

Some control systems also provide stops at the control surface to absorb loads due to wind action on a moored sailplane. Where there are stops at each end of the system, the stop near the control should contact first and the stop near the surface should be about to contact.

13.5 CONTROL SYSTEM FREEPLAY

Excessive control system freeplay can cause flutter. All freeplays must be within the manufacturer's specifications where these are available. Where manufacturer's freeplay limits are not available, the freeplay must be less than 2.5% of control surface chord.

From the US FAA Basic Glider Criteria Handbook.

CAUTION

Flutter may occur if, when the cockpit control is blocked in the central position and finger pressure is applied at the trailing edge causing the control surface to rotate, the trailing edge moves in excess of 2.5 percent of the control surface chord.

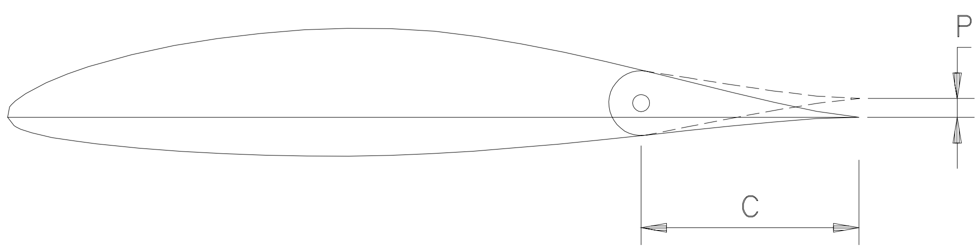


Figure 13-3 Control Surface Freeplay

For example: If an aileron has a chord (C) of 250 mm then the maximum freeplay (P) at the trailing edge is 6.25 mm, from the calculation:

$$250 \times \frac{2.5}{100} = 6.25\,\text{mm}$$

If freeplay is excessive, check for the following defects:

a. Slack cables.

b. Worn hinges.

c. Worn pivot pins and holes.

d. Worn bearings (of all types).

e. Movement in bell crank mounting points.

f. Loose bolts.

Excessive freeplay beyond the manufacturer’s limits, or (if there are no manufacturer’s limits) beyond 2.5% of the control surface chord, requires rectification before the sailplane flies again.

13.6 CONTROL SYSTEM FRICTION

Mechanical systems always contain friction which tends to inhibit movement. A small amount of friction is beneficial because it tends to damp out vibrations which could cause flutter but if the friction is excessive it leads to stiff and heavy controls.

If there is too much friction in the flight control systems then it can make the sailplane difficult to control. E.g. As the pilot tries to move the control, friction prevents its movement. The pilot increases the force until the system 'breaks out' and starts to move. As the sliding friction is often less than the static friction, the control system 'jumps' past the desired position leading to over control of the sailplane.

Friction in other control systems such as the undercarriage retraction mechanism or trimmer, causes them to be heavy to move, may overstress the components and may be beyond the physical strength of some pilots (e.g. juniors, females) to operate.

There are three possible reasons why a control system may have excessive friction:

a. Lack of maintenance. This is usually a lack of lubrication.

b. Improper maintenance. If the geometry of the system is not set up correctly parts may bind, causing friction.

c. Damage. If parts are damaged they may be rubbing on other parts, misaligned etc. causing extra friction.

The maximum friction which is acceptable varies from type to type and information may be contained in the aircraft's Maintenance Manual. Measuring control system friction should be done at the normal place the pilot grips the control. The friction is the force required to just make the system move. If the Maintenance Manual does not contain any limits, the following values should be used as a guide:

Control System	Typical Maximum Friction
Elevator	15 N (1.5 kgf)
Aileron	10 N (1.0 kgf)
Rudder	50 N (5.0 kgf)
Tow Release	75N (7.5 kgf) Unloaded cable load. Or <170N (17kgf) for two releases.
Trim	15 N (1.5 kgf)
Flaps	50 N (5.0 kgf)

Table 13-1 Control Friction Limits

If friction is above these values then further investigation of the system is warranted.

13.7 ENDFLOAT OF CONTROL SURFACES

All control surfaces should be free to move along their hinge line. This is important because the control surface and the mounting structure will expand and contract differently with changing temperature. This could cause failure of the hinges if there is no possibility of the hinges sliding endways.

A similar effect occurs as the wing flexes. This may also load the hinges axially unless there is sufficient end float.

13.8 CONTROL SYSTEM STIFFNESS

The manufacturer sets the stiffness of the control system during the design phase and does stiffness measurements during type certification. Inspectors must check for any obvious reduction in the stiffness of a control system.

Reduced stiffness may be caused by damage to the control system, damaged control system mounts or incorrect system rigging. Possible causes of reduced control system stiffness include:

a. Damaged mounts due to water damage, delamination, cracking, etc.

b. Slack control cables.

c. Buckled pushrods.

d. Incorrect control system geometry.

13.9 GAP SEALS

The majority of sailplanes have tape sealing the control surface gaps. Gap seals reduce drag and improve control effectiveness. Note the following points when reinstalling gap seals:

a. Some types have specifically approved types of gap seal and only these may be used.

b. The use of incorrect tape has caused control system buzz. This may be a prelude to flutter.

c. Restricted control surface travel is possible if the control surface is not fully deflected in the direction of maximum tape stretch when fitting gap tape. Recheck the control surface travel after fitting gap tape. Some tapes shrink after installation and they must be loose enough.

d. Tape that is not secure, either because of incomplete removal of the old adhesive or the new adhesive is faulty, may work loose and jam the flight controls. Note: Skin oils from the fingers may affect the adhesive.

e. The tape may work loose from the leading edge and then “stand up” in flight. This may reduce control effectiveness to the point where it is impossible to maintain flying speed. In one incident the pilot has to use more than 3/4 forward stick to maintain 55 knots.

f. Note some types have fowler type flaps or even ailerons and are not meant to have gap seals.

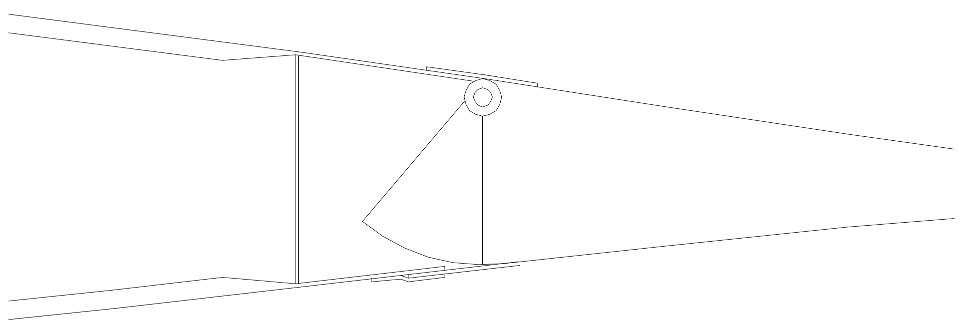


Figure 13-4 Typical Sealing For Side Hinged Control Surface

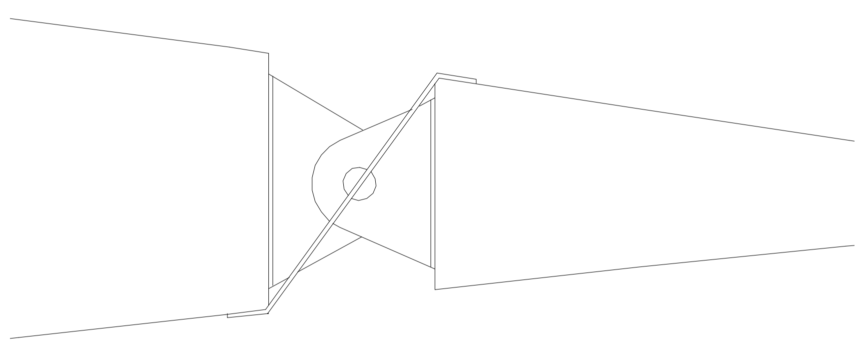


Figure 13-5 Older Style Seal

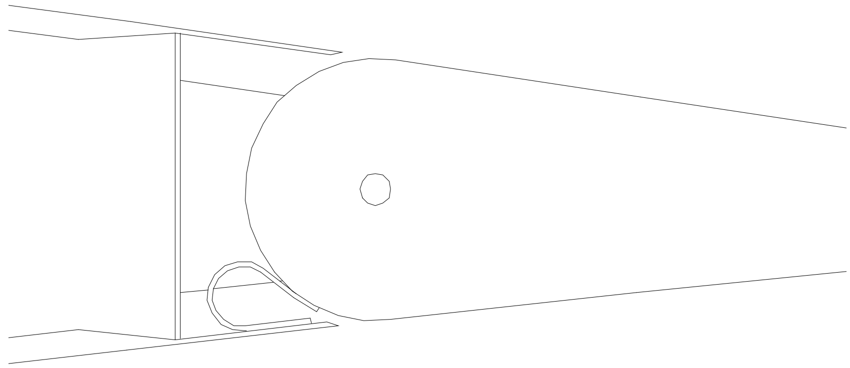


Figure 13-6 Internal 'U' Seal

13.10 PUSH ROD RIGGING

The flight control systems in most modern sailplanes use pushrods and bell cranks. The design of pushrods takes into account both tension and compression loads. For most pushrods the critical loading is compression because of pushrod buckling. Any damage to the pushrod such as dents or bends can seriously reduce the compression strength of the pushrod and the control system stiffness. This may reduce control effectiveness and possibly cause flutter.

13.10.1 ROD END SAFETY

Most pushrods have an adjustable rod end at one end to allow adjustment for manufacturing tolerances in the control system. When installing a rod end, screw it in past the witness hole. Test for correct safety by inserting a piece of wire through the witness hole. It should be possible to detect the rod end with the piece of wire. Inspectors should be careful as on some designs it is possible to push the wire past the rod end even though it is correctly in safety.

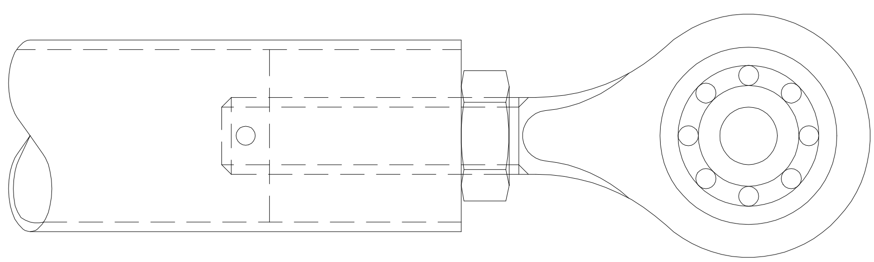


Figure 13-7 Rod End Safetying

Where there is no witness hole, the length of thread engagement must be at least 1.3 times the outside diameter of the rod end thread for steel in steel fittings.

13.10.2 ROD END ALIGNMENT

When reinstalling rod ends on a pushrod, the relative alignment of the rod ends must be correct or the rod ends will bind. When installing pushrods, ensure they do not bind throughout their travel.

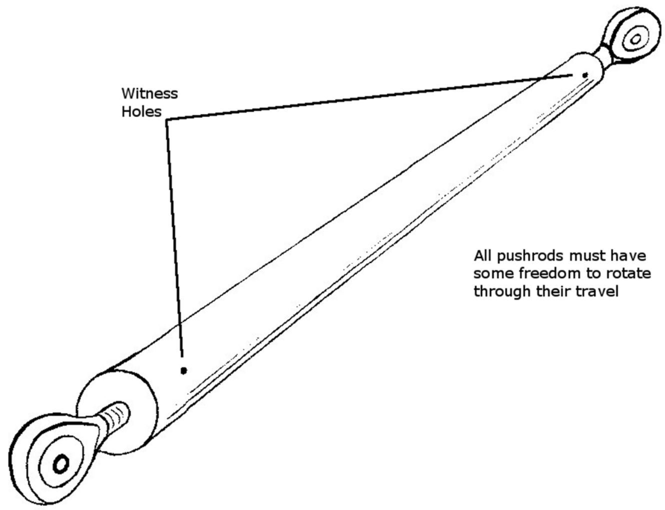


Figure 13-8 Pushrod Rotation

13.11 AIRCRAFT GEOMETRY

Check the aircraft geometry after any repairs if there is a possibility for the wings, tailplane or fuselage to have moved relative to each other.

13.11.1 CHECKING RIGGING ANGLES

The usual way to check rigging angles is with a water tube manometer. This consists of a length of clear plastic tubing filled with water. To make the water level more obvious use food dye to colour the water. It is also helpful to add a small amount of dish washing liquid to the water as this lowers the surface tension of the water and gives a more accurate reading. Be careful not to shake the tube as the froth will make accurate readings impossible.

L

Typical set-up for measuring wing incidence

H

Figure 13-9 Water Tube Manometer

h/l = tangent of angle of incidence.

if h/l is less than 0.15 then the angle of incidence in degrees equals h/l x 57.24.

Dimension l is best measured using two plumb bobs, one at the leading edge and one at the trailing edge and measuring between the two.

Checking of aircraft geometry using laser levels is becoming more common as the price has fallen. Incidence boards and survey dumpy levels are also possible tools. However the water tube manometer remains as a simple and accurate tool.

When measuring the geometry of a sailplane that has undergone substantial repairs, use a good steel tape measure to measure distances to ensure the aircraft is symmetrical.

13.11.2 WING-TAILPLANE ANGLE

This is the angle between the tailplane and the wing and is very important to the stability and handling of the sailplane. Verify this angle after any repairs to the rear fuselage, wing mounts, tailplane, etc. In metal aircraft (aluminium or steel tube) this angle may slowly change with a succession of heavy landings.

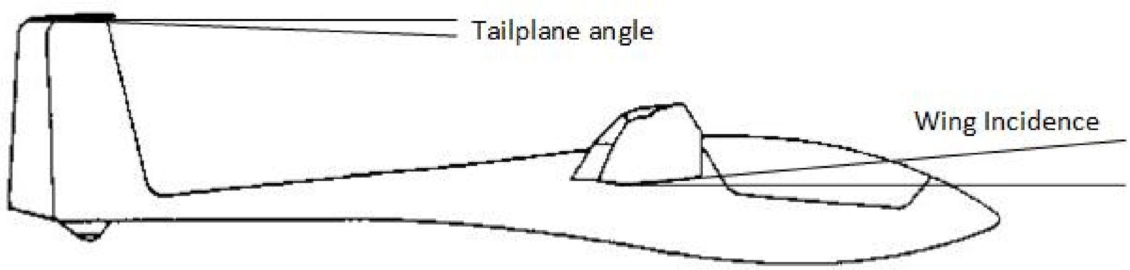


Figure 13-10 Wing Tailplane Angle

13.11.3 DIHEDRAL

The dihedral angle is the angle of the wing relative to the horizon when viewed from the front. It is normal to check this angle only after a major repair or if the inspector is suspicious that something is wrong.

13.11.4 WASHOUT

The washout of a wing is the twist of the wing along the span. This must be the same in both wings to within ½° at each span wise station. Incorrect washout can produce unpleasant stalling characteristics and a tendency for the aircraft to fly one wing low.

13.11.5 WING TO FUSELAGE

The wing to fuselage angle is important when checking if the level reference is still valid.

13.11.6 TAILPLANE TO FUSELAGE

The tailplane to fuselage angle is important when checking if the level reference is still valid.

13.11.7 FIN ANGLE

Changes in the fin geometry will noticeably affect the handling of the sailplane. All T-tail sailplanes, particularly those of metal construction, are vulnerable to changes in the fin geometry due to heavy landings and ground loops.

Displacement of the vertical fin as shown or twisting in plan view, are possible. Either defect will be evident by the need to fly with crossed controls.

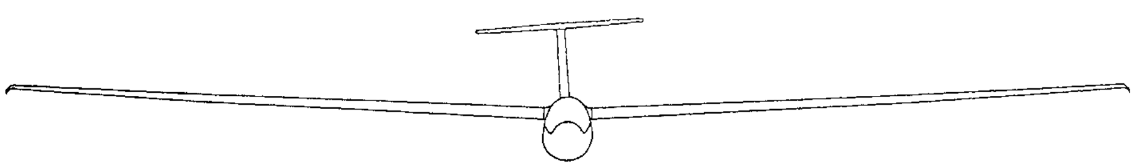


Figure 13-11 Fin Misalignment

13.12 STRUCTURAL FREEPLAY

Excessive freeplay between the different components of a sailplane such as wings to fuselage or tailplane to fuselage can cause flutter, excessive wear of rigging pins and premature fatigue due to the movement of the pins in the bushes.

13.12.1 TANGENTIAL PLAY OF WINGS

One of the most common forms of structural freeplay is tangential play of the wings on FRP sailplanes. The main cause of freeplay is wear on the main pins or in the main pin holes that prevents the wings from pulling up tight on the drag fittings. Typically the maximum fore and aft play measured at the wing tip of a 15 m sailplane is 20 mm.

To remove this play use any of the following methods:

a. Provided there is sufficient material left in the bushes, assemble the wings and line bore the hole until it is round and obtain an oversize pin. Take special care to ensure that the bush thickness is not below the minimum allowable.

b. Install shims on the drag pick-ups as detailed below.

c. Other methods exist; however, these are not covered by BSE.

13.12.1.1 SHIMS

Most manufacturers specify the correct method for installing shims to remove wing freeplay. If the manufacturer does not specify how to install shims, use the following method:

a. The shims are simply custom made washers. Manufacture them so that the inside diameter is just larger that the pin and the outside diameter should be large enough to cover the part of the structure that transfers the loads.

b. Thoroughly clean the pin and the shim using a solvent such as acetone. Be careful not to spill any on the paint or the canopy.

c. Gently roughen the surface of the shim and the flange of the lift pin and glue the shim in place using suitable glue such as contact adhesive.

d. Record the location and thickness of each shim in the log book. It is also advisable to permanently write the shim thickness on the wing or fuselage next to each pin.

13.12.1.2 TAILPLANE

Play in the tailplane fittings is possible on most types of sailplanes. Removal of this play usually requires re-manufacturing of the pins or purchasing new pins from the manufacturer. Typically the maximum play permitted at the tailplane tip is 5 mm. This freeplay is critical in all flying tailplane designs as flutter has occurred due to excessive tailplane freeplay.

13.13 CONTROL CIRCUIT FLUTTER

Flutter is a very important subject that used to kill many sailplane pilots. When it was realised and procedures and practices were implemented, largely promoted by the GFA worldwide, the number of flutter incidents has reduced until now it is almost unheard of. But it is still possible and even likely if things are done wrong.

Flutter is caused and influenced by many factors; design, maintenance, various control surface or system aspects, overspeeding and therefore instruments, and then pilot understanding and operation such as reducing Vne with altitude and how indicated airspeed works, and poor speed control.

So flutter is in a chapter on its own, Chapter 11. Be sure you understand and address all the factors involved as it could be caused due to many different Chapter subjects. And maintenance and modifications all have a part to play!

13.14 REFERENCES

Basic Glider Criteria Handbook. Federal Aviation Administration, Flight Standards Service, Washington DC, 1962

14. WORKSHOP PRACTICE

14.1 GENERAL

Before an inspection can be performed, certain facilities and equipment are required. Without an adequate workshop or the correct tools it is not possible to perform the tests which are required, make any rectifications or to disassemble the sailplane.

14.2 SAFETY

14.2.1 CHEMICALS

Minor maintenance which often involves cleaning with solvents, finish touch up and lubrication of components is usually associated with most inspections.

Solvents, greases, paints, resins and other chemicals can enter the body when a person breathes in their vapour, through skin contact, or through the mouth from contact with food or fingers. Vapour can be concentrated in enclosed spaces, such as inside a sailplane fuselage, so good ventilation should be available. Some chemicals can impair memory and cause headaches, dizziness, fatigue, mood changes or nausea and exposure to high levels can cause liver damage, unconsciousness, death and cancers.

Solvents can also be flammable so care must be taken to keep them away from sources of ignition, such as lead lights. A battery powered torch is safer in these situations.

All chemicals used when working on sailplanes should only be used as recommended by the manufacturer and detailed in their Safety Data Sheet (SDS) - previously called a Material Safety Data Sheet (MSDS). This is a document that provides information on the properties of hazardous chemicals and how they affect health and safety in the workplace. For example an SDS usually includes information on:

a. The identity of the chemical,

b. Health and physicochemical hazards,

c. Safe handling and storage procedures,

d. Emergency procedures, and

e. Disposal considerations.

The SDS should always be referred to when assessing risks in the workplace. A file of relevant SDSs should be maintained and kept in the workshop for reference.

14.2.2 MANUAL HANDLING

Lifting and moving equipment and materials as well as working in awkward postures are part of most inspection tasks.

Work tasks may involve bending and stretching as well as twisting sideways which increase the risk of manual handling injury. It is possible to control risks associated with manual handling by:

a. Organising the work to reduce the number of manual handling tasks involved

b. Providing mechanical lifting devices such as trolleys, hoists and jacks where appropriate

c. Taking regular resting breaks from awkward tasks

d. Making sure the workplace layout allows enough space to move and work safely and comfortably.

If lifting equipment or other aids are not available, the job may require more than one person to achieve.

14.2.3 SLINGING AND SUPPORTS

During inspection and other work, the sailplane will be derigged and the major pieces worked on separately. They can be supported on trestles or in purpose built cradles. Parts such as the fuselage which can support their own weight may be steadied by slings, ropes or ratchet tie downs. In all cases thought should be given to the risk of damage if the sailplane part should fall off the trestle or slings loosen. Clamping wing spars to trestles and using multiple slings for fuselages will reduce the likelihood of accidental damage.

Extra care should be taken both when working underneath major sailplane parts such as when changing wheels etc. and when working alone. People have been killed when the fuselage has rolled on top of them and no one was able to assist to lift it off.

14.2.4 HOUSEKEEPING

A slip or fall can cause injury to the arms, legs, back, neck or head. Neck and head injuries can cause damage to the spinal cord and nervous system. Many people have suffered permanent disabling injuries as a result of a fall. Poor 'housekeeping' in the workshop leads to slips, trips and falls. Oil spills, parts, extension cords and hoses left on the workshop floor can all result in preventable accidents. Bins should also be provided for disposal items such as old rags, empty containers, paper and other rubbish. These should not be allowed to overflow.

14.2.5 WORKSHOP FACILITIES

It is almost impossible to perform a complete and thorough inspection without a place to work that is out of the weather. If an inspector is trying to work outdoors then allowance must be made when scheduling work for delays due to rain. Any workshop used should have excellent light as many cracks are impossible to detect in dim light.

14.3 EQUIPMENT

14.3.1 WORKSHOP EQUIPMENT

The following workshop equipment is likely to be required by the inspector and so should be readily available:

a. Trestles or other supports.

b. Bench with vice.

c. Equipment for slinging

d. Mobile lighting

14.3.2 HAND TOOLS

Inspectors require the correct tools for the job. Each inspector should own a basic tool kit which consists of:

a. Spanner and socket set (1/4" drive sockets are recommended).

b. Screwdriver set (Phillips and chisel).

c. Inspection mirror.

d. Good torch with batteries.

e. Bearing cleaning and greasing equipment.

f. Steel ruler.

As an inspector gains experience the following tools, among many others, should be gradually added to their tool kit:

g. Inclinometer (incidence measuring tool).

h. Magnet on a stick.

i. Magnifying glass or loupe.

j. Spring balance or electronic luggage scales

k. Micrometer or digital callipers.

l. Lock wire pliers

m. Water tube manometer for ASI checking.

n. A pair of small diameter brass tubes for rope release re-assembly.

o. Various short lengths of non-ferrous rod for drifts and hole alignment tools.

p. Artery clamps for split pins and other small parts.

q. Torque spanner for propellers and spark plugs.

r. Centre punches for bearing peening.

s. Files for minor smoothing.

t. Drill and bits for perspex relief holes etc.

u. Boroscope.

Inspectors should also consider purchasing a cheap set of spanners which can be "modified" to fit difficult to reach nuts and bolts.

14.4 DISASSEMBLY

When disassembling a sailplane, particularly if you are not very familiar with it, it is recommended that a sketch be made of how all the parts fit together. The sketch need not be very complicated but it needs to show all of the relevant details necessary to reassemble the parts. Instead of a sketch, often a photograph on a mobile phone may assist later reassembly.

If possible, the parts themselves should be marked to show the correct reassembly. Care needs to be exercised here because any scratches or dents can form stress raisers that may lead to fatigue cracking. Also if the part is repainted then pen markings will be lost.

14.5 STORAGE OF PARTS

As parts are removed from the sailplane, small parts should be placed in a sealable container which has been clearly marked as to where the parts are from. Suggested containers are plastic bags with the zip closing mechanisms. These bags often have a printed area which can be written on using a normal pen thus making labelling of the parts easier.

Larger parts must be stored so they are not damaged and are protected from the elements. Parts that are carefully greased each time the sailplane is rigged may have the grease removed during maintenance, which makes them susceptible to corrosion, so protection is needed during storage.

14.6 FOREIGN OBJECTS

The introduction of foreign objects during maintenance is a problem which is as old as aviation itself. Spanners, nuts, bolts, off cuts and personal items such as coins or keys have caused fatal accidents, sometimes months or years after the maintenance has been completed. These foreign objects slowly work their way through the structure until they jam the flight controls leaving the pilot with no hope of recovery.

Before closing any compartment, either during a repair or when reinstalling a seat pan or inspection panel, a careful inspection, preferably by an independent person, is required to ensure no foreign objects are left behind. All tools should be accounted for and tools should never be placed in the sailplane. Use a separate bench, preferably a mobile one, so that tools are accessible but are not in the sailplane.

Each part which is removed from the sailplane should be placed in a storage place so that it is not lost and can be accounted for.

14.6.1 TOOL CONTROL

Some ideas to reduce the chances of leaving items inside the sailplane are:

a. Keep socket sets in the original case and spanners in tool rolls for quick identification of missing items. Make a dedicated tool holder for other items.

b. Purchase or paint tools a bright colour to be more easily spotted.

c. Use a small table to store the tools on prior to use. Using masking tape identify the tools that are being used by writing the tool name and sticking the tape to the table. Remove the tape when the tools are returned to the table.

d. Use a tool trolley and cultivate the habit of putting tools down on the trolley.

e. Do not use tool sets belonging to more than one person.

f. Place all tools away at the completion of each job or at the end of each working period.

14.7 REASSEMBLY

It is preferable that the person reassembling the parts is the person who disassembled it but sometimes this is unavoidable.

When assembling a sailplane following maintenance it is important to ensure that:

a. Parts are reassembled correctly. Now is the time that sketches and photographs made during the disassembly are useful. When unsure of how a part goes back together the inspector must rely on the manufacturer's manuals and if necessary contact the RTOA or CTOA for guidance.

b. All parts are accounted for. If parts are missing the manufacturer will need to be contacted for a replacement and the possibility that the part is located in the sailplane waiting to jam a control must be considered. Even nuts and bolts which are replaced should be accounted for. Excess parts are obviously a problem

15. SAILPLANE MATERIALS

15.1 GENERAL

The inspection of sailplanes requires knowledge of the properties of the different materials that sailplanes are constructed from. The inspector must know the failure modes the material is likely to exhibit when overloaded and the signs which are exhibited once failure has occurred.

15.2 MATERIALS

Sailplanes can be constructed from a number of different materials and it is important for inspectors to know the tell-tale signs of damage in each. Materials can be broadly classified into two classes according to their failure mode; brittle and ductile. Brittle materials fail by catastrophic cracking and usually show little sign of damage prior to failure. Ductile materials permanently deform steadily above the limit load and can carry significant loads up to ultimate failure.

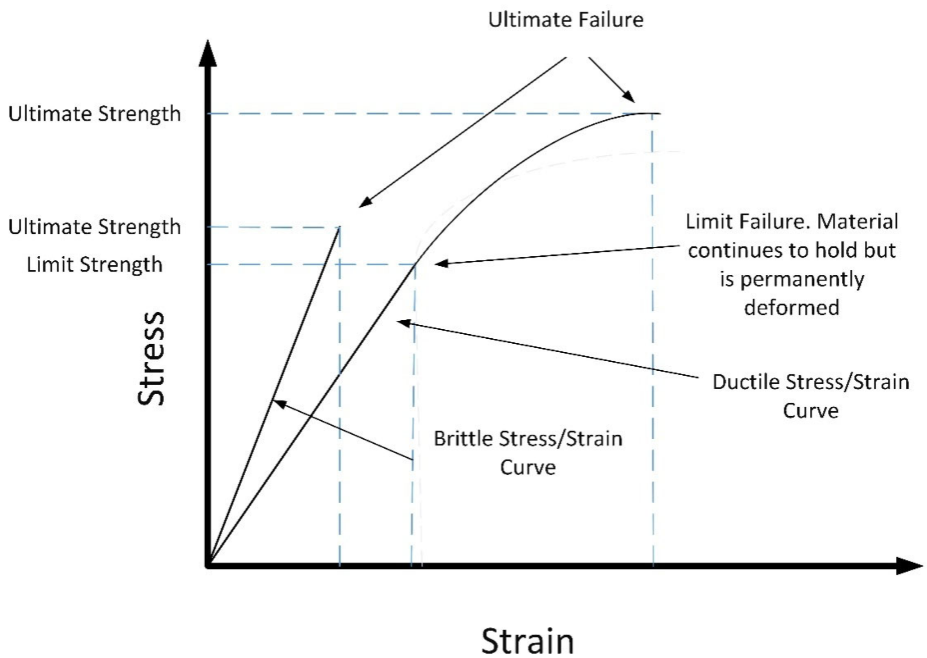


Figure 15-1 Ductile And Brittle Materials

Thin materials loaded in compression or shear can also fail by buckling. Most buckling failures are catastrophic because the material deforms and the new shape is only able to carry less load. It is possible for structures loaded in shear to undergo elastic buckling during which the sheet continues to carry load and returns to its original shape when the load is removed. This type of buckling is usually found on the top surface of wings during flight and is regarded as normal behaviour of the structure. If a buckled shape is present after the load is removed then a repair is required.

15.3 FRP CONSTRUCTION

Composite materials are constructed by wetting out layers of cloth, one on top of the next, using a liquid resin which then sets binding the fibres together so they are strong and stiff. This ‘mixing’ of materials produces a composite material which is better than the original components. The fibres increase the toughness of the resin and the resin holds the fibres in place so they can hold the load better and prevents the individual fibres from buckling under compression loads.

This laminating of the material allows the strength of the part to be tailored to provide strength where it is needed. This is done by orientating most of the fibres in the direction which has the largest load. Examples of this are the orientation of the fibres at ±45° to the flight directions in the wing skins as this is the direction of highest load due to wing torsion.

The only exception to laminating of layers is when the loads are simple compression or tension. The cloth material is replaced by long strands of fibres called rovings. These are very good at carrying pure tension or compression and so are used in the spar caps to provide maximum strength in the required direction.

The epoxy resin and the fibres are brittle, with carbon being extremely brittle. Therefore composites are brittle in their failure mode.

15.3.1 GENERAL COMPOSITE INSPECTION TECHNIQUES

Techniques which can detect damage in all composite materials are as follows:

a. The exterior surface may be deformed showing buckles or waviness where the skin is no longer attached to the internal stiffeners.

b. An actual fracture surface which can be seen or felt. Be careful as sharp fracture surfaces easily cut skin.

c. The gelcoat surface will show cracks. Paint materials are more flexible than the composites they cover and so an impact which cracks the matrix will not necessarily crack the paint. Painted sailplanes require very careful inspection.

d. A strong light shone along the surface (at a very flat angle) will high-light defects by casting a shadow.

e. A light placed inside the structure will allow any cracks or defects to be seen as they will tend to show up as dark shadow lines. This test requires a fairly dark workshop and a strong light. It will not work through sandwich construction.

f. The tap test, where a coin or similar round edged, hard object, is tapped over the surface is a reliable method of finding damage in FRP sailplanes. If the part is damaged the sound will be dull compared with undamaged structure.

g. Placing a stethoscope on the structure and then deflecting it may find damage because any fracture surfaces will rub against each other as the structure is deflected.

h. Ultrasonic inspection is becoming normal practice for composite inspection of airliners. While this method is not yet used with sailplanes, this it may well change in the future.

i. Inspection cameras on cables, typically attaching to a computer's USB port, are now cheap and they enable internal inspections which were previously very difficult.

15.3.2 GLASS REINFORCED PLASTIC

The inspection of Glass Reinforced Plastic (GRP) is relatively easy because damaged areas turn white. This change of colour is marked and provides a reliable guide to presence of damage.

A problem area with GRP is where it is subjected to crushing loads, such as occurs under screw or bolt heads. In time, the hole enlarges and the component may become unserviceable until repaired.

15.3.3 CARBON FIBRE AND KEVLAR REINFORCED PLASTIC (CFRP AND KRP)

When the fibre reinforcement is Carbon or Kevlar, the detection of damage is much more difficult. Unlike GRP, damaged CFRP and KRP do not change colour when damaged. Parts must therefore be examined more closely and other techniques used to detect damage. Be aware that CFRP in particular can transmit overloads through the entire structure and damage may exist well away from the point of impact.

15.3.4 DELAMINATION

One of the most common failure modes of composite materials is delamination. This is the separation of the layers of fibres caused by failure of the matrix material.

When the components are laid up in one cure cycle, chemical bonds form throughout the part and delamination is unlikely in normal situations.

Delamination is most likely to occur where parts have been manufactured and then joined together by some form of glue or else when the original layer has been allowed to cure before more layers are added.

Failure in these locations is more likely because the bond on the surface is mechanical, ie the bonding resin only flows into the tiny sanding marks in the surface of the part being joined to. Despite this a properly prepared surface can give a mechanical bond which is as strong as a wet layup one.

When preparing a part for a wet-on-dry layup, it is a good idea to blow the part clean and look for shiny spots which indicate insufficient sanding.

15.3.5 CRACKING

When a composite structure is overloaded it is common for the structure to be deflected and damaged and then to spring back to the original shape. The consequences of this are that the structure may look largely intact with only a small fracture in the finish but the damage can be very serious with delaminated bulkheads and shattered skins.

Other cracks can be the result of fatigue. Like sailplanes constructed of other materials, these often form around the corners of the dive brake boxes, especially on the lower surfaces which are subject to tension. Fatigue cracks in sailplanes of composite construction can also grow in parts subject to compression. Once some small damage has occurred, the crushing of the damaged matrix material causes the damaged area to grow.

15.3.6 FAILURE OF SANDWICH MATERIALS

There are two primary failures which occur to sandwich materials; the outer layers of fibreglass can separate from the foam or balsa core and the core material itself can be crushed or damaged. Delamination can best be detected by the tap test and because the separated laminate tends to bubble up from the core creating a bulge. Crushed core material is normally detected because the surface is dented or pushed in.

15.3.7 GELCOAT CRACKS

Cracks in gelcoat are caused by deflection of the underlying structure taking the gelcoat past its limits, this may or may not damage the underlying structure, or by failure of the gelcoat itself. Gelcoat failure is usually the result of exposure to ultra violet light, water and the presence of microscopic scratches which are introduced during the final sanding of the gelcoat.

Impact cracks are usually identified as they seem to originate from a point and radiate out or they follow the stress lines of the sailplane. Gelcoat failure cracks tend to be fine, close together lines which run fore-aft on the wings except for the leading edges where they run span wise following the sanding marks along the mould line.

15.4 WOOD CONSTRUCTION

Sailplanes constructed from wood are in many ways similar to inspect to FRP because timber fails in a brittle manner. The inspection techniques in Section 15.3.1, except for shining a light through the structure, are effective on wooden structures. In addition, wood structures have failure modes which are specific to timber construction and these must be inspected for.

15.4.1 COMPRESSION SHAKES

Perhaps the most insidious failure that can occur in a sailplane is the compression shake. A compression shake occurs when timber is subject to a shock compression load. Shakes leave the timber almost unmarked with no deformation or change in shape but the strength of the material is reduced to almost zero.

Compression shakes are microscopic buckling of the cellulose fibres in the timber. These buckles effectively sever the fibres which provide the timber’s strength. Only the most careful inspection will detect shakes and often the only sign is damage to varnish across the shake.

Figure 15-2 Compression shakes

15.4.2 DRY ROT

Dry rot is a fungal growth in timber which eats away at the strength of the part. Despite its name, dry rot only begins in the presence of water and it can be detected by a bluish discolouration which looks something like water ‘tide’ marks.

As the fungus is eating away the cellulose, the strength of the timber reduces very rapidly from the onset of dry rot and this is why wooden sailplanes should never be allowed to get wet.

15.4.3 GLUE FAILURE

Repairs to older wooden sailplanes and newly constructed amateur built wooden sailplanes use, almost universally, epoxy glues to join the timber. The epoxy is many times stronger than the timber being joined and because it is inert, once set, it is immune to the effects of water and fungus. Unfortunately many of the older glues are not so stable.

Resorcinol is a black glue which also shows as black lines between the various components. Like epoxy, resorcinol is very resistant to water damage and fungal attack but it requires high precision in the fit of one part to another. For this reason careful inspection is required as components which have gaps between them are unlikely to have a full bond.

Older glues such as casein are very susceptible to water damage. Sailplanes constructed from casein are best inspected by nose! If casein is wet it gives off a strong, unpleasant smell and reduces to zero strength almost immediately. Another type of glue which has shown a tendency to failure when wet is kaurit. Kaurit was used on older German types such as the K7. Kaurit is a pink glue and sailplanes which have been wet or have resided in a tropical climate are very likely to have failure of this type of glue.

15.4.3.1 THE FINGERNAIL TEST

In several regions of the sailplane small gussets should be given "The Fingernail Test" to determine the quality of the glue joint. The fingernail test is performed by inserting a fingernail behind the gusset and applying pressure until it feels uncomfortable. Note: If small gussets cannot be broken off using reasonable finger pressure then the glue is considered to be satisfactory. If the gusset breaks off the surfaces must be inspected and interpreted as follows:

a. Failure in the timber, shown by wood fibres attached to the glue, indicates that the glue is in good condition. Gussets must be glued back on by appropriately rated persons.

b. Failure of the glue, no wood fibres attached to the glue, indicates that the glue is in poor condition and further investigation must be undertaken to determine the extent of the substandard glue and repairs made as necessary.

Wherever there are signs of water having entered the structure the fingernail test must be performed.

15.4.4 FAILURE OF FABRIC COVERINGS

Most sailplanes constructed from timber and the control surfaces of many FRP and aluminium sailplanes are covered by fabric to give the aerodynamic surface. All fabric is a lifed component and will, due to exposure to heat, dust, moisture and especially UV light, gradually weaken until it can no longer be considered airworthy.

Fabric can be divided into two classes. The older cotton fabric which is tensioned on the airframe by the use of tautening dopes (dopes which contract as they dry removing the slack from the fabric) and the more modern polyester fabrics which shrink onto the airframe after heating. Cotton in regular use has a life of 7 to 10 years, whereas the heat-shrink fabrics seem to last at least twice as long.

Inspecting fabric requires significant experience to determine whether the strength has degraded to the point where the fabric requires replacement. Signs that the fabric is nearing the end of its life include:

a. Loss of tension.

b. Permanent dimples introduced by a solid push with the thumb.

c. Cracks in the paint surface.

d. A slight tearing sound when the fabric is loaded with the thumb.

15.5 METAL CONSTRUCTION

Sailplanes constructed from metallic materials exhibit different failure modes than those constructed from FRP or wood. This is because metals tend to exhibit ductile failure. Materials which have ductile failure modes have a limit load and if the loads in the part are less than this it returns to its original shape but if it is loaded to more than its limit load if takes on a deformation which remains after the load is removed.

15.5.1 RIVET FAILURE

When a sailplane constructed from sheet aluminium is overloaded, it is common for the rivets that attach one part to another, to fail. If the load is high enough, the rivet will fail completely and fall out of its hole. If the load is less than that required to completely fail the rivet, the heads of the rivet will remain in place but the rivet may be damaged such that its strength is significantly reduced. This can take the form of tilting of the rivet head or partial shearing through the shank.

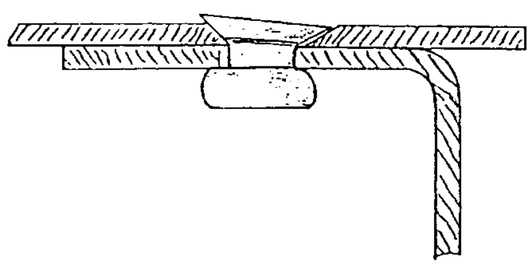


Figure 15-3 Tilting Of Rivet Head

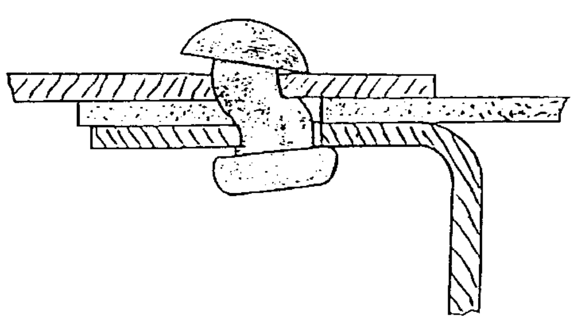


Figure 15-4 Partially sheared rivet

In addition to overloading, rivets may loosen and move in their holes. This is known as a working rivet. Because the rivet moves in the hole the internal surfaces rub against each other which continuously removes the protective oxide coating. The removal of the coating allows corrosion to occur and the corrosion products form a black ring around the rivet head.

A certain number of working rivets is allowed but the actual number varies from type to type and with the position of the rivets on the sailplane. For this reason the sailplane's Maintenance Manual should be consulted to determine the maximum number of working rivets allowable at any location.

15.5.2 FATIGUE CRACKING

Metallic materials, much more than other materials, are prone to fatigue cracking. These cracks are a result of repeated loading of the part and are most likely to occur at holes and cut outs as these increase local stresses to many times what the material would experience if the discontinuity was not there. Fatigue cracks are usually very fine and the non-destructive testing methods of Section 1.22 are well proven methods of finding these cracks.

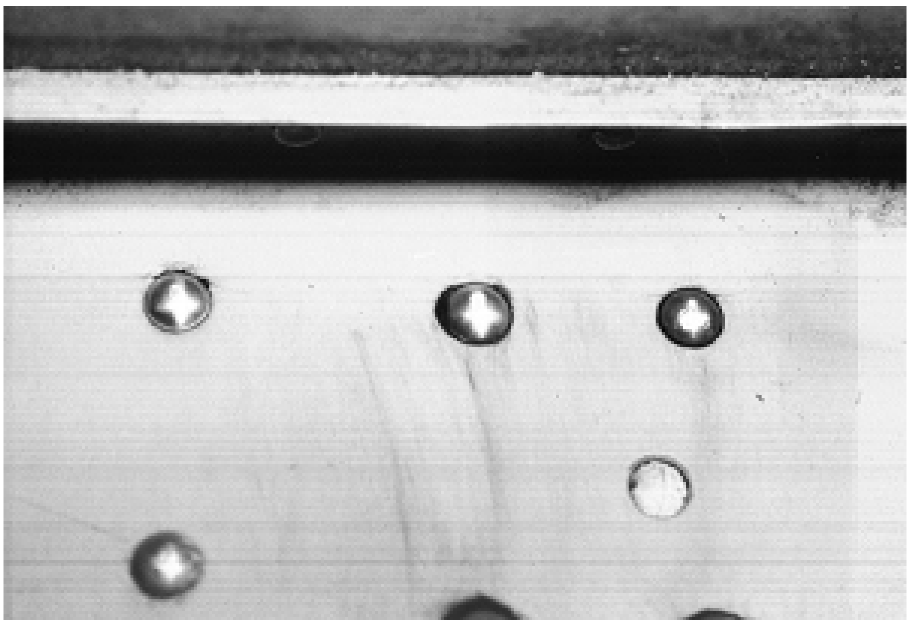


Figure 15-5 Fatigue Cracks Initial Stages

Figure 15-6 Final Stages Of Fatigue Cracking

15.5.3 BUCKLING

All thin materials can fail by buckling, however aluminium based materials are more likely to take on a permanent set after buckling because they are ductile. The change of shape after a structure has non-elastically buckled causes a significant reduction in the strength of the part as it is no longer correctly aligned to take the load. Aluminium structures must be carefully inspected for creases and wrinkles which may have been caused by buckling. If buckling is detected the internal structure requires careful inspection as frames, ribs, bulkheads or stiffeners may have been damaged.

15.5.4 INTER-RIVET BUCKLING

Buckling on a small scale can occur between rivets causing corrugations in the metal.

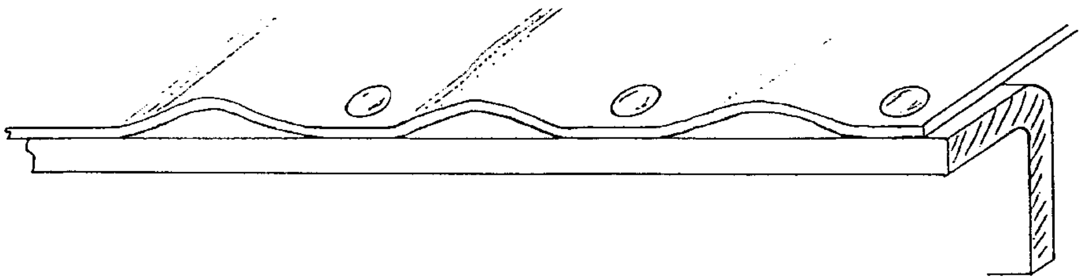


Figure 15-7 Inter-Rivet Buckling

15.5.5 CORROSION

Metallic materials are susceptible to corrosion however the degree of susceptibility and the type of corrosion depends on the type of metal and the alloying elements which have been added to produce the desired material properties.

15.5.5.1 STEEL

Steel is an alloy of iron and carbon. When it corrodes, the iron combines with oxygen in the presence of water to form iron oxide which is the familiar red powder seen on rusted steel. Iron oxide is a crumbly, porous material which retains water and allows the corrosion process to continue.

Small surface corrosion of steel can be tolerated provided the surface is repaired. The old paint should be removed and the rust treated with a rust converter (phosphoric acid). The paint must be renewed to prevent the rust returning. Large areas of corrosion require replacement of the component.

15.5.5.2 ALUMINIUM

The most common aluminium used in aircraft structures is an alloy of pure aluminium and copper. Aluminium is very easily corroded forming aluminium oxide. Fortunately, aluminium oxide bonds very well to the underlying metal and provides a protective coating which prevents further corrosion.

Pure aluminium produces the best oxide coating therefore aluminium alloys corrode more readily than pure aluminium. To take advantage of this many aircraft are manufactured from Alclad where a thin layer of pure aluminium is coated onto the stronger alloyed aluminium so providing improved corrosion resistance.

The most common form of corrosion seen on aluminium sailplane skins is pitting corrosion which starts with a small defect, often a stone chip, which disrupts the protective coating and allows corrosion to start. The newly formed surface layer will be imperfect and so corrosion can grow at this spot.

While aluminium and copper (plus a few extra trace elements) is the most common alloy for sheet metal, the larger aluminium parts such as spar caps and fittings are manufactured from different alloys. These parts are often extruded and need to be stronger, because of the concentrated loads, than the copper alloys. Typical alloying materials are magnesium and silicon.

These alloying elements and the extrusion process which is commonly used to manufacture the part, results in a susceptibility to exfoliation corrosion. Exfoliation is corrosion between the grains of the material and is characterised by swelling of the material as corrosion products form a white powdery dust.

15.5.6 FAILURE OF STEEL TUBES

Steel tube structures fail in a number of ways. They can gradually deform over time which changes the angle between the wings and the tailplane. This can have a significant effect on the controllability of the sailplane and may make the level reference used for weighing invalid.

Steel tubes subject to high compression loads can fail by forming a bulge adjacent to a cluster joint. These bulges require special inspection, especially following heavy landing as they are difficult for the untrained eye to spot. The tubes appear to be normal to a casual inspection and only careful inspection of each junction will reveal their presence.

15.6 METAL FITTINGS

The inspection techniques for metal fittings do not differ significantly from the techniques for other metal airframes except that the area where metal fittings attach to timber or FRP structures are often a weak point. Points to look for include whitening of the surrounding FRP, loose bolts, crushed timber and cracking of the fittings.

Spigot pins are constructed with a taper to aid in assembly of the parts and these can be damaged by misaligned bearings during the assembly process. When next assembled the damage marks on the pins can catch on the bearings, knocking them out of alignment and making rigging difficult. Any ridges or burrs on the pins should be dressed out with a fine file and emery cloth paying special attention to ensuring the surfaces the bearings normally bear on are not damaged. The use of extreme pressure grease is recommended.

Spigot pins are subject to wear, especially if play is excessive. Check for this by noting the fore and aft wingtip play on the assembled sailplane. Be prepared to replace worn spigot pins when necessary.

15.7 REFERENCES

ANC 18. Design of Wood Aircraft Structures. Aircraft Committee Munitions Board, 1951.

Acceptable Methods, Techniques, and Practices, Aircraft Inspection, Repair & Alterations, U.S. Department of Transportation, FAA, 1998.

Military Standardization Handbook. Metallic Materials and Elements for Aerospace Vehicle Structures. Department of Defence, Washington DC. 1983.

16. TOW RELEASE MAINTENANCE

16.1 INTRODUCTION

This chapter specifies the GFA Standard System of Maintenance for tow releases in sailplanes and towplanes. MOSP 3 Sections 13.3 and 23, and this section of BSE replaces previous GFA ADs 277 and 293. It takes precedent over release manufacturer's manuals. It does not take precedence over the aircraft Maintenance Manual or all other applicable ADs – these cover the specific installation which may require differences. However, the servicing and overhaul of the releases must be done according to this procedure for Australian sailplanes and towplanes.

Sections **Error! Reference source not found.** to **Error! Reference source not found.** are background about releases. Sections **Error! Reference source not found.** onwards are the test procedures previously specified in AD 277 and AD 293. But note there are slight differences.

Significant changes in this version from the ADs and previous BSE:

a. Common testing regime for Tost and Tost-like releases. GFA has decided to use the same testing regime for all releases. Because TOST is the most common and best developed, we have decided to use TOST documentation and added consideration for the dusty Australian conditions.

b. Mandatory requirement to change Tost main springs in releases is now defined in MOSP 3 Section 13.3.

c. Revised acceptable value criteria for tests 2 and 3. We have changed to the current TOST manual specifications and made them more logical.

d. Revised Test 4, now tests the back-release operates within a specified angle range when under a given tow load. Previously in AD277 it measured the force of the load required to activate the back-release at a given angle – this was not what TOST intended.

e. GFA has confirmed TOST specification values and changed to these. There were slight variations which new TOST components may not have met.

This chapter does not apply to the following release types:

f. Blanik: Blanik sailplanes usually have Blanik branded releases which are to be maintained according to the manufacturer's documentation. See GFA AD 015 which still applies.

g. Schweizer: Schweizer sailplanes usually have Schweizer branded releases which are to be maintained according to the manufacturer's documentation.

Other types of releases not able to comply with the procedures described in this chapter must request approval from the GFA CTO for their use and their maintenance regime.

16.1.1 TERMINOLOGY

This chapter uses the following terms extensively:

Actuation force	The force, when applied directly to the release lever arm attachment point, that is required to activate the release.
Pilot actuation force	The force that the pilot exerts in the cockpit to activate the release. It includes any force required to overcome friction in the release control circuit.
Tow load or force	The force exerted on the beak of the tow release by the tow or test ring.
Units	A multitude of units are used. BSE uses kgf (kg force ie the force exerted by 1 kg mass subject to gravity). CAO 100.5 uses N (Newton is a force unit ~ 0.1kgf.) and kN which is ~ 100kgf. TOST uses daN which is 10N ~ 1kgf. These are approximate as the unit of gravity relates to them and is not exactly 10 m/s^2, it is 9.8 m/s^2. But for our uses, 10 m/s^2 is good enough.
±	A range of values is specified X±Y. this means any value from and including X-Y to X+Y. eg, 7.5±1.5 is 6.0 to 9.0 or +83°±7° is 76 to 90°. Y is the tolerance.

16.1.2 WHO MAY INSPECT, MAINTAIN AND TEST TOW RELEASE MECHANISMS

Daily Inspectors must inspect releases installed in aircraft prior to the first flight of the day.

Testing and servicing of tow releases and associated control circuits shall only be conducted by, or under the direct supervision of, persons with a GFA Annual Inspector maintenance authorisation.

The GFA has approval from the manufacturer to carry out maintenance on Tost releases, as long as their supplied parts are used, thus meeting their requirements without having to send the releases to Germany.

GFA Annual Inspectors are authorised by CASA to overhaul towplane releases. Tow pilots are authorized as detailed in CAAP 42ZC, Schedule 8 to remove and replace sailplane tow hooks. However any maintenance of the release mounting or release control circuit must be undertaken by a certified LAME. Note that the maintenance and operation of the towplane releases must be in accordance with CAO 100.5 Appendix 1 Clause 12 as most towplanes do not have an exemption to CAO 100.5. (Only GFA registered sailplanes currently have an exemption in total to CAO 100.5). By following this maintenance schedule CAO 100.5 will be complied with.

16.1.3 PURPOSE OF THE TOW RELEASE SYSTEM

The tow release system attaches the sailplane to a launching force that may be aero-tow, winch or auto-tow. It transmits the launch force from the tow cable to the airframe. It enables the pilot to release the tow rope/cable at his command.

The tow release system comprises the tow cable ring assembly, the tow release and the release control circuit. To reliably operate, all components of the release system need to be of sound design, properly cleaned, maintained in serviceable condition, inspected regularly and tested.

Releases designed specifically for winch launching (some time referred to as centre of gravity or C of G releases) include an automatic back-release function to ensure the sailplane does not inadvertently progress beyond the normal top of climb with the cable attached.

16.1.4 MANUFACTURERS OF RELEASES

By far the most common tow release device used on sailplanes in Australia is the Tost release, of which there are several models.

 Tost E85 aero tow release assembly	 Tost Winch launch release assembly with back-release.

Figure 16-1 Tost Releases

The 2nd most common release is the Ottfur OM100 series, which was original equipment in many older British sailplanes. The Ottfur was originally manufactured by Vickers in the UK and then from 1990 until 2005 by Cair Aviation also in the UK. The mechanisms are very similar to Tost.

 Ottfur OM100 Type D	 Ottfur OM100 Type E

Figure 16-2 Ottfur Releases

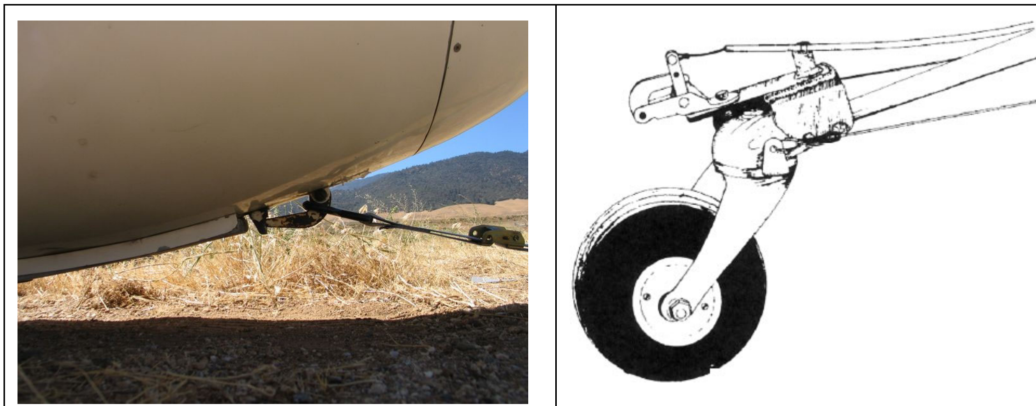
Other makes of release sometimes found on older sailplane types are:

a. Blanik - Blanik sailplanes were manufactured with a Blanik specific release.

b. Davies - Small numbers possibly still in use. Similar to Tost.

c. Bennet - Small numbers possibly still in use. Similar to Tost.

d. Schweizer - These releases use a very different method of capturing the tow ring, locking and triggering release compared with Tost like releases.



Schweizer release on a sailplane | Schweizer release on a tow plane

Figure 16-3 Scweizer Releases

Fitting a release of a different type to that specified by the sailplane's manufacturer is considered a modification and approval must be obtained from the GFA CTO who can arrange an Engineering Order.

16.1.5 AIRCRAFT FITTED WITH TWO RELEASES

Many sailplanes are fitted with both nose and belly releases. As they are connected by a common control circuit, a malfunction in one may affect the operation of the other.

At annual and periodic inspections, if both releases are connected in the circuit then both releases must be serviced/overhauled, even if one has not been used for launching since last overhaul. This is because the unused release is still considered as in service and its performance may be degraded by dirt, use and operation of the release control circuit will actuate the release and fatigue the spring.

In some cases, it may be decided to remove a release that is not being used and alter the control circuit accordingly. In which case AIRW-15 Schedule of Permissible Unserviceabilities must be complied with.

16.2 RELEASE PRINCIPLES: OVER-CENTRE & CAGED

It is important to understand the two main design principles that make these releases function: over-centre and caged.

16.2.1 OVER-CENTRE

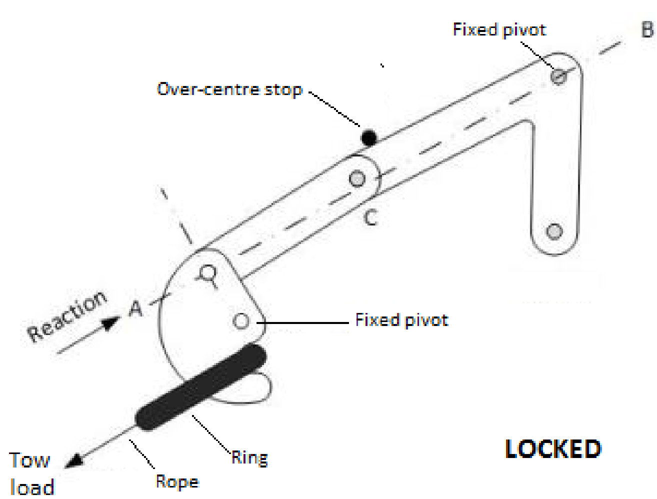
The hook locking action and unlocking action is described and shown in diagrams below:

<u>Locked</u>

In the locked position, (C) has gone "over-centre", ie it has "crossed over" the straight line between A and B.

In this configuration, the cable can be pulled as hard as is desired and the mechanism will not "unlock" because the cable load locks the mechanism harder against the stop.

The location of the stop determines the "degree of over-centre". This is adjustable using a screw in some releases.



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<u>**Open**</u>

To open the release, the pilot rotates the mechanism from the "over-centre" position, through "centre", to "open".

Once past "centre" the tow cable load will continue the opening action assisting the pilot.

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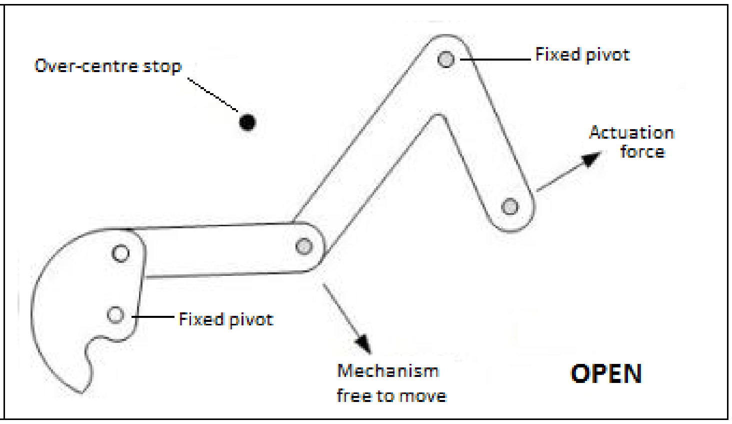

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The mechanism is pushed into an over-centre locked state initially by the release mechanism's main spring. Then when subjected to a tow load on the beak, a resulting force further acts to maintain the over-centre position.

The pilot actuation force (as required by the pilot in the cockpit) to unlock the mechanism is thus proportional to the tow cable/towrope load and the amount of "over-centre", plus the main-spring tension and friction in the release control circuit.

It is important to understand how the position of the stop affects the pilot actuation force required:

a. <u>Too much over-centre</u>: This will result in a high pilot actuation force being required to achieve release, especially at high tow cable loads. The pilot actuation force must be reasonable and such that a low strength pilot can operate the release up to the maximum tow cable load (as determined by the weak link used).

b. <u>Too little over-centre</u>: This can result in a "hair trigger" release which requires little pilot actuation force and can make the release sensitive to dirt and main spring tension. This has resulted in numerous uncommanded releases whilst under tow.

c. <u>Correct over-centre</u>: This creates a reasonable level of pilot actuation force even with a maximum tow cable load.

16.2.2 CAGED

The purpose of the cage is to ensure the force on the beak during a tow is always longitudinal to the sailplane. Ie no sideways pull is experienced by the beak.

Some older sailplanes are not fitted with a cage built into the release but rely instead on two angle pieces located on the skin of the sailplane to act as a cage. These can become worn down because of wheel up landings. The angle pieces must be installed to the dimension shown in the manufacturer's documentation and parallel to each other for proper release function.

In most releases designed for aero-tow, slots in the side plates of the mechanism body form jaws on either side of the beak to position the ring in the correct position for the beak to hook over.

With an automatic back-release as used for winch launching, the jaws are usually part of the moving cage. As the sailplane is towed aloft, the angle of the rope relative to the fuselage longitudinal axis increases, causing the cage and jaws to rotate. At a designed angle and minimum load, unless a commanded release has already occurred, the ring is effectively swept off the beak by the moving jaws and the ring is released.

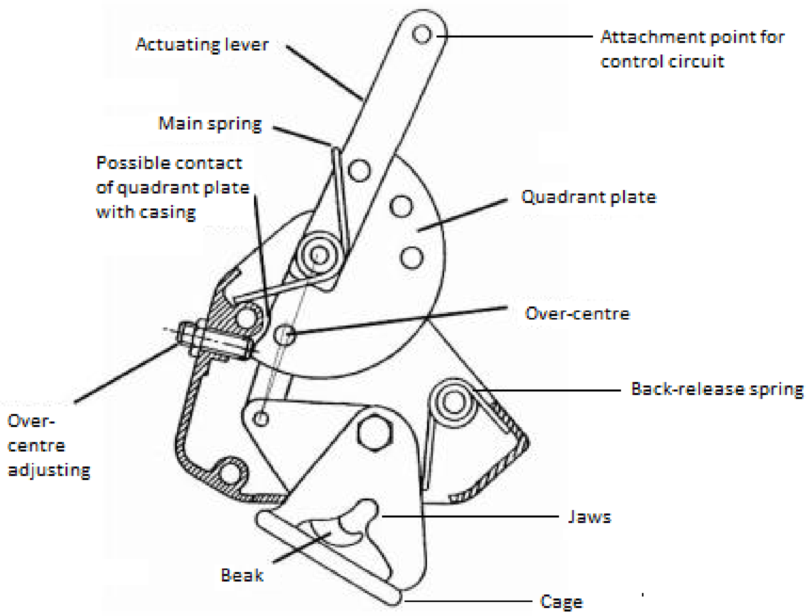


Figure 16-4 Release Components (belly release with automatic back-release)

16.3 RELEASE CONTROL CIRCUIT

The release control circuit consist of cables, Bowden cables (ie cables in tubes/sleeves) and sometimes rods, pulleys or U-tubes to transfer the pulling force of the pilot to the release lever. Some sailplane manufacturers vary the release operating lever length so as to change the operating force. Or include pulley returns etc. The problem is the extra friction and lever arm that may prevent the release closing properly.

In some instances the sailplane manufacturer may have included in the control circuit an additional spring to ensure the mechanism always returns from the release state to locked state properly.

The release control circuit must allow full travel of the release mechanism. In the closed position, the release must lock (over-centre) and in the open position the hook beak must fully retract into the casing. The release circuit must therefore have some ‘dead movement’ to ensure it does not hold open the release.

The release control circuit must not introduce too much friction. Excessive friction can stop a release closing properly or cause it to be inoperable under high tow load. The level of friction can change whilst in service due to loss of lubrication or dirt ingress, and therefore regular maintenance checks are necessary.

16.3.1 COMMON RELEASE CONTROL CIRCUIT ISSUES

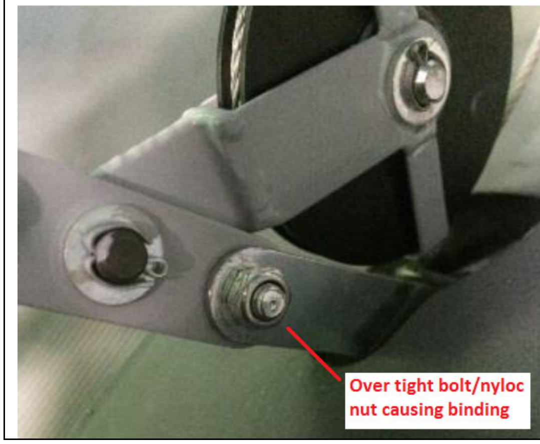
Faults in the release control circuit can cause the release not to fully lock. The most common issues are:

a. Control cable too short preventing the release mechanism from going fully over-centre and locking.

b. Bad guidance of control cables (particularly Bowden cables) casing excessive friction that the main spring cannot overcome and thus the release fails to close and lock.

c. Too little return (pull-back) force due to worn out or broken release main spring. Perhaps even the wrong spring.

d. Binding in the control mechanism, eg. a bolt being used as a pivot point has been over-tightened causing a clamping action on a component that should swivel or a cable has come off a pulley.



Example issue (Ref Airworthiness Alert 2015-2)

Multiple uncommanded releases experienced on a nose hook installation fitted to a new ASK 21 Mi sailplane.

It was found that the bolt with nyloc nut attaching the pulley system to the Tost lever (shown in photo) was too tight causing binding just prior to the release fully closed position.

Figure 16-5 Example of a Release Issue

A few other examples of other issues that have occurred:

e. A jammed open belly release, full of dirt, allowed a shackle on the slack operating cable to swing over and the thimble to catch. This in turn limited the operating movement on the nose release preventing it from opening fully.

f. A yellow release knob on a cable that was too long became jammed in the control column in the rear cockpit seriously reducing aileron movement.

Example issue (Ref AWA 2007-2)

Duo Discus release control cable damaged at exit of Tee-handle.

The failure was not easy to detect as the broken wires were effectively shielded from easy view by the protruding steel swage at the base of the release handle.

Figure 16-6 Example of Release Knob Issue

16.3.2 INSPECTION AND MAINTENANCE OF RELEASE CONTROL CIRCUIT

During Annual Inspection and following any maintenance of the control circuit:

a. Inspect cables for corrosion, wear and fatigue.

b. Check pulleys for signs of jamming, bearing condition and correct caging.

c. Cleaned and lubricated cables, rods and levers at their connecting points and pivots.

d. Check the entire circuit is reasonably free of friction. Check for misalignment of pulleys, displaced fairleads and rods or levers fouling on other structures.

e. Adjust the release control circuit to allow full travel of the release mechanism. Cables must have at least 10mm of freeplay when the release is locked.

f. Check the pull knob or handle is securely attached to the control cable and is clearly yellow in colour.

g. Where two releases are fitted and operational, make sure they both lock properly and that both hooks retract fully.

When replacing cables, make sure that cable joining sleeves, turnbuckles and shackles do not foul or cause other problems.

Some operating circuits are quite complex. A sailplane fitted with two releases and having two controls (one for each seat) will need careful checking and adjustment and should be tested in all operating positions.

16.4 TOW RELEASE CLEANING, SERVICING AND OVERHAUL

16.4.1 REGULAR CLEANING WHILST INSTALLED

During operation, the release is often exposed to dirt, especially if operating from gravel runways and during out-landings. Because Australia is dry and dusty compared to European grass runways, it is necessary to clean and check our releases more frequently than European manufacturers specify.

The best method of cleaning the release whilst fitted in the aircraft is with compressed air and a brush, while operating both the hook and the back-release mechanism.

Be very certain that a sluggish back-release action is actually dirt and not due to a deteriorating return spring or other mechanical binding. This is a very common mistake.

Excessive lubrication may create a build-up of dirt which may cause excessive friction or prevent full travel of components. Dust may combine with the lubricant to form a grinding paste which makes wear more rapid.

It may be necessary to use suitable solvents if there is an accumulation of oily dirt and then relubricate sparingly. TOST recommend WD-40.

16.4.2 ANNUAL SERVICE

Servicing of tow releases consists of cleaning, inspection, lubrication and testing. It can often be accomplished without having to remove the release from the aircraft and does not always require stripping the assembly.

If an AD requires maintenance action or faults/suspicions arise from the service, then the release will need to be removed from the aircraft and overhauled as detailed in the next section.

At each Annual Inspection, or every 250-Hour Inspection for high use sailplanes, if more than 200 launches have been completed since the last service, then the following servicing must be completed:

a. Check the GFA, the sailplane manufacturer's and the release manufacturer's or National Aviation Authority websites for any ADs relating to the type of release being serviced – they are mandatory. Service Bulletins may give useful advice.

b. Clean the release as described above. Consider removing the release from the airframe and disassembly to allow deep cleaning which may prolong life. If friction continues to inhibit operation then disassembly is required.

c. Operate the release to feel if the main spring is broken or feels weak. In most cases the main spring has to return the control circuit as well as lock the release and therefore is a relatively firm spring. Release spring performance is affected by breakage, wear, loss of tension, corrosion and dirt contamination. Perform the tests as detailed later in this chapter.

d. Inspect the hook beak.

    i. Tow cable rings tend to wear the hook beak and jaws which can become grooved or burred. This can make it difficult to operate the release under load, or else the tip can become rounded-off causing premature release.

    ii. The profile of the hook beak must be such that as the hook rotates it will enable the towing ring to move out of the release.

    iii. On some types of release the original profile can be returned by careful filing or grinding providing sufficient material remains. However, if the hook is case hardened and the hardened surface is worn through, the part is no longer serviceable.

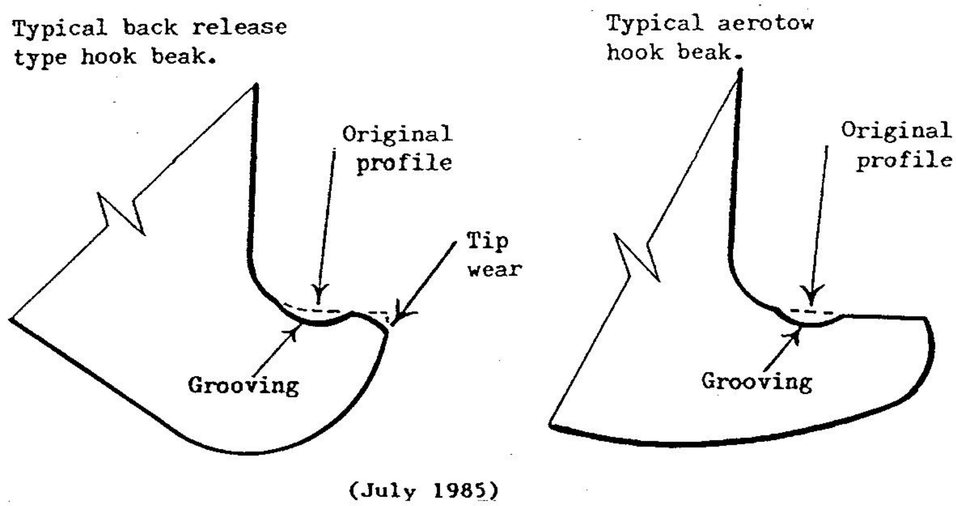


Figure 16-7 Groved Beak, Worn Beak Diagram

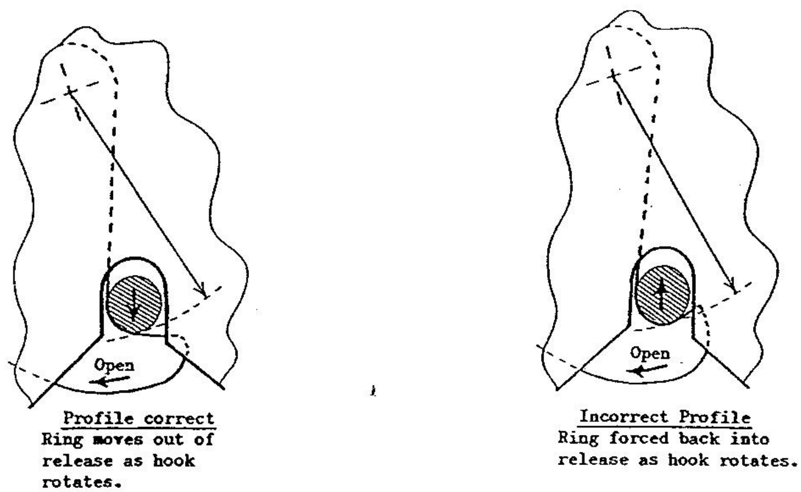


Figure 16-8 Beak Profile Diagram – Slot Type Ring Retention

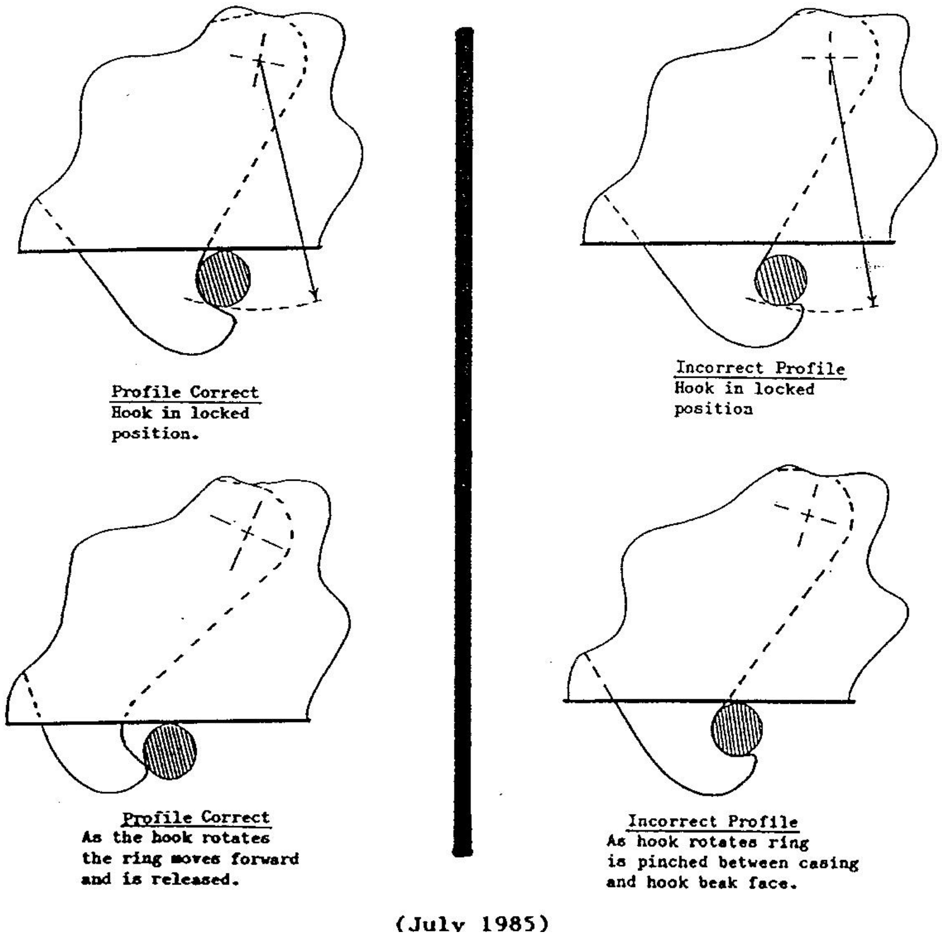


Figure 16-9 Beak Profile Diagram – Casing Type Ring Retention

e. Check the jaws have not become excessively worn by the ring with repeated use (see picture below). Excessive wear of the jaws can mean the ring is not held in the correct position so the beak may not engage the ring fully. With extreme wear, or use of undersize rings, the ring may slip out causing an uncommanded release. In some cases it may be possible to build up with weld and file to the original dimension; but usually a replacement release or new part will need to be obtained.

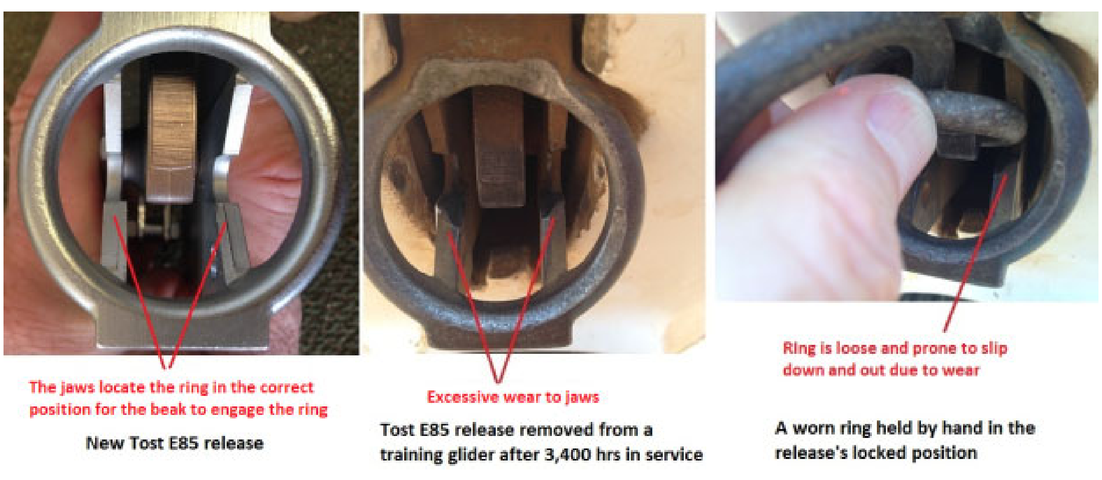


Figure 16-10 Jaw Wear Inspection

f. Lubricate only the pivots and bearings as excess lubrication will retain dirt.

16.4.3 OVERHAUL

Tost releases require the main spring to be replaced at intervals described later on. When the spring is to be replaced, the release must be given an overhaul.

Non-tost releases do not require spring replacement at overhaul unless it fails the tests. However, 2,000 launches is a recommended interval to replace the spring and give it an overhaul.

Overhaul involves: removal from the aircraft, testing, disassembly, cleaning, inspection, repair or replacement of worn or faulty components, lubrication, re-assembly, testing and refitting in the aircraft.

With TOST, these days, it is probably better to obtain a new exchange release from TOST if the beak, jaws or cage are excessively worn. GFA only keep the common replacement parts, springs, because GFA is the only approved maintenance organisation. TOST suppliers in Australia keep exchange releases and some parts.

Procedure:

a. Some types of release have multiple mounting holes and use different length bolts in specific holes. To ensure correct refitting to the aircraft, mark the mounting position before removing the release.

b. Before dismantling, mark the parts first and/or take photographs to aid reassembly. On many releases the toggle link and bell crank are reversible and as the limit stop usually contacts one of these components, a potential problem arises if incorrectly reassembled. It is often best to remove the linkage mechanism from the casing and clean and lubricate the pivots with the hook, toggle link and bell crank left attached to each other.

c. If the release includes a back-release mechanism, it can be removed and cleaned separately.

d. Wash all components in solvent to clean them. Check all components, especially pivots and bearings not normally visible, for wear. Excessively worn parts will need to be replaced.

e. Lubricate the mechanism components lightly before reassembly. TOST recommend WD-40. Some releases can be tricky to re-assemble and any extra lubrication will quickly get on your hands and all over the release making the job even more of a challenge.

f. After any overhaul activity involving disassembly, the over-centre locking and main spring tension must be tested and in accordance with Tests 1 and 2 described later, plus Test 4 if it has a back-release.

g. Most GFA approved releases rely on over-centre locking and on some types the amount of over-centre can change through incorrect assembly. Examine your pre-dismantling notes and photographs and conduct the required tests – get it right!

16.4.3.1 REASSEMBLING TOST RELEASES

Reassembling Tost releases requires a few tools such as spanners, screwdrivers etc plus a vice with soft jaws (aluminium pieces between the vice jaws and the release to protect the casing) to securely hold the body of the release. A small amount of wire is also useful to make loops to hold the spring ends.

There are a number of different techniques for installing the main spring. Many inspectors who do a lot of inspections make up specialised tools to make the reassembling of the release easy. Australian Gliding magazine published details of such specialised tools in September-October 1998. These are republished at Appendix C.

The following method has been used successfully and has the advantage that no special tools are necessary:

a. Assemble the release up to the main spring and bell crank fitting stage, leaving the hook pivot bolt out.

b. Grip the casing in a vice (be careful not to crush it) so that the hook pivot hole is accessible.

c. Manoeuvre the mechanism (through the hook pivot hole) so that the bell crank can be lined up with its pivot hole - try a dry run without the main spring.

d. Mount the main spring on the bell crank and slip a loop of lock wire around both ends of the spring.

Hook a screw driver under the loop and lever the spring ends up as the bell crank is pushed into the case.

When installed correctly, actuating the mechanism tightens the main release spring. It is possible to get it wrong, so take care. The correct orientation is depicted in a diagram earlier in this chapter.

16.4.4 REPLACEMENT OF THE TOW RELEASE ASSEMBLY

If a new or reconditioned release is to be fitted to the sailplane, it should be inspected and tested before being installed and adjusted if necessary.

16.4.5 AIRCRAFT NEW TO THE AUSTRALIAN REGISTER

During the first GFA survey inspection, used release assemblies (ie >200 launches) are to be tested in accordance with the maintenance requirement for the type fitted. New releases need not be tested if they arrive with a Release Note (RN) from the manufacturer, in which case the RN number is to be recorded in the inspection documentation.

16.5 RELEASE TROUBLESHOOTING GUIDE

SYMPTOM	PROBLEM	POSSIBLE CAUSE	REMEDY
Uncommanded release	Release not locking	Dirt in release	Clean release
		Excessive friction in operating circuit	Inspect and overhaul if necessary
		Operating circuit restricting release closure	Check for control cables long enough, catching sleeves/turnbuckles, seized pulleys, etc. Adjust if necessary
		Main spring weak or broken	Replace main spring
		Release not set over-centre	Overhaul, load test and adjust if necessary
	Ring pulls out whilst release is locked	Ring thickness not to specification	Replace with new ring
		Worn jaws and/or cage	Replace release mechanism
		Hook beak tip worn	Repair or replace
	Back-release (if fitted) not holding	Back-release spring weak or broken	Replace back-release spring
		Hook beak tip worn	File or grind hook beak to correct profile or replace hook
Hang up under load	Under tow load, the release did not release even though knob pull to stop	'False stop' encountered because of wear in jaws and grooving in hook beak preventing beak sliding over ring	File or grind hook to correct profile or replace hook. Build up worn areas of jaws and file to original shape or replace component
	Pilot unable to apply enough force to operate release	Release set too far over-centre	Conduct over-centre test and adjust as necessary
		Excessive friction in release circuit	Inspect, repair and lubricate circuit
		Insufficient leverage in operating circuit	Modify system - Consult RTOA/CTO

16.6 SPRING REPLACEMENT

16.6.1 TOST MAIN SPRING REPLACEMENT IN SAILPLANES

Tost Technical Notice No TM 1-2001, removed the requirement for 4-yearly overhaul and mainspring replacement of its releases and instead based the replacement requirement on 10,000 actuations. Since each launch usually involves multiple actuations, the overhaul interval for sailplanes is specified by Tost as a maximum number of launches. Since sailplanes used for training typically use more actuations per launch, Tost has specified a lesser interval for training sailplanes.

Tost releases shall be overhauled and the main spring replaced at the following interval after a new main spring is fitted:

1,250 launches	All sailplanes used mainly for training (ie most two-seat sailplanes)
2,000 launches	All other sailplanes

Contact GFA Office for details of how to obtain replacement springs.

16.6.2 TOST MAIN SPRING REPLACEMENT IN TOW PLANES

Tost has not provided a specification for tow planes other than the 10,000 actuations limit. Therefore towplane registered operators should make their own determination of the time until next replacement based upon the aircraft's frequency of use for towing operations. If the use cannot be estimated, the spring is to be replaced at the next annual inspection.

A typical example of consideration of the time until next spring replacement is:

Towplane is flown for 100 weekend days plus 10 day camp/course per annum = 110 days.
Assuming 5 release actuations per day gives 550 actuations per year.
Time to complete 10,000 actuations limit = 18.2 years.
As this is a rough estimate then halve the time to be careful.

Details of how the main spring life was determined should be recorded on the GFA form "Towplane Release AIR F010" along with the test results to inform the LAME of the actions you have taken.

16.6.3 NON-TOST SPRING REPLACEMENT

For springs other than Tost main springs there is usually no guidance from the release manufacturer as to the spring's service life. Therefore it is acceptable to replace them depending on condition and not depending on number of launches, actuations or hours. In other words, if a non-Tost spring is broken or fails a test, then replace it with a suitable new spring. However this strategy does risk uncommanded releases and thus owners are recommended to replace springs periodically. For uniformity, GFA recommends all springs are replaced every 2,000 launches.

16.7 TESTING RELEASES

Prior to this version of BSE, the testing procedures for Tost and Non-Tost releases were different and detailed in GFA AD277 and GFA AD293 respectively. With effect from 2017, the test procedure and acceptability criteria have been standardised in BSE, resulting in some subtle differences compared to past practices.

To maintain flight safety, tow releases used for all types of launching procedures must:

a. Be able to sustain the forces experienced during towing operations.

b. Not be prone to uncommanded release.

c. Release when commanded by the pilot, requiring a level of pilot actuation force that is within the capability of all pilots likely to fly the aircraft for up to the maximum tow load the sailplane may experience.

To meet these 3 requirements, each release assembly and control circuit must be properly designed, installed, maintained and regularly tested.

It is recognised that many of the "Ottfur", "Davies" and other releases in-service, have historically had a large amount of over-centre in their mechanical function, requiring significant pilot pull force to operate. That feature can lead to the pilot having insufficient strength to operate the release under high towrope loads. Compliance with these test procedure and the standards of acceptability will ensure ‘over-centre' travel is reduced and enhance pilot safety under high tow rope loads.

16.7.1 BACKGROUND TO TESTING ACTUATION UNDER HIGH TOW FORCES

For safety reasons, the most important test for a tow release is proving that the pilot can activate a release of the tow rope using reasonable physical effort whilst the release has the maximum tow force applied. Historically the test requirement has been specified in a number of different ways:

GFA AD277 specification for Tost releases:	No specification for maximum pilot actuation force but: 6.75 kgf maximum actuation force at 450 kgf tow force (from Chart 1 of AD277). Note this is with release removed from aircraft and no main spring which adds about 4kgf and so effectively the force installed would be 10.75 kgf.
Tost manufacturer’s operating manual	When the release hook is under a load of approx. 150 daN (150 kgf) you should still be able to operate the manual release lever in the cockpit with the same force, ie, 7.5 ± 1.5 daN (7.5 ± 1.5 kgf.). (ref Tost E85)
GFA AD293 specification for non-Tost releases:	20 kgf maximum hand load with a tow load equal to the sailplanes rated weak-link, or 450 kgf if not stated.
CAO 100.5 (24 December 2015) specification for tow planes:	“Pilot effort must be tested to ensure that it is less than 200N (20 kg force) with a 4.5kN (450 kg force) load applied to the release anywhere in a 30 degree cone.”

When one considers that the average human, when standing and leaning back, can typically only pull a horizontal force of 30-40kgf and that this is enough to move a sailplane, then applying higher tow forces and anchoring aircraft is fraught with difficulty and risk. But by using tools and levers this can be done safely. Be careful and do it correctly.

In practice it is impractical and unsafe to conduct a test with the release installed in the aircraft and with tow loads of 450kgf, or even 150kgf, applied by pulling against the aircraft.

High tow load testing of sailplane Tost releases in Australia has for a long time been conducted with the release removed from the airframe and utilising the purpose designed GFA 450 Release Tester (new hydraulic or the older spring tester). This is a safe and practical means of testing a release’s integrity (ability to survive without damage the applied load) and the over-centre setting.When combined with thorough inspection of condition (wear and cleanliness) of the release and the control circuit, this method has proved to be effective.

GFA has thus adopted the strategy that high tow load testing is to be conducted with the release removed from the aircraft and installed in a suitable test rig (such as the GFA 450 Release Tester).

However, some actuation force testing is wise to ensure friction and actuation system errors are found and corrected. This mainly occurs during design of aircraft but GFA have added a small amount of this testing as below.

16.7.2 THE GFA TOW RELEASE TESTS

The tow release test regime for all sailplanes and tow planes comprises using the following tests at various times of maintenance:

a. Test 1: Over-centre. This test measures the actuation force required to activate the release at various levels of tow load. When graphed, the data provides an indication of the level of over-centre in the mechanism. The test also proves that release of the ring is achieved when commanded and that the release's beak can sustain a straight line pull of up to 450kgf without premature release. The test is always conducted with the release removed from the aircraft and with the main spring removed from the release. The GFA 450 Release Tester (new Hydraulic release tester or the older Steel Stallion) enables testing up to 450kgf which is sufficient to simulate the maximum tow load experienced by most modern sailplanes.

b. Test 2: Main Spring Stiffness. This test is to determine that the main spring is strong enough to return the actuating mechanism to the closed position and exerts sufficient force to hold the mechanism over-centre and thus locked at all times so as to avoid uncommanded release. (As required for tow planes by CAO 100.5 Appendix 1 Clause 12.4c).

c. Test 3: Pilot actuation. This test ensures the pilot is easily able to operate the release. It measures the pilot actuation force required to operate the release with no tow load force. (This is a Tost test requirement). It also checks that with a small, humanly possible tow load that the pilot effort has not increased significantly as it might if there was wear or excessive over-centre.

d. Test 4: Back-release. This test confirms that the automatic back-release mechanism (if fitted) activates within the specified angle range.

e. Test 5: Pilot actuation force with release actuation force as for 450 kgf tow load. This test is for tow planes only, to satisfy CAO 100.5, and ensures that there is not excessive friction in the control circuit. When used with the results from Test 1, it tests that the pilot actuation effort does not exceed 20kgf when the tow load is 450kgf (as required for towplanes by CAO 100.5 Appendix 1; 12.6

Details of how tests are performed and result acceptability criteria are described in later sections.

16.7.3 SUMMARY OF WHEN TESTS ARE CONDUCTED AND SPRINGS REPLACED

A summary of when the tests are to be performed is shown below. Details of the tests are provided in later sections.

Aircraft	Maintenance Intervals	Tests Required
Sailplanes	All releases: Annual Inspection when >200 launches since previous testing.	Tests 2 and 3 Test 4 if back-release type
	Non-tost releases: At every 2,000 launches following last main spring replacement. - Remove release from sailplane, overhaul and test. - Replace main spring if faulty or fails tests.	Tests 1 and 2 to determine if main spring ok If main spring replaced, repeat Tests 1 and 2 Test 3 Test 4 (if back-release)
	Tost releases: Following the stated number of launches since last main spring replacement, • Trainers 1,250 launches • Non-trainers 2,000 launches - Overhaul the release, including replacement of the main spring irrespective of condition.	Tests 1, 2, 3 and 4 (if back-release)
Tow planes	Daily inspection	Test 2
	Reoccurring maintenance at whichever of the following happens first: (a) every 1,000 hours time-in-service; (b) every 12 months. - Remove release from tow plane, perform annual service and tests.	Tests 1, 2 and 3
	Tost release only: Replacement of release main spring at interval as determined by the Registered Operator in accordance with 16.6.2 above. - Remove release from tow plane, perform overhaul, replace spring and test.	Tests 1, 2 and 3

16.7.4 LOGBOOK AND MAINTENANCE RELEASE ENTRIES

When certifying compliance with the requirements of this chapter, the logbook entry should state:

a. “Release check as per BSE Chapter 16 version xx”, where “xx” is the version of BSE Chapter 16 used as reference.

b. “Tests 1, 2, 3, 4 completed”, as applicable.

   i. Next service due at next Annual Inspection if greater than XX launches” (where “XX” is the last service launch count + 200).

c. If the main spring has been replaced, record:

i. The source and tracking data (batch number etc) of the replacement spring.

ii. The number of recorded launches at which main spring replacement is next due.

d. Any other action taken.

For example:

"*Release check as per BSE version 24. Tests 1, 2 and 3 completed. Next service due at next Annual Inspection after xxxx launches. Main spring replaced, sourced from GFA, batch XYZ. Main spring due next replacement at yyyy launches*".

The future required maintenance that may be required during the year is to be recorded in the Maintenance Release. For example:

Item No.	*Recurring Maintenance Items*	*Due date or time in service*	*Maintenance certified by*	*Date completed*
1	*Release main spring due next replacement at*	*yyyy launches*		

The spring replacement requirement is before 10,000 actuations and therefore may be required before the next annual inspection. At Annual Inspection it is wise to consider if the spring may expire before next annual and replace it early to avoid hassles. It is a low cost item.

16.8 CONDUCTING THE TESTS

Always check to see if a new AD has been issued on the topic before commencing tests.

The following procedures are derived from both manufacturers' specifications and local research. There may therefore be variations if direct comparison is made with manufacturers' publications.

Use the form at Appendix B to record the test results. A completed copy of the form should be retained with the sailplane maintenance records.

Before commencing any of the tests:

a. The tow rings used for the test must be dimensionally the same as serviceable genuine rings as specified by the release manufacturer.

b. The release must be cleaned, inspected for wear (especially beak and jaws) and lubricated.

16.8.1 NOMENCLATURE

Throughout this chapter the following terms and names are used:

Term	Meaning
X axis	Direction of flight
Y axis	Spanwise direction
Z axis	90° to the direction of flight (up)
P	Actuating Force on lever (kgf)
P_R	Spring return force (kgf) to close it again
Q	Load applied to beak (kgf)
l	Lever arm (standard arm has 68 mm lever distance but varies from 35 to 120 mm on different sailplane types).

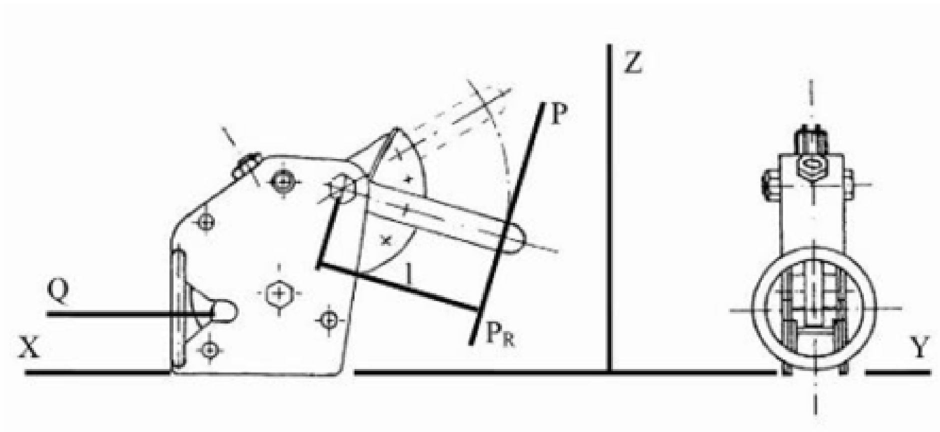


Figure 16-11 Typical Aerotow Release

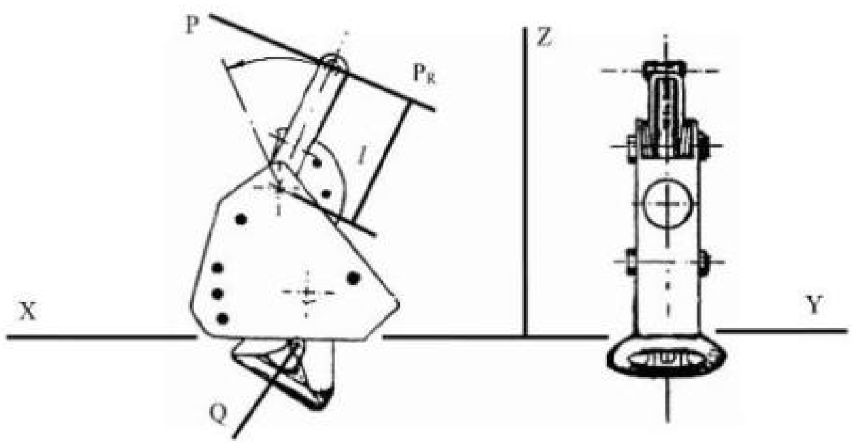


Figure 16-12 Typical Winch Release

16.8.2 NON-STANDARD LEVER ARM - CONVERSION OF FORCE READINGS

The interpretation of the data assumes that the lever arm is 68mm, which is the most common length. If the lever arm of the release, or the total effective lever length created by an attachment specific to sailplane type, extends the lever then a conversion to the equivalent force must be made. The calculation is made using the following formula:

Equivalent force = measured force x (lever length / 68)

Example: A 3.3 kgf spring balance reading on a 140mm lever is equivalent to:

Equivalent force = 3.3 x (140 / 68) = 6.8 kgf on a standard 68 mm lever.

16.8.3 CALIBRATION OF SPRING BALANCES

Spring balances used for tow release tests must be checked and adjusted for accuracy before being used for any tests. They are calibrated by adjusting the scale to read the correct mass of a known object such as.

a. The GFA 450 Release Tester has its weight stamped on it (around 5 kg).

b. For the lower end of the scale, a plastic bucket with a couple of measured litres of water can be used. Noting that 1 litre of water has a mass of 1kg.

Since Force = Mass x Acceleration, then the force exerted by the acceleration due to gravity on 1 kg is 1x 9.8 kgf or 9.8 Newtons (which is 0.98 daN) and is correctly termed 1kgf (kg force).

16.9 TEST 1: OVER-CENTRE

This test measures the actuation force required to activate the release at various levels of tow load. When graphed, the data provides an indication of the level of over-centre in the mechanism. The test also proves that release of the ring can be achieved when commanded and that the release's beak can sustain a straight line pull of up to 450kgf without premature release.

This test is performed with the release removed from the aircraft and with the main spring removed. The spring is removed to avoid variability of the spring and the release has to be dismantled anyway to replace the spring and possibly adjust the over-centre.

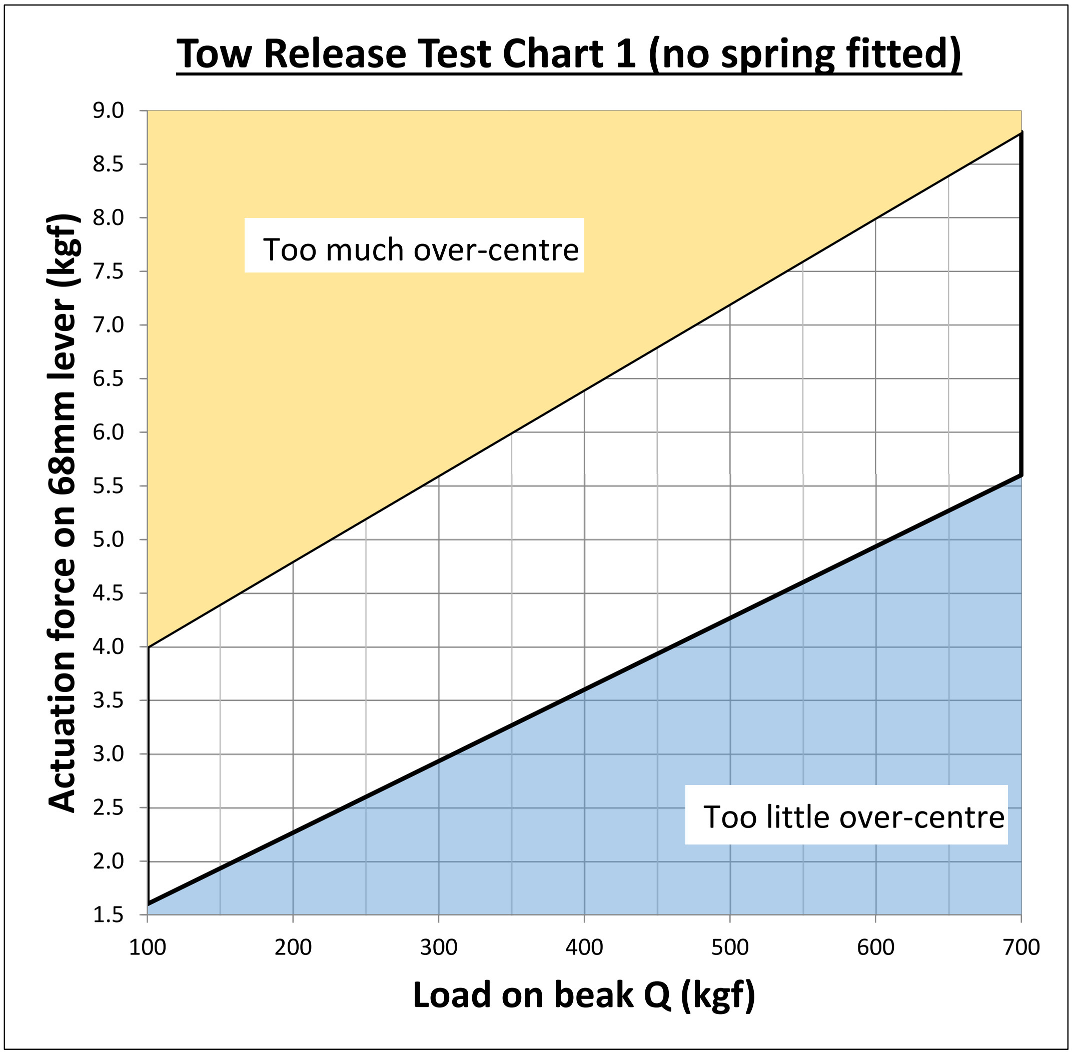
The test is intended to be performed using a GFA 450 Release Tester (either the new Hydraulic release tester or the older Steel Stallion) which is a GFA purpose designed device for holding the release and applying a calibrated tow load up to 450kgf. These are available in large clubs or on loan from RTO-As. Annex A to this chapter details how to use the GFA 450 Release Tester and how the GFA 450 Release Tester is calibrated.

16.9.1 TEST 1 PROCEDURE

Step	Action
a.	Remove the release from the aircraft. Disassemble, clean, inspect and lubricate the release. Re-assemble, ensure all body nuts/bolts are tight and only the main spring has been removed. Secure the GFA 450 Release Tester in a bench vice.
b.	Check that the mechanism has some over-centre otherwise the release may open when the load is applied. To test, pull on the beak with the fingers and move the lever arm. The lever should move about 5 mm before the release can be opened by the beak.
c.	Install the release in the GFA 450 Release Tester and apply a load Q of 200 kgf to the beak.
d.	Measure the actuation force “P” required to open the release using a spring balance attached by cord and acting at an angle of 90° to the actuating lever.
e.	If the actuating lever is not the standard 68 mm lever, then determine the “equivalent force” using the formula and plot the result on release test Chart 1 using the equivalent force.
f.	Repeat steps 3, 4 and 5 using a Q of 300 and 400 kgf. The actuation force “P” required should increase with load.
g.	On Chart 1, plot the three test result points and draw a straight line of best fit through them. If the results are not close to a straight line the release should be carefully inspected for other faults.
h.	The line of best fit should remain within the unshaded area on Chart 1 within the Q range of 200-400 kgf. If necessary adjust the over-centre and repeat the test until acceptable results are achieved.

Note: On the hydraulic tester 100kg load = 1,000kPa on the hydraulic gauge. It has been manufactured to give this 10:1 ratio and convert the units.

16.9.2 TEST 1 CHART

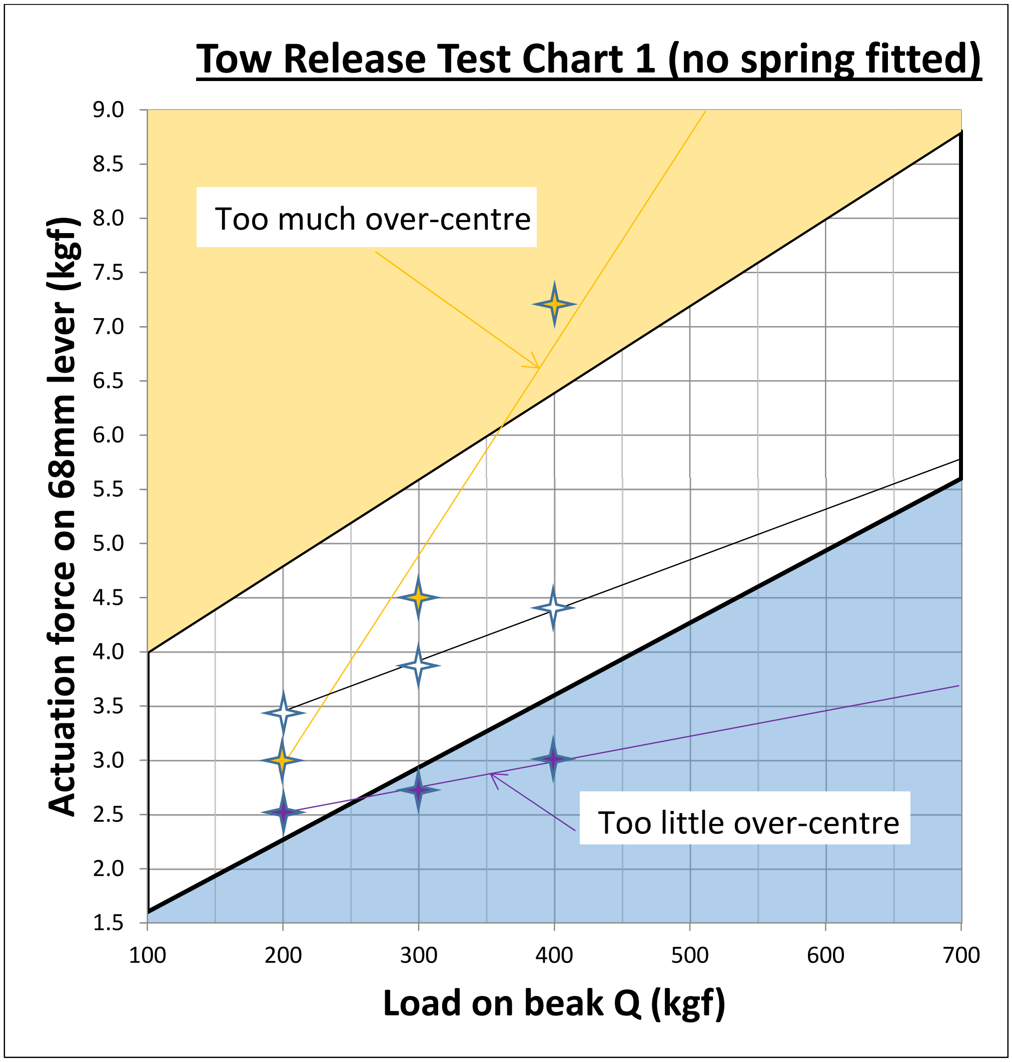


16.9.3 INTERPRETATION OF TEST 1 RESULTS

Result	Reason
Release opens immediately when the load Q is applied	The release is not over-centre.
No increase in P as the load Q is increased (ie the line of best fit on the graph is horizontal or slopes down to the right)	The mechanism is on the centre-line but not over-centre and therefore has "hair trigger" behaviour. The release is entirely dependent on the main spring for locking and is vulnerable to other factors, such as wear and vibration that may cause it to release. **** The amount of over-centre must be increased ****
Load P increases but is still below the minimum line on Chart 1	The release is over-centre but not enough to allow for possible future wear.
Load P is above the maximum line on Chart 1	Too much over-centre and the pilot may not be able to operate the release in an emergency.

Note: If the beak has a groove the actuation force P will be high. If the tip of the beak is worn it will require a lower actuation force P.

16.9.4 WORKED EXAMPLE OF TEST 1 CHART



Theoretically the lines would go through the zero point without a main spring installed but may be curved. Don't be concerned what may happen below 200kgf beak load. Reduce over-centre if the projection to 700kgf goes far above the line. The lines should be fairly straight, if not this may produce odd projections and there may be other wear factors at play.

16.9.5 ADJUSTING THE OVER-CENTRE

See Figure 16-4 which illustrates the internal construction of a typical release.

16.9.5.1 RELEASES WITH ADJUSTING SCREWS.

Unlock the locknut. Turn the adjusting screw with an 'Allen' key anticlockwise to increase over-centre and clockwise to decrease over-centre. The adjuster is fairly sensitive, half a turn being the difference between a correctly adjusted release and one that is not.

If difficulty is experienced getting enough over-centre, check that the bell crank is not contacting the casing. It may be necessary to relieve the bell crank in this area to utilise the adjusting screw.

Tighten the lock nut before retesting otherwise the screw may turn during the testing. Once testing is complete punch lock the screw to prevent it moving in service.

16.9.5.2 RELEASES WITH SUNKEN ADJUSTING SCREW.

To gain access to the screw it may be necessary to remove a cover plate. This can be done with a hammer and a small chisel or punch. A special spanner will be needed for the sunken locknut. This can be made from a tube spanner cut down and a handle welded to it. Proceed as above.

16.9.5.3 RELEASES WITHOUT ADJUSTING SCREWS.

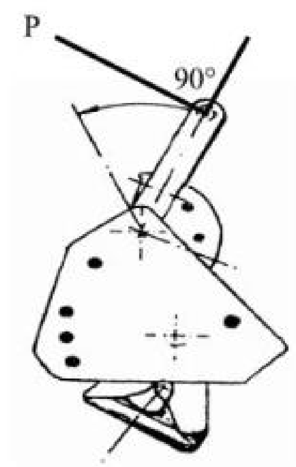
To increase the over-centre on this model, remove metal from the bell crank where it contacts the casing. To decrease the over-centre the bell crank must be built up with weld and filed or ground to suit. Be careful, it's easier to remove metal than put it back on.

16.10 TEST 2: MAIN SPRING TENSION

This test is to determine that the main spring is in good condition which means:

a. Strong enough to return the actuating mechanism to the closed position and exerts sufficient force to hold the mechanism over-centre and thus locked at all times so as to avoid uncommanded release.

b. Not too strong, so as not to burden the pilot with excessive effort required to overcome it.



This test may be conducted with the release remaining in the airframe if access and space permits.

Step	Action
1.	With the release in the aircraft or else removed and secured in a GFA 450 Tester or a bench mounted vice. If the control circuit does not impede the test or affect the reading, it may remain attached.
2.	Attach a spring balance via a cord to the actuating arm at the normal point of connection with the release control circuit.
3.	With no load applied to the beak, apply a force P at right angles to the actuating arm to fully rotate the lever through its arc. The spring force should increase as the actuating arm rotates. **Check and record** whether the spring force increases as the actuating arm rotates.
4.	Gently relax and allow the arm to pull the spring balance until the release is closed. **Measure and record** force P_R just before the release is fully closed. The allowable P_R is 2.5 to 5.0 kgf.

A force below the allowable may indicate a weak or broken spring is installed or that the spring is fitted incorrectly.

A force above the allowable may indicate that a non-standard spring, which is too strong, has been fitted or there is excessive friction in the release.

16.11 TEST 3: PILOT ACTUATION FORCE

This test ensures the release fully closes and locks, and that the pilot is able to operate the release without excessive effort. It measures the pilot actuation force required to operate the release with no tow load force and confirms that with a light tow load, pulling through the normal operational arc, the release will let go of the ring.

Step	Action
1.	With the release fully assembled, fitted in the aircraft and fully connected with the normal release control circuit:
2.	Attach a spring balance via a cord to the cockpit tow release knob/handle
3.	With no load applied to the beak, apply a force to the release knob in the cockpit until the release activates, ie the ring will drop out **Measure and record** the maximum force that was required for the activation. The allowable force is 6 to 9 kgf .
4.	If the sailplane has 2 tow releases connected, the maximum pilot actuation force to achieve a release with the tow rope in either release must not exceed 17 kgf for any tow load.
5.	If there is doubt repeat the test at Step 3 with an assistant applying a tow load of approx 25, 150, or 450 kgf (use a lever and spring balance to multiply the load or the GFA release tester as described in Appendix A). ** <u>Caution – warn your assistant the rope is about to be released. Setup the test with care to avoid damage to personnel and aircraft – there is a lot of force involved at 150 or 450kgf.</u> ** . Apply the spring balance pull to the release knob until the release activates. **Measure and record** the maximum force that was required for the activation. Repeat the above with tow load pulls at 30 degrees either side of the centreline. This helps check the condition of the beak and cage. The allowable force in all situations is again 6 to 9 kgf.
6.	Pull the release knob to its extreme limit of travel and gently allow the knob to retract under the spring tension. **Check and record** that the knob does not foul with any of the controls and that it easily fully retracts. Measure the force at 68mm lever length at the release (or adjust to 68mm) at the point of closure while the knob is slowly released. It must exceed 1.5kgf as per TOST to safely close the release. This test may be impractical in certain sailplanes and then a best assessment that there is more than 1.5kgf closure force is satisfactory.
7.	If the sailplane has 2 seats and two release knobs/handles, then repeat this test from the second pilot seat.

If the pilot actuation force with 25 kgf tow load is significantly different (>0.5 kgf) to that with zero tow load, then suspect that beak, jaws or cage are excessively worn. Or else that there is a fault with the control circuit or there is excessive over-centre.

16.12 TEST 4: BACK-RELEASE

The purpose of this test is to ensure the release will automatically let go of the winch rope should the sailplane fly too far overhead the winch.
This test can usually be performed with the release installed in the sailplane but may be performed with it out of the airframe.

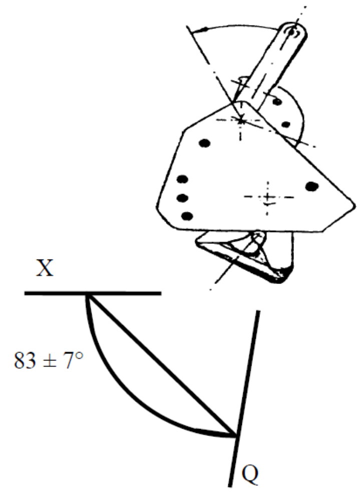


Figure 16-13 Back-Release Test Setup

Step	Action
1.	Check that the cage is able to pivot and that there is sufficient spring force from the back-release spring to hold the cage in the forward position.
2.	Apply a Load Q of 20kgf using a spring balance. Start initially with the load at a small angle to the X-axis and then progressively increase the angle.
3.	**Measure and record** the angle at which the back release activates. It must activate at an angle of 83 ± 7° ie 76 to 90°

Failure of the back-release to automatically operate in the specified angle range indicates a fault which could be:

a. A high level of friction or jamming due to dirt, insufficient lubrication of pivots or possibly over-tightening of the release securing bolts.

b. Wear of the beak, jaws or cage.

c. An over-strength back-release spring

Appendix C GFA 450 RELEASE TESTER

The GFA 450 Release Tester is a device designed to load tow releases to simulate a range of towing forces for testing purposes. It is used with a spring balance, which measures release actuation forces.

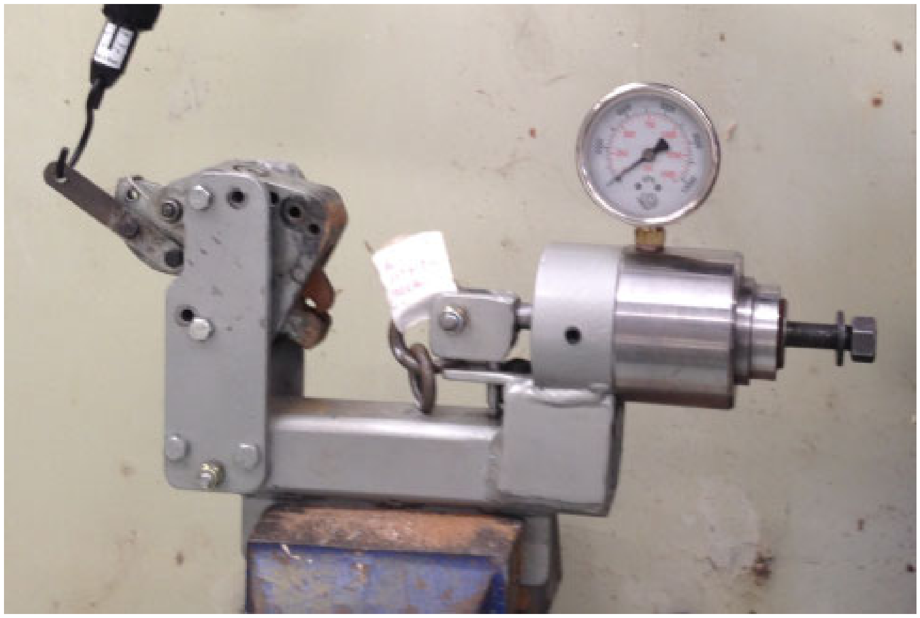


Figure 16-14 GFA 450 Release Tester, new Hydraulic version

Dean Hill made the first hydraulic tester after the stallion was being used and because it was so violent due to the big spring. Dean agreed GFA could make it.

Also still in service and acceptable for these tests, is the earlier GFA spring tester usually called a “Steel Stallion.

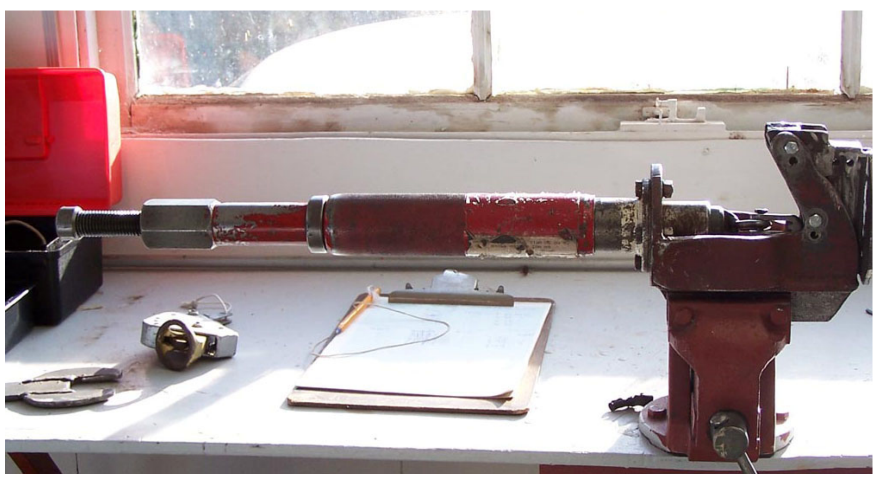


Figure 16-15 GFA 450 Release Tester, old Steel Stallion

Articles are available from GFA comparing these and showing them compatible. Both can test releases in or out of the aircraft. These days we consider the new hydraulic version is better in all ways.

The Steel Stallion can test releases in situ in most cases. The front adapter is unbolted and the end of the tester bears on the TOST release ring. By propping it up it can test moving or unmovable cage releases. But beware it jolts the sailplane/ towplane and is violent at high loads.

A new front adapter would be required for the hydraulic version to test in the same way in situ.

C.1 WARNING OF DANGER

Forces of up to 450 kgf can be applied when using the GFA 450 Release Tester so it is essential that safety precautions are taken.

When using the tester in a bench vice, it is not necessary to touch the tester when the release is operated - so KEEP CLEAR.

Avoid physical contact with the end of the tester as injury could result.

C.2 BENCH TESTING RELEASES

Grip the GFA 450 Release Tester in a bench vice. Attach an adapter appropriate for the release to be tested. Mount the release in the adaptor in appropriate set of holes and tighten bolts. Because of interference with the adaptor it may be necessary to relocate the release operating arm or fit another arm for the test.

Fit tester ring to release and make sure the release mechanism has gone over-centre before applying test load. Tighten the nut until desired load is reached.

To measure operating force, apply spring balance to operating arm and pull gently at right angles to arm.

NOTE: - This kind of work is fairly hard on the spring balance. If a 150 mm piece of wire or cord is fitted between the spring balance and the operating arm the spring balance won't be knocked around as much.

Where a back-release is fitted, it will need to be locked in some way. Use a block or wedge to lock it during the test.

C.3 CALIBRATION OF GFA 450 RELEASE TESTER

Regional GFA 450 Release Testers are to be calibrated by the GFA Regional Equipment Officers at least every two years by comparing test readings for a calibrated tow release that is borrowed from GFA and only used for calibration. If the readings are within 2% of the calibrated values, the Regional Tester is deemed to be within calibration.

The GFA Regional Equipment Officers are responsible for maintaining a testing logbook of the aircraft registrations on which the GFA 450 Release Tester has been used during inspection.

Should a GFA Release Tester be found to be out of calibration, then the RTO-A will consider whether it is necessary for all releases tested by the tester since last calibration to be retested. He should first consider if the standard release may be at fault. The Release Tester logbook will be used to contact owners who may have had suspect test results.

This is important quality control and so the RTO-A is responsible for ensuring this happens and to receive a report every two years on the aircraft tested, the results of the calibration, and the rectification undertaken. Luckily the testers hardly every go out without it being noticed and fixed.

Appendix D TOW RELEASE TEST SHEET

APPENDIX B : TOW RELEASE TEST RESULTS **(for all release types) July 17**

Release type: ___________ S/N: __________ Aircraft: VH- ______ Position: Nose ☐ Belly ☐

Launches to date: ______________ Release due replacement (launches):___________

Release testing tool employed for test:

GFA 450 Tester, S/No.______ ☐ Other ________________ ☐

Spring balance calibration method: ______________________________

Release actuating arm lever length:

Either (a) Standard Arm = 68 mm ☐ Use Chart 1 directly

OR (b) Actual arm length = ____mm ☐ Use conversion equation below:

Converted force = Measured force x (Arm ____ mm) / 68

TEST 1: Over-centre test (release removed from aircraft, main spring removed)

Tow Load (kgf)	Allowable Force (kgf) Chart 1 with Arm =68mm		Actuating forces measured at arm length as above: Measured Prior to Adjustment (kgf)	1st Adjustment (kgf)	2nd Adjustment (kgf)	3rd Adjustment (kgf)
200	2.2 to 4.8	Measured				
		Converted				
300	2.9 to 5.6	Measured				
		Converted				
400	3.6 to 6.4	Measured				
		Converted				

Note: Convert measured force to equivalent force at standard arm (68mm) only when release arm length is not 68mm

Plot above 3 data points on Chart 1 and project results to 450 kgf tow load: Satisfactory ☐ Unsatisfactory ☐

Confirm actuation force increases with tow load Yes ☐ No ☐

Result: Satisfactory without adjustment ☐ Satisfactory after adjustment ☐ Unsatisfactory after adjustment ☐

	Measured	Allowable	Acceptable	
TEST 2: Main Spring Tension			(measured at release actuating arm)	
Force just before release fully closed	________ kgf	2.5 to 5 kgf	Yes ☐	No ☐
Main spring action taken.	New main spring installed?		Yes ☐	No ☐

TEST 3: Pilot Actuation (measured at cockpit release knob)

	P1 seat	P2 seat	Allowable	Acceptable		
Pull force with nil tow load	________ kgf	________ kgf	6 to 9 kgf *	Yes ☐	No ☐	
Pull force with 150 kgf tow loac	________ kgf	________ kgf	6 to 9 kgf *	Yes ☐	No ☐	+/- 30 deg ☐
Residual Pull force with nil tow load at 68mm lever	________ kgf	________ kgf	>1.5 kgf	Yes ☐	No ☐	
Release knob retracts under spring tension and release locks				Yes ☐	No ☐	

* If two operational releases then max allowable is 17 kgf. For Tow Planes CAO 100.5 allows <20kgf @ 450kN tow load.

TEST 4: Back release spring (Belly release only)

Angle of activation with 20 kgf tow force _____ degrees 83 +/- 7 Yes ☐ No ☐

TEST RESULT: Tow Release fit for purpose? Yes ☐ No ☐

Notes following test:

Appendix E TOST RELEASE REASSEMBLY AIDS.

It was at a sailplane maintenance school at Kingaroy several years ago that I observed a tost spring replacement tool used. It was designed by Craig Tuit from Brisbane, and made the task so easy it was almost enjoyable. Not enjoying doing things the hard way I decided to invent a kit to make overhauling releases more rewarding.

Tool no. 1 is used for replacing the main return spring.

Tool no. 2 is used to hold the release spring back out of the way when replacing cage in to release assembly. These tools are made using 3mm thick FMS about 30mm wide, length about 200mm. Dimensions provided in the diagram are accurate enough but it is handy to have a release on hand to allow fine tuning for a neat fit.

Tool no. 3 is a pilot to replace the parrot beak/back release cage pivot bush. There is sometimes a problem aligning shim washers in this mechanism and this tool makes it easy. The tool can be made out of any round bar and lathed to size, a 6mm nut can be fixed to some type of handle and when the bush is fitted to the pilot it can be screwed on behind it to push into the assembly.

Tool no. 4 is a general alignment tool also made out of round bar. Dimensions shown are accurate enough, length is not critical and a handle is also fitted. Plastic file handles are good.

Tool no. 5 is used to hold the release while working on it. The release is bolted into the holder which is then clamped in a vice, this stops damage to the release cage. It is made by welding two side plates of 75 x 50 x 3mm flat plate to a length of 25 x 25mm RHS. Holes are pre-drilled to suit the release. Drill holes slightly oversize to make fitting the release easier.

Full size plans are available from the Grafton Gliding Club.

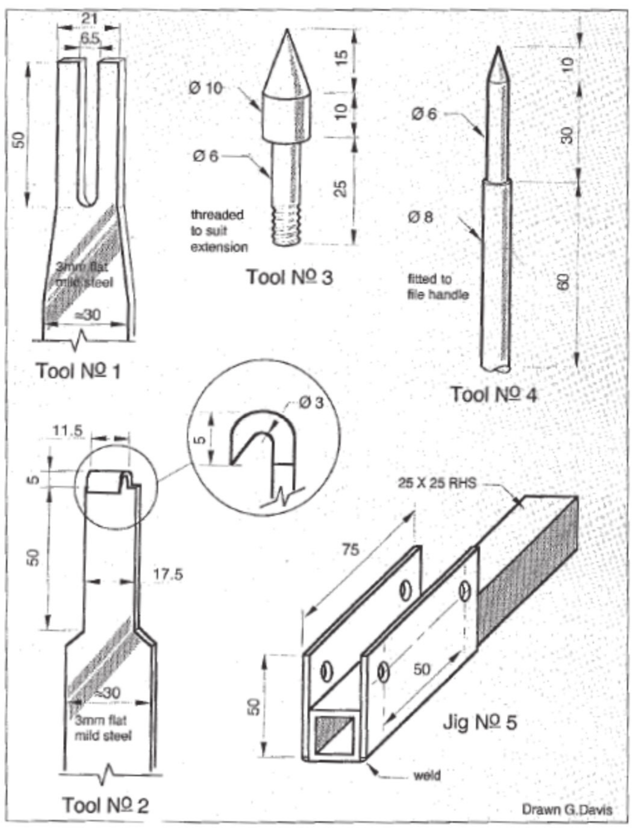
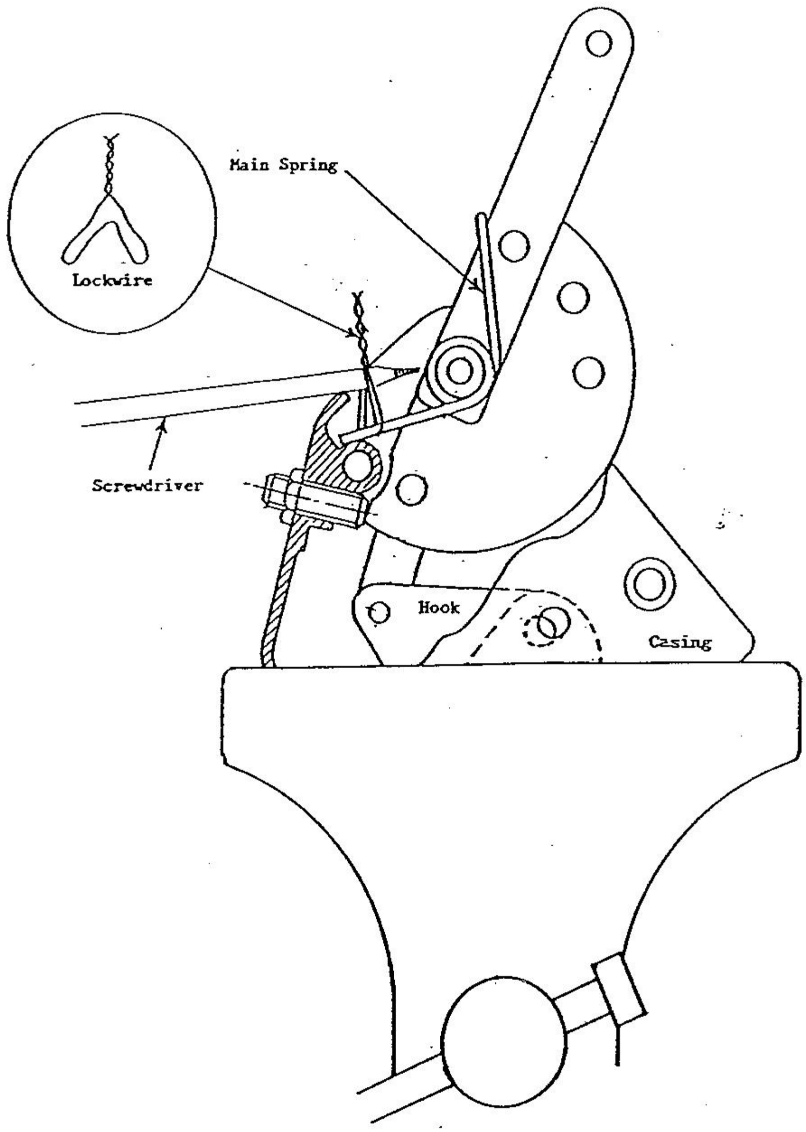


Figure 16-16 Release Test Tools

Copied from Australian Gliding Sep/Oct 98

Many people develop tools like this to help.



(July 1985)

Figure 16-17 This is a very simple tool that is effective once you perfect its use.

17. OXYGEN

This chapter of Basic Sailplane Engineering covers the installation, maintenance and inspection of gaseous oxygen systems, providing guidelines for both inspectors and operators. These guidelines are compiled from general aviation practice, CIG recommendations, Australian Standards and CASA requirements and tailored to suit our needs.

Operational guidelines for the use of oxygen may be found in the relevant section the GFA MOSP Part 2 Operations.

Australian regulations differ from other regulatory bodies, such as FAA and EASA. Please only use CASA regulations when operating in Australia. CAO 108.26 - System specification - Oxygen systems, applies to GFA sailplanes and LSA gliders. Compliance with MOSP 3 and BSE should guide compliance with CAO 108.26 but it retains precedence.

Note: GFA AD348 Oxygen Systems was cancelled on 02 March 2016 and superseded by MOSP 3 and BSE.

17.1 GFA RECOMMENDATIONS AND REQUIREMENTS

Since circa 2005, portable light weight oxygen systems with sophisticated flow control devices specifically designed for sailplanes and sports aviation have emerged and become popular due to their higher duration per kg load, relative simplicity of use and safety features. These have rendered older permanently installed systems undesirable and largely obsolete.

GFA recommends when choosing a new oxygen system for use in a sailplane:

a. Choose a portable oxygen system designed and manufactured by a reputable manufacturer specifically for aviation use.

b. The oxygen regulator should be mounted directly to the oxygen cylinder with no high pressure plumbing involved.

c. Permanently installed high or low pressure plumbing, rigid or flexible, is best avoided.

The new permanent installation of any system, including ex-military systems, requires GFA approval for each individual installation.

CAUTION

For sailplanes with an existing permanent oxygen system, due to the high maintenance requirement and inherent safety risks, GFA recommends the removal from sailplanes of any oxygen system that has high pressure plumbing and/or rigid fitted low pressure plumbing. If installed it must be properly approved and maintained.

Annual Inspectors and Replacement of Component inspectors are expected to be trained and receive a rating to perform inspections of oxygen installations and to remove systems. But extra expertise is required to design, produce and install permanent systems. If you have this expertise and the necessary design approvals then you may install permanent oxygen systems but most people are best to leave this high risk activity to experts.

17.2 OXYGEN SPECIFICATIONS

The type of oxygen used in sailplanes must be “Aviators Dry Breathing Oxygen” (ADBO).

CAO 108.26 (2/11/2007) states the specifications of ADBO:

3	**Oxygen specifications**
3.3	(1) Oxygen used in gaseous oxygen systems must comply with a specification acceptable to CASA. The following specifications are acceptable: C.I.G. Gas Code 420 or 430; RAAF Specification G172; U.K. Ministry of Defence DEF STAN 68-2 1/1; U.S. Military Specification MIL-0-272 10.

Code 430 oxygen is usually described by suppliers as “Oxygen, Dry Breathing, Extra High Pressure, Compressed” and is readily available in Australia. Code 420 is similar to Code 430 but supplied at a lower pressure and is rarely available in Australia.

There is considerable debate as to whether there is any significant difference, other than price, between the various grades of oxygen such as; industrial, food, medical and dry breathing. Whilst the method of producing the oxygen may be identical, the subsequent storage and protection/testing for impurities does vary. In particular, industrial and food (processing) grades of oxygen are not intended for human consumption and thus contamination from cylinders and lines may cause a health hazard.

It is normally stated that medical grade oxygen (eg Gas code 400) is unsuitable for aviation use because it may contain more moisture than ADBO and thus may cause a freezing hazard at low temperatures. Sceptics pointed out that medical oxygen is so dry that for pro-longed consumption it is usually humidified and warmed by a bedside device (because breathing compressed gas causes drying, and may cause damage to, the tracheal mucosa). However medical oxygen is not intended for use at the -30C temperatures that sailplane pilots might experience at altitude. Whatever the merits of the arguments, the use of medical grade oxygen in aviation oxygen systems is not approved by CASA and thus it must not be used in sailplanes.

CAUTION

"Aviators Dry Breathing Oxygen" is expected to have moisture content less than 0.005 milligrams of water vapour per litre of oxygen at a temperature of 15°C and a pressure of 760 millimetres of mercury. "Medical" oxygen may not meet the moisture requirements for “Aviators Dry Breathing Oxygen”.

Operators responsible for the filling of oxygen cylinders, either at a recognised re-filling station or by decanting in the field, must be absolutely sure that the gas being used is oxygen and the correct grade of oxygen.

17.3 SAFETY PRECAUTIONS WHEN WORKING WITH OXYGEN

WARNING

When high pressure oxygen comes in contact with grease, oil, or any form of hydrocarbon, instant fire and/or explosion will occur. Total working cleanliness is absolutely imperative for sailplane and pilot safety.

17.3.1 CLEANLINESS

The importance of absolute cleanliness during installation, use and maintenance procedures for oxygen equipment cannot be over emphasised. The inspector, pilot and operator must at all times respect the fact that oxygen and malfunction are potentially lethal.

17.3.2 WORK PRACTICES

Good work practices when working with oxygen include:

a. Always turn the gas valves on and off slowly to prevent heating of system components, possible internal combustion or rupture of oxygen lines.

b. Always work with tools that have been degreased.

c. Hands and clothing must be free of oils and greases. Note: Beware of suntan oils and creams.

d. Do not use lubricants on oxygen system components unless they are oxygen compatible and comply with manufacturer's specifications.

17.4 UNDERSTANDING OXYGEN SYSTEMS

17.4.1 TYPES OF INSTALLATION

Oxygen systems may be permanently installed in a sailplane or be portable:

a. Permanently installed oxygen systems - have all, or some, of the components permanently installed in the sailplane. The installed components may be plumbing, valves and cylinder. The cylinder may be refilled in situ via a refilling port or removed to a refilling station.

b. Portable oxygen systems - all components of the system are removable from the sailplane, except that the cylinder mounting bracket may remain. GFA requires that the oxygen regulator must be mounted directly to the oxygen cylinder with no high pressure plumbing involved.

Portable systems are considered optional equipment and count as part of the cockpit baggage load and thus are part of the pilot's responsibility, not the Annual Inspector's. However, portable system components should still be secured and restraint tested using the same considerations as fixed systems, as all aircraft will experience turbulence and a badly secured bottle could become a potentially fatal missile.

The installation of permanent systems, including ex-military equipment, requires engineering approval via GFA (MOSP 3 Section 18.7.1)

17.4.2 SYSTEM COMPONENTS

All oxygen systems have the following main components:

a. The cylinder which stores the oxygen under high pressure.

b. An on/off valve fitted to the cylinder.

c. A high pressure gauge which shows the pressure within the cylinder and thus indicates the quantity of oxygen. In modern portable systems, the gauge and on/off value are often an integrated fitting (with the gauge sited before the on/off valve) and permanently fitted to the cylinder. Often the gauge is part of the regulator and removable, ie after the valve.

d. A regulator which converts the stored high pressure oxygen to the delivery low pressure. Regulators may have one or more low pressure ports (outlets).

e. The low pressure plumbing or flexible hose which is used to transport the oxygen from the regulator, via a controller, to the pilot.

f. The flow or demand controller which meters out the correct amount of oxygen according to either the pilot chosen setting or automatically, depending on the type of controller. Some demand controllers are designed to supply two users simultaneously.

g. The mask or cannula that interfaces the oxygen system to the pilot.

It is normal practice to refill a cylinder by removing the regulator and connecting the charging tube to the on/off valve. However a permanently installed cylinder that is refilled in situ, may additionally have a filling port and an on/off or non-return valve.

Older permanent installations may have high pressure plumbing to enable the high pressure gauge and a secondary on/off valve to be located more conveniently for the pilot to see and operate.

17.4.3 SYSTEM CONFIGURATIONS

The following diagrams illustrate some common system configurations. The first diagram shows the modern and most common portable single user system.

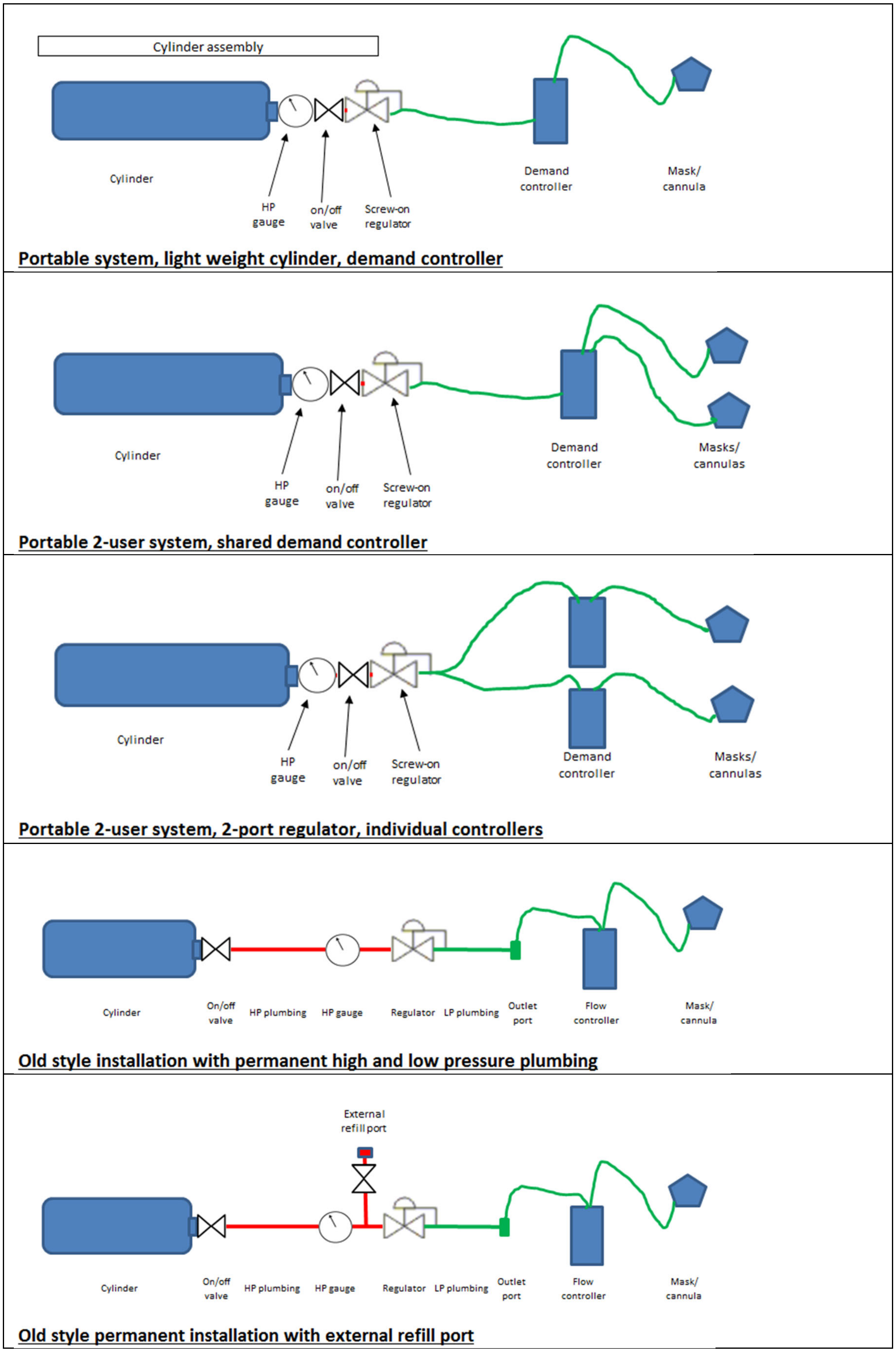


Figure 17-1 Common oxygen system configurations

17.4.4 CYLINDERS

Oxygen cylinders used to all be made of steel, but modern cylinders used in sailplanes are now usually aluminium and sometimes Kevlar or a composite. They are available in a wide variety of sizes, the most popular being in the range 160- 250 litres. Aluminium cylinders have a maximum working pressure of 2000-2200 psi ie 140 to 150 bar and steel cylinders are often 3000 psi ie 200 bar.

All cylinders are stamped with the date of the last inspection and pressure test, the cylinders maximum allowable working pressure, together with a stamp identifying the organisation certifying the cylinder.

The cylinders are pressure vessels and therefore are subject to the Australian Standards on testing and serviceability. Further information on cylinder testing is provided later in this chapter.

WARNING

Under no circumstances should a cylinder that does not have a current pressure vessel certification, be used. No cylinder is to be filled to a pressure beyond its certified working pressure.

17.4.5 SYSTEM TYPES AND THEIR CONTROLLERS

There are two types of oxygen systems generally used in sailplanes:

a. Demand systems: Oxygen is mixed with air and is only delivered to the mask as the pilot inhales. This system is the most precise and gives the most economical consumption and thus duration. There are three types of controller available:

   i. Diluter Demand Controller

   ii. Pressure Demand Controller

   iii. Electronic or Pulse Demand Controller. This is the most commonly used controller in sailplanes.

b. Continuous flow systems: Oxygen is delivered continuously to the cannula/mask at a constant flow rate. This type uses more oxygen than Demand systems and thus larger cylinders are required for a similar endurance. There are two forms of controller available:

   i. Pre-set constant flow

   ii. Pilot adjustable flow to match the operating altitude.

Oxygen generators, automatic emergency systems and portable therapeutic sets are not used in sailplanes and are not covered by this document.

17.4.5.1 CONSTANT FLOW

This type of system delivers a fixed rate and continuous flow of oxygen from the storage container. It is a relatively low cost solution as it doesn’t need complicated masks or controllers to function. But it is also very wasteful—the flow of oxygen is constant whether you’re inhaling, exhaling, or pausing in between breaths. It uses a bag on the mask to store the oxygen between breaths and reduce wastage.

An improvement on a pre-set rate continuous flow is the pilot adjustable controller. This again is relatively simple – the pilot sets the flow rate according to the altitude he is flying. However soaring rarely involves flight at a constant altitude so multiple adjustments of the controller are necessary and there is a risk of pilot mismanagement.

The constant flow system is limited to a maximum height of FL250 feet with a mask but only FL180 with a cannula. MH3 useable to FL180 MH4 useable to FL250 (with a mask)

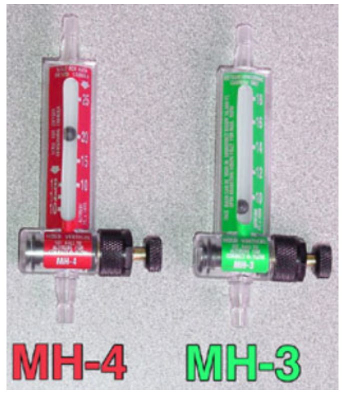


Figure 17-2 Examples of Pilot Adjustable Continuous Flow Controllers From Mountain High

17.4.5.2 DILUTER DEMAND CONTROLLER

A diluter demand regulator supplies oxygen only in response to the pilot's breathing. The oxygen is automatically diluted with air according to the height at which the system is operating. So at 10,000 feet the pilot only breaths a small amount of supplemental oxygen whereas at 35,000 feet the pilot is breathing pure oxygen. This is the maximum height for use of this type of controller.

17.4.5.3 PRESSURE DEMAND CONTROLLER

The pressure demand regulator works in a similar way to the diluter demand regulator but above 35,000 feet it supplies oxygen at a pressure slightly over the ambient pressure at the operating altitude. This pressurisation enables the lungs to absorb sufficient oxygen for safe operation at heights up to 42,000 feet.

17.4.5.4 ELECTRONIC (PULSE) DEMAND CONTROLLER

The electronic pulse demand controller monitors micro-pressure changes during the breathing cycle and delivers a precise pulse of oxygen at the very beginning of each breathing cycle. Delivery of the oxygen to the pilot is via a cannula or face mask.

These systems feature lower oxygen consumption rates compared with other demand systems, but do require electronics to function correctly. Power loss due to flat batteries will cause the system to fail to operate.

The maximum altitude of use is specified by the manufacturer but will be circa 25,000 feet.

Figure 17-3 The Mountain High EDS O2D1 pulse demand controller

Figure 17-4 MH regulator and gauge

17.4.6 FLEXIBLE LOW PRESSURE HOSES

Some systems use low pressure small bore flexible hoses from a permanently installed oxygen outlet and others use it throughout such as in modern portable systems. These hoses should be of the type specified for use with oxygen. Depending on the design of the system, it may use either made up hoses or cut lengths of hose with push connectors.

Flexible hose will be non-kink in normal usage and may be colour coded. Do not use general purpose flexible hose purchased from the DIY stores, as this may not be compatible for use with oxygen.

17.4.7 CANNULAS AND MASKS

17.4.7.1 NASAL CANNULAS

Nasal cannulas have become increasingly popular alternatives to face masks. Cannulas free the pilot to talk, eat, or drink without the hassle of a conventional facemask. In short, they're more comfortable.

They are restricted by Australian CAO 108.26 to a maximum of FL180 altitude because of the risk of reducing blood-oxygen saturation levels if one breathes through the mouth or talks too much.

> **CAO 108.26** (including Amendment Order Nbr 1 2007)
>
> 5.1.3 *Every unit* (individual dispensing unit) *provided in an aircraft operating above flight level 180 must be designed to cover the nose and mouth.*

You can keep them clean by using mild water and soap. Then disinfect them. They should be considered a personal use item rather than shared.

17.4.7.2 MASKS

The partial rebreather mask is the most common mask used with a constant flow system and usually has an external plastic bag that inflates each time you exhale. The purpose of the bag is to store any unused oxygen, so that it can be inhaled with the next breath and increase system efficiency. These masks work fairly well up to 25,000 feet — as long as the mask seals well against the face.

Masks designed for altitudes higher than 25,000 feet will be sturdier, better forming to the face and of course more expensive.

Excessive sun exposure and normal wear and tear can make a mask less effective at altitude. The heat of a baking cabin can deform the face seal of any mask, as well as bring on cracks in the re-breather bag.

Beards and moustaches don't go well with oxygen masks as they may prevent the mask sealing properly to the face. For this reason, some manufacturers suggest that bearded pilots fly no higher than 18,000 feet on oxygen. Above that altitude, the risk of oxygen leakage is too great.

Masks can be ordered with built-in microphones. This spares the pilot of the bother and risk of removing and replacing the mask every time a radio transmission is made. The down side is that the masks can impart an odd muffled sound to transmissions, sometimes making them nearly undecipherable.

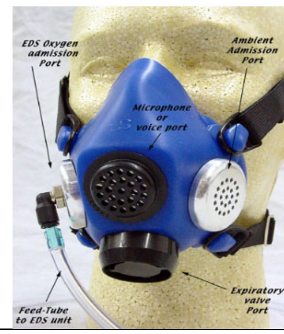
The Aerox 4110-711 Series continuous flow oxygen mask. Intended for use of crew and passengers in the general aviation industry up to a maximum altitude of 25,000 feet.	
The Mountain High ALPS Mask For use with Mountain High continuous flow or EDS systems.	
The Aerox Diluter Demand Mask This 4110-725 series mask is intended to be used by crew and passengers in the general aviation industry up to an altitude of 40,000 feet MSL.	

Figure 17-5 Examples of aviator oxygen masks

17.4.8 SYSTEM MANUFACTURERS

Below are details of some manufacturers of aviation oxygen systems whose products are frequently used in sailplanes:

a. Mountain High http://www.mhoxygen.com/

b. Aerox https://aerox.com/

c. Precise Flight https://www.preciseflight.com/

d. Delta Oxygen Systems http://www.deltaoxygensystems.com/index.html

Note: Inclusion in the above list does not constitute a recommendation or endorsement by GFA.

17.4.9 BASIC REQUIREMENTS FOR ALL OXYGEN SYSTEMS IN SAILPLANES

The basic requirements for any oxygen system used in a sailplane are:

a. There must be an "on/off" valve located as close to the cylinder/s as possible to which a pilot has access in flight. In a tandem two seat sailplane this may be difficult and must be solved. This valve is analogous to the master switch in an electrical circuit and is there in case something goes wrong with the regulator, mask etc. If the cylinder valve is inaccessible in flight, a separate on/off valve must be installed.

b. The pilot, or one of the pilots in a tandem two seater, must have visual and physical access to the regulator and be able to see the pressure gauge and the flow (a mirror is acceptable).

c. A mask or cannula, compatible with the regulator, must be provided for each seat.

d. Cylinders, lines, regulators, flow meters and pressure gauges must be compatible with; each other, the function of the system and the range of pressures for which the system is designed.

The four specific requirements above, combined with the guidelines in the following text, will allow Annual Inspectors to certify the airworthiness of new and existing installations by logbook entry.

17.5 CYLINDER INSTALLATION AND RESTRAINT

Irrespective of whether the oxygen system is portable or permanent, the oxygen cylinder must be adequately secured to the sailplane during flight.

Oxygen cylinders come in all shapes and sizes and can be difficult to site due to their bulk and weight. The weight of the cylinder for assembly should be calculated as the sum of weight of: empty cylinder, full oxygen gas fill, on/off valve, gauge, regulator and mounting bracket.

When determining the mounting location for an oxygen cylinder the vital points to consider are:

a. Effect on weight and balance.

b. Possible interference with flight control systems.

c. Ease of re-filling or removal for re-filling.

d. Restraint under crash and flight loads.

e. Remote from oil, grease and heat (powered sailplanes).

The cylinder and all other components must be installed and restrained in accordance with Installation of Optional Equipment Chapter of this manual. In particular, if the oxygen cylinder is located behind the pilot, it must be restrained to the 15g crash load case.

Most modern composite sailplanes feature a built-in oxygen cylinder mounting point that satisfies the appropriate Type Certification standards in the country of origin. When a sailplane type is issued a Certificate of Type Acceptance in Australia, the mounting point will be checked against CASA relevant standards and thus comply with this restraint requirement. It may be necessary to purchase an approved specific mounting plate or clamps from the oxygen system supplier to secure the cylinder.

Where a mounting plate must be custom fabricated, then it must be engineered so as to withstand the g force loads specified in the Optional Equipment Chapter and must be approved by an Annual Inspector.

If the sailplane does not have suitable built-in oxygen mounting points, then consult with the RTOA regarding previous solutions or a new design and new engineering order. A logbook entry will be required for an approved modification (see MOSP 3).

17.6 PERMANENT PLUMBING INSTALLATIONS

17.6.1 TERMINOLOGY

"Low Pressure"	Pressures below 2750 kPa (400 psi)
"High Pressure"	Pressures up to 25000 kPa (3650 psi) (250 bar)
"Working Pressure"	Maximum pressure the component will experience in normal service.
"Burst Pressure"	Pressure at or in excess of which failure of the component is expected.

17.6.2 SECURITY

All plumbing, high pressure and low pressure, must be located and secured through the airframe such that there is no possibility of touching or jamming flight controls or causing abrasion to the plumbing itself. If plumbing is not properly secured and can vibrate, it will eventually fatigue causing cracking and gas leakage. Clearance of 15 mm from pushrods and bellcranks and 50 mm from cables will usually ensure no abrasion in service.

Plastic or cord ties are better than wire or metal brackets (unless the metal brackets are lined with a soft material to stop abrasion).

Where rigid lines are used, it is important to provide sufficient flexibility at each end to prevent cracking or work hardening due to repeated connection and disconnection.

Particularly where vibration is present (powered sailplane), plumbing should be secured at intervals of no more than 350 mm.

17.6.3 HIGH PRESSURE PLUMBING

High pressure plumbing extends from the cylinder to the regulator. It must have a safety factor of not less than 3 between maximum allowable working pressure and calculated burst pressure. (BS 3N 100:1985).

17.6.3.1 Copper Tubing

Some older systems have used copper tubing for high pressure oxygen plumbing. These are fraught with potential dangers due to fatigue cracking. GFA recommends removal of old copper plumbing and replacement with flexible hose, or a simpler low pressure system. If copper systems are installed, they must conform to FAA AC 43.13.

17.6.3.2 Flexible Hose

If a flexible hose is to be used for high pressure plumbing, it must be very clearly approved for Aviators Dry Breathing Oxygen. Many hoses rated for oxygen are only intended for industrial oxygen and must not be used for breathing oxygen.

WARNING

Teflon in pure or "virgin" form is safe in oxygen systems. However most teflon hose linings etc are not pure and can, in systems over 600 psi, cause combustion in combination with any foreign matter. It is strongly recommended not to use Teflon in any components in a sailplane oxygen system. Teflon seals in regulators etc must be viewed with caution.

17.6.4 LOW PRESSURE PLUMBING

Permanently installed low pressure plumbing is now unusual but may sometimes be found in two-seat sailplanes where low pressure lines may extend from the regulator to separate oxygen outlet sockets for each pilot. Both aluminium alloy and copper tubing are acceptable for low pressure lines, with either flareless or flared fittings.

17.6.5 COMPONENT CLEANING

The cleaning process prior to and during assembly of a system is a most important part of installation. All lines and fittings must be degreased internally and externally to remove all traces of oils, greases, dust, swarf etc. If silver soldered fittings have been used, all traces of flux must be removed from the inside of lines and fittings.

The recommended practice is to degrease using a vapour degreaser or sonic cleaner followed by flushing with stabilised trichloroethylene, acetone or similar non oily solvent.

Parts can be immersed and cleaned in trichlorotrifluoroethane ("fluorosil" is an acceptable product for this purpose). Any brushes used should have 100% nylon bristles.

CAUTION

Fats and oils can be deposited by fingers. This means that care should be taken while handling parts between cleaning and final assembly.

"Carbon Tetrachloride" is now illegal to use and "Methylated spirits" is not recommended as degreasing agents.

Following degreasing, the lines and parts must be dried by either:

a. Heating to 70°C for half an hour

b. Blowing dry with dry, clean air or nitrogen.

WARNING

Air from a compressor will be wet and most likely have significant oil content from the compressor lubricant. It therefore must not be used in a sailplane.

17.6.6 SEALING PLUMBING AND FITTINGS

The aim of all plumbing systems is to not have to use any form of sealing compound. However, if a leak occurs in a joint made by a threaded tapered male fitting that locates into a female threaded fitting, then the leak will be around the thread and either of the following sealants can be used, (keeping the sealant off the first one or two threads):

a. "Oxy Tape". Pure Teflon tape marketed in a dispenser preventing finger contact. (MIL T 27730).

b. Loctite 520. A white paste which, unlike other "Loctites", will set in the presence of oxygen.

Leaks in flared fittings, "Swagelocks" etc. will be due to damage to metal to metal seats. The best cure is not to use a sealing compound but to remake the joint.

Note: At no time must sealing material be allowed to enter the plumbing system.

17.7 WEIGHT AND BALANCE

After a new installation or major change to an oxygen system has been completed, the changes to the sailplane's weight and balance must be considered. The sailplane should be weighed or a calculated change in weight and balance completed. New pilot weight limits or ballast requirements may need to be set and cockpit placards amended. Many sailplanes fitted with oxygen are extremely limited in pilot weight allowance.

In many sailplanes it will be necessary to placard load limits for two separate configurations:

a. With oxygen fitted; and

b. With the oxygen system removed.

The sailplane must not be flown with the centre of gravity, the maximum gross weight or the maximum weight of non-lifting parts outside of the manufacturer's limits.

17.8 SYSTEM TESTING

Following the installation of a new system or the breakdown of a system for component maintenance, cylinder refilling etc., the system must be tested.

17.8.1 CYLINDER TESTING

Testing and inspection of pressure vessels is very important as a rupture failure could have very serious or fatal consequences. Testing can be arranged through a number of organisations approved for this class of work.

In many cases imported oxygen cylinders are made to overseas standards not recognised/approved in Australia. This makes it difficult to have them pressure tested, inspected and recertified since the organisation doing that work can only certify cylinders made to recognised standards. You may have to provide the cylinder manufacturer's specification documentation to the testing organisation in order to have the cylinder accepted.

Individual Australian State laws on pressure vessels have been applied in the past to some sailplane oxygen cylinders resulting in the derating of those cylinders to lower maximum working pressures

Oxygen cylinders must be inspected and hydrostatically tested at the intervals as specified by the cylinder manufacturer but not greater that the interval specified in MOSP 3.

MOSP 3 makes CASA CAO 100.5 Appendix 1 Section 15 mandatory for GFA registered aircraft which states:

15.11 Subject to subclauses 15.12 and 15.13, inspection and testing of cylinders under this clause must be carried out at intervals not exceeding every 5 years after manufacture.

15.12 For 3HT cylinders, inspection and testing under this clause must be carried out at intervals not exceeding every 3 years after manufacture.

15.13 For DOT-E type cylinders, inspection and testing under this subclause must be carried out:

(a) at the intervals mentioned in the latest revision of the applicable DOT Special Permit; or

(b) at intervals not exceeding every 3 years after manufacture.

The test interval makes no differentiation between in-use and storage.

Cylinder manufacturers often specify a service life specified by years from manufacture or the number of refill charges and CAO 100.5 imposes maximums. Both limits must be adhered to.

Reputable gas suppliers have a responsibility for statutory testing and will refuse to refill any cylinder that is out of test date. Some cylinders will have a limited service life, others have unlimited service lives. Due to the complexity of different types, the testing inspector or manufacturer will be able to advise on the service life.

17.8.2 LEAK TESTING

All joints should be tested with the system at full pressure, by applying soapy water to all joints and watching for bubbles. Observation of pressure drop over time can also be used for leak detection, the effects of temperature change must be considered in any observed change.

Some items of equipment have small leaks inherent in their design, those leak rates should be specified by the manufacturer.

If a leak is found, relieve the pressure before attempting to rectify the problem.

If any gas other than Dry Breathing oxygen is used for system leak testing, then the system must be flushed out with Dry Breathing oxygen before use.

17.8.3 FLOW CHECK

Once the system is verified as leak free, its ability to flow at or more than the minimum required rate must be confirmed. In a two seat sailplane installation, both outlets must be tested individually and together.

17.8.3.1 CONTINUOUS FLOW REGULATORS

The minimum flow rate should comply with the chart (labelled Appendix II) published in CASA CAO 108.26 which is based on low efficiency masks. Note that cannula manufactured under the name “Oxymizer” are permitted at lower flow rate due to their better efficiency. Flow rate can be checked using a "rotameter".

17.8.3.2 DEMAND REGULATORS

This includes diluter, pressure demand and electronic regulators. The regulator must meet the manufacturer’s gas flow specifications, which requires testing by an approved laboratory. This testing should be done in accordance with the manufacturer’s schedules.

When installing or inspecting this equipment, the Annual Inspector only need do a functional check as detailed in the regulator manufacturer’s handbook.

17.8.4 DORMANT OXYGEN SYSTEMS

Most oxygen systems can lay dormant for long periods and in many cases components are changed from sailplane to sailplane. This aspect of oxygen systems presents a number of safety considerations:

a. If a cylinder is kept disused at a pressure less than 350 kPa (50 psi), there is a strong chance that internal corrosion will be found in the cylinder. The presence of moisture can often be detected by a pungent odour in the oxygen remaining in the cylinder. If the Inspector has any doubts, the cylinder should be sent away for inspection and hydrostatic test.

b. Where cylinders or other components are removed and plumbing left in place, the plumbing must be sealed with a proper plug or cap - not a piece of rag or masking tape.

c. Before returning an old system back to service, all of the procedures applicable to a new system should be followed to ensure system cleanliness and safety.

d. If there is any suspicion of fatigue cracks in existing copper or alloy lines, the lines should be renewed

17.9 PLACARDING

The placarding requirements are specified in MOSP 3 Section 8.3.11.

17.9.1 INDICATED AIRSPEEDS

With gain of height comes reduction in air density. The lowering of air density causes an increase in true airspeed at constant indicated airspeed and while this does not affect the structural loads applied to the aircraft at constant indicated airspeed, the aircraft is being flown closer to its flutter limit as this is related to true airspeed.

The reduction of Vne with gain of altitude must therefore be placarded. Refer to Section 4.5.5 for an example.

17.9.2 SYSTEM SAFE HEIGHT LIMITS

Each type of oxygen system has its own operating height limitations and some individual equipment items, due to their design or quality, are height restricted. To ensure pilot awareness of system limits, the manufacturer's system limits must be placarded. This is usually incorporated in the Vne placard as shown above.

If the system used is portable, there is probably no placarding in the sailplane. The pilots are responsible to ensure they operate to the manuals. Placards are recommended.

GFA members must follow the manufacturer's safe height limits for the equipment in use.

17.9.3 CYLINDER MOUNTING BRACKET

Because the bracket is likely to be specific to a manufacturer or bottle size, the bracket or mounting should be placarded with the type and size of bottles for which it has been tested. Eg

Tested for use with Mountain High AL-180 oxygen cylinders only.

17.9.4 FILLING INSTRUCTIONS FOR PERMANENT INSTALLATIONS

Where an installation is permanent and the cylinder will be filled whilst fitted in the sailplane, a placard stating the maximum filling pressure and a caution about keeping the surroundings clean and free from oil and grease must be fitted adjacent to the filling valve. An example is shown below:

DANGER OXYGEN MAXIMUM PRESSURE 12,400 kPa (1,800 psi) KEEP OIL AND GREASE AWAY FROM THIS FILLING POINT

17.10 AIRWORTHINESS CERTIFICATION

17.10.1 INITIAL INSTALLATION

A GFA authorised Annual Inspector (of any category) must supervise or carry out the installation of a permanent oxygen system or the mounting plate/straps of a portable system. This enables the documentation of compliance with this Chapter of BSE to be recorded by logbook entry. If necessary, design approval of the cylinder restraint and any modifications to original structure and systems should be sought from the GFA. Weight and balance must be checked by an appropriately authorised W&B Inspector.

17.10.2 ANNUAL INSPECTIONS

17.10.2.1 PORTABLE OXYGEN SYSTEMS

The Annual Inspector should check the following:

a. The cylinder mounts for corrosion, cracks, general condition and security.

b. No significant change to weight and balance causes by changes to the portable oxygen system used in the sailplane

c. Placards present and correct.

The pilot is responsible for checking the portable oxygen equipment before use for: correct gas, gas content, serviceability, non-interference with controls, operating limits and restraint.

17.10.2.2 PERMANENTLY INSTALLED OXYGEN SYSTEMS

The annual inspection may be handled one of two ways by an Annual Inspector:

The Inspector may confirm that the cylinder and all other components are securely mounted and not interfering with flight controls or other systems but not carry out any inspection or checking to confirm the serviceability of the system. In this case the Inspector should endorse the Maintenance Release "Oxygen system to be inspected for serviceability before use". This is the preferred procedure if the oxygen system is not to be going into service soon after the Annual Inspection.

Alternatively the Inspector may fully inspect and functionally check the system in accordance with this Chapter of BSE plus any particular check or inspection required by the equipment manufacturer. That will allow the system to go straight into service. That should include:

a. Confirmation that all components that have pressure testing or overhaul requirements (cylinder, regulator etc.) are not out of date or will not exceed their overhaul period during the life of the new Maintenance Release. Where an item of equipment will exceed its overhaul period that fact must be written into the sailplane's Maintenance Release.

b. Check the cylinder, cylinder mounts, for corrosion, cracks, general condition and security.

c. Check plumbing for damaged, corroded, squashed tubing and regulator and flow meter for condition and security.

d. Check the system for function and carry out a leak check. This will require the system to be fully charged.

e. Placards and weight and balance correct.

17.10.3 RETURN TO SERVICE INSPECTION

Where a permanent system has been dormant for some time, a full inspection should be carried out by an Annual Inspector, following the guidelines above. It should be recorded by a logbook entry and cancel any restrictions on the Maintenance Release.

17.10.4 DAILY INSPECTIONS

Security of the cylinder, plus security and condition of the other visible components is considered part of a normal Daily Inspection. Gas type, gas content and system function are not a Daily Inspector’s responsibility.

17.11 DECANTING

Decanting is the act of filling one container from another at a higher pressure. In gliding, this means filling an empty or partly empty cylinder from a high pressure cylinder. This can be done in two ways:

a. The empty cylinder may be left in the sailplane and the higher pressure cylinder brought to it. For a permanently installed system, this is the preferred method so as to avoid breaking plumbing connections that will need to be leak checked when the cylinder is replaced.

b. The empty cylinder can be taken out of the sailplane to the high-pressure cylinder.

Irrespective of which way it is done, this process is potentially very dangerous and requires due care as follows:

c. If decanting into the sailplane the filling point and the area around it should be thoroughly cleaned before connecting the plumbing from the external cylinder and that plumbing must be clean.

d. The plumbing to the external cylinder must be long enough and flexible enough to not risk fracture or damage while being used.

e. There must be a pressure regulator or pressure limiting valve fitted at the external cylinder set such that the sailplane system cannot be over-pressurised

f. Before connecting the line from the external cylinder the line must be carefully purged with oxygen from the cylinder to remove air, moisture or any foreign objects.

g. The filling procedure must be carried out slowly to prevent the generation of excessive heat in the system and the sailplane cylinder.

h. Accurate filling is subject to oxygen temperature so the following chart of pressure versus temperature should be used to control the filling procedure. Both oxygen cylinders should be kept out of direct sunlight.

i. On completion, all joints disturbed for the filling process must be leak checked with detergent and water or by noting any pressure drop.

17.11.1 FILLING PRESSURES

The following tables give the correct filling pressures for a given pre-fill cylinder temperature.

TO OBTAIN 3600 PSI AT 15°C		
TEMP °C	**PSI**	**kPa**
0	3318	22890
5	2420	23590
10	3522	24300
15	3625	25000
20	3727	25710
25	3829	26410
30	3931	27120
35	4034	27820
40	4136	28530

Table 17-1 3600 PSI

TO OBTAIN 2000 PSI AT 15°C		
TEMP °C	**PSI**	**kPa**
0	1836	12670
5	1886	13010
10	1936	13360
15	1986	13700
20	2036	14040
25	2086	14390
30	2135	14730
35	2185	15070
40	2235	15420

Table 17-2 2000 PSI

TO OBTAIN 1850 PSI AT 21°C		
TEMP °C	**PSI**	**kPa**
-1	1775	12200
4	1825	12600
10	1875	12900
16	1925	13300
21	1975	13600
27	2000	13800
32	2050	14100
38	2100	14500
43	2150	14800

Table 17-3 1850 PSI

Table 17-1, Table 17-2 & Table 17-3, assume a 14°C rise in temperature due to the heat of compression and they assume that the cylinders are being filled at their maximum rate. These values are approximations and must not be used if the filling information of a specific system gives different values.

17.12 REFERENCES

References in the following list are recommended however, where any differences between this Chapter of the BSE and any reference is noted, this Chapter is authoritative.

a. FAA AC 43.13-1B. Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair, 1998.

b. FAA AC 65-15A Airframe & Powerplant mechanics - Airframe Handbook.

c. CAO 100.5 General requirements in respect of maintenance of Australian aircraft. Section 15 Compressed gas cylinders.

d. CAO 108.26 System Specification - Oxygen Systems - Amendment Order (No. 1) 2007

e. British Standard BS 4N 100-1:1999 Oxygen Systems

f. AS 2030.1-2009 Gas Cylinders - General Requirements

g. AS 2030.5-2009/Amdt 1-2015 Gas cylinders - Filling, inspection and testing of refillable cylinders

h. BOC Gas Agents Manual 2009

i. Ian Robertson. Stirling Range Wave Camp Manual. Beverley Soaring Society. Nov 1994.

j. FAA FAR 91.21

18. FLIGHT OVERLOAD

18.1 GENERAL

The design strength of a sailplane is described in this chapter using the manoeuvre and gust envelopes as illustrated in this chapter with diagrams. Please refer to these as you study the following. (Getting a printout of the relevant pages may help).

Remember that safe flight is <u>within</u> the envelope.

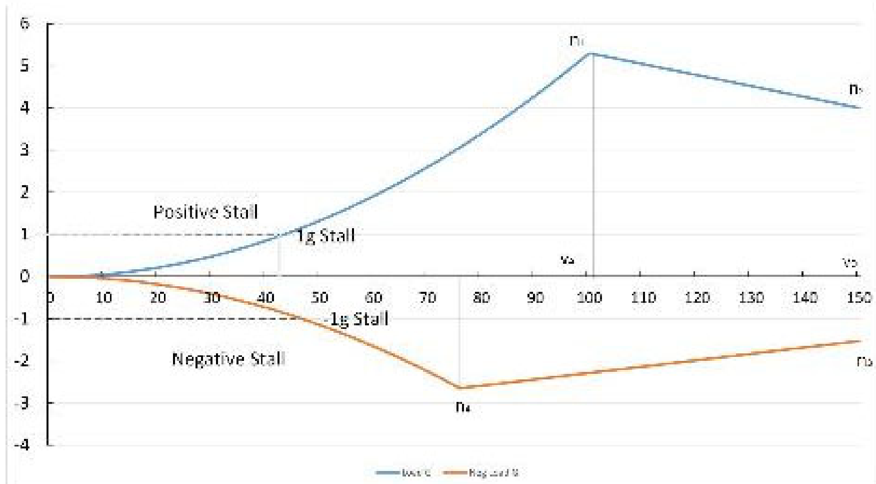


Figure 18-1 Flight envelope

The manoeuvre envelope shows the design limits of a sailplane flying in still air. You will notice that at V_A, it is possible to reach the design limit of 5.3 g (at which a 100 kg pilot is effectively a 530 kg pilot) by application of the elevator alone, provided the elevator is sufficiently powerful to stall the wing at this speed.

But we don't usually fly in still air, so the next envelope (the gust envelope) is important. On this diagram, please note V_B, the rough air speed. This corresponds to the loading produced by an up-gust of 15m/s (30 knots)

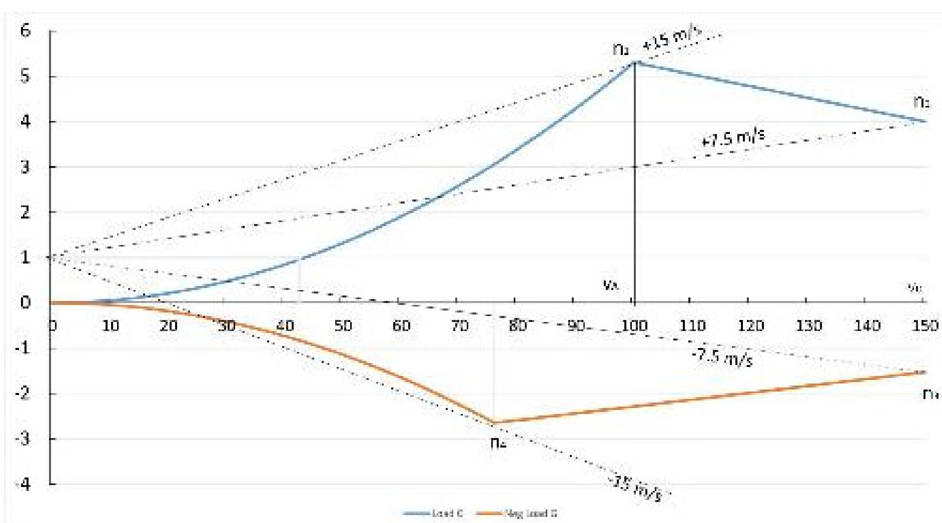


Figure 18-2 Gust loading

But look more carefully and compare this diagram with the previous manoeuvre envelope. See how the top left-hand corner shows that flying close to the rough air speed and using coarse elevator control can lead to flight outside the envelope, and therefore outside the design strength of the sailplane.

Next, consider weight. As we saw with the 100 kg pilot, the loads carried by the structure depend on the g-force multiplied by the weight carried. This is why the cockpit weight allowance is placarded, and why the "weight of the non-lifting parts" is an important airworthiness measurement.

Now look at the high-speed limits. The top right corner corresponds to 4g and an up-gust of 7.5m/s at V_D, the design dive-speed. What is the risk here? The answer is "flutter". Before this was understood, a lot of pilots in fast aircraft suffered a terrible surprise as their aircraft disintegrated around them. It is a very real result of flying faster than the design of the aircraft allows. Sailplanes have suffered from flutter, FRP is more flexible than metal, and therefore flutter is a real possibility. For this reason, it is critically important that control surface weight and balance limits be adhered to and control surface free-play be kept within allowable limits.

Especially with low-drag modern sailplanes, it is possible that some aerobatic situations will result in flight outside the design envelope. Dives and negative "g" manoeuvres are examples of this.

18.1.1 WINCH LAUNCHING

There is an exception to saying that "flight within the envelope is safe" and that is when the sailplane has a big additional load applied which is not considered in the envelopes. That load is the launch cable or tow-rope.

The additional load of this cable or rope makes it necessary to specify a new and lower maximum speed during launching to ensure that the wing will stall before its design loading is exceeded.

In addition, a weak link is included in the cable assembly (or is inherent in the rope used) which is designed to protect the sailplane from overloading due to pilot error. Please refer to the GFA "Winch Launch Manual".

Note that impact loads due to rigid cables can result in much higher loads. The normal spring wire is heavy and hangs in a loop; this provides give which reduces loads. However modern dyneema and other light synthetic winch cables or even tow ropes are very rigid and hang straighter so they have less give. If changing cables be aware and if you feel more shock loads in the sailplane or have more weak link failures you may need to include a 'spring' to absorb shock. Rather use proven technology.

18.2 WHEN CAN OVERLOAD OCCUR?

Aerodynamic overload, other than flutter, will only occur if the sailplane is flown outside its placarded speeds and weights and then subjected to pilot-induced or atmospheric loading.

The following list covers most overload possibilities:

a. Aerobatics:

   i. Executing manoeuvre and aerobatics the airframe was not designed for.

   ii. Applying full control deflection at speeds higher than the placarded maximum manoeuvre speed.

b. High speed flight:

   i. Flying faster than the placarded max rough airspeed and encountering turbulence.

   ii. Flying faster than the max manoeuvre speed and applying coarse control surface deflection

   iii. Coarse use of dive-brakes at high speed. This can cause an overload due to the rearward force transmitted through the wings to the spars and attachment points, as well as overstressing the dive-brake mechanism itself. It is not unknown for dive-brakes to "suck open" by themselves as a result of high-speed flight and incorrect adjustment of the dive-brake mechanism.

   iv. Coarse use of flaps at high speed. Positive flap increases the wing lift at any speed, and therefore increases the loading produced by gust or control inputs.

c. Winch launching:

   i. Exceeding the maximum winch speed and encountering a strong vertical gust.

   ii. Exceeding the maximum winch speed and applying coarse control inputs.

d. Aero-towing:

   i. Exceeding the maximum placarded speed and encountering severe turbulence.

e. Flying overweight:

   i. Flight in excess of placarded limits. Each limit is specified to correspond to a design strength.

f. Non-airborne overload:

   i. Ground Loops. These occur when a wingtip digs into the ground and the sailplane rotates around this wingtip. The tail can slam onto and dig into the ground while the fuselage is rotating at high speed. The sideways momentum of the sailplane tail-end can then twist the fuselage into a torsional failure.

   ii. Tail Slam. Some 2 seaters sit nose-down with a front pilot and tail-down with none. Serious damage can occur if the tail is allowed to slam down onto a hard surface. But even single-seaters can suffer tail-slam, for example as the result of heavy braking.

   iii. Heavy Landings. The vertical speed of the sailplane is greater than designed for when it contacts the ground.

The sailplane design contains energy absorbing features such as the deflection of the tyre, the deflection of the entire structure including the wings, and maybe features such as energy-absorbing undercarriage struts. If the downwards kinetic energy of the sailplane arrival exceeds the sum of the energy-absorbing features, then damage can result.

18.3 FLIGHT OVERLOAD INSPECTION

As with heavy landings, damage can be expected anywhere and not be obvious. Here is a checklist. All these things have happened in practice:

a. Equipment dislodged

b. Critical fuselage areas (in front of the fin, near the wing leading edge and trailing edge, near the main wheel, near the tail wheel or skid, near the wing /fuselage connection pins)

c. Rudder and rudder stops

d. Wing root area, especially near the lift-pins and the main spar.

e. All flight control-runs. Rods can be buckled, cables can be stretched and fittings can be distorted.

f. Water ballast tanks can be damaged causing leaks.

g. The wing leading edge itself may be damaged, especially along the join-line, where the wing upper shell joins the wing lower shell.

h. Dive-brake/wing box damaged.

i. Torsional damage to wing

j. Bending damage to wing. In positive g loading, the upper side of the wing will have compression damage (buckling, delamination and creasing) while the underside will show tension damage, especially cracking.

k. Bending damage to tailplane. A little-known effect of over-speeding can be that the tailplane is damaged in downwards bending. Why downwards? Because the faster the forward speed, the more downwards force the tailplane must provide to counter the nose-down pitching moment of the wing. Thus the compression damage will be in the tailplane underside.

l. All flight control hinges and stops strained or otherwise damaged, (flaps, ailerons, elevator and rudder).

18.4 FRP OVERLOAD INDICATION

Fibre Reinforced Plastic (FRP) is a wonderful material as far as overload inspection is concerned if it can be seen properly.

Here's why: The plastic, that is the epoxy resin, is translucent and it stays that way with normal loading. But in an overload, the resin is less elastic than the glass fibres. It then fails in the form of millions of tiny cracks. These have the effect of making the translucent resin appear opaque white.

So white around stressed areas is a good indication of overload. Further, the white areas do not transmit light, and so a light inside the fuselage at night will enable overstressed areas to be seen. Unfortunately, this light trick doesn't work with wings because the foam sandwich material is impervious to light.

18.5 OTHER INSPECTION TECHNIQUES

18.5.1 SOUND

Sound can be a useful inspection technique when used as follows:

a. Tapping the area being investigated (an object like a coin is used) can reveal information about the underlying structure. For example, it is easy to tell where the main spar is located, in particular, any delamination or loss of bonding between the FRP and the sandwich core will show a distinctly different tap sound.

b. Listening, with an ear on the surface or with a stethoscope, while an assistant applies loads, can enable internal movements to be heard.

c. Ultrasonic inspection machines are already in use for airliners, and it is expected that they will soon be available for sailplane inspections.

18.5.2 FEEL

The hand is quite sensitive to ripples in a smooth surface and sometimes a defect can be felt before it is seen.

18.5.3 SIGHT

Sight is a useful and most common inspection techniques, such as:

a. The use of a strong light, placed very low on the surface, can reveal defects not obvious in normal light. As with the interior light test, this is best done at night.

b. Sighting up the whole sailplane is an often overlooked check. Although composite structures have a strong tendency to spring back into shape, they may not do so completely.

c. Is the tailplane still true with respect to the wings? Sighting from the front or rear will show this.

d. Are the wings still straight with respect to the fuselage? Measuring from each wingtip to the fin will show this.

e. Are the wing and tailplane incidence still the same? A water-filled tube can be used to check the incidence of each wing and the tailplane.

18.6 GELCOAT CRACKS

Gelcoat, generally polyester resin with white pigment added, is less elastic than the underlying FRP. This means that cracks in the gelcoat may or may not be an indication of underlying damage.

Interpreting gelcoat cracks takes a lot of experience, so don't be shy about asking for help from senior people in the GFA. It is not at all unusual for experienced inspectors to carefully remove gelcoat along a crack to see if the crack continues into the underlying FRP.

The need for care cannot be overstated. The glass/epoxy layer is eggshell-thin, and it can easily be damaged by sanding. Here are a few techniques which do not involve sanding:

a. Mark the end of the crack and then apply loading and flexing to see if any movement can be seen or any growth of the crack occurs, or any sound can be heard.

b. Use your internal light source if possible for a fuselage.

c. Use an internal camera or borescope for a wing, looking for damage to the inner skin in the vicinity of the outer crack. The internal control-fittings in the wings can also be examined, looking for distortions or damage to the structure where they are fixed.

18.7 CARBON REINFORCED PLASTIC

Carbon fibres are much stiffer than glass fibres and they are opaque black. There is good and bad resulting from this:

a. A good feature is that gelcoat cracks are less likely to occur in the absence of underlying damage. Compared with FRP, CRP is brittle.

b. A bad feature of CRP is that the structure can transmit forces such that damage can occur well away from the point of impact. While this possibility cannot be overlooked with glass, it is much more so with carbon.

18.8 INTERNAL INSPECTION TOOLS

Years ago, inspectors were limited to lights and mirrors to see inside closed areas such as wings. Then affordable borescopes became available and more recently small USB cameras that plug into a laptop computer. They are quite cheap and great for taking photos. They enable the inspector to examine, for example, the inner skin of a wing and the leading edge joint from the inside. But don’t be misled as most do not have the resolution to see fine cracks and the old optical borescope works better.

18.9 WING LIFT PINS

These are the connection between the wing and the fuselage. There are 4 lift-pins and they carry all the non-lifting parts. Even the tailplane is a non-lifting part, as we discussed when considering lift-pins in the overload possibility from over-speed.

In most sailplanes (Astirs are an exception) the pins are free to move in and out of the bearings. They do this in flight in response to yawing forces. The effect of this movement and the steel-to -steel contact is that wear can occur quite rapidly.

The wear on these pins is therefore an important maintenance check and their replacement must be regarded as a standard procedure. Excessive wear will cause the wings to have unwanted free-play, with a reduction in the flutter threshold.

When inspecting these pins after a heavy landing or suspected flight overload, the first procedure is visual: is there any evidence of distortion of the pins themselves or in the structure which holds them? Is there any sign of overload in the epoxy in the vicinity of the pins? Can a camera or borescope be used to inspect the inner wing root?

The second procedure carries the risk that damage may be caused from the investigation when none existed to begin with. A tube is put over the pin to enable more force to be applied than is possible with the hand. This obviously requires care and experience, the aim being to apply enough force to detect a damaged embedment without applying enough force to damage a good one.

In this and the other overload inspections, the most important attributes for a good inspector are the diligence to be thorough and the willingness to seek out help. The great advantage we have in maintenance is that instant decisions are not needed since we generally have the time to research what is the right decision.

18.10 MAINSPAR PINS AND BEARINGS

Most of the preceding discussion applies to the mainspar fittings, with the exception that there is not usually any movement between the pins and their bearings, and therefore no wear. But an overload event can certainly cause damage here. One clue to look for or ask about is whether or not the sailplane de-rigged normally afterwards.

18.11 CRACKS IN WING FITTINGS

Sailplane manufacturers have generally used mild steel for wing fittings. This material is not prone to cracking, but the possibility exists, especially in the vicinity of a weld. A weld has an associated zone where the weld-steel and the "parent metal" intermingle, and degradation of the steel properties can occur. For example, "hydrogen embrittlement" has caused failures to occur.

Most cracks occur as the result of cyclic loading slowly enlarging a tiny flaw, but the possibility of a crack resulting from an overload event should not be ignored. Crack detection is not easy, but the inspector needs to be wary enough to avoid allowing a suspect fitting to be flown. Again, seek advice if unsure! It may be an option to send a suspect part away for testing.

The most common ways of testing for cracks are dye penetrant and magnetic flux. Dye penetrant test kits are readily available and should be part of an inspector's equipment and there have been Airworthiness Directives which have specified that this test be used. See the later Chapter on non-destructive testing.

19. EXAMINING DAILY INSPECTOR CANDIDATES

19.1 GENERAL

This chapter gives guidance on the technique to be followed when training and authorising Daily Inspectors.

Authorising Daily Inspectors is extremely important as this is for most people the first introduction to the GFA airworthiness systems. A favourable impression during the training for the DI qualification may kindle an ongoing interest in airworthiness.

The Examiner must ensure that each candidate who is authorised meets the minimum standard and is competent to certify a Daily Inspection. This is the last and most frequent inspection that should find faults or deterioration to prevent failure in flight. Since a sailplane may fly many times on the basis of the Daily Inspection, including the carriage of passengers and the general public, a responsibility rests with the Examiner to ensure the candidate has the skills and knowledge necessary to certify a sailplane is safe for a day's flying.

19.2 DOCUMENTATION

The GFA maintains several documents relevant to the training of Daily Inspectors. These can be found on the GFA's website. Relevant to the training is:

a. Daily Inspector's Handbook Sailplanes (AIRW-M03)

b. Daily Inspector's Handbook Powered Sailplanes (AIRW-M04)

c. GFA MOSP 3 Section 10.7 (AIRW-M01)

d. Flight/Maintenance Manual(s) for the appropriate sailplanes

Persons who are authorised as a Daily Inspector Examiner may authorise persons as Daily Inspectors for that particular field of expertise. GFA MOSP 3, Section 10.18 outlines how to become a Daily Inspector Examiner. But all Annual Inspectors are trained and authorized to be a Daily Inspector Examiner.

The DI authority is a pilot logbook entry and GFA does not keep a record. The DI Authority is often for a specific type first and additional Field(s) of Expertise are added.

19.3 CANDIDATE PREREQUISITES

Persons wishing to be Daily Inspectors should obtain the Daily Inspector's Handbook from the GFA Website. This handbook provides the basic technical reference to be used when checking inspectors against the syllabus.

The candidate must meet the requirements of MOSP 3 Section 10.7.

In addition to the formal requirements, the candidate must have good vision and hearing. Many of the clues to problems are very small cracks and damaged structures often creak and groan as they are moved.

It is also desirable that the candidate be a near solo pilot as this will ensure they have been involved in gliding long enough to have a feel for what is considered normal. However there will be exceptions and the candidate's previous experience should be taken into account.

19.4 TRAINING

The training of daily inspectors can be performed by an authorised Daily Inspector. The best method of training is for the candidate to assist on as many daily inspections as possible.

Candidates should work with as many Daily Inspectors, on as many types as possible. This will give the candidate a broad range of experience and knowledge of specific items such as L'Hotellier couplings, wing attachment designs and tailplane attachment designs.

19.5 DAILY INSPECTOR SYLLABUS

While all aspects of the DI Handbook are testable, an Examiner must make sure that the candidate is specifically tested for knowledge of the following areas:

a. Why a DI is important and the extent of authority and responsibility for the safety of the sailplane for the day. Note that GFA liability insurance covers DI inspectors if they are qualified and follow the procedures.

b. When a Daily Inspection is required

c. Why a Daily Inspection is required

d. The significance of a Major Defect and where to record it

e. The significance of a Minor Defect and where to record it

f. Maintenance procedures that a DI may sign off and record new entries for

g. How to certify a Daily Inspection and Independent Control Checks

h. How to determine that nuts, bolts and turnbuckles are correctly safety locked

i. How to determine that control cable is serviceable

j. Checking control systems for movement in the correct sense

k. Various types of control couplings and how each type is safety locked

l. Various types of wing and tailplane attachments and how each is held in safety

m. How to measure available free play and assess whether there is too much

n. Specific features of each construction type being authorised

o. Where to go for further information

19.5.1 TESTING

When testing potential daily inspectors, the DI Examiner must ensure that the candidate fully understands all of the items in the syllabus. This understanding should be in place before testing begins. If a candidate has not understood the syllabus, as demonstrated by the need to review the handbook for the answers to almost all questions, then the testing should be halted.

19.5.2 ORAL TEST QUESTIONS

While candidates will have had access to the questions and answers contained in the DI Handbook, an effective testing technique will be to work through the questions only allowing the candidate access to the handbook to demonstrate why a particular answer is incorrect.

It is also desirable to include a few questions which are not directly from Self-Test Questionnaires in the handbook as this will confirm the candidate's understanding of the topic.

19.5.3 PRACTICAL TESTS

Because daily inspection is a practical function, the candidate must demonstrate the ability to perform an inspection of a sailplane.

The practical tests should be completed on as many sailplanes as are required to demonstrate a full understanding of the necessary skills. It is desirable to perform the test on a type which the candidate is not fully familiar with. This will allow the candidate's ability to think through a problem to be demonstrated rather than the ability to remember the peculiarities of a particular sailplane or type.

WARNING

The intentional introduction of defects into sailplanes is dangerous and is strictly PROHIBITED. The Examiner is responsible to ensure all defects are corrected before the DI is signed for the day.

All sailplanes are imperfect and so will have a variety of defects and imperfections which the candidate should be able to find. A good time to test a candidate is during maintenance or rigging while some items are incompletely assembled. It is desirable to perform DI tests on older sailplanes as they are more likely to have minor defects and they are also more likely to contain unusual design features.

19.5.4 NOTIFICATION OF AUTHORISATION

Upon successful completion of the DI examination, the DI Examiner should make an appropriate entry in the logbook of the pilot, indicating which Field(s) of Expertise they are authorised to perform Daily Inspections, and be signed, dated and the Examiner's membership number recorded. The GFA is not required to be notified of the authorisation(s) obtained.

19.6 POWERED SAILPLANES

The process for authorising Powered Sailplane Daily Inspection Authorisations is similar to that for a sailplane however the powered sailplane's Flight Manual will need to be used as the reference. Most manuals contain a specific section on how to complete a DI on the type and the candidate should demonstrate a detailed knowledge of all specific DI requirements on the type.

Depending on the specific requirements for the particular powered sailplane type, Daily Inspector candidates must demonstrate knowledge of:

a. How to check for water in the fuel system.

b. How to check the oil level.

c. How to check the coolant level.

d. How to examine the exhaust system (for security, cracks and tight bolts).

e. How to ensure the propeller is correctly mounted and the bolts correctly lock wired.

f. The allowable damage to a propeller.

g. All specific requirements related to the type.

20. ELECTRICAL SYSTEMS

20.1 GENERAL

Nearly all sailplanes have electrical systems, either installed by the manufacturer or added by owners since manufacture. Electrical systems include:

a. Devices that make piloting easier eg electronic variometers, GPS nav, glide computers, IGC tracking.

b. Devices that improve safety eg radios, FLARM, wheel-up warning systems

c. Portable electronics devices eg mobile phones, personal computers (eg Oudie) which may be physically connected to the installed electrical system, connect via Bluetooth or else be independent.

d. In motorgliders, electrical systems may also be used for starting, ignition, fuel control or in very recent designs, as the energy source for propulsion.

It is worth remembering that sailplanes fundamentally do not require an electrical system to fly and that having an electrical system creates safety hazards that would otherwise not exist. Hazards introduced by electrical systems include:

a. Battery as a projectile: if not secured to the crashworthiness standard, a lose battery has sufficient mass to cause major injury in a crash.

b. Battery thermal runaway: rapid discharge causing smoke, fire, or explosion.

c. Wiring short circuits or overload: causing heat, smoke or fire.

d. Portable devices charging inflight: risk of device batteries overheating.

e. Entanglement of pilot's limbs or control linkages due to lose wires.

It is vital to safety that where electrical systems are installed, they are fitted correctly, inspected regularly and faults are properly remedied by competent persons.

This chapter of Basic Sailplane Engineering explains typical sailplane electrical systems, provides guidance for Annual Inspectors in the inspection of electrical systems in sailplanes (excluding electrical systems specific to motorgliders) and has information to aid building battery packs and making basic electrical repairs.

Design and installation of sailplane electrical systems requires significantly more knowledge than is contained in this chapter. See also the related Chapter 27 RADIO, ANTENNAE, FLARM AND AVIONICS.

All repairs and alterations to sailplane electrical systems must be inspected and approved by an Annual Inspector and recorded in the sailplane's logbook.

20.2 TYPICAL SAILPLANE INSTALLATION

Practically every sailplane electrical system is unique because of changing manufacturers' options during the production life and owners' subsequent customisation. However, all installations comprise of the following elements:

m. Battery. Stores electrical energy which it delivers on demand from the sailplanes electrical system, until it is depleted and needs recharging. Usually, the battery is removeable for charging.

n. Primary fuse (sometimes referred to as the master or battery fuse). Located at the battery to protect all cabling downstream, from overcurrent.

o. Master switch. Connects and disconnects all electrical equipment loads from the system.

p. Cabling. A network of insulated wires that connect elements in the system. These include:

    i. Power cables distributing the supply (usually 12V) to the equipment.

    ii. Power cables distributing the supply to the equipment.

    iii. Control circuits e.g. microphone press to talk, and electric variometer cruise/climb switch. These carry a relatively small current.

iv. Audio cables e.g. microphone and loudspeakers.

v. Data cables connecting electronic devices such as components of a GPS/electronic variometer system. These carry a relatively small current.

vi. Combined power and data, as in a USB cable.

vii. Radio frequency cables connecting radios, Flarm, GPS to their antennas. These are normally braded coaxial.

q. Connecting blocks/busbars. If the system has little electrical equipment, these might be simply a multi-wire crimp connector or not present at all. When there are more than 3 equipment devices installed, there are usually connector blocks.

r. Equipment circuits. Equipment is divided onto a number of independently protected circuits. Devices with a relatively high current draw (eg radios) usually have a dedicated circuit. Other equipment may be grouped logically and/or considering redundancy ie if two GPS devices are fitted it may be best to put each on a different circuit so that a fault causing a secondary fuse to blow only results in the loss of one GPS.

s. Secondary fuses. Each equipment circuit is protected from current overload by its own fuse.

t. Circuit switches. These allow the pilot to electrically isolate (switch off) selected equipment. Circuit switches may be omitted if the fuses or circuit breakers are accessible to the pilot in flight (eg positioned on the instrument panel) and thus provide a means of isolation.

u. Equipment and devices such as radio, electronic variometer, Flarm.

v. An auxiliary DC power converter for a portable device such as a flight computer.

20.2.1 CIRCUIT DIAGRAM

Every sailplane should have a circuit diagram showing the configuration of its elements and the fuse values that should be fitted. In addition, it is suggested that a set of photographs of the cabling in the control panel and backs of equipment is a useful reference, maintenance aid and record.

A circuit diagram of a typical dual battery (selectable) installation for a sailplane is shown below:

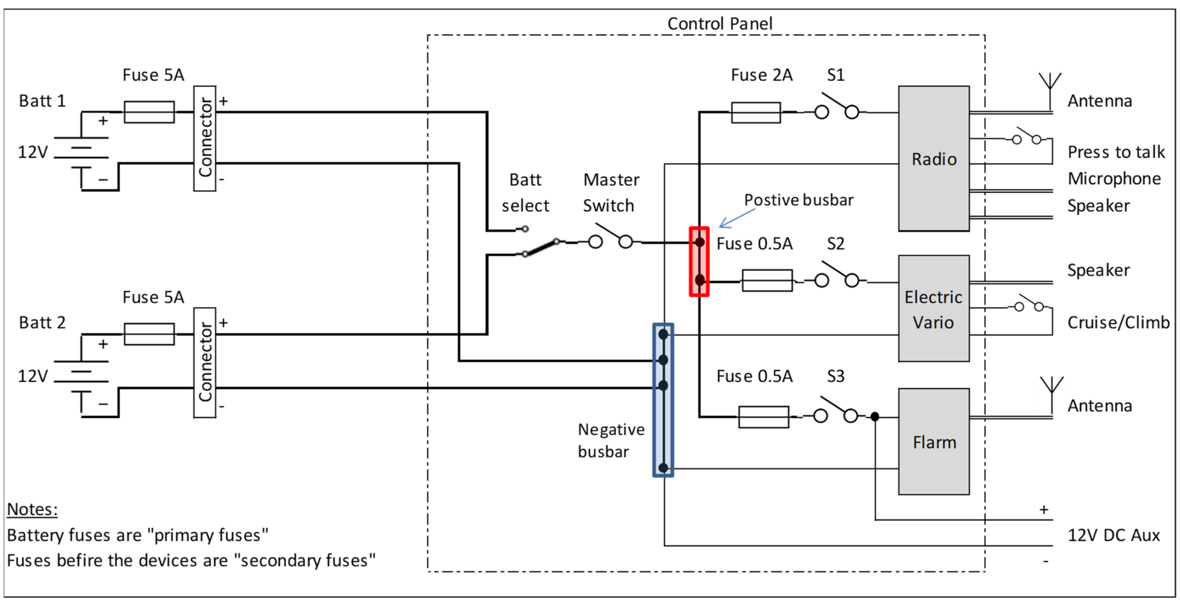


Figure 20-1 Typical dual battery sailplane electrical circuit diagram

Points to note:

a. The primary fuse is positioned in the +ve line at the battery.

b. The wiring gauge (size) from the battery is maintained all the way to the secondary fuses, and until and throughout the negative busbar.

c. In a dual battery selectable system, the selector switch is electrically located before the master switch. In a single battery installation, the selector switch is omitted.

d. Secondary fuses are positioned before equipment switches and as close to the positive bus bar as possible. Secondary fuses protect the wiring to the electrical equipment.

e. All equipment devices, including the auxiliary DC output are protected by secondary fuses.

f. Switches S1-S3 and wiring on the device side of the secondary fuses can be a lower current rating than the cables from the batteries. The current rating of the cable and switch must be appropriate to the expected current and secondary fuse rating.

g. Switch S1 is frequently omitted as most radios have an inbuilt on/off switch.

h. The radio is usually the device with the highest current draw which occurs during transmission. For this reason, the radio is normally given its own dedicated fuse.

The battery negative terminal (marked "-" and/or coloured black) must electrically connected to all devices requiring electrical power. In a metal sailplane (as with motor vehicles) it is possible for the metal fuselage to be used as the negative conductor and all devices are connected, referred to as "grounded", to the fuselage. In wood and FRP sailplanes, wire cables are provided as the negative conductors which must be the same quality and gauge as their corresponding positive conductors.

20.2.2 SINGLE LINE CIRCUIT DIAGRAMS

For simplicity on circuit diagrams, details of the negative wiring are sometimes omitted and single line diagrams drawn. A symbol (often an electrical earth symbol) is used to show the devices connect to "ground", whereas in fact there is a network of negative conductors running alongside the positive conductors (except for aluminium sailplanes where the hull may be used as the negative conductor).

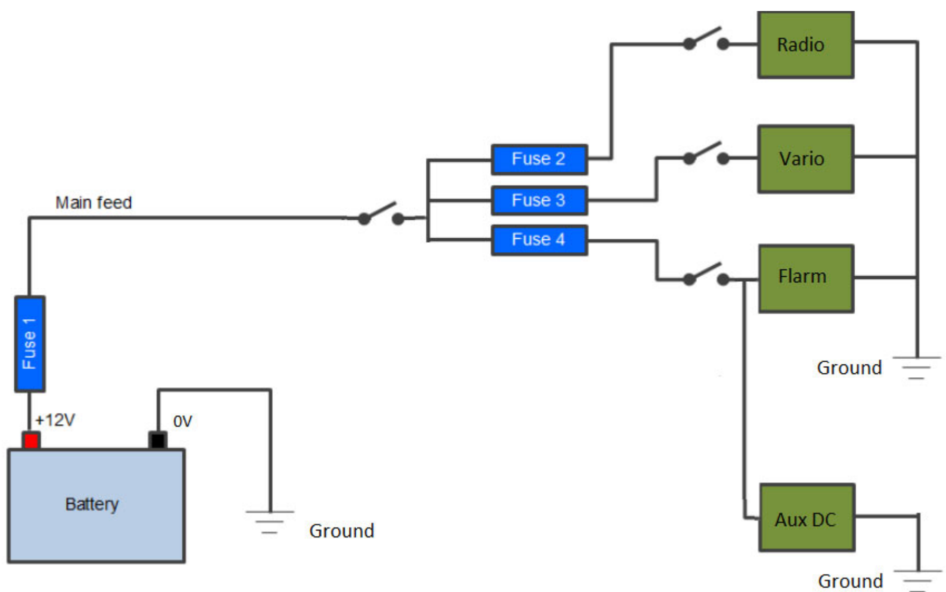


Figure 20-2 Single Line Circuit diagram example (only +ve connections shown)

20.3 THE BATTERY

The battery stores and provides electrical energy to drive the equipment. Sailplanes usually use a nominal 12-volt system where the actual voltage may vary between fully charged 13.5V and a minimum useful voltage of 11.5V. (Note: The maximum charged voltage depends on the chemistry of the battery type and also its condition).

There are numerous different chemistries of batteries. For many years the standard sailplane battery was a Lead Acid but with the issue of MTAR1/2017, GFA authorised the use of specific Lithium batteries. Check with GFA to establish the current status of battery types, brands and models permitted for use in Australian registered sailplanes.

The most common size battery for a single seat sailplane is 151 x 65 x 95mm. Battery capacity is usually referred to in terms of Amp-Hours (Ah) eg A battery of 5 Ah is capable of delivering a current of 1 amp for a period of 5 hours or 2.5 amps for a period of 2 hours.

Lithium batteries have become popular because they have two clear advantages:

a. A higher charge/weight density. Example: a same standard size Lead Acid 12V is rated 7Ah whereas the same physical size lithium-ion battery is rated as 12Ah.

b. A significantly more useful discharge profile in that Lithium-ion batteries maintain a near constant voltage before rapidly decaying at around 90% discharge, whereas a lead acid battery may have fallen below 12V when only 40% discharged.

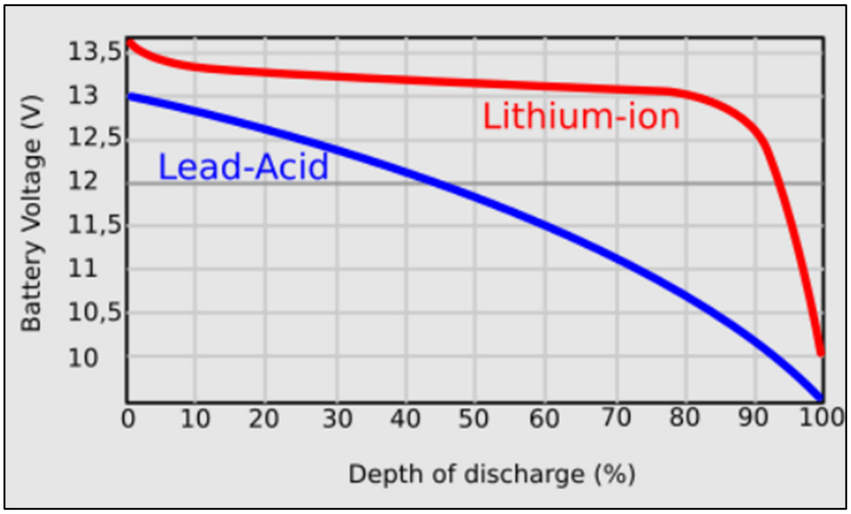


Figure 20-3 Discharge Curves for Different Battery Chemistries

Lithium batteries have gained an unfortunate reputation for thermal runway. During a short circuit situation, the battery rapidly discharges and generates of a lot of heat within the battery. When it gets hot enough, the heat causes the break down of the electrolyte in the battery and the expanding gases within the case can rupture the battery case. The gasses are very flammable and if ignition occurs, the resulting fire is very difficult to extinguish until the battery is completely discharged.

Lithium batteries now usually contain voltage and current control circuitry designed to prevent overcurrent in a short circuit situation external to the battery. However, a damaged battery (eg from being dropped) may experience an internal short circuit which the control circuitry is unable to protect, therefore it is vital that all batteries are handled with care and carefully inspected for damaged prior to use in a sailplane. **IF THERE IS ANY DOUBT ABOUT THE SERVICEABILITY OF A BATTERY, DO NOT USE IT.**

Battery performance (ie discharge voltage vs time) will degrade with age, number of charge cycles, depth of discharge and storage temperature. Using a multi-meter across a battery's terminals will indicate the voltage at that instant which serves only to show whether the battery is dead (ie no charge) or charged. To test a battery's performance, the simplest test method is to measure and then graphically plot the voltage at regular intervals (say every 10 minutes) as the battery discharges into a known resistance (often a light bulb is used) selected to imitate the discharge current that the battery will experience in the sailplane.

A sailplane owner can determine the electrical load imposed on the battery by auditing the device manufactures specifications and tabulating/summing the current draw. Alternatively, and probably more accurately, an ammeter can be used in-line at the battery positive terminal. Consider the normal load (all devices switched on, radio in receive mode) and the intermittent load when the radio is on transmit.

20.3.1 REMOVABLE BATTERIES

Most sailplanes use a removable battery pack comprising the battery, a fuse or circuit breaker, short lead and connector plug. The pack is often located on the parcel shelf behind the pilot and sometimes either in the nose or in the tail fin.

Sailplane owners will from time to time need to have replacement battery packs built. A person competent with electrical hand tools may construct a battery pack but an Annual Inspector must approve it before it is used.

There are numerous designs of battery packs in use in Australia and few examples are shown below. Gliding Australia does not mandate any specific design, however the important features to be achieved are:

a. There must be an inline fuse or circuit breaker located not more than 175mm from the battery's positive terminal (marked "+" and/or coloured red). This is the primary fuse and should be the highest rated fuse in the installation.

b. The battery to sailplane connector should have a 'key' function' that only fits one way with the matching connector in the sailplane. This is to ensure the correct polarity is always achieved on connection.

c. The connector must have a locking function so that the battery cannot unintentionally disconnect from the aircraft electrical system whilst in flight.

d. For club sailplanes where batteries may be swapped between different aircraft, it is important that a common standard of wiring for all battery, sailplane and charger plugs and sockets is used so as to ensure compatibility and correct polarity.

e. There should be strain relief for the terminal connectors so they don't pull off the terminals. With the common battery style shown in Figure 20-6, a good quality tape wrapped around the battery will usually give support to the sometimes flimsy battery terminal connections

f. Battery terminals must be electrically insulated. The use of insulated Faston connectors is recommended. Heatshrink can be added for extra insulation. Insulation tape wrapped around battery terminals is not acceptable

g. Be wary that the method of restraint of the battery in the sailplane does not pose a risk of short circuit to the terminals and electrically unprotected short length of cable. Metal clamps, metal buckles on fabric straps and metal containers pose considerable risk if they can be wrongly positioned or the battery moves and makes contact.

Battery terminals are usually designed to connect with Faston connectors which lock on to the terminal lugs. Crimp Faston connectors are available in straight or 'flag' 90° format. The flag format is less prone to being pulled off the battery terminal lugs.

Soldering cables onto the battery lugs is not recommended as a lot of heat is required and much of it will be conducted to within the battery case, potentially damaging the voltage/current protective circuitry (if present).

Special crimpers are required for Flag terminals

Insulated Flag 90° Faston vs insulated inline Faston crimp connectors

Figure 20-4 Types of Faston Crimp Connectors for Battery Terminals

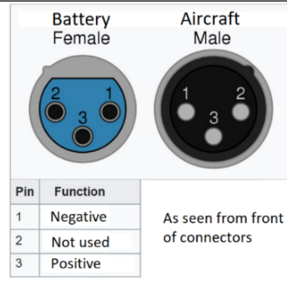
	
Many sailplanes use XLR inline plugs/sockets. The female socket is fitted to the battery (think house wall socket, don't want protruding pins on the power supply).	**CAUTION:** The pin wiring shown above is by no means standard in Australia. Clubs should publish their standard and owners are recommended to use the standard set by their local club.

Figure 20-5 XLR Inline Plugs and Sockets Often Used For Battery Packs

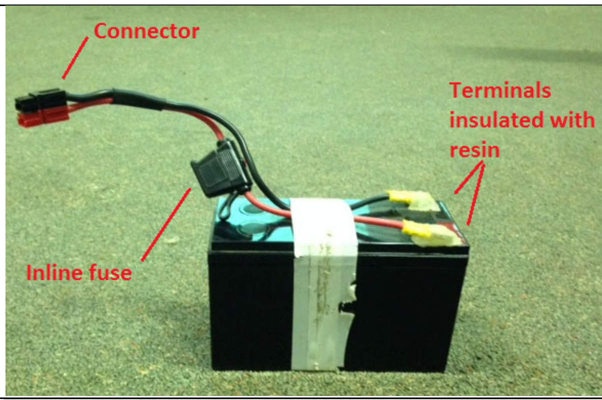
	A typical removable sailplane battery
	Battery connector using flag Faston connectors and automotive in-line fuses (mini and micro shown) and XLR socket
	Commercial battery cap with inbuilt 10A circuit breaker

Figure 20-6 Examples of Removable Sailplane Battery

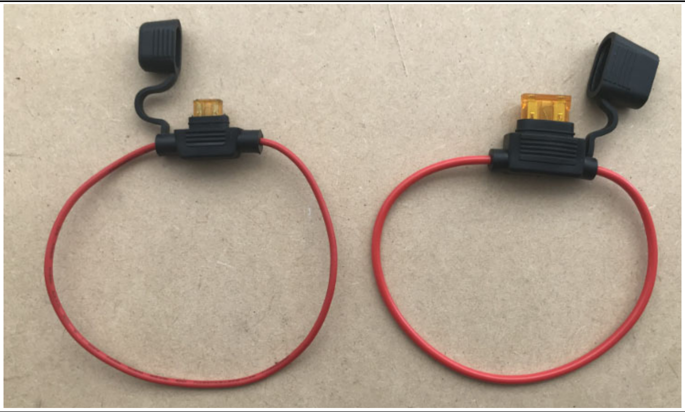
	Inline Fuses: There are several different types of inline fuse that can be used on the battery connector cable. The most commonly fuse is an automotive inline blade fuse or mini-blade fuse. These are available from Altronics and Jaycar and are usually of large format (physical size and thick wire). Smaller format inline fuses are available from various online suppliers. Fuses are usually supplied with a 250-300mm loop of wire connected which is cut in the middle to give two wire ends. This is sufficient length for most connectors.
 Crimp Butt Connector (red) Crimp Butt Connector (red) with heat shrink sleeve	If a longer cable is needed, then it is recommended to use an inline insulated crimp butt connector to extend the positive wire and cut the negative wire to the length required.

Figure 20-7 Inline Fuse

20.3.2 DUAL BATTERY (SELECTABLE) INSTALLATIONS

When a standard size lithium battery in good condition is used with modern radios and avionics, the battery is usually capable of supporting flights of 6 or even more hours. The biggest drain on the battery is the radio when transmitting which normally has a low duty cycle (ie the proportion of flight time spent transmitting is very small).

Where Lead Acid batteries are used or flights longer than 6 hrs flight duration are planned or a back-up is required, then sailplanes may be equipped with two batteries and a battery changeover/selector switch. The selector switch must not have a centre off position and need only switch the positive supply.

Switching between batteries with the selector switch will cause a momentary loss of power to the supplied electrical devices which may cause them to reset, render then useless for a short period and/or loose data. It is possible to bridge the changeover without loss of continuity of supply by using a suitable capacitor but that is beyond the scope of this Chapter.

Without careful consideration of fusing and current flow protection, sailplane batteries should not be installed in a parallel arrangement where both batteries simultaneously supply power with the intention of increasing power duration or current available. There is a risk if one battery suffers and an internal short circuit that the other battery will rapidly discharge due to the short-circuit across its terminals causing the inter-battery wiring to overheat.

20.4 THE MASTER SWITCH

The master switch is a very important item in the electrical system because it enables the pilot to quickly disconnect the power from all electrical equipment after the master switch. This is a key safety action if the pilot senses an acrid smell, smoke or fire.

However, a short circuit could still occur in the cabling from the battery to the master switch. As the battery is often located behind the pilot, the cable from battery to master switch frequently runs under the pilot's seat – this is not a place you want an overheating cable or fire! This is why a primary (master) fuse is located very close to the battery terminals.

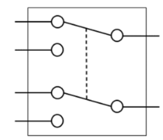
The master switch must have sufficient capacity to carry the peak current loads to which it will be subjected. The capacity of the switch should be greater than the capacity of the primary fuse/circuit breaker. The master switch need only switch the positive feed from the battery. It is not required to switch both the negative and positive feeds, in fact having both wired to the same 2-pole switch increases the risk of short circuit.

What do SPST, SPDT, DPST, and DPDT mean when describing switches?

SP and DP refer to Single Pole and Double Pole: Pole refers to the number of circuits controlled by the switch: SP switches control only one electrical circuit. DP switches control two independent circuits (and act like two identical switches that are mechanically linked). Do not confuse 'pole' with 'terminal'. The DPST switch, for example, has four terminals, but it is a DP, not a 4P switch.

ST and DT refer to single throw and double throw: Throw refers to the extreme position of the actuator: ST switches close a circuit at only one position. The other position of the handle is Off. DT switches close a circuit in the Up position, as well as the Down position (On-On). A DT switch can also have a centre position (frequently On-Off-On). A throw position may also be 'momentary' ie needs to be physically held in the position.

All master switches must be wired as single throw ON-OFF with no centre position. A Double Throw (DT) switch may be used provided the terminal at one end of the throw is not used.



For most applications in a sailplane, only a SPDT switch is needed. However, a commonly available switch format is the Double Pole, Double Throw DPDT ON-ON switch (which has 6 terminals). A DPDT switch can easily be used as SPDT by ignoring one of the poles. The circuit symbol for a DPDT switch is shown right.

It is usual for the master switch to be a toggle switch (rather than a rocker, push button or rotary switch) because they provide a more affirmative feel and indication of the off position in an emergency. The aviation standard for switch installation is toggle UP or forward for ON.

Dual battery (selectable) installations must have a single ON-OFF master switch in addition to a battery selector switch. The battery selector switch should be a Double Throw (DT) switch with ON-ON capability. DT switches of the ON-OFF-ON type shall not be used as a combined master switch and battery selector for dual battery installations due to the risk of passing through the OFF position in an emergency and unintentionally selecting the alternate battery.

There are hundreds of different switch types available from suppliers such as Element14 and RS. You are not limited to just the products sold in automotive shops or electronics shops such as Jaycar and Altronics. The characteristics to consider when selecting a switch include:

a. Switch action. It is recommended use only toggle switches because they give a clear visible and tactile indication of switch status.

b. Current/voltage rating. It is best to use a switch rated at 24V or 12V Direct Current (DC) and at least the desired max current eg 7.5A. However, many switches are only rated in Voltage Alternating Current (VAC). As a rule of thumb, a product rated as 10A at 120VAC is usually suitable for 10A at 12V DC.

c. Number of poles and throws. Select SPST or DPDT. Do not use On-Off-On switches.

d. Dust proof. This is highly desirable in a sailplane.

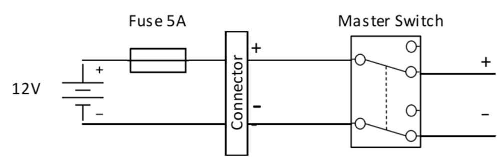
e. Physical size. The switch does not have to be big to handle the current, see figure below.

f. Panel hole diameter. If replacing a switch, it is important that the switch diameter matches.

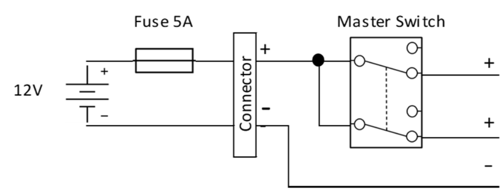
g. Terminal connections. The options are: soldered, screws, Faston. Soldered is most commonly used.

Figure 20-8 Example of Different Size DPDT On-On toggle switches Rated at 7.5A - all are suitable as Master or Battery Selector

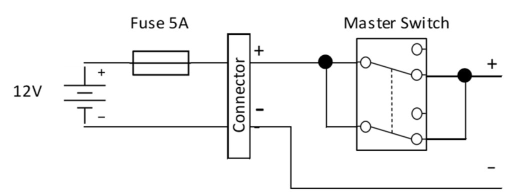
Annual Inspectors may come across DPDT Master switches that have been wired in several ways other than as a Single Pole switch. Often this is with the intent of 'sharing the load' across two poles so that a lower rated switch DPDT switch can be used. These are some of the configurations that might be found:



Switching positive & negative
This is not recommended. It is not required to switch the negative feed as well as the positive. The close proximity of both the positive and negative feed wires at the switch creates a risk of shorting



Creating 2 seperately switched circuits
This is is acceptable. The switch rating needs to match the circuit with the highest maximum current.



Parallel switching the positive feed
This is not recommended. At first glance this appears to split the current across two poles and thus would enable a lower current rated switch than if just one pole. However it cannot be guaranteed that both switches operate at precisely the same time, so in practice one switch may be taking the full current.

Figure 20-9 Examples of Alternative DPDT Wiring

20.5 CIRCUIT PROTECTION

Circuit protection is provided by either fuses, circuit breakers (CBs) or a combination of both.

The purpose of a fuse/CB is to prevent a current flow in excess of the capability of the wiring system or equipment item. A fuse/CB is the "weakest link" in the circuit, the part that fails first, (fuse "blows" and CBs "pop"), and thus prevents the cabling or equipment overheating and at worst catching fire.

In a sailplane, the circuit protection comprises:

a. The primary fuse (also known as master fuse or battery fuse). There must be one located as close to the positive terminal possible (not more than 175mm) for each battery. This has to be large enough to supply the current required by all the equipment loads operating at the same time (worst case) but must be less than the rating for the cable supplying the secondary fuses. A 5A fuse is usually suitable in single seat sailplanes.

b. Secondary fuses (also known as equipment or circuit fuses). So that a fault can be isolated and not affect the entire system, the equipment is divided into circuits with each circuit having its own overload protection. As the current flow from the battery is divided between the circuits, the individual equipment circuits wiring current will be lower than the battery current and the secondary fuses will have a lower rating than the primary fuse. The circuit switch rating and circuit cable gauge may be smaller thus saving weight, space and making the installation easier to install. However the secondary fuse must always be rated lower than the following switch and cable that it protects.

In the past fuses have been used almost exclusively due to cost and the bulk of CBs but now small and inexpensive circuit breakers have become available from aircraft equipment suppliers. The Klixon 7277 series is an example of one type of miniature circuit breaker.

Whilst circuit breakers are very useful solution in certain applications, it should be noted that a good quality fuse will ultimately be more reliable (there are no moving parts) so should be considered first. Where sensitive electronic equipment is involved a circuit breaker is not recommended because the time taken for the circuit breaker to operate can be longer than it would take a traditional fuse to blow, potentially exposing the equipment to damaging overload currents for longer.

Overcurrent protection should be checked on an annual basis ie check the fuses or CBs match the manufacturer's specification or circuit diagram and appear appropriately rated. Particularly in club sailplanes, blown fuses have often been replaced with a fuse that was at hand rather than a fuse of the correct rating.

20.5.1 FUSE/CIRCUIT BREAKER RATINGS

Each fuse or circuit breaker used in the electrical system must be correctly rated for the circuit it has to protect. The rating of each fuse should be slightly greater than the equipment manufacturer's specified maximum current draw (but the same as their recommended fuse rating) and lower than the cables it protects.

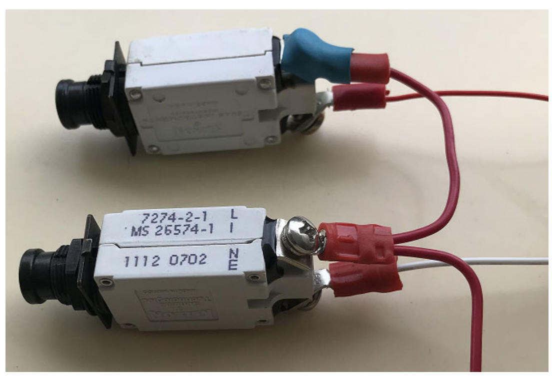


Figure 20-10 Two Klixon Circuit Breakers Being Prepared for Installation.

Voltage drop in long cables (due to the cable's resistance) must be considered when sizing overcurrent protection as a voltage drop will cause a current increase for the same power draw by the equipment load.

When installing fuses/CBs, the correct values should be taken from the manufacturer's published data for the equipment. Where this data is not available, Table 11-3 in FAA AC 43.1B provides some limited guidance.

20.5.1.1 FUSES RATING AND MARKING

Fuses are rated and marked with the following:

a. Continuous Rating: Fuses are marked with the current that they will continuously pass (at a standard temperature) without blowing, known as the continuous rating. It is good practice not to allow the continuous current to exceed 75% of the fuse's rated value to accommodate momentary current surges that might cause the fuse to fatigue over time or blow unnecessarily (nuisance blow).

b. Blow Rating: In simplified terms this is the current rating at which the fuse will blow. Most fuses have a blow rating around twice that of the marked continuous rating. A 5A continuously rated fuse will have a blow rating of approximately 10A. Some older style fuses may still be marked with the blow rating rather than the continuous rating so care should be taken when replacing an older style fuse with a modern one that the ratings are understood and the correct fuse used.

c. Voltage Rating: Fuses are marked with the maximum voltage they can be operated up to. It is normal to find 230V rated fuses in a sailplane's 12V system.

20.5.1.2 TYPE OF FUSES

The most common fuse types found in sailplanes are:

a. 3AG. These measure length of 1-1/4 inches and 1/4 inch diameter. ‘3AG’ means Size 3 Automotive Glass. Sometimes call ‘the American Fuse’.

b. M205. These measure 20m x 5mm diameter. Sometimes called the ‘European Fuse’.

c. Automotive standard, mini and micro blade fuses.

Fuse holders for each fuse type are available as in-line or panel mount. For secondary fuses, it is recommended they be panel mounted so as to be easily accessible to replace or remove (to isolate a circuit). Also, the 3AG and M205 fuse in-line holders that are generally available are often of poor electrical quality.

	M205 panel fuse holder. This type is recommended.
	5A 3AG Inline Fuse Holder. This type of holder is not recommended for battery packs or behind panels.
	20A 3AG In-line Fuse Holder. This type is not recommended behind instrument panels.
	Automotive blade fuses panel-mounted in an Astir, (the 2 black items on the left). Not often seen but nothing wrong with using them. Fuses should be marked with a device description and current rating. Eg Radio 3A. Also shows a double USB socket bottom left.

Figure 20-11 Examples of Fuses

20.6 VOLTAGE DROP

All components, including cable and connectors, in an electrical circuit have a level of resistance to the flow of the electrical current and thus a potential difference is established across the component according to Ohms Law V=IR. This potential difference is known as the component's voltage drop. The bigger the current, the large the voltage drop across each component. The resistance to current flow causes heat to be generated.

In sailplane electrical system, the battery provides a potential difference (measured as voltage) that drives current around the circuit to reach a target device eg the radio. Since all components in the circuit have a voltage drop, the voltage available at the target device is less than the voltage at the battery. If too much voltage is 'dropped' across the circuit components, then there may be not enough voltage remaining to operate the device.

Radios on transmit mode may fail to transmit properly when the voltage at the radio drops below 12 volts but will usually continue to receive provided the supply voltage in excess of 10 volts. Modern avionics are relatively tolerant of voltage drop because they have voltage regulators that convert the presented supply voltage down to 6 volts for the electronic circuits. 12 volts, as measured at the radio, is thus considered the minimum useful voltage.

Voltage drop is much more an issue with systems using Lead Acid batteries because the battery voltage diminishes significantly and early during the discharge cycle, so the threshold of useful voltage at the radio is reached sooner. Lithium batteries discharge at a near constant voltage so the threshold of minimum voltage at the device will not be met until near the end of the discharge cycle. However, voltage drop is always an 'enemy' because it is a parasitic drain on the battery charge and thus is best minimised.

Major causes of voltage drop in sailplane electrical circuits and strategies to minimise it are:

CAUSE	MITIGATION STRATEGY
Battery voltage drop with discharge	Use lithium battery
Small gauge battery feed cable	Use minimum 18AWG tinned stranded copper.
High resistance joints and connectors	Minimise joints and connectors Use ferrules to avoid loose strands and ensure max contact with screw terminals Screw terminals tight but not over tight. Use crimps rather than solder
Circuit breakers have a high resistance, especially low Amp rated CBs.	Use fuses.
The smaller the CB rating the higher the voltage drop.	Use the highest safe value of circuit breaker.
Cable has resistance	Minimise cable lengths, increase cable diameter (ie reduce gauge)
Switch internal resistance – dust penetration, contact degradation due to age or use beyond specification	Use good quality dust proof switches of suitable rating
Radio draws a high current so all components in radio circuit have bigger voltage drop	Radio must have own dedicated sub-circuit

Table 20-1 Voltage Drop Cause and Mitigation

20.7 WIRES AND CABLES

20.7.1 DEFINITIONS

A wire is described as a single, solid conductor, or as a stranded conductor covered with an insulating material. Because of in-flight vibration and flexing, all aviation wire should be stranded to minimize fatigue breakage.

The most common conductor material is copper but occasionally aluminium may also be found in sailplanes. The copper wire strands are usually coated or 'tinned' with tin or silver to stop oxidation of the copper surface and hence improves conductivity.

Wires are insulated with a non-conductive sheath to prevent short circuits. Insulation is usually a single wall but double wall insulated wire is available.

The most common forms or cable insulation found in sailplanes are:

a. PVC: Relatively soft and flexible. Most automotive grade cable is PVC. A fingernail will usually dent insulation and then it restores.

b. ETFE (often called Tefzel wire): Hard and relatively inflexible. A fingernail will not dent insulation. Good quality wire strippers are needed to work with this type of cable.

c. Rubber/silicon: Very flexible and feels spongy. Not as common as PVC and ETFE.

In aviation, wire is considered to be either:

a. Hook-up wire (for use behind a panel) - single wall insulated.

b. Airframe wire (for use in exposed situations) - double wall insulated.

See AC 43-13 Chapter 11 for details on this topic. Sailplanes usually only use 'hook-up' wire.

Where two wires (each individually insulated) are together covered with a sheath of insulation, it is referred to as 'jacketed'.

The term "cable," as used in aircraft electrical installations, includes:

a. Two or more separately insulated conductors in the same jacket.

b. Two or more separately insulated conductors twisted together (twisted pair).

c. One or more insulated conductors covered with a metallic braided shield (shielded cable).

d. A single insulated centre conductor with a metallic braided outer conductor (radio frequency cable).

The term "wire harness" is used when an array of insulated conductors are bound together by lacing cord, metal bands, or other binding in an arrangement suitable for use only in specific equipment for which the harness was designed; it may include plug/socket terminations. Wire harnesses are often supplied with radios and flight computers to connect with other electrical components.

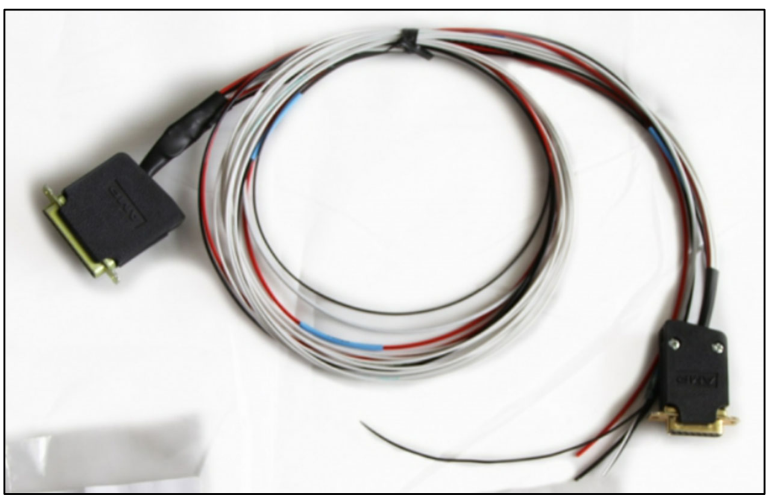


Figure 20-12 Example of Wiring Harness

All wire has resistance to current flow and therefore will consume power and under high current will heat up. A wire will fail if it becomes so hot that the wire melts or the insulation melts/burns. A thicker diameter wire has less resistance and therefore can conduct more current but has bigger weight and costs more. Therefore, in general, we seek to use the minimum diameter wire that can carry the circuit maximum current plus a safety margin so that neither the wire or insulation melts.

Wire is rated for the maximum current (plus a safety margin) it can pass without melting the wire or insulation when used in free air. If used in bundles or in conduits, the safe current capacity must be down rated but this is rarely required in sailplanes.

Most wire and cables have specification codes printed on the outer insulation at regular intervals. This can be difficult to read (a magnifying glass or mobile phone camera is useful) and may be missing on short lengths. The outside diameter of the insulation is not a valid indication of the diameter of the conductor wire or the wire's rating.

20.7.2 AIRCRAFT GRADE WIRE

There are a bewildering number of standards that apply to wire. Reference to "aircraft grade wire" is normally taken to mean wire than conforms to SAE AS22759 standards (also seen written as MIL-W-22759 or M22759). This is an old standard from which the military and commercial aircraft manufacturers have moved on to newer standards. However, M22759 is still widely cited and available.

The product coding system for M22759 is shown below.

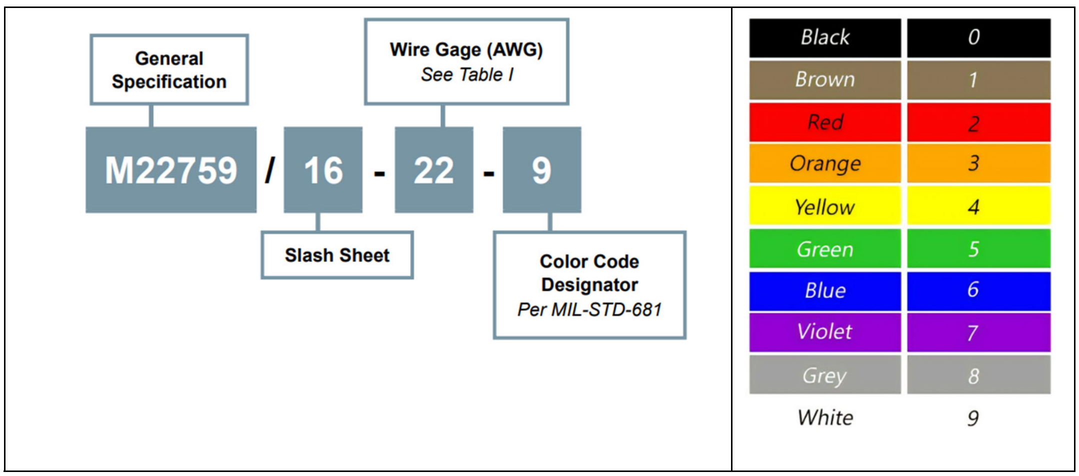


Figure 20-13 M22759 Coding System

The most commonly used single insulated wire is M22759/16 which is unshielded multi-strand copper wire with each strand usually coated with tin or silver) with extruded EFTE (ethylene-tetrafluoroethylene) insulation. ETFE insulation has fire resistance properties well suited to the aviation environment. It is preferred by many sailplane owner/operators and is compliant with CASA motorglider engine system wiring requirements.

There is also M22759/32 which is also ETFE but much thinner insulation than /16.

M22759/16-20-0 (black) and M22759/16-20-2 (red) wire is probably the best option if you want a general-purpose good quality hook-up wire. This is available from Australian suppliers such as Cambridge Technologies or various specialist auto racing supply companies, usually in 30m rolls.

The most common brands of aircraft grade cables historically have been:

d1 Tefzel®. Tefzel is a brand name belonging to Dupont and describes the insulation material which is a modified ETFE fluoropolymer known for its mechanical toughness and outstanding chemical inertness.

g1 Spec 55 and Spec 44. These are brand names owned by Raychem - TE Connectivity and describes a range of cable products insulated with modified radiation cross-linked ETFE polymer and compliant with the AS22759. Spec 55 has its own part numbering system as shown below.

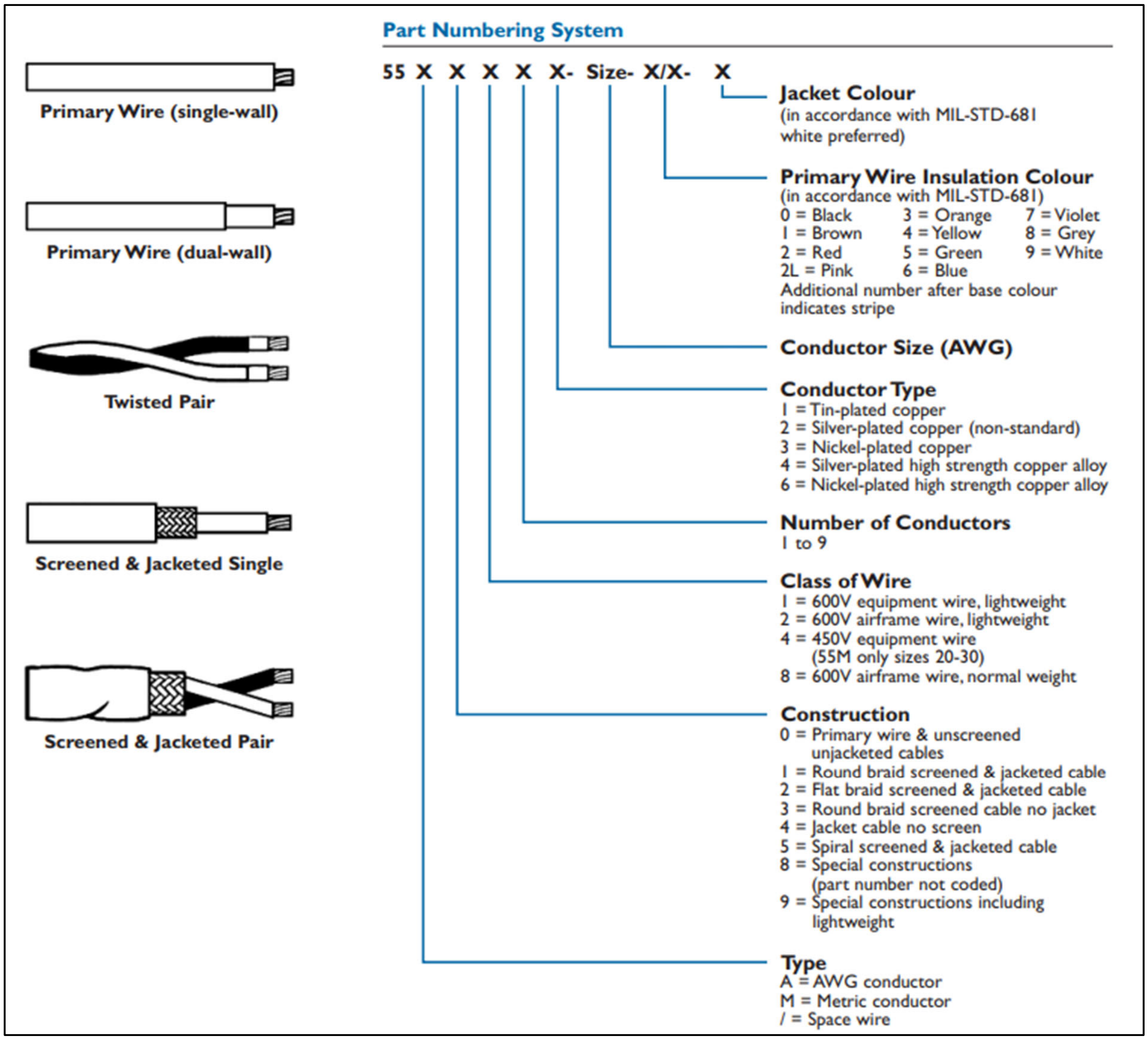
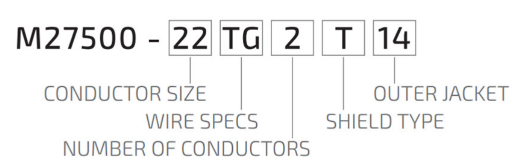


Figure 20-14 Specification of Type 55 Wire and Cables

Another common specification for cables is MIL-C-27500. This is a specification of screened / shielded cables often used for sailplane microphones.



MIL-SPEC	WIRE GAUGE
M27500-24TG2T14	24
M27500-22TG2T14	22

As a general guide for aircraft grade wire current ratings, the following table based up AC43-13 (Table 11.3), Tefzel wire manufacturer's information, AN standards and common practice may be useful:

Wire Gauge AWG	Cable Max Amps	CB Max Amps AC43-13	Fuse Max Amps AC43-13	Core Diameter mm	Core cross section mm^2	Use and comments
24	3.5	N/A	N/A	0.51	0.20	Very thin, light duty only. Microphones (when shielded)
22	7.0	5	5	0.65	0.33	Adequate for most panel work but not radio power supply. Fiddly to work with.
20	11	7.5	5	0.81	0.52	Good for most panel work, easy to work with
18	16	10	10	1.02	0.82	Battery feed
16	22	15	10	1.29	1.31	Battery feed

Note: All of the above current ratings are conservative (ie below the theoretical maximum for situations likely in a sailplane).

20.7.3 AUTOMOTIVE AND MARINE CABLE

Automotive and marine cable is often insulated with PVC which does not perform as well under heat as Tefzel and is a softer material.

Automotive and marine cable is usually sold in nominal sizes of “2.5mm”, “3mm”, “4mm” etc. Note the dimension is often neither the conductor diameter or conductor cross-section area.

The cable manufacturer will normally specify a current rating at an ambient temperature of say 30ºC for a single cable. It will then give tables of “derating factors” for situations of cables being bundled and/or operating at higher ambient temperature.

For example: A leading Australian manufacturer of automotive cable states: “3mm” (1.13mm^2 cross-section) cable rated at 20A at 30ºC. When used bundled with a second similar cable apply factor of 0.8. When used in an ambient temperature of 50ºC apply factor of 0.76.”

So in a typical sailplane application it would be advisable to regard this manufacturer’s 3mm cable maximum current capacity as:

20A x 0.8 x 0.76 = 12A

Note that retailers of automotive cable may have already applied the derating factors to their products by the time they appear packaged and on the shelf. So it is common to see automotive cables labelled as “2.5mm (0.64mm^2) 5A” and “3mm (1.13mm^2) 10A”. You need to read the specification to see that it has been derated sufficiently to match the sailplane environment but it is likely that the retailers have been conservative in the current rating they state.

20.7.4 WIRES AND CABLES IN SAILPLANES

a. All wire must be multiple-strand for maximum flexibility and of sufficient gauge to carry the maximum expected current load for that circuit. Do not use 230V house electrical cable.

b. All wire around engines and engine systems (including charging systems to batteries) must be of aircraft-grade wire according to CASA specifications. All other wire should be at least high-quality automotive/marine cable.

In practice, the main cabling elements in sailplanes are:

a. The power feed from the battery connector to the distribution busbars or secondary fuses. As this is often 1.5m or more long, it should be at 18AWG or thicker so as to reduce voltage drop. Preferably it should be jacketed 2-core automotive/marine cable or at least aircraft grade single wall insulated to offer a good level of physical protection.

b. Device wiring harnesses. It is common practice for the manufacturer of complex devices to provide a harness with a plug at one end that matches a socket on the device and lose wires at the other end to be terminated in connector blocks or joined to other wires. The harness may not use aircraft grade wire but it can be assumed the manufacturer has been diligent in the design and construction of the harness. In many cases the harness installer will not have shortened the harness wires and thus left a coil/bundle of wires behind the panel which can include numerous unused wires. A skilled technician may be able remove excess wire length and neaten the installation.

c. Link wires. These are relatively small wire lengths linking devices and creating busbars. 20AWG wire is recommended as it has ample current capacity for in sailplanes and is easy to work with.

d. Microphone cables. Cabling should be 22AWG or 24AWG 2-core aircraft-grade screened cable to reduce the possibility of interference noise.

e. Speaker cables. Usually figure-8 general purpose 22 AWG or 20AWG copper speaker cable is adequate. The cable described above for microphones is also suitable.

f. Radio antenna cable. Radio antenna cables (including Flarm and GPS aerials) should be good quality 50Ω coaxial antenna cable with good quality fittings. Poor radio performance is frequently due to antenna cabling issues.

g. Data cable Where data cables are used, such as between flight computers, GPS, FLARMs etc, any commercially manufactured cable for the appropriate data type that conforms to the relevant communications standard.

20.7.5 WIRE COLOUR CODING

In accordance with normal electrical practice, red wire is normally used between the positive terminal of a battery through to the devices, and black is used for all negative (ground) wires.

The use of a different coloured wire for the positive of different sub-circuits can aid clarity, especially if this information is recorded on the circuit diagram.

Commercial and military aircraft often use exclusively white wire/cable. This is acceptable in sailplanes but it must be well labelled to enable easy maintenance in the future.

20.7.6 WIRE SECURITY

All electrical wire must be secured to prevent movement. Wires should be secured to the aircraft structure and not to items such as control systems etc. Securing the wires will reduce abrasion, fatigue and general wear and tear on the wires. Special care must be taken with securing wires in metal aircraft as abraded insulation may result in a short circuit to the metal structure.

Use proper cable clips or else nylon/plastic cable ties. Do not use insulation table to secure cables as this dries out and comes undone.

When installing electrical wires it is important that they are not stretched too tight. The correct amount of slack is shown in the figure below. If there is more than about 12 mm slack in a wiring loom, then extra supports will be required.

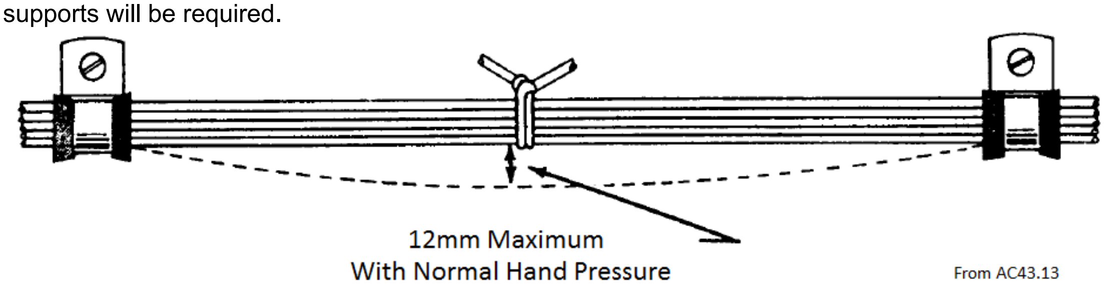


Figure 20-15 Slack between supports

Wires and cables that supply movable devices (eg PTT, cruise/climb buttons in control columns) must be specifically selected for this task and sufficient allowance for full travel movement should be made for this application.

20.8 JOINS AND TERMINATIONS

Wherever an electrical system is installed, joins between wires and terminations with equipment will need to be made. The most effective ways to achieve these are:

a. Joining 2 or 3 wires together – wire splice/butt joints (soldered or crimped)

b. Joining multiple wires - Terminal blocks (screwed, spade/Faston or stud/ring)

c. Common earthing point for multiple negative terminals - Single stud using crimped ring terminators

d. Plug/socket connectors – with soldered or crimped terminals

It is not acceptable to rely on mechanically twisting wires together or wrapping wires around pins/studs to make joints and terminations.

The connector types shown below in Figure 20-16 are not to be used as they have questionable reliability in a sailplane environment.

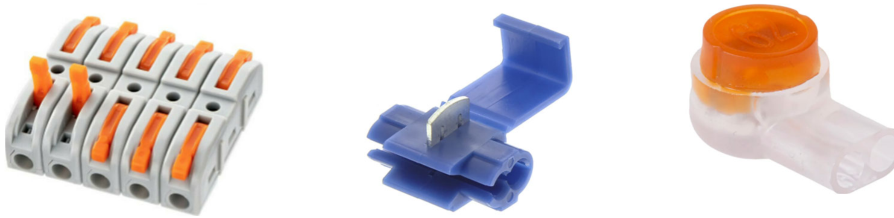


Figure 20-16 Connectors That Should Not Be Used In Sailplanes

Heatshrink tubing is often used when making joins and terminations to add a layer of insulation and/or form of basic labelling. A heat gun or back of a soldering iron is used to apply heat. Beware of damaging heat blowing/conducting to other components such as the fuselage and canopy!

Insulating tape does not provide an effective long-term joint insulating solution as the adhesive is prone to failure with age and heat.

20.8.1 SOLDERING

Soldering involves using a lead-free metal alloy wire with rosin flux core that melts at relatively low temperature when heated with an electric powered soldering iron.

There are numerous videos available on YouTube that demonstrate soldering techniques such as butt joints, wrap joints, tinning etc. It is best to practice on spare wire before attempting on a sailplane electrical system. Beware of using large soldering irons which can rapidly transfer high temperature heat that can damage insulation and devices.

It is usual to cover soldered joints with heatshrink tubing. It is important to consider when to place the unshrunk heatshrink on the cable as it may not be possible to position it after the soldering has been done.

When inspecting soldered terminals and joints an inspector should check for:

a. Damage caused by corrosive flux that may have been used causing the joint to deteriorate over time.

b. Fatigue (ie bending) failure. Wire strands are stiffened by the solder and can become susceptible to failure.

c. Wire insulation charred and/or shrunk back during the soldering process, exposing wires. This is often a problem with PVC insulated wire.

d. Stray strands or sharp solder protrusions puncturing the heatshrink.

Heatshrink covered low temperature solder butt connectors are available. The solder is melted with the heatshrink in place using a heat gun or soldering iron. It takes practice to use these effectively!

20.8.2 CRIMPED JOINS AND TERMINALS

Crimping involves squashing a metal tube around the wire. It is, electrically and mechanically, a very effective way of joining cables or attaching a lug to a cable. The most important tip for achieving a firm conductive crimp is invest in good quality crimpers which match the crimps you are going to use. Do not try and crimp with normal pliers or a cheap automotive crimp tool as they rarely achieve a secure result.

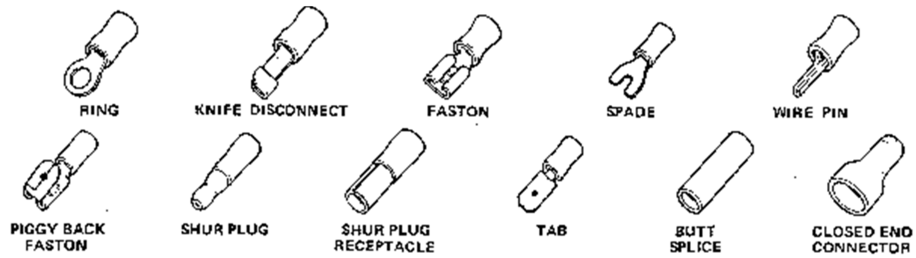


Figure 20-17 Types of crimp terminals

Figure 20-18 Commonly used types of crimp terminals in sailplanes

Crimp terminals are colour coded for wire size (gauge). The correct size of crimp terminal must be used for the wire that is to be connected. Red (20-24 AWG) is the most commonly used terminal colour in sailplanes.

When using ring terminals, the ring internal diameter should be matched to the diameter of the bolt or stud it is to attached to. 3.5mm diameter rings are used with switches and CBs. 4mm or 5mm diameter rings are used with terminal studs.

Spade terminals must not be used as they are prone to becoming detached.

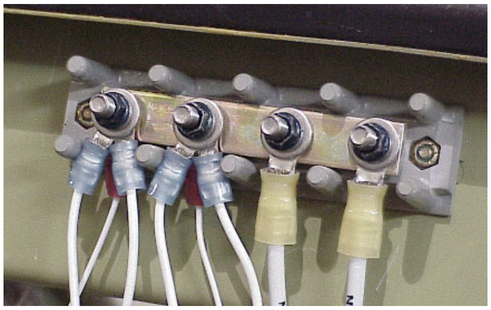
Heatshrink pre-covered terminals are available.

Faulty crimps should be replaced by a competent person using the correct crimp tool.

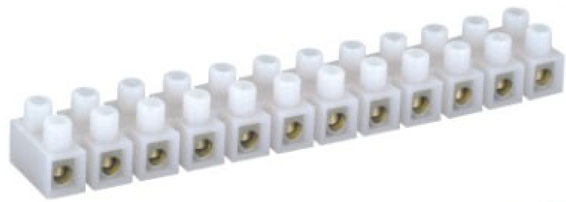
Where crimp terminals have been used, the inspector should ensure that the crimps are secure by gently pulling on the wire to see if it will pull free of the crimp.

20.8.3 TERMINAL BLOCKS

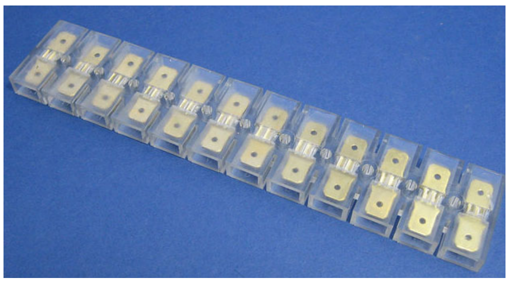
20.8.4 Terminal blocks are a convenient way of joining multiple wires. There are numerous types including studs, spade blocks and screw terminal blocks.



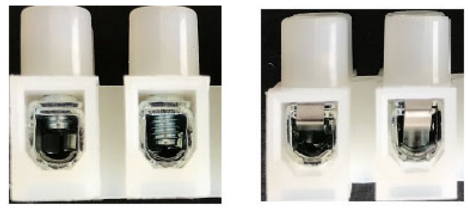
Stud block



Screw terminal block



Faston blade terminal block



Screw down   Screw & flap

Two types of screw block are available

Figure 20-19 Examples of terminal blocks

Screw terminal blocks are commonly used in sailplanes for power, data and control wiring. The following points should be observed:

a. Use a good quality block that is correctly current rated and securely fixed to an appropriate part of the sailplane. Usually a 6A rated block is suitable. Higher current rated blocks are designed for larger wire and may not securely grip small wires used in sailplanes.

w. No more than 3 wires per screw clamp.

x. If inserting more than one wire under a screw, twist the wires together before inserting under the screw and tightening the screw firmly. Two wires may be crimped together in a ferrule before inserting under the screw.

y. There must be no mechanical load on the wires (ie force that might pull the wire out from under the screw.

z. Ensure minimum exposure of bare wire and no lose strands. Insulated ferrules (sometimes referred to as ‘boot lace’ terminals) prevent this.

aa. It is recommended not to mix power supply connections with other connections (eg speaker, microphone or data connections) on the same connector block. This reduces the risk of inadvertently feeding power where it might cause damage.

bb. Stud blocks must be well insulated if used for positive connections.

Terminal module blocks should be securely mounted and provided with adequate electrical clearances or insulation strips between mounting hardware and conductive parts, (not necessary when the terminal block is used only for grounding purposes). (ref AC43-13A).

Where multiple connections are required, a terminal block is best configured as a ‘busbar’ as shown below for a screw terminal block. Note the same gauge wire as used from the Master Switch, is used for all connections along the top of the terminal in the diagram.

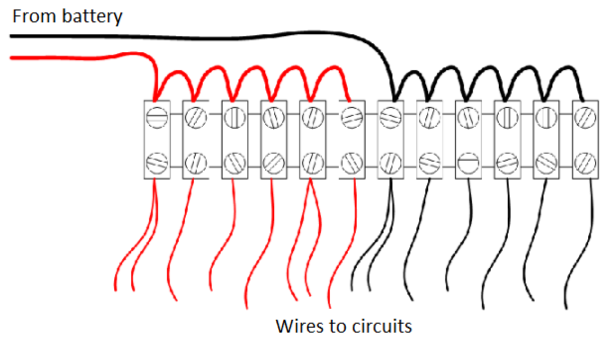


Figure 20-20 Screw Terminal Block Configured as a Busbar

Rather than constructing positive and negative buses, some technicians prefer to interleave the positive and negative terminals as pairs. This is not wrong but does mean there is an increased possibility of short circuit between positive and negative wires.

A single lone threaded stud (usually 4 or 5mm diameter) secured to the instrument panel frame can be used as a common 'earthing point' for negative wires in a sailplane. It is not necessary to insulate an earthing point provided positive wires are secured well away and insulated.

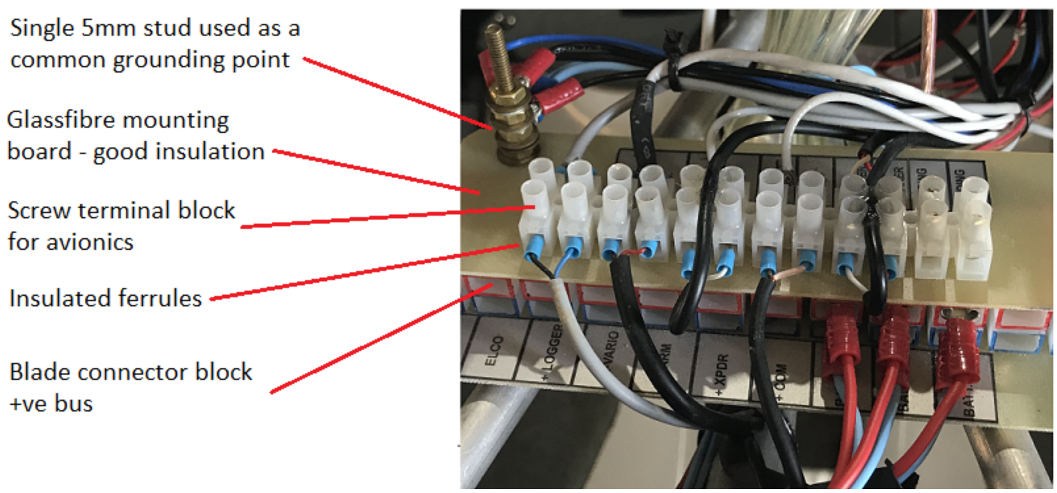


Figure 20-21 Single Threaded Stud as a Common 'Earthing' Point and Connector Blocks

20.8.5 CONNECTORS

Wherever there is a need to disassemble a wiring loom for maintenance, such as to remove an instrument panel, it is recommended that a multi-pin connector be installed. Use connectors with suitable current ratings.

Other places where electrical connectors can be used are; for all wires entering or leaving the instrument panel, the wires for the press-to-talk switch on the control column and where several wires go into the one instrument such as the radio.

20.9 RADIO PRESS TO TALK (PTT) SWITCHES

The radio press to talk switch is probably the most used switches in a sailplane. Whilst it appears to be just a simple spring return OFF-ON (Momentary) switch there are other characteristics that need to be considered:

a. Size - small enough to fit in the end of the control stick

b. Reliable – must work consistently

c. Tactile – ideally the switch should have a feeling of a 'click' as it makes contact

d. Positive contact – when pressed it makes a good contact, no need to keep pressing hard

e. Sealed – protected against dust and body sweat

f. Current rating – not usually a factor as little current passes through

There are numerous cheap options available at Jaycar, Altronics and online. However, it is probably worth buying a higher quality but more expensive switch such as shown below.

Figure 20-22 Example Push to Talk Button

20.10 AUXILLARY DC POWER OUTPUTS

Many pilots choose to use portable electronic devices for navigation, soaring performance data or communication. They often wish to power these devices from the sailplane power system but until recently this facility was rarely provided by sailplane manufacturers. Thus, the addition of a DC power outlet or lead is a common modification which needs careful consideration and implementation.

Many of the portable devices use the USB standard voltage of 5V DC. Since the sailplane system voltage is nominally 12V, a 12V DC to 5V DC power converter is required. Some panel fitted variometer or GPS devices offer a 5V power output suitable for USB.

If a voltage convertor is required, it must be decided if the converter is to be permanently wired into the sailplane system or else a 12V DC outlet connector provided so a portable converter can be connected.

> **CAUTION**
>
> It has been found that many cheap 12V to 5V converters cause radio interference.

20.10.1 PERMENANTLY INSTALLED POWER CONVERTERS

Some sailplane specific portable devices are supplied with their own 12V power converters. As an example, the Naviter Oudie is supplied with a 12V to 5V mini-USB power converter and also includes prewiring of the mini USB with a data connection via a RJ45 plug with standard IGC pin-out.

For a smart phone or PDA device running a soaring application such as XCSoar, a USB socket may be desired to extend battery life. Commercially manufactured DC converters for permanent installation are available relatively cheaply and normally provide a 5V output of up to 3A shared usually by 2 pre-wired sockets or leads with female jacks. For such a unit, the input current would be approx. 1.5A at max output load.

Typical 12V/5V converter with USB sockets

“Oudie 2” power lead and converter

Figure 20-23 A typical DC power convertor

Most USB connected devices do not draw much current but consideration must be given to the worst case of connecting a device with a flat battery which will draw a charging current as well as an operating current. Also consider if multiple USB devices will be connected.

Whilst a converter will usually have inbuilt protection for output short-circuiting and over current, there is no protection for the input supply cables and malfunction of the converter. Therefore, it must be connected so that it is protected by the secondary fusing of a circuit.

The point of connection to the sailplane's 12V system should either be to:

a. An existing circuit, but not the radio circuit. Connect after the circuit fuse and switch (if fitted). Check that the fuse rating is suitable for the now changed maximum current load possible in the circuit. Check that the fuse rating is lower than any of the wiring used in the existing circuit and the added wiring to the converter.

cc. A new circuit. This requires a new secondary fuse to be added and connected to the positive busbar. The fuse should be rated slightly higher than the expected current draw by connected devices but must be rated lower than the cabling used.

It is dangerous to connect an auxiliary output socket or lead to the positive busbar without a secondary fuse. In the event of a short-circuit in the relatively thin wire used on these sockets and leads, without a suitable fuse, the wire may overheat and burn.

20.11 RADIO INTERFERENCE

Radio systems are prone to interference from other components or Radio Frequency (RF) feedback due to poor antenna matching. The interference may manifest as unwanted noise on receive and distorted transmissions. Using shielded cables or twisted wires on microphone leads and good quality antenna leads can help.

RF feedback can be reduced by positioning RF filters, known as ferrites, on cables. Ferrites are metal beads made from a specially formulated ferrite powder. These are occasionally seen as bulges on printer and USB cables. It's important to ensure they are suitable for the VHF frequency range used by sailplanes. Slip on and clip on versions are available.

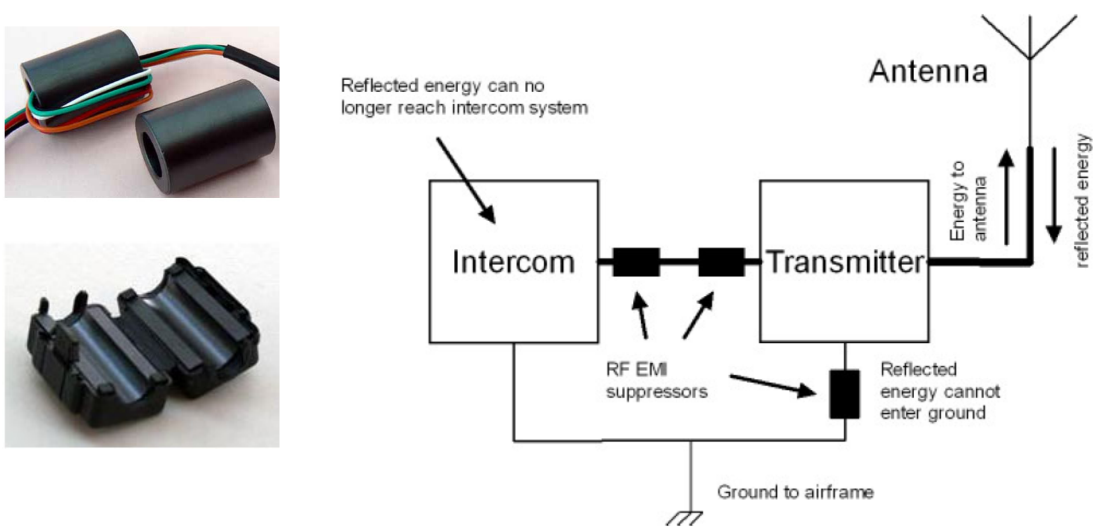


Figure 20-24 Examples of RF ferrites and where to use them (MGL products)

There is a good explanation of the causes and possible solutions to radio interference at this URL:

http://www.mglavionics.co.za/Docs/EMI%20suppressor%20for%20VHF%20frequencies.pdf

20.12 ELECTRICAL BONDING

Sailplanes with metal or conductive parts (eg carbon fibre) may be fitted with electrical bonding – wires joining all conductive parts together to create an equipotential structure. This bonding prevents static electricity build-up that can interfere with radio and navigational equipment. Bonding also provides lightning protection by allowing the current to pass through the airframe with minimum arcing.

Bonding wire is usually multi-strand fine braided with crimped lugs and uninsulated.

In motorised sailplanes, bonding is used to minimise the risk of dangerous static discharges in aircraft fuel tanks and hoses.

20.13 PLACARDS

Sailplanes fitted with electrical systems must be placarded to allow safe operation. Specifically:

a. The master switch must be labelled MASTER and at least the ON position identified. It must be positioned to operate ON in the UP orientation.

b. The battery selector switch must be labelled for the different batteries eg BATT1 – BATT2.

c. All fuses and CBs must be labelled as to which circuit they protect. Fuses should additionally be labelled as to fuse rating to be used e.g. 2A.

d. Any circuit (power) switches for individual equipment must be labelled for ON and OFF and the equipment operated by the switch e.g. RADIO, AVIONICS, AUX.

e. Control switches should be labelled with their function e.g. CRUISE/CLIMB.

20.14 UNDERCARRIAGE WARNING SYSTEMS

Many sailplane owners choose to install an undercarriage warning system to alert the pilot that the undercarriage is not down when the airbrakes are deployed. Such systems reduce the risk of landing “wheel up” by sounding a buzzer and/or illuminating a warning LED when on final.

The system usually uses two sensing switches; one that closes the circuit when the undercarriage lever is moved from the wheel-down and locked position and one that closes the circuit when the airbrake (dive brake) lever is moved from the retracted (in and locked) position. The basic system is shown in Figure 20-26.

The switches may be operated mechanically by physical contact (usually called a micro-switch) or by else by sensing a magnet in close proximity (usually called a reed or proximity switch). These switches usually have connections for Normally Open (NO), Normally Closed (NC) and Common (COM). Normally Open means an electrical current passes if a microswitch is not in physical contact or a reed switch is not in proximity with a magnet.

With a magnetic reed switch, it is usual for the switch to be fixed to the airframe and the magnet to be attached to the control rod to avoid wires moving when the rod is activated.

Warning system switches, magnets and wiring must be secure and not interfere with the movement of controls.

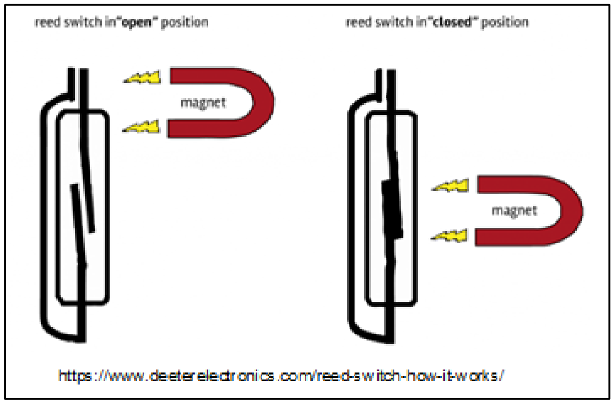


Figure 20-25 Magnetic Reed Switch Principle of Operation

CAUTION

Some undercarriage warning systems include a "Test" function. In most cases this is merely a test that the battery is fitted and switched on, and that buzzer makes a noise that can be heard by the pilot. The Test function does not confirm that the mirco-switches are correctly sensing the positions of the undercarriage and airbrakes. Therefore, when inspecting the undercarriage warning system, it may be necessary to lift the glider so that the wheel is clear of the ground and cycle the system to ensure that it is operating correctly.

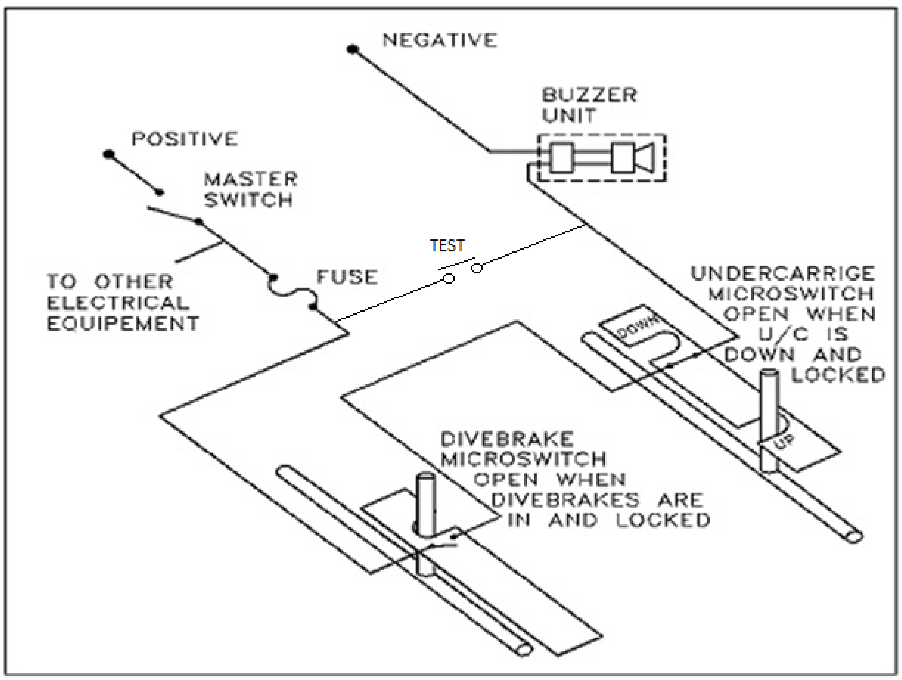


Figure 20-26 Undercarriage Warning System

A slightly more advanced version has the test switch wired to short just the undercarriage switch. Thus, on the ground with the test switch pressed (simulating the wheel up), operating the divebrake should cause the buzzer/LED to operate.

For 2-seater aircraft, test switches and warning LEDs can be sited in both cockpits by adding a 2nd test switch in parallel with 1st test switch, and 2nd LED in parallel with 1st LED.

20.15 MOTOR GLIDERS

The engine electrical system must be maintained in accordance with the information supplied by the manufacturer.

If an electrical system for driving the avionics is added to a motor glider, it must be completely independent of the engine electrical system unless the design is approved by the motor glider's manufacturer or GFA.

Electrical systems in a motor glider have the additional effects of vibration and heat to be considered. This usually restricts the use of soldered connections unless the joint is supported and protected by heat shrink tubing.

Further information regarding electrical systems in motor gliders can be found in the GFA "BSE – Engines" publication.

20.16 INSTALLATION OF EQUIPMENT

Most electrical systems installed in sailplanes are modifications to the manufacturer's original Type Approved sailplane. These modifications, like all modifications, must be in accordance with the standard procedures set down here in BSE and MOSP3.

When inspecting systems such as radios, variometers, undercarriage warning systems etc. these systems must be checked for physical interference with flight controls when these controls are deflected to their maximum travels with the sailplane rigged and derigged.

When fitting electrical components, it is vital that all components are is properly restrained. The installation should be done in accordance with BSE. In particular, when a battery or other component is installed directly behind the pilot, the crash load case of at least 15G forward must be used. See Sections 9.5.1 EQUIPMENT RESTRAINT and 9.5.2JUSTIFYING THE STRENGTH OF A RESTRAINT.

If a battery (or any other equipment) is installed in a position where it has a significant effect on the weight and balance characteristics of the sailplane, the changes to the aircraft weight and balance must be determined by persons authorised for weight and balance work.

20.17 ANNUAL INSPECTION

At each Annual Inspection, the electrical system must be checked to ensure that it is still in airworthy condition. If the manufacturer installed an electrical system in the sailplane, it must be maintained in accordance with the manufacturer's instructions.

All electrical equipment should be kept free of dust, dirt and grime.

When inspecting an electrical system, the inspector should ensure that the system has safe operating characteristics with respect to master switches, fuses, wiring quality etc. as described in the previous sections.

During the inspection, the following should be examined:

a. All batteries that are normally used in the sailplane for the presence of a primary (master) fuse (or CB) in the positive lead, a suitably rated fuse is in use and that the battery terminal connections are secure and insulated to prevent short circuit.

b. The battery mounting/securing device. The battery must be secured so as to remain in position if subjected to a force of 15G in the longitudinal plane.

c. The Master Switch isolates all devices and has the correct orientation (On is up or forward).

d. The following for damage or overheating:

    i. Equipment

    ii. Switches

    iii. Connections

    iv. Wiring

v. Insulation

e. Electrical bonding integrity. However, if bonding was not fitted by the manufacturer there is no need to fit it.

f. No dirty equipment or connections.

g. Cables are adequately supported and secure so that no risk of cables causing limb or controls entanglement.

h. Connectors and terminals for:

i. Loose connections.

ii. Poor crimps

iii. Excessive number of wires in the same terminal screw-down hole or stud.

iv. Excessive exposure of wire at terminals due to too much insulation cutback or shrinkage.

v. Stray wire strands (not contained in the connector/terminal) that might cause a short circuit.

vi. 'Orphan' wires that go nowhere and are not terminated with an insulator.

i. Check there is sufficient clearance between exposed current carrying wires/parts and ground/negative (especially where a metal airframe is used as the current return), e.g. at the +ve busbars.

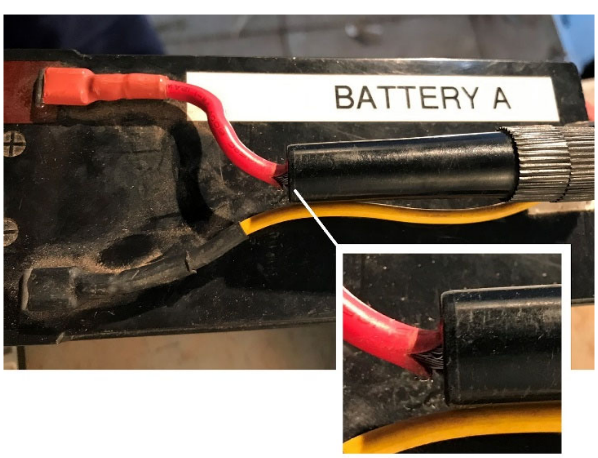
j. Circuit protection fuses and/or circuit breakers for appropriate rating.

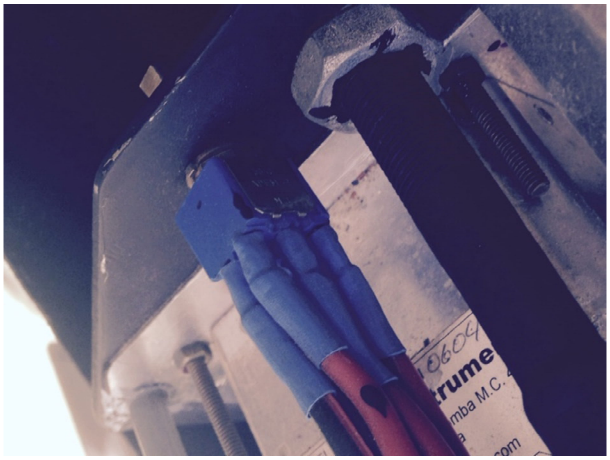
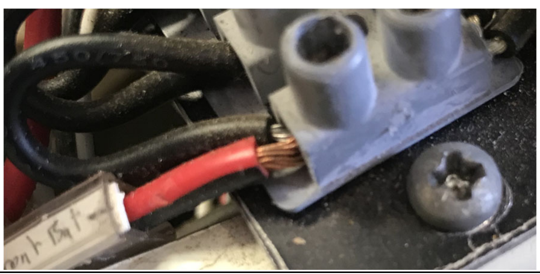
k. Placards on switches, fuses and CBs.

l. Functionality of undercarriage warning system, if fitted.

m. Condition of tail battery, if fitted. Check for leakage and potential damage to components below the battery.

20.18 EXAMPLES OF FAULTS AND CONCERNS

	Concern: Soldered connections to battery – not recommended. Clear heatshrink in placed but has not been shrunk! Risk: Increased risk of short circuit on battery side of fuse where there is no fuse protection
	Fault: 30A fuse holder has exposed wire on battery side of fuse holder and insulation is splitting. Risk: Increased risk of short circuit on battery side of fuse where there is no fuse protection

	Battery changeover switch with positive and negative wires both switched at a small profile DPDT switch. The heat shrink has been well applied. It is not possible to check the soldering without damaging the heatshrink. Concern: It is not required to switch both positive and negative wires. Risk: Unnecessary risk of short circuit due to +ve and -ve wires from 2 batteries in close proximity.
	ASK21 Master Switch pitted after 20+ years in service. Concern: General deterioration of the switch, possible dust ingression. Risk: Unable to switch off system. Note: Switch failed in service approx 2 months after photo taken!
	Fault: Insulation cutback too far or screw terminal lose. Risk: Wire could depart from terminal, short circuit.

20.19 REFERENCES

AC 43.13-1A Change 3. Acceptable Methods, Techniques and Practices. IAP Inc., Casper, Wyoming, 1988.

Tony Bingelis. Sportplane Construction Techniques. Sportplane Builder Publications, Austin, Texas, 1986.

21. LUBRICATION

21.1 GENERAL

Lubrication is a wide subject, with a seemingly endless variety of greases and oils available, each with its own particular properties.

To be able to choose suitable lubricants, proper account must be made of the way the lubricants will be expected to work in the sailplane/powered sailplane and the types of bearings to be serviced.

21.2 LUBRICANT REQUIREMENTS

Many factors influence the choice of lubricant. While you should endeavour to use the recommended or required types according to your aircraft maintenance manual, sometimes nothing is specified. Consideration of the following factors will help the selection of an appropriate type in the absence of specific guidance from the manufacturer:

a. Environment:
   - i. Heat Range,
   - ii. Moisture, and
   - iii. Dust;

b. Load carrying ability:
   - i. Impact,
   - ii. Speed (high or low), and
   - iii. Cyclic;

c. Material compatibility:
   - i. Bronze,
   - ii. PTFE,
   - iii. Steel,
   - iv. Aluminium, and
   - v. Nylon;

d. Seal type (rubber, nylon etc):
   - i. Serviceability,
   - ii. Access for lubrication, and
   - iii. Maintenance intervals;

e. Bearing type:
   - i. Slide,
   - ii. Plain rotary,
   - iii. Ball rotary,
   - iv. Roller rotary, and
   - v. Sealed rotary.

21.3 TYPES OF LUBRICANTS

There are four main types of lubricants that can be used in a sailplane:

a. Oil

b. Grease

c. Solid film

d. Silicone

21.3.1 OIL

Oil is a liquid at room temperature and comes in both organic and synthetic forms. It is not normally used in sailplane applications, except where used in motors and hydraulic systems (e.g. wheel brakes, oleo struts).

Oils suffer from evaporative losses so have a shorter service interval compared to other forms. They do tend to attract dust and dirt, and can wick into unprotected composite fibre structures if used excessively.

21.3.2 GREASE

Grease is just oil with a thickener added to make it semi-solid at the appropriate working temperature. Three main classes of thickeners are used; metal soaps, organic (urea) or inorganic. The thickeners contribute greatly to the properties of the lubrication, such as the temperature range that it will lubricate at (both low and high temperatures), but the actual lubrication is still performed by the contained oil. The thickeners also contribute other useful properties, such as anti-oxidant, rust prevention, and ability to work under extreme pressures.

21.3.3 SOLID FILM

These are non-oil-based methods of coating a surface to help prevent sticking and interference. They are typically used in situations where oil and grease would not survive for any reasonable length of time, such as suspension and gas struts. Typical soft examples are graphite, PTFE (Teflon) and hard examples Titanium Carbide/Nitride (TiC/TiN) and Chrome. These lubricants, apart from graphite, will not be applied by an Annual Inspector. If wear is found in surfaces with these lubricants then the item should be checked with an appropriately authorised professional service.

21.3.4 SILICONE

Silicone is a synthetic lubricant that is particularly good where rubber may be used in sliding applications and dirt pickup is not desirable. It typically comes in a pressure pack.

It is not good for rubber seals around water dump systems (standard grease is better here), but the sliding rails on clearview panels can benefit from silicone if they are sticky.

Silicone can be very problematic around paint and fibreglass, making it impossible to paint or repair areas. It must be very carefully applied if being used, to ensure that none gets on the main structures of the aircraft.

21.4 RECOMMENDED LUBRICANTS

It is not GFA policy to specify commercial products, particularly lubricants as there is such a wide range available, and applicable to different roles, as the previous checklist outlines. Use of a Molydenum Di-Sulphide grease in one application, would be incorrect in another application. When in doubt, first check the aircraft's Maintenance Manual for requirements.

Use aircraft low temperature grease on control linkages to avoid freezing at high altitude.

Don't use copper slip in aluminium head spark plug threads. Use Nickel Anti-Seize.

21.5 SHELF LIFE OF LUBRICANTS

Oils and greases are generally quite stable and do not deteriorate over time if left in the original container, unopened. Some special purpose oils, such as hydraulic (brake) fluid, will have a very limited shelf life as they will accumulate water if left in an open container, so it is important to be aware of the type of fluid and storage requirements. Check the packaging for storage requirements.

As a general rule, synthetic oils and greases will last for 10 or more years with no discernible impact on performance. Greases can appear to separate so that you get standing liquid and the thickener. Typically a quick mix of the two together will restore the grease to a workable solution.

21.6 LUBRICATION TECHNIQUES

Applying lubricants to various surfaces always should start with a thorough cleaning. Solvents may be used, but first check as some solvents have a habit of destroying rubber seals and other essential components in the system being lubricated. Most of the time, a good wipe with a clean rag will be sufficient cleaning before applying the new lubricant.

Once cleaned, exposed items like spar pins should also be checked for deterioration in the underlying item. Spar end pins have a tendency to get a light amount of rust due to water from the trailer or being left outside tied down during a storm – clean and polish it off. Undercarriage and control surface hinges will gather a lot of dust, which can cause scoring or excessive wear. Where possible, a quick test fit should be done without lubricant applied to ensure that there is not too much freeplay in the system. Lubricants, particularly grease, should not be used to compensate for out of tolerance play.

Don't lubricate a bearing without understanding how the bearing is made and how the manufacturer considers it should be serviced. The sailplane/powered sailplane manufacturer will also provide some directions for lubrication maintenance; those recommendations should be adhered to wherever possible.

Some bearings, such as plastic linear control rod bearings must not be lubricated.

21.6.1 SIMPLE GREASE GUN

While many greasing tasks can be performed with just the use of a finger and rag, sometimes a grease gun will be better to lubricate bearings. Several commercial options are available from the local auto parts store and will work sufficiently well. Alternatively, a homemade grease gun can be fashioned from a simple bolt and piece of hose.

To use it, fill the hose up with grease using your finger and then press the open end of the hose to the target bearing. Press on the bolt head until the clean grease starts to appear on the other side of the bearing. See the following figure.

A cut off disposable syringe also works well and come in various sizes from the chemist.

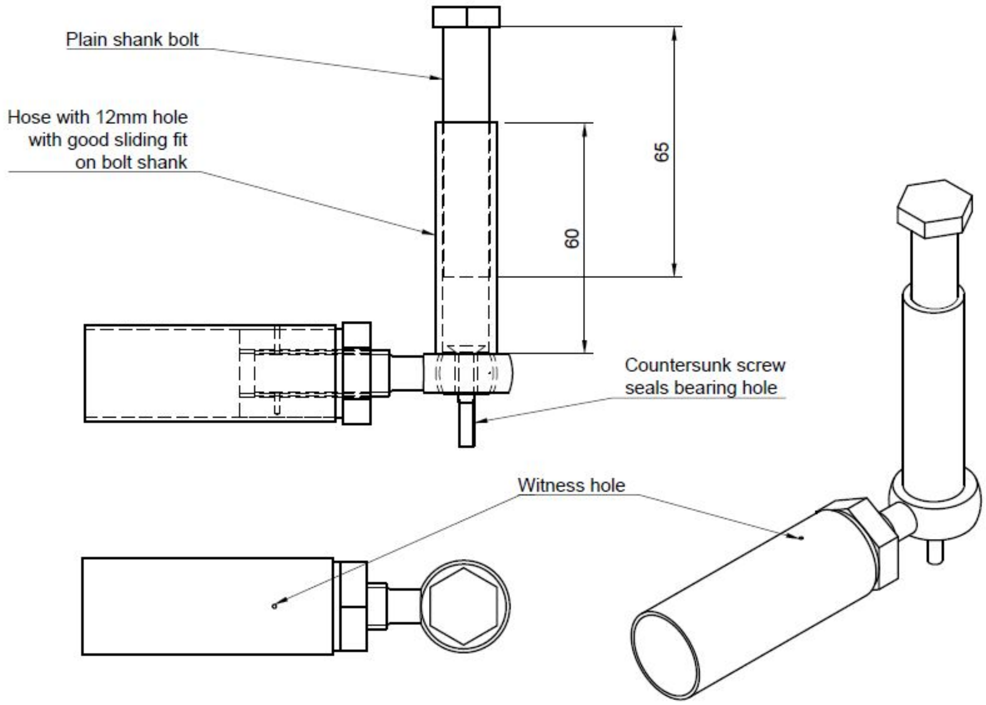


Figure 21-1 Simple Grease Gun

21.6.2 GREASE NIPPLES

The Blanik L13 and other European sailplanes and powered sailplanes are manufactured with grease nipples that are not compatible with Australian hand grease guns. In these cases the grease nipples may be replaced with a local type to allow grease guns to connect properly.

It is not uncommon to see older metal sailplanes still in service with the European nipples, which usually means those parts, in particular the undercarriage, may never have been properly greased. This usually results in rapid wear of undercarriage mechanisms.

Newer sailplanes should have had these replaced as part of their initial issue of the Certificate of Airworthiness checks when they are brought into the country, so an Annual Inspector should not need to check this often. If nipples have been replaced, an appropriate entry should be found in the logbook.

21.6.3 PRESSURE PACK LUBRICANT WARNING

Most spray can (pressure-can) "Freeing Agents", such as WD40, are not true long term lubricants, as the following article warns:

Control Lever Rod End Wear

In the process of monitoring an increase in replacements of control lever cable rod ends due to excessive wear service engineers have made a surprising discovery: some rod end bearings are being lubricated to death. A review of operator maintenance practices reveals that a significant portion of the failures are being induced by over lubrication through improper procedures.

The Heim F34-14 bearing has a split outer race and an SAE 52100 steel element. The bearing is pre-greased upon assembly and a small reservoir to hold the operating grease is built into the rod end.

A review of operator maintenance techniques has revealed that operations with the highest frequency of F34-14 bearing failures are those who are lubricating them with pressure-can lubricants such as LPS or WD4O. While affording some benefit immediately after application, the method of application of these lubricants may actually contribute to the failure of the bearing.

Application of pressure-can lubricants, through the use of the extended application tubes furnished with the can, delivers the lubricant with such force that it actually washes the manufacturer's lubricant out of the rod end removing its protection and contributing to the failure.

Few of the pressure-can lubricants are effective in high temperature areas such as the engine installation due to accelerated evaporation of the lubricant carrier. It is felt that elimination of direct application of pressure-can lubricants will contribute to the life of the F34-14 bearing. If the operator determines that lubrication is required, it is recommended that the ball element be hand packed with MIL~G-81322, the moisture and temperature resistant grease used in the landing gear wheel bearings.

21.7 GREASING FREQUENCY - UNDERCARRIAGE

In club trainers, experience shows that 50 hour lubrication periods result in extended undercarriage life. GFA strongly recommends, even where the sailplane/powered sailplane manufacturer does not request it, that a regular "grease and oil change" be adopted as a maintenance policy. This could be hour or number of flights based.

21.8 REFERENCES

AIR5433A Lubricating Characteristics and Typical Properties of Lubricants Used in Aviation Propulsion and Drive Systems

AeroShell Listing of US Aviation Lubrication Standards
https://www.shell.com/content/dam/shell/static/aviation/downloads/AeroShell-Book/aeroshell-book-10busspecs.pdf

22. WOODEN CONSTRUCTION INSPECTION AND REPAIR

22.1 WOOD

22.1.1 GENERAL

While wooden sailplanes are no longer being commercially manufactured there are many vintage wooden aircraft still flying. There are a significant number still in regular club service. Some wooden aircraft continue to be amateur built from plans.

This chapter provides information on inspection, maintenance, repair and construction of wooden sailplanes.

22.1.2 CHARACTERISTICS OF WOOD

22.1.2.1 GROWTH RINGS

Each stage in the growth of a tree is visible by a dark ring formed during the latter part of the growing season, when the fibres have somewhat heavier walls. For timber grown in temperate climates these rings represent yearly growth.

For any one species of timber, wood density is indicated by closeness of the growth rings. Widely spaced growth rings indicate faster grown, less dense and consequently weaker timber.

Aircraft specifications always call up a minimum permitted number of growth rings per unit of radial dimension of the timber. This is necessary to ensure that minimum strength properties used in design are achieved in practice. For most timbers the growth rings should not be less than six per 25mm, when measured at right angles to the growth rings.

22.1.2.2 SAWING OF TIMBER

A log may be cut in three distinct planes with respect to the annual rings:

a. Cross wise, exposing the transverse or end grain surface.

b. Lengthwise along any of the radii of the annual rings, exposing the radial, or so called full quarter sawn, or edge grain surface.

c. Lengthwise at a tangent to any of the annual rings, exposing the tangential or so called full back sawn or flat grain surface.

The annual rings often run diagonally across the end of the timber, so that it cannot be said to be either full back sawn or full quarter sawn. These methods of sawing are illustrated below:

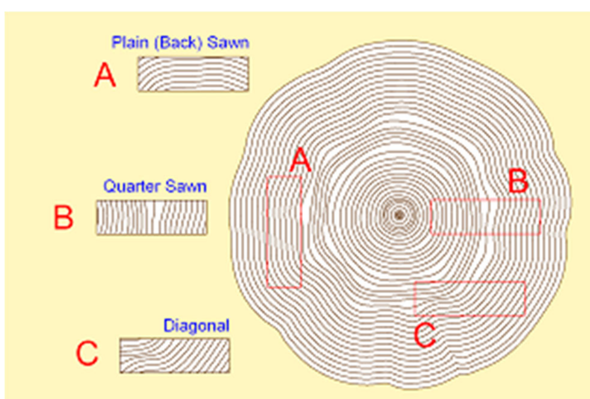


Figure 22-1 Growth Rings

22.1.2.3 MOISTURE CONTENT

Wood will continually give off or take in moisture in accordance with the relative humidity and temperature of the surrounding atmosphere. The strength is directly related to the moisture content, the higher the moisture content, the lower the strength.

After felling, green timber is cut, seasoned and kiln dried to a moisture content of about 15%. In service, moisture content of wood in a typical sailplane will vary from almost zero in Central Australia up to 12% near the coast. Moisture content will also vary between summer and winter seasons.

When wood loses its moisture, it shrinks. This shrinkage is greatest across the grain in the direction along the growth rings (tangentially), about half to two thirds as much across these rings (radially) and relatively little along the grain (longitudinally).

Shrinkage and associated distortion in wooden sailplanes is often a problem, not only because the resulting “starved horse” effect reduces performance, but also large internal stresses may be set up and metal fittings loosen as the wood shrinks.

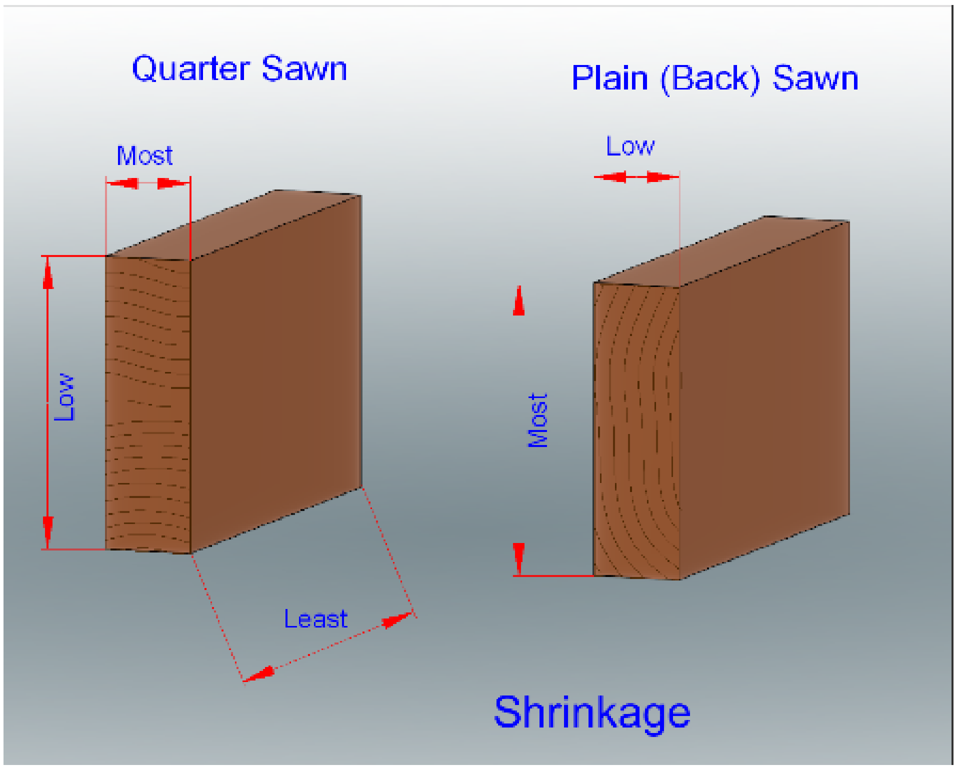


Figure 22-2 **Shrinkage**

Quarter sawn timber shrinks less in width than back sawn timber and is less likely to twist and develop checks during seasoning. On the other hand, back sawn timber is cheaper and any knots present will be round or oval, instead of long spike knots.

22.1.2.4 GRAIN EFFECTS

Timber is a complex structural material consisting of large numbers of hollow fibres cemented together. The individual fibres are relatively strong in tension, but depend on collective restraint against buckling for their compressive strength. Timber is strongest when loaded in the direction of the grain.

The compressive strength of timber is about half of the tensile strength and this fact governs the design of major parts such as wing spars.

Because the individual hollow fibres are also comparatively weak across the grain, the orientation of the grain in a piece of timber is of vital importance.

22.1.2.4.1 MEASUREMENT OF SLOPE OF GRAIN

Slope of grain is expressed as the number of units in which a deviation of one unit occurs. A slope of 1 in 15 means that in a distance of 150mm along the longitudinal axis of the piece, a given fibre has deviated by 10mm. The grain direction on a radial surface is clearly indicated by the darker bands of summer wood which appear as lines along the length of the piece. On a tangential or near tangential surface, however, the indication of fibre direction is much less clear, the principal indications being checks, pores, resin ducts and wood rays. A clear indication of the fibre direction on a tangential surface may be obtained by drawing a sharp steel scriber along the surface in the direction in which the grain seems to run.

22.1.2.4.2 CROSS GRAIN

Cross grain in wood means that the fibres are not parallel to the major axis of the piece.

Cross grain is objectionable because it reduces strength, may cause warping in drying and makes it difficult to surface wood smoothly when planing against the grain.

Cross grain may be of two major types, namely; diagonal grain or spiral grain, or a combination of both.

Diagonal grain is a deviation of the plane of the annular rings from parallel with the longitudinal axis of a piece of wood. It is due to such natural causes as crook, bulges, butt swell, pitch and bark pockets, blister grain, some types of curly grain, healing over of knots and injuries, and to the common practice of sawing tapered logs parallel to the pith instead of to the bark.

The fibres in some trees are not vertical, but follow a spiral course similar to the stripes on a barber's pole. Spiral grain in peeled posts, poles or tree trunks is evidenced by inclined rather than vertical season checks. Ordinarily the steepness of the spiral decreases from the bark towards the pith of the tree, however this is not universally true. Also the slope of the spiral sometimes fluctuates, especially near the butt of the tree.

When spiral grain is present, the principal evidence on a radial surface of a piece is the tendency for the surface to be chipped in planing, and for a splinter raised by a knife point to run into the piece, instead of tearing out to a uniform depth.

22.1.3 DEFECTS IN TIMBER

Some of the common timber defects are:

a. Checks, splits and shakes

b. A check is a longitudinal crack in wood generally in the radial direction, or across the annual rings. Checks are due to uneven shrinkage in seasoning. Thick stock is more susceptible to checks than thin stock and aircraft veneer is too thin to be subject to checking.

c. A split is a longitudinal crack extending through the thickness of the piece from side to side regardless of whether the piece is edge grained. A split is caused by rough handling or other artificially induced stress, and veneer, because of its greater fragility, splits much more readily than heavier stock.

d. A shake is separation between adjoining layers of wood, due initially to causes other than drying. Shakes may become accentuated during seasoning.

e. A longitudinal shake is one running parallel with the length of the fibres, and usually exceeds half a metre in length, as compared with checks which are likely to be less than 100mm in length. A transverse shake is one running across the fibres. A ring shake is one occurring between two adjoining annual rings. A heart shake is one extending radially from the pith of the tree, and a star shake is a number of heart shakes arranged more or less in the form of a star. A falling shake is a longitudinal or transverse shake caused during felling of a tree.

Checks, splits and shakes may seriously weaken wood members in longitudinal shear, and timber containing them should be rejected.

22.1.3.1 COMPRESSION FAILURES

Compression failures are deformations of the fibres due to excessive compression along the grain either in direct end compression or in bending. The deformations range from well-defined buckling of the fibres, visible to the unaided eye as wrinkles across the face of the piece, to slight crinkling of the fibre walls visible only with a high power microscope.

Compression failures can best be detected under a concentrated light, placed so that it shines along the fibres at an angle of about 20^0. When viewed at an angle of about 45^0 to the grain, from the side on which the light is located, the compression failure will show up as an irregular line extending across the grain.

Figure 22-3 Compression Shake

22.1.3.2 KNOTS

A knot is the base of a limb embedded in the tree trunk. The only type of knot permitted in aircraft is a sound, tight knot, solid across its face, and so fixed by growth or position that it will firmly retain its place in the piece. Intergrown knots are always tight in the sizes permitted in aircraft stock, but encased knots are frequently loose.

Knots are objectionable because of the distortion, and in encased knots, the discontinuity of grain which they produce, thus weakening the wood, causing irregular shrinkage and making machining more difficult.

22.1.3.3 DOTE

Dote is a disease which, when present in spruce, renders the timber useless for aircraft use. Advanced stages are easily detected as obviously decayed timber, but in the early stages it is present in the form of yellowish or brownish spots. However small the evidence may be, the timber must be rejected because the decay, once present, will spread.

22.1.3.4 PITCH POCKETS

Pitch pockets are approximately plano-convex lens shaped openings within annual rings, usually longer than they are wide. As a rule, they contain resin and occasionally bark. They occur frequently in spruce, pine and douglas fir. They may weaken small members, and resin may exude from them, especially when the wood becomes warm. In quarter sliced veneer, pitch pockets appear as narrow slits.

22.1.3.4.1 BARK POCKETS

A bark pocket is a patch of bark partially or wholly enclosed in the wood. There is usually some separation involved which has a weakening effect. They are occasionally found in most aircraft woods, particularly in spruce, and are considered equal in damaging effect to pitch pockets of similar size, which they superficially resemble, the main difference being that they lack pitch.

22.1.3.4.2 PITCH STREAKS

These are defined infiltrations of resin in the fibres in the form of streaks, usually extending a greater distance along than across the grain. They occur mainly in spruce, pine and douglas fir, and in the better grades of timber are quite small.

22.1.4 SELECTING AIRCRAFT TIMBER

Aircraft specification timber should be free from rot, dote and all forms of incipient decay or discolouration, deleterious shakes, knots, resin pockets and reaction or compression wood.

There shall be no grain disturbances which may constitute a weakness and the maximum inclination of the grain to the length of the piece shall not exceed 1 in 15. The timber shall be free from brittleness.

The detection of spiral grain in finished spruce is rather difficult, and if present, it is detected by examining the flower side or figured surface of a piece of timber. It is important to note that grain direction coincides with that of the gross stripe pattern only on quartered or near quartered faces. The most reliable test is to cut off a short piece and split it with a chisel at right angles to the growth rings. The maximum limit of spiral grain is also 1 in 15.

Although wood with small resin pockets is acceptable, wood with resin veins should always be rejected. A vein, as distinct from a pocket, runs with the grain in the form of a streak embracing one or more growth rings, and can be detected by discolouration.

Moisture content should be in the range of 12-15%.

Density must be within the range specified for the type of timber being inspected.

The number of growth rings must comply with the specification, or not less than 6 rings per 25mm radial measurement.

Where possible structural timber should be bought from a recognised aircraft timber supplier, certified that it complies with the relevant standard. Where the inspector/repairer has to select his own material, compliance with the relevant specification will allow the material to be used.

A copy of British Standard BS 2V 37:1968 Sitka spruce as finished timber is attached at the end of this section.

22.1.5 AIRCRAFT TIMBERS

Not all timbers are suitable for use in aircraft. A good strength to weight ratio is required and the species of trees used should grow to a good length with straight grained timber, free from faults.

Species used in sailplanes include:

a. Spruce

b. Kiefer

c. Douglas Fir

d. Ash

e. Beech

f. Birch

g. Balsa

h. Klinki

i. Mahogany

j. Improved Wood

22.1.5.1 SPRUCE

Spruce is a light reddish brown coloured wood grown in Canada and northern USA. Most Australian and British sailplanes were built from spruce which is particularly easy to work. When broken, good spruce breaks with a fibrous fracture and all along the broken surfaces will be found tiny whiskers of grain that have pulled up. Bad, dry spruce breaks “short” or snaps like a carrot and the whiskers are absent. Sub-species are Red Spruce and Sitka Spruce. Sitka Spruce is superior and is generally specified for spars (e.g. Kookaburra, Arrow, and Skylark).

22.1.5.2 KIEFER

“Kieferholz” is literally German for pine wood, also known as Baltic Pine, Polish Pine or Red Deal.

Slightly more yellow in colour than Spruce, it is also more fibrous, the fracture being less “short grained”.

First grade Kiefer is slightly heavier and stronger than Spruce and repairs to Polish and German sailplanes should only be made with the correct material. (E.g. Schleicher Ka2, Ka6, Ka7 etc., Mucha, Bocian and spars for Australian built ESKa6).

22.1.5.3 DOUGLAS FIR

Douglas fir or Oregon, is also heavier and stronger than Spruce. The growth rings are very pronounced and the timber is prone to split. It has been used as a substitute for Kiefer (e.g. ES49 spars built in Australia, also BG12).

22.1.5.4 ASH

A white hardwood with characteristic flecks in the grain. Its great merit is that it has good resistance to bending and is therefore used for skids and occasionally for the keel of sailplanes. Australian mountain ash and alpine ash have been used also.

22.1.5.5 BEECH

A hardwood used for re-enforcing blocks in certain places. In colour it is a whitish wood, darker than Ash and contains short flecks in the grain.

22.1.5.6 BIRCH

A hardwood used mainly in the manufacture of plywood but used on its own in certain applications. It faintly resembles Beech but is of a darker colour. It is used for re-enforcing blocks, tailskid spring carrying members and in many aircraft where the fittings of the wings are attached to the spars.

Birch veneers are sliced and glued to make TBU-7, having seven veneers per millimetre and TBU-11 having 11 veneers/mm. TBU-7 is used in the spars of the ES60 series sailplanes.

22.1.5.7 BALSA

Balsa is a very light wood used as a non-structural former and as a core material in early glass fibre aircraft (e.g. Early Libelle).

22.1.5.8 KLINKI

Klinki pine is grown in New Guinea. It is light in colour and selected grades are as strong as spruce. It has a very “green stick” fracture and is difficult to cut cleanly with an edged tool, the wood tearing. It is generally used only in plywood and for laminating (e.g. Kookaburra and Boomerang bulkheads).

22.1.5.9 MAHOGANY

This is a generic term for a whole family of timbers. It is a dark timber which comes from various places in the world (Honduras, Africa and other places). It varies in hardness but it has great resistance to shock, hence its use in places like wheel boxes and propellers.

22.1.5.10 IMPROVED WOOD

Various grades of Improved Wood or “Pregwood” are made from Spruce and Beech (e.g. Lo150).

The most commonly used type is known as “Compreg” which is made by assembling resin treated veneers under pressure greater than normally required for a good adhesive joint, the pressure being accompanied by heating. The resulting product is quite hard with a specific gravity of 1 to 2 compared with 0.3 to 0.5 for normal wood. The strength is entirely dependent upon the amount of impregnation and compression. The material has a definite fatigue strength which is much lower than that for untreated timber of the same variety. Care must be taken to ensure a roughened surface for gluing.

22.1.6 AIRCRAFT PLYWOODS

“Three Ply” is constructed of three veneers of wood glued together with a thermosetting synthetic type resin while under pressure. The grain of the outer veneers runs parallel with the length of the sheet, while the grain of the middle veneer (or core) runs at right angles to that of the outer veneers, or across the sheet. With “Diagonal Ply” the grain directions are set at 45^0 to the length of the sheet. Diagonal ply has become difficult to obtain in recent years. Where more than three veneers are used, the material is termed “multi-ply” or “five-ply” or “seven-ply” as the case may be. Five-ply is commonly used in sailplane wings.

The range of plywoods includes:

a. Birch Ply

b. Klinki Ply

c. Gaboon Ply

d. Mahogany

e. Coachwood

f. Hoop Pine

22.1.6.1 BIRCH PLY

Birch ply is the most commonly used plywood for sailplanes. Metric sizes are sourced out of Europe. Three ply with thicknesses from 0.8 to 1.5mm and 5 ply from 1.5 to 2.5mm thick are commonly used. Standard sheet size is normally 1.2m square. This ply is available in GL1 and GL2 grades. GL2 specification allows more defects per unit of area than GL1.

22.1.6.2 DOUGLAS FIR

Marine grade plywood manufactured in USA.

22.1.6.3 KLINKI PLY

Klinki ply is available in marine grades and is used as a substitute for American marine ply specified in some designs for homebuilding (e.g. BG-12 and Cherokee). It was also used to make thick bulkheads for local designs (e.g. Kookaburra, Arrow, and Boomerang).

22.1.6.4 GABOON PLY

Gaboon or African mahogany plywood is less dense and more stable than Birch and was extensively used to cover wing leading edge torsion boxes (e.g. Ka6, Dart, and Skylark). Gaboon is not as strong as Birch and therefore should not be used as a substitute for birch plywood. It is light in colour with less “grain” showing than birch.

22.1.6.5 MAHOGANY

American Mahogany plywood is lighter and almost as strong as birch. The Mahogany is red-brown in colour. It is sometimes used with a core veneer of another wood such as birch. American three ply may have the usual construction of three equal veneers, but some are of 1:2:1 construction. That is the core veneer is twice the thickness of the facing veneers. This plywood is equal in strength in the two major directions, unlike normal aircraft plywoods which are designed to take higher load in one direction.

22.1.6.6 COACHWOOD

Locally made in Australia. It is heavier than most other plywoods, so its use should include consideration of higher structural weight.

22.1.6.7 HOOP PINE

Locally made in Australia in marine grade. It is lighter than coachwood, but more brittle.

22.2 ADHESIVES

22.2.1 GENERAL

This section covers glues used in wooden aircraft construction.

For all glues the surfaces to be glued are covered with liquid adhesive. It is necessary for the adhesive to ‘wet’ the surface and penetrate the microscopic pores and hollows of the wood.

Surfaces to be glued must be free from any traces of oil or grease. Therefore the gluing surface should not be touched.

The liquid adhesive can be transformed into a solid by heat, chemical reaction or the evaporation of solvents.

Both the wetting and transformation processes need to be well managed by the operator to ensure a successful outcome.

22.2.2 LEGACY AIRCRAFT ADHESIVES

While it is unlikely that a new wooden aircraft build or repair would be carried out with any glue other than an epoxy, a knowledge of legacy wood adhesives is essential since most of our sailplanes were built and had previous repairs using the legacy glues.

Legacy glues were "water resistant". Some were more resistant than others. None took kindly to continuing damp conditions. Many glue failures in the wooden sailplane fleet can be traced to moisture exposure.

The following glues were commonly used in sailplane construction:

a. Casein

b. Urea Glue

c. Resorcinol

22.2.2.1 CASEIN

Casein was derived from milk proteins and supplied in powder form. This was mixed with water to form a liquid glue. With proper care Casein built sailplanes will remain airworthy for very long periods.

Most sailplanes built by Edmund Schneider were glued with Casein.

Casein is highly susceptible to fungal attack if water is present. Fungal attack gives off a tell-tale smell like sour milk.

22.2.2.2 UREA GLUE

Urea formaldehyde glue was generally used by applying the glue to one surface and the hardener to the other before the surfaces were brought together.

Urea was commonly used on British built sailplanes (e.g. Slingsby T31, Gull4, Skylark 2, and Olympia 2).

Kaurit was a German Urea glue commonly used on Schleicher Ka 1, Ka 2, Ka 2B, Ka 3, Rhönlercher II (Ka 4), Ka 6 series, K7, K7 conversions, K8 series, K10, ASK 13 series, ASK 14, ASK 16, ASK 18 series aircraft. This glue has shown some problems with age. It is suspected that the problems are moisture induced. The BGA has issued an ongoing detailed inspection schedule for these aircraft.

22.2.2.3 RESORCINOL

Resorcinol was mixed from a liquid resin and a powder hardener. The resulting glue is a dark reddish brown colour.

Resistance to hot, wet conditions and fungal attack is good.

Resorcinol was used extensively on German aircraft and later British designs. The main spar of the ESKa6 is built of Resorcinol, but the remainder of the structure used Casein.

22.2.3 AIRCRAFT EPOXY GLUES

A range of 2 part epoxy glues is available for wooden aircraft construction and repair. It is recommended that epoxy glues be used for repairs.

Manufacturers publish full data sheets on their resin systems, including recommendations for surface preparation, mixing and curing.

In general:

a. Ratios must be accurate

b. Mixing must be thorough

c. Temperature and humidity must be within specified limits

d. Higher temperature will reduce glue viscosity and reduce pot life.

Epoxy resins may have an adverse effect on skin. The relevant MSDS should be obtained and health and safety recommendations followed.

The following epoxy glues have been successfully utilised on wooden sailplanes and GA aircraft in Australia:

e. Huntsman Araldite 106

f. Huntsman Araldite 134

g. Huntsman Araldite 2011

h. International Epiglue

Other epoxy glues are likely to be acceptable. In selecting a suitable glue consideration needs to be given to the following issues:

i. Suitability for gluing wood

j. Glue strength

k. Cure time

l. Pot life

m. Working temperature and humidity range

n. Shelf life

Epoxy resins and associated hardeners have reasonable shelf life if stored in good airtight containers. They should be stored away from extremes of heat and cold. In particular freezing conditions will substantially reduce shelf life.

22.2.4 GLUING PROCEDURES

22.2.4.1 TEST SAMPLES

It is a wise precaution to make test glue joints for destructive testing with each batch of glue mixed. The main benefit of test samples will be identification of erroneous resin/hardener ratio being used.

The following diagram shows a test sample made for destructive testing:

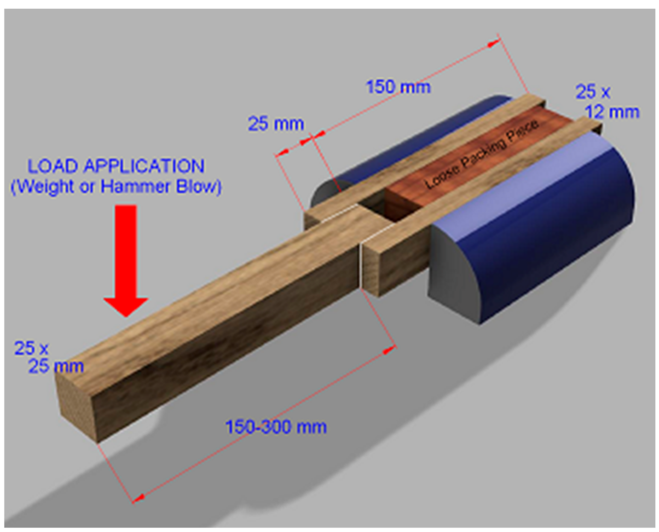


Figure 22-4 Test Sample

Reduction of the test piece to half the above dimensions is satisfactory.

The test piece should be clamped. It should also be marked with the date and time the glue batch was mixed.

Following destructive testing the glue faces should contain embedded timber.

With epoxy resins the residual glue in the mixing cup should cure to a brittle plastic. If the residual is too plastic to shatter with a hammer blow it is likely the mixture ratio was incorrect.

22.2.4.2 SURFACE PREPARATION

The essential points to be observed when gluing are as follow:

a. The surfaces must be clean. The faces should not be handled after final sanding.

b. The surfaces must fit accurately. The fit must be over the whole area to be glued.

c. Plywood has a surface condition called “case hardening” which prevents proper wetting. Accordingly it should be lightly sanded on all glue faces with 220 grit paper.

d. If repairing existing structure the original glue must be removed totally to allow the new glue to wet the timber.

22.2.4.3 GLUING CONDITIONS

Ensure gluing is carried out within the temperature and humidity ranges recommended by the data sheet.

If gluing in cold conditions and heating equipment is used, remember to pre warm the two components. It is the temperature at the glue face that is important.

Establish before you start, the time you have available from finished mixing to joint closed (pot life). This governs how much work can be done in one operation and how many helpers are required.

Keep glue faces and general area free of dust and moisture.

22.2.4.4 GLUING PREPARATION

Make a “dry run” without glue to check the assembly time and to make sure there are sufficient clamps and blocks available.

Mixing ratios specified in the data sheet must be carefully observed.

Use good quality scales if mixing by weight.

Use clean mixing pots and stirrers. Disposable plastic cups can be used, however do not use polystyrene cups.

Stir to achieve a thorough mix. Allow air bubbles to release before use.

Do not use glue which is beginning to gel.

When mixing an additional batch of glue use a fresh container.

22.2.4.5 CLAMPING REQUIREMENTS

‘G’ clamps should be used with softwood blocks to spread the load. Tighten by feel - don’t crush.

Brad strips are used over plywood. Brad length and ply strips are selected to give adequate pressure and distribution. Use packing blocks sufficient to back up the brad strips. Do not leave brads in the timber.

A staple gun can be used as an alternative to brads provided the job is reasonably solid. For best results use a strip of cloth to obtain full pressure from the staples. This also facilitates removal of the staples.

Wedges, special blocks and tourniquets are useful.

Small spring clamps are useful on small repairs.

Weights often won’t provide sufficient pressure.

Clamping must provide an even pressure over the area to be glued. Clamps should not be too far apart or too close to the edge.

Sequence of clamp tightening should start from the centre and work outwards.

A uniform squeeze out should show along the glue joint. Where possible wipe squeeze out off before the glue gels.

Clamps may be removed when the squeeze out is hard.

In cold conditions heat the job till the glue has cured. Do not allow the structure to be overheated.

All clamps, brad strips and other devices should be wrapped with glad wrap or similar material to prevent bonding to the work piece.

Curing of epoxy resins is an exothermic reaction. A larger amount of mixed resin in a cup will warm up and significantly reduce pot life. Residual mixed resin in a cup should not be left on a wing or other aircraft component due to the risk of excessive temperature rise as the resin cures.

22.3 WOOD REPAIR

22.3.1 GENERAL

There are a number of basic rules to be observed in structural timber and ply repairs:

a. Materials

b. Jigging

c. Repair Schemes

d. Grain Direction

e. Ventilation/Drainage

f. Interior Sealing

22.3.1.1 MATERIALS

Always use materials used in the original structure or as recommended in this manual, or specified by the type certificate holder. Where other alternatives are to be used modification design approval will be required.

22.3.1.2 JIGGING

Aerodynamic shape and structural alignment must be maintained. Inadequately jigged repairs will lead to poor flying characteristics. Take particular care to maintain subtle shape changes like wing tip washout etc.

22.3.1.3 REPAIR SCHEMES

Use repair schemes provided by the type certificate holder or shown in this manual. Where alternative schemes are to be used modification design approval will be required.

22.3.1.4 GRAIN DIRECTION

Original grain directions are critical and must not be varied, particularly 45^0 plywood skinning and spar material grain. In some cases continual in service cracking can be traced to the manufacturer selecting the wrong grain direction, or wrong cut, producing cracking, loosening of fittings etc. In these cases, a change in grain direction is desirable.

22.3.1.5 VENTILATION/DRAINAGE

Ensure the finished repair has vent and drainage holes re-instated and not blocked with glue.

22.3.1.6 INTERIOR SEALING

Use shellac, epoxy or marine varnish on all interior surfaces to moisture proof timber surfaces. Take care to ensure the moisture proofing coat does not infringe on the gluing faces.

22.3.2 SPLICING

Aircraft wooden structures depend on glued joints for their integrity. When loaded to ultimate loading the timber adjacent to the glue should fail before the glue. To achieve this joints must always be loaded in shear or compression in the glue line, never tension. Scarfed joints are used in splices to achieve shear loading rather than tension.

a. Standards for Scarf Angles

b. Splicing Quality

c. American Splice Method

d. Supporting Plywood Skin Splices

22.3.2.1 STANDARDS FOR SCARF ANGLES

Minimum scarf angles for splices on sailplanes should be:

a. For plywood with supported edge: W/T = 12

b. For plywood with unsupported edge: W/T = 15

c. For structural timber (spars, ribs etc.): W/T = 15

Unsupported edge plywood repairs should only be used for smaller damage areas on relatively flat ply surfaces.

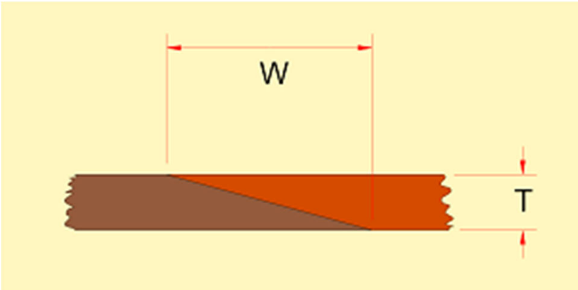


Figure 22-5 Splice

22.3.2.2 SPLICING QUALITY

Cutting, fitting and gluing splices is not easy. The following sketches show the common defects that must be avoided.

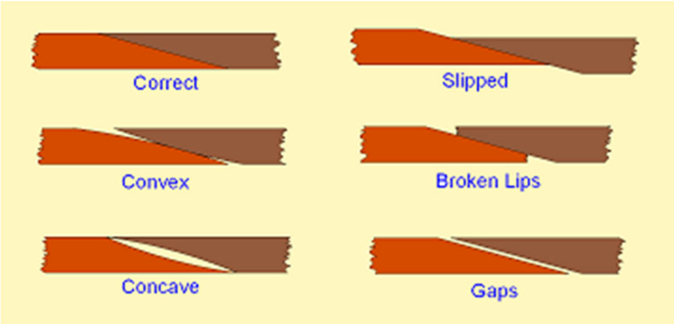


Figure 22-6 Splice Quality

22.3.2.3 AMERICAN SPLICE METHOD

AC43 shows a method of cutting a low splice angle and using side plates to support it. This method is not considered suitable on the light, highly flexible structures found in sailplanes since the plates tend to cause changes in local stiffness which changes stress distribution.

A longer unsupported splice is required to maintain original structure flexibility.

22.3.2.4 SUPPORTING PLYWOOD SKIN SPLICES

To enable ply skin to be properly spliced and the joint clamped correctly with a tacking strip the minimum support shown below must be provided. The support block should be installed and its glue cured before gluing in the patch.

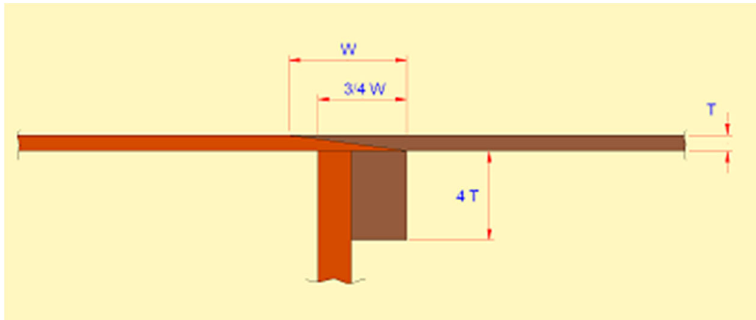


Figure 22-7 Splice Support Block

22.3.3 'D' NOSE REPAIR

Older wooden sailplanes generally had a plywood 'D' nose with ply grain running at 45^0. A repair requires steaming and forming of ply to bend around the leading edge. Following bending the ply must be allowed to thoroughly dry before final cutting, scarfing and gluing.

It is much easier to achieve a satisfactory repair if the span wise scarf line is a bit further back away from the tightly bent leading edge. Splice angles and backing should follow the requirements shown in 22.3.2 above.

Later wooden sailplanes with Wortman profiles (e.g. ES60 series, Bergfalke IV) had a significantly different 'D' nose structure. The plywood was generally thicker (5 ply) with the grain running along the wing. The plywood was not wrapped around the leading edge. A leading edge timber or plywood face carried the wing torsional load. Generally 'D' nose repairs are simpler with this arrangement since there is no requirement to tightly bend the plywood.

22.3.4 DESIGN OF REPAIRS

Before commencing work on a repair, sit back and consider all aspects of the repair design. Rash cutting back of the damage area can lead to the job becoming substantially larger than it needed to be.

Design considerations should consider material specifications and quantities, scarf locations, backing timber locations and final surface re-instatement.

23. SAILPLANE FABRIC INSPECTION AND REPAIR

23.1 GENERAL

23.1.1 EXTENT OF USE

Aircraft fabrics have been used to surface aircraft since the days of the Wright brothers.

Most wooden aircraft have fabric covered ribs and control surfaces, some have fabric covered steel tube fuselages. They also commonly had fabric covering over ply surfaces.

Many metal and some composite sailplanes also have fabric covered control surfaces.

23.1.2 FUNCTION OF FABRIC AND ASSOCIATED FINISHING MATERIALS

Fabric covering on aircraft together with associated finishing materials serve the following functions:

a. Provide the aerodynamic surface over open rib areas

b. Provide a lightweight skin

c. Prevent moisture ingress to the internal structure

d. Block damaging UV rays from reaching the fabric and structure

23.1.3 CONDITION OF STRUCTURE UNDER FABRIC

With modern fabrics lasting 10 to 15 years in service it is important to carefully inspect and repair any structures before applying new fabric. Particular care needs to be taken to identify corrosion, glue deterioration or wood failures since they will be covered up for a prolonged period.

23.2 LEGACY FABRICS AND DOPES

23.2.1 LEGACY FABRICS

Traditionally wooden aircraft were covered with linen and then later cotton fabrics. These were heavier and generally had a shorter service life than a modern polyester fabric.

23.2.2 LEGACY DOPES AND FINISHES

23.2.2.1 DOPES

A taughtening dope was utilised with the legacy fabrics. The earliest dopes were nitrate based and are considered more flammable than later butyrate dopes. The dope had multiple functions:

a. It glued the fabric to the structure

b. It caused the fabric to shrink and tighten

c. It provided an air and water proofing function.

23.2.2.2 FILLERS

Some types of fillers were used with the legacy fabrics for UV protection and weave filling. The most common one was “red oxide” which is an anti-fungal and moderate UV blocker. In a thick mix it was also used as a filler for small gaps and bumps.

23.2.2.3 PAINTS

Following application of fabric and dope, the surfaces were painted. A wide range of paint types were utilised, some were better than others. Problems encountered with the paints were:

a. Commonly they were not very effective at excluding UV radiation. This lead to early deterioration of the underlying fabric.

b. Generally they were not flexible enough to match the in-service deflections of the aircraft structure. This lead to early paint cracking. During maintenance additional paint coats were added to cover the cracks. This lead to overweight aircraft.

23.3 CURRENT FABRICS

23.3.1 TYPE OF FABRIC

All currently utilised aircraft fabrics used on sailplanes are woven from polyester thread. Polyester is subject to shrinking when heated. Normal non-aircraft fabric is pre-shrunk as part of the manufacturing process. Aircraft fabrics are woven from unshrunken fibre, allowing them to be heat shrunk after installation on the aircraft. Currently available fabrics include the following:

23.3.1.1 CECONITE / POLYFIBER

Ceconite and Poly-Fiber fabrics are manufactured in USA and are now both owned by Consolidated Aircraft Coatings. Each type has 3 weights of fabric. While they are labelled differently they are in fact identical. The 3 fabric weights are as follow:

Ceconite Label	Poly-Fiber Label
Uncertified Light	Uncertified Light
Ceconite 102	Medium
Ceconite 101	Heavy-Duty

Ceconite 101 / Poly-Fiber Heavy Duty are not normally used on sailplanes.

Ceconite 102 / Poly-Fiber Medium is required on aircraft with wing loadings over 44kg/m2. Wing loadings on all our wooden sailplanes are substantially below this value.

Uncertified Light is generally acceptable for use on sailplanes, however consideration should be given to using Ceconite 102 / Poly-Fiber Medium on areas subject to unusual loads. This would include undersides of fuselages subject to launch cable and loose stone impact and areas subject to excessive prop wash on motorgliders.

23.3.1.2 ORATEX

Oratex fabrics are manufactured in Germany by Lanitz-Prena Folien Factory GmbH. They produce 2 weights of fabric as follow:

a. Oratex 6000

b. Oratex 600

Oratex 6000 is the heavier fabric and is recommended for use on sailplanes subject to heavy use, such as for training. Oratex 600 may be acceptable on sailplanes which fly less frequently or carry less weight. If in doubt information can be found in the Oratex application manual or a factory “application request” can be sought.

Oratex fabric differs from the Ceconite / Poly-Fiber range by being precoated. It is available in a range of colours.

23.3.2 CARE OF FABRIC PRIOR TO APPLICATION

All fabrics should be kept clean and free of dust, oils and any other contaminants which may affect the glues or paints which will be used in the covering application. They also should be kept dry and not exposed to harsh light.

Folding polyester based fabrics (Ceconite and Oratex) should be avoided as it may introduce “white breaks” in the fabric fibres and reduce the tensile strength of the covering. This is especially true of the inner creases of fabric which has been folded multiple times. Storage of these fabrics should be by rolling them

Before beginning, check the whole fabric roll for blemishes, such as weaving mistakes or minor cuts, which may spoil the final finish. The blemishes may be able to be worked around if found early enough, but once cutting the fabric has begun, late discovery will be harder to work around.

23.4 CURRENT ADHESIVE AND COATING PRODUCTS

23.4.1 CECONITE (RANDOLPH) NITRATE / BUTYRATE DOPE SYSTEM

Ceconite fabric is utilised with a series of nitrate and butyrate coatings and associated materials to provide a complete finishing scheme. The following basic products are utilised to complete the scheme:

a. Fabric is attached to the airframe using “New Super Seam” cement.

b. Following heat taughtening with a calibrated iron the whole surface is covered with a brush coat of “Rand-O-Proof” nitrate dope. Rand-O-Proof provides the basic water proofing of the structure. Over closed plywood areas like the ‘D’ nose Rand-O-Proof is applied to the surface and allowed to dry before the fabric is installed. The brush coat through the fabric re livens this earlier coating and bonds the fabric to the plywood. Rand-O-Proof is thinned down with Nitrate thinner before application. This coat must be applied by brush. Spraying will not penetrate the fabric properly. Rand-O-Proof is usually tinted green but tan tinted and clear are available. These two types differ from the green tint for aesthetic reasons only. Typically they are used in places where the inside of the fabric is visible (eg in cockpit areas) or for non-painted schemes.

c. Additional coat(s) of Rand-O-Proof are sprayed on to ensure water tightness of the surface.

d. Non-taughtening clear butyrate dope can now be sprayed on to fill the fabric weave. With the uncertified light fabric this may not be necessary. Elimination of this stage will reduce weight of the finished job.

e. Silver coloured Rand-O-Fill non taughtening butyrate dope is then applied. This dope carries aluminium flakes in suspension and provides critical UV protection for the fabric and underlying structure. Sufficient Rand-O-Fill coats should be sprayed on so that light cannot be seen through the fabric.

f. Finish colour can be achieved by use of either coloured butyrate dope or Ranthane polyurethane paint. Ranthane gives a shinier finish, however it has 2 significant disadvantages:

    i. Future fabric repairs will be much more difficult due to the need to sand the polyurethane off the edges of the old fabric without damaging the underlying fabric.

    ii. The spray mist during application is extremely toxic and requires careful use of a good quality fresh air respirator.

The following notes are applicable to the Ceconite / Nitrate / Butyrate process:

g. The spray mist from all the products is harmful. MSDS sheets for each product should be studied before use. Ranthane is especially toxic.

h. The spray mists are also highly inflammable. Ignition sources including electrical sparking should be eliminated.

i. Butyrate dopes were developed to be less flammable and more flexible than nitrate dopes but they do not adhere as well to the fabric fibres or other surfaces. They should not be used as first coats.

j. For detailed information on the Ceconite / Randolph products refer to the Ceconite Procedure Manual 101. It should be recognised that this manual has been written for heavier GA aircraft and some of the requirements and suggestions are inappropriate for sailplanes which have much lighter wing loadings, lower maximum airspeeds and significantly more rigorous aerodynamic requirements.

Randolph Dopes Application Matrix "Y", Correct Application "NP", Non Preferred Application	210 Tautening Nitrate Dope (clear)	9701 Tautening Butyrate Dope (clear)	G-6302 Rand -O-Proof (green)	W-7868 Non -Tautening Nitrate (blue)	E-4964 Non -Tautening Nitrate (clear)	W-8350 Non - Tautening Butyrate (tan)	A-1690 Non - Tautening Butyrate (clear)	G-6303 Rand-O-Fill (silver)	EV-400 Epoxy Varnish	Colored Non - Tautening Butyrate Dope	Ranthane Polyurethane
Organic fabrics till shrunk	NP	Y									
Organic fabrics fill after shrinking						Y	Y				
Organic fabrics UV protection after fill								Y			
Ceconite Tapes, precoat and 1st coat			Y	Y	Y						
Ceconite 2nd coat and fill						Y	Y				
Ceconite UV protection coat(s) after fill								Y			
Varnish/Undercoat for wood									Y		
Colour top coat										Y	Y
286 Nitrate thinner	Y		Y	Y	Y						
9703 Butyrate thinner		Y				Y	Y	Y		Y	

23.4.2 OTHER NITRATE / BUTYRATE DOPE SYSTEMS

A number of other manufacturers provide Nitrate and Butyrate dopes for aircraft use. The use of these products is similar to the Randolph system described above.

23.4.3 POLY-FIBER VINYL COATING SYSTEM

Poly-Fiber fabric is utilised with a series of vinyl coatings and associated materials to provide a complete finishing scheme. The following basic products are utilised to complete the scheme:

a. Fabric is attached to the airframe using "Poly Tak" cement.

b. Following heat taughtening with a calibrated iron the whole surface is covered with a brush coat of "Poly-Brush" vinyl coating. Poly-Brush provides the basic water proofing of the structure. Over closed plywood areas like the 'D' nose Poly-Brush is applied to the surface and allowed to dry before the fabric is installed. The brush coat through the fabric re livens this earlier coating and bonds the fabric to the plywood. Poly-Brush is thinned down with the appropriate Poly-Brush Reducer before application. This coat must be applied by brush. Spraying will not penetrate the fabric properly. Poly-Brush is usually tinted pink.

c. Additional coat(s) of Poly-Brush are sprayed on to ensure water tightness of the surface.

d. Thinned silver coloured Poly-Spray vinyl coating is then applied. This product carries aluminium flakes in suspension and provides critical UV protection for the fabric and underlying structure. Sufficient Poly-Spray coats should be sprayed on so that light cannot be seen through the fabric.

e. Finish colour can be achieved by use of either Coloured Poly-Tone or Aero-Thane polyurethane paint. Aero-Thane gives a shinier finish, however it has 2 significant disadvantages:

i. Future fabric repairs will be much more difficult due to the need to sand the polyurethane off the edges of the old fabric without damaging the underlying fabric.

ii. The spray mist during application is extremely toxic and requires careful use of a good quality fresh air respirator.

The following notes are applicable to the Poly-Fiber process:

a. The spray mist from all the products is harmful. MSDS sheets for each product should be studied before use. Aero-Thane is especially toxic.

b. The spray mists are also highly inflammable. Ignition sources including electrical sparking should be eliminated.

c. For detailed information on the Poly-Fiber products refer to the Poly-Fiber Aircraft Coatings manual. It should be recognised that this manual has been written for heavier GA aircraft and some of the requirements and suggestions are inappropriate for sailplanes which have much lighter wing loadings, lower maximum airspeeds and significantly more rigorous aerodynamic requirements.

Poly-Fiber System Application Matrix "Y", Correct Application "UL", For weak UV protection. Poly-Fiber suggest for Ultralights only.	Poly--Tak Fabric Cement	Poly--Brush	Poly--Spray	Poly-Tone Finish	Ranthane Polyurethane	Enamel	Aero-Thane	AO-I00 Clear Aero-Thane	UV-550 Urethane Varnish	EV-400 Epoxy Varnish	EP-420 Epoxy Primer (green or white)
Fabric cement for seams/main attachment	Y										
1st & 2nd coat and tapes etc.		Y									
UV protection coats			Y					UL			
Fabric colour topcoats				Y	Y		Y				
Metal/FRP colour topcoats				Y	Y	Y	Y				
Metal primer											Y
Aluminum varnish								Y			
Wood varnish									Y	Y	
R 65-75 Reducer (65-75 Deg. F)		Y	Y	Y							
RR 8500 Reducer Retarder (85+ Deg. F)		Y	Y	Y							
BR-8600 Blush Retarder		Y	Y	Y							
RJ 1200 Rejuvenator				Y			Y				
G-4200 Ranthane Reducer					Y						
D-7201 Ranthane Accelerator					Y						
UE-820 Urethane Reducer							Y	Y			
UR-826 Urethane Retarder							Y	Y	Y		
E-500 Epoxy Reducer										Y	Y
EX-501 Epoxy Accelerator										Y	Y
Enamel Reducer						Y					
Ultra Violet Blocker				Y							
Flattener				Y	Y	Y	Y				

23.4.4 ORATEX SYSTEM

Oratex fabric is delivered completely pre finished with polyurethane. It is available in a range of colours. The following process is used to complete the job:

a. Fabric is attached to the airframe using “Oratex Dispersion Hotmelt Adhesive”. The adhesive is painted on to the structure and the fabric and allowed to completely dry. This is a water based product and is best left 24 hours. Once dry, the surfaces are brought together and tacked using a calibrated hot air gun at 50^0C. Once tacked a final setting pass is made with an iron at 90^0C. The following points should be noted in relation to this process:

b. A piece of stiff felt is used to impart pressure to the joint in the first (hot air gun) pass. The iron is used to impart pressure to the joint in the second pass. Heat and pressure need to be applied for about 10 seconds.

c. The fabric can still be moved slightly during the first lower temperature pass. The second higher temperature pass fully hardens the adhesive. The fabric cannot be moved during this pass.

d. To prevent iron marks on the fabric a Silicon Release Paper is placed between the iron and the fabric.

e. Following attachment to the surface the fabric is heat shrunk. Unlike the Ceconite and Poly-Fiber processes, shrinking is carried out with a calibrated hot air gun. Shrinking commences at 100^0C. Each 10^0C the fabric shrinks approximately 1% biaxially. Recommended maximum stretching temperature over wood structures is 180^0C. Temperatures above 200^0C will damage the fabric. During fabric installation it should be hand stretched as much as possible to ensure a satisfactory final tension without exceeding the recommended temperatures.

The following notes are applicable to the Oratex process:

a. For detailed information on the Oratex process refer to the Oratex Application Manual. It should be recognised that this manual has been written for heavier GA aircraft and some of the requirements and suggestions are inappropriate for sailplanes which have much lighter wing loadings, lower maximum airspeeds and significantly more rigorous aerodynamic requirements.

b. Because the Oratex products don’t contain organic solvents they can be air freighted.

c. While Oratex does use water based adhesives, water ***must not*** be used to thin the adhesive.

d. Oratex utilises modern chemical UV blockers rather than an aluminium layer. Accordingly light can be seen through the fabric (see detail comments, 1.5.2).

e. Because temperature control is critical to the process it is recommended that Oratex supplied iron and hot air gun be used. It is also strongly recommended by the factory that the shrinking takes place with multiple steps of small temperature increases, rather than one big attempt at shrinking.

f. When using the Oratex system on refurbished steel tube structures the factory recommend using a two pack paint as they have found some older and single pack paints do not adhere to the steel well enough for the Oratex adhesives to have a secure bond. If in doubt, a small patch can be glued in an unobtrusive spot and a peel test carried out.

g. Spot shrinking of wrinkles etc, should not be carried out until the whole structure is covered as there is a small chance that the fabric could be pulled out of position.

23.5 FABRICING OF WINGS

23.5.1 FABRIC LAYOUT

Wooden powered aircraft, especially those of US origin, traditionally were covered with a length of fabric applied along the top surface with a separate length along the underside. This resulted in joints at the leading and trailing edges. The leading edge joint was taped.

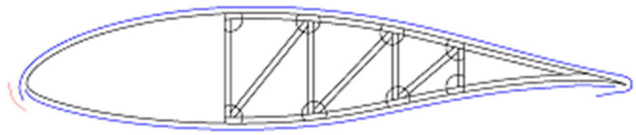


Figure 23-1 Typical Powered Aircraft Wing Fabric Layout

Wooden sailplanes were covered with a length of fabric wrapped around the trailing edge and bonded to the top and bottom surfaces around the spar line. Commonly European built sailplanes did not have fabric over the leading edge. Sailplanes built by Schneider in Australia had a leading edge fabric which was bonded over the trailing edge fabric. These lap joints should not be taped.

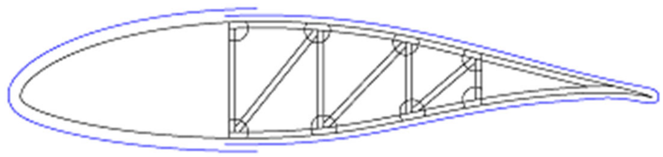


Figure 23-2 Typical Sailplane Wing Fabric Layout

Generally paint over plywood without fabric failed prematurely in Australian conditions. It is recommended that plywood be fabric covered in any resurfacing.

Handbooks published by fabric/dope manufacturers follow the traditional powered aircraft fabric layout. Since jointing/taping at the leading edge will degrade a sailplane's aerodynamic performance, it is recommended that traditional sailplane fabric layout be followed. This is critically important for later wooden aircraft like the ES60 Boomerang and Scheibe Bergfalke IV which utilise early Wortmann laminar flow profiles.

23.5.2 FABRIC DETAIL

While we do our best to keep our aircraft protected from the elements we must accept that they will be caught in the rain from time to time. Accordingly fabric needs to completely cover all wooden surfaces including root ribs, inside aileron cut outs and preferably under metal fittings bolted to the surface (aileron hinges etc). It is generally better to apply fabric in these areas before laying down the main fabric. This way the main fabric can be lapped over the detail material.

Fabric should also be folded down into and bonded at airbrake cut outs etc.

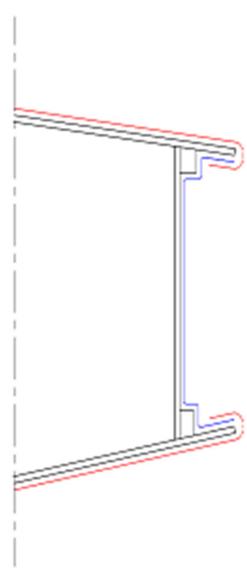


Figure 23-3 Fabric Detail in Aileron Cut Out

When using fabrics which require no further coatings, such as Oratex, colour differences in the substrate may show through where the fabric is in direct contact with the substrate. A light coloured fibreglass nose fairing with dark repair patches may cause a “blotchy” finish. Where this happens the substrate should be given a light coat of a consistent colour. This is most noticeable on lighter coloured schemes and is less noticeable if the different coloured areas are some distance apart, for instance, the nose and turtle deck. This has no effect on the strength or airworthiness of the finish but it can make an otherwise acceptable finish less aesthetically pleasing.

Polyester fabric schemes should only be shrunk as much as is needed rather than as much as possible, to avoid damage to the underlying aircraft structure.

23.5.3 RIB STITCHING

Traditionally powered aircraft were rib stitched. Sailplanes, with their lower wing loadings and slower speeds, were not.

With cotton fabric and nitrate dope, the dope penetrated the cotton thread and acted as both the bonding agent and the taughtening agent. With polyester fabric the fabric cement does not penetrate the fabric threads, but is dependent on encapsulating the fabric weave. If the rib is not stitched it is critical to ensure thorough encapsulation to effect a satisfactory bond.

With nitrate/butyrate and Poly-Fiber vinyl schemes the fabric is heat shrunk after bonding to the structure, but before application of any dopes. The dopes utilise identical solvents to the fabric cement. On concave surfaces (underside ribs) initial brush coats of dope are likely to temporarily soften the fabric cement to the extent that the taught fabric pulls clear of the ribs. This is difficult to repair, so care should be taken when applying the brush coat if rib stitching is not utilised. Oratex fabric is precoated so this problem will not be encountered.

If rib stitching is used, either a propriety stitching thread or a good quality linen thread can be used.

23.6 FABRICING OF FUSELAGES

23.6.1 FABRIC LAYOUT – WOODEN FUSELAGE

Fuselages vary in shape and size. It will be necessary to consider the fabric layout before commencing each job. The following issues should be taken into consideration:

a. Width of fabric

b. Location of lap joints

c. Complexity of shape and associated difficulty applying large sections. The nose cone area can provide a challenge which may be best handled with a separate piece of fabric.

d. If laps are required at right angles to the airflow the leading fabric should be lapped over the trailing fabric

23.6.2 FABRIC LAYOUT – STEEL TUBE FUSELAGE

The issues shown in 23.6.1 above are also relevant to steel tube fuselages. The following issues also need to be taken into consideration:

a. Fabric can only be jointed at a tube. The first piece of fabric applied is wrapped around the tube and the second piece is lapped over the first.

b. The underside fabric around the wheel and release is commonly subject to damage in service. It is best if the fabric layout provides a separate piece of fabric in this area which is installed last. This allows easy replacement of damaged fabric during maintenance. This final piece of fabric can also be of a heavier grade to resist damage.

c. Fins are bolted to the steel tube fuselage. It is best to fabric the steel tube fuselage and the fin separately. Once the fin is bolted on a bridging tape or fabric section can be applied. This allows relatively easy fin removal during later maintenance/survey.

d. Where fabric bends around a longeron it is subject to wear and handling damage. Placing a tape over the bend provides a wear surface and is relatively easy to replace if it is damaged. This is particularly the case with lower longerons where the fabric is subject to grass/stone damage.

23.6.3 FABRIC DETAIL

Fabric detail considerations should be similar to those for wings (see 23.5.2 above).

23.7 FABRICING OF TAILPLANES

23.7.1 FABRIC LAYOUT

Fabric width is sufficient to cover a tailplane without joints except at the trailing edge. Where a tailplane leading edge is tapered it will be necessary to have a fore/aft lapped joint at the centreline of the tailplane.

23.7.2 FABRIC DETAIL

Fabric detail considerations should be similar to those for wings (see 23.5.2 above).

23.8 WEIGHT AND BALANCE AND LOGBOOK ENTRY

23.8.1 WEIGHT AND BALANCE REQUIREMENT

If the whole aircraft or any significant section is refabriced the aircraft must be reweighed and pilot weights recalculated by an inspector holding the necessary authorisation.

23.8.2 LIKELY WEIGHT OUTCOME

Generally aircraft requiring new fabric have had paint added over time during maintenance so they are likely to lose weight when refabriced. The potential outcomes of this are as follow:

a. Total empty weight will reduce. A higher allowable maximum pilot weight is possible

b. Total weight of non-lifting parts will reduce (assuming tailplane/fuselage have been refabriced). A higher allowable maximum pilot weight is possible.

c. Empty centre of gravity will move forward (assuming tailplane/fuselage have been refabriced). This will allow a lower minimum pilot weight to be placarded. In a few aircraft (e.g. Motorfalke) this may incur a reduction in maximum pilot weight due to forward centre of gravity limit consideration.

23.8.3 LOGBOOK ENTRIES

The logbook entry for the refabric work must accurately describe the aircraft components refabriced and details of the scheme utilised including the final topcoat colour. This will make life much easier for future fabric maintenance.

Following reweigh, the weight and balance records must be updated in the logbook and the pilot weight placard updated in the cockpit.

23.9 REMOVAL OF OLD FABRICS AND DOPES

23.9.1 NECESSITY

It is critical that all remnants of previous coverings be removed before commencing new fabric work. It is likely new materials will not be compatible with previously used schemes.

23.9.2 REMOVAL TECHNIQUES

Often fabric can be carefully pulled away from the surface complete with its topcoats. Care should be taken to not damage underlying structure while pulling the fabric.

Old degraded cotton fabric with many layers of paint is likely to disintegrate when pulled. It will then be necessary to remove the paint and dopes layer by layer. Paints and dopes will generally respond to appropriate strippers and solvents. Polyurethane top coats are especially difficult and will need to be sanded off. Caustic paint strippers should be thoroughly cleaned off plywood surfaces with a solvent to prevent damage to the plywood.

Following removal of fabric, residual dope must be removed from the surface. This is best done by laying a rag soaked with the relevant solvent on the surface for 10 minutes, then scraping. Solvent soaked steel wool rubbed along the timber grain does a good job of final clean up.

23.10 FABRIC REPAIRS AND INSPECTION

23.10.1 TYPES OF DAMAGE

Fabric damage is likely to take one of the following formats:

a. Large damage area associated with structural damage

b. Smaller fabric penetrations due to hangar/trailer rash or access holes cut for inspection/maintenance

c. Fabric "dents" in open structure areas

d. Surface coating degradation and cracking

23.10.2 REPAIR MATERIALS

Since dopes and paints are not compatible across schemes, fabric repairs should be made using the same products as the original.

23.10.3 REPAIR FUNDAMENTALS

Fabric repairs should be carried out as follows:

a. Be generous with the lap width

b. For solvent based fabric cements existing surfaces have to be stripped back to the bare fabric before the patch is glued on.

c. With Nitrate/Butyrate and Poly-Fiber schemes a significant dent on open panel areas will need to be cut out and patched. With Oratex fabric the dent is likely able to be stretched out with the hot air gun.

23.10.4 REPAIR TECHNIQUES

The following techniques are useful:

a. When repairing damage in the middle of an open panel it may be easier to cut back and repair to a point where the fabric is solidly supported

b. When solvent removing dope etc around the edge of the damage area it is best to support the inside of the fabric by holding a small piece of plywood or sheet metal behind the fabric. This will minimise the amount of stretching of the fabric. Alternatively, not cutting the fabric repair to its final size until after the dope has been removed can also avoid unwanted stretching of the remaining fabric.

c. Polyurethane top coats will not respond to any solvents or dopes. Where the fabric lap is over plywood it can be carefully sanded back using 280 grit paper. Once through the polyurethane remaining dope layers can be removed with solvents. In open fabric areas where access to the rear of the fabric is available through the hole, soaking the rear with appropriate solvent will allow the complete surface coatings to be prised away from the fabric.

d. Pinking the edges of a patch will help to get the edges to sit down neatly.

e. Finishing and top coats should be identical to the original.

f. Sprayed Butyrate or Poly-Tone top coats will be easy to blend in with the original surface. With Polyurethane top coats it is likely the complete panel will need to be sprayed over to achieve a blend.

g. With Oratex don't leave any cement on the surface beyond the limit of the joint. It will be difficult to remove later.

h. Rejuvenators are available to bring degraded/cracked Butyrate and Poly-Tone top coats back to life. Polyurethane surfaces weather better, but cannot be rejuvenated. If a top coat is cracking and it is not caused by an underlying structural fault, it may indicate that the original coatings were too thick.

23.10.5 FABRIC INSPECTION

The sailplane inspection regime must include the fabric and associated coatings. With polyester fabrics the fabric will last a long time provided the surface UV protection is effective.

If there is any doubt about the integrity of the fabric, the only true test is to remove a sample and subject it to tensile test. AC 43.13.1B allows minimum tensile strength to degrade to 35 pound per inch before the fabric must be replaced (sailplanes). The test is easy to conduct. A one inch wide strip of fabric with coatings removed needs to be carefully clamped at each end and pulled with a spring balance to failure. If it exceeds 35 pound the fabric is still airworthy.

At any time fabric damage occurs and a repair is necessary it is worth considering removal of a sample for testing. The additional size of the ensuing repair does not add much time to the job.

Cotton fabric tears very easily once it has a hole. Minimum tear strength of brand new cotton for sailplanes was only 3 lb (AC 43.13.1B). Accordingly tear strength is a poor indication of fabric condition. While polyester fabrics have better tear strengths, tensile testing is still the only reliable test for integrity.

23.11 REFERENCES

AC 43.13-1A Change 3. Acceptable Methods, Techniques and Practices. IAP Inc., Casper, Wyoming, 1988. (Chapter 2)

Aviation Maintenance Technician Handbook–Airframe, Volume 1, 2012. (Chapter 3)

Standard Repairs to Gliders (Section 2), British Gliding Association.

Ceconite Procedure Manual 101, June 2008.

Polyfiber Procedure Manual 1, “How to Cover an Aircraft Using the Poly-Fiber System”, Revision 21.

Oratex Application Manual ADxC-51-001-AMM Edition 5.4

Stewart Systems Fabric Covering and Finishing Manual 21, Second Edition, March 2009

24. SAILPLANE UNDERCARRIAGE

24.1 GENERAL

The undercarriage supports the sailplane when it is on the ground. It allows the sailplane to move with minimal friction when landing, taking off or moving on the ground. The undercarriage also provides some degree of suspension when moving over rough surfaces or during landing. In some types, the undercarriage can be retracted, in part or totally, into the sailplane to reduce drag. It also carries the brakes and provides braking. And influences ground handling and balance on the ground dependent on configuration (but has little influence in the air).

24.2 MAIN UNDERCARRIAGE ARRANGEMENTS

The main undercarriage supports all of, or a major part of, the weight of the sailplane. There are a number of different ways this can be achieved:

24.2.1 SKID

The most basic and earliest form of undercarriage is the skid where a solid structural member slides along the ground. It is not usual to find any sailplanes now with a skid alone, a main skid is more normally used in combination with a main wheel located behind the centre of gravity. Typically found on older training sailplanes such as Bergfalkes and Schleicher K7/8/13.

24.2.2 MONOWHEEL

A single large wheel located near the sailplane centre of gravity is by far the most common form of undercarriage and is the type commonly found on non-powered sailplanes. It can be either fixed or retractable.

24.2.3 TAILDRAGGER

A “conventional” undercarriage arrangement consists of two main wheels located forward of the centre of gravity. This arrangement is common on touring motorgliders such as the Grob 109, Dimona H36 and some later Motorfalkes. Retractable versions can be found on the Stemme S10, Ximango and IS28M2.

24.2.4 TRICYCLE

A tricycle undercarriage consists of two main wheels located behind the centre of gravity and one other main wheel located under the nose. The nose wheel is usually the same size as the mains but it may be slightly smaller than the other two. Examples are the Super Dimona and Valentin Taifun.

24.2.5 OTHER

Other types of undercarriage, such as skis for snow or floats for water do exist and have been used on sailplanes. However, as these would not practically be used in Australia they will not be addressed in this manual.

24.3 SUPPLEMENTARY UNDERCARRIAGE ARRANGEMENTS

In addition to the main undercarriage located somewhere near the centre of gravity, there are often supplementary parts of the undercarriage at the extremities of the aircraft which support a minor portion of the aircraft weight, are used for balance and/or are located to reduce shocks to the airframe when it is moving.

24.3.1 SKID – NOSE OR TAIL

A skid is used for its simplicity. It has no moving parts, so is easier to maintain than a wheel. It has more friction than a wheel which can assist in the braking of a sailplane when landing. This was helpful in older sailplanes which had poor or non-existent wheel braking systems, however this causes wear on the skid structure itself. To reduce wear, the skid usually has a wear plate of metal or tough plastic.

Most monowheel sailplanes of the 1960s to 1980s with wheels forward of the centre of gravity were produced with tailskids. Tailskids can be found on virtually all wooden sailplanes, Blaniks, LS and Schleicher sailplanes, Schempp Hirth Standard Cirrus, Nimbus and Ventus as well as Grob Single and Twin Astirs. Many of these tailskids were subsequently modified to tail wheels.

Some sailplanes, notably the Blanik, may have a small nose skid or bumper to prevent damage to the underside of the nose if the aircraft is upset by too severe braking or sudden stopping.

Where the main wheel is located behind the centre of gravity the sailplane will rest on its nose when loaded for flight. In this case the skid is normally substantial as it is subject to large forces on badly handled landings and really forms part of the main undercarriage (see 24.2.1).

24.3.2 WHEEL – NOSE OR TAIL

Instead of a skid it is more common on modern aircraft to find a tail wheel or nose wheel and on some trainers depending on the location of the main wheel with respect to the centre of gravity. In cases where the empty sailplane tail rests on the ground, but the loaded sailplane nose rests on the ground, both a nose and tail wheel might be found on the one aircraft. The nose wheel for takeoff and landing, the tail wheel for ground handling.

The balance varies from one extreme to the other. Eg the PW-6 is strongly nose heavy on the ground and so acts as a nose-wheel aircraft. Whereas IS-28 and many self-launchers have heavy tailwheel balance and act as tailwheelers. Others like the DG-505 or some DG-1000 are neutrally balanced – this makes for easy ground handling. They all fly the same but on the ground act differently, and in a botched landing may whip lash from front to rear in different ways and so must be inspected for damage accordingly.

While a small wheel arguably is more complex than a simple skid, wheels give better directional stability on the ground and less rolling resistance during takeoff. A nose wheel used in place of a skid is substantially lighter.

In a few cases, such as the SF27M, the tail wheel may be steerable, self-launchers need a steerable wheel – nose or tail. Eg the ASK21Mi has a front steerable nose wheel.

24.3.3 OUTRIGGERS

Outriggers are smaller supplementary wheels mounted on long stalks under the wings in approximately the half span position. They are used to keep the wings level during low speed taxiing on mono-wheel motorgliders. This arrangement is seen on the Motorfalke, Fourniers and the Europa.

24.3.4 WINGTIPS

The wingtips may also carry a supplementary device to prevent damage to the under surface of the wing tips. These can be small skids, wheels or wire loops. Sometimes these items also serve as the tie down attachment point. They should not be overlooked when maintaining the whole undercarriage. And deserve inspection at every daily inspection as they often suffer.

24.3.5 DOLLIES AND WiNG WALKERS

Wing walkers and tail dollies are used when ground handling. They are not a part of the aircraft when it is flying, so strictly are not covered by any certification or other rules. They can be supplied by the manufacturer or locally made to suit the aircraft.

They should be examined carefully to ensure that they will not cause inadvertent damage to the sailplane. They should be maintained just as well as the other parts of the sailplane undercarriage.

They have often caused damage to sailplanes mainly by poor installation and handling. Check they are suitable and are handled carefully.

24.4 TYRES

24.4.1 GENERAL

An aircraft tyre must withstand a wide range of operational conditions. While on the ground, it must support the weight of the aircraft. During movement, it must provide a stable, cushioned ride while resisting shock loads, rotational stresses, abrasion, and wear. The tyre is a composite of a number of different rubber compounds, fabric material and steel. Each component serves a specific purpose in the performance of the tyre.

Two different and distinct aircraft tyre constructions are available.

a. The Bias tyre (cross-ply construction), this is the most common type.

b. The Radial tyre, this type is not usually seen on pure sailplanes.

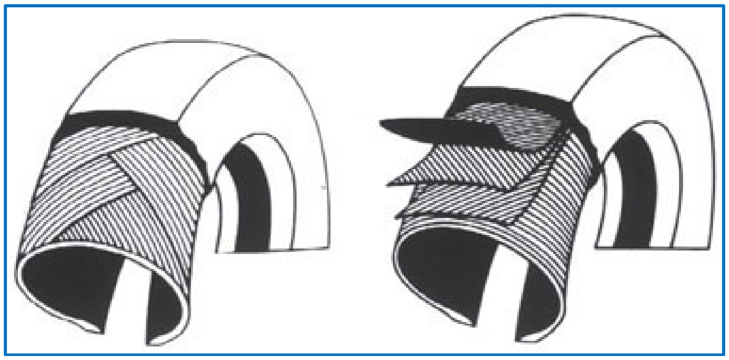


Figure 24-1 Tyre Construction. Cross Ply (Left), Radial (Right)

24.4.2 PARTS OF THE TYRE

Tread: The tread refers to the part of the tyre that comes in contact with the ground. The tread rubber compound is formulated to resist wear, abrasion, cutting, cracking, etc. It prolongs the life of the casing by protecting the underlying tyre structure. The tread may contain grooves or patterns which act as a visual indicator of tread wear and provide a mechanism to channel water from between the tyre and runway surface.

Casing Ply: The ply consists of fabric cords between two layers of rubber. They give the tyre its primary strength and are anchored around the bead wires. Multiple layers of plies are bonded together, as necessary, to form the casing and give the tyre the capability to hold the inflation pressure.

Casing: The combination of all the parts of the tyre except the tread zone.

Bead The bead contains wires or synthetic rope which anchor the tyre to the wheel and transfer the load to the wheel.

Sidewall: A layer of rubber covering the outside of the casing. Its purpose is to protect the casing and it can carry surface markings.

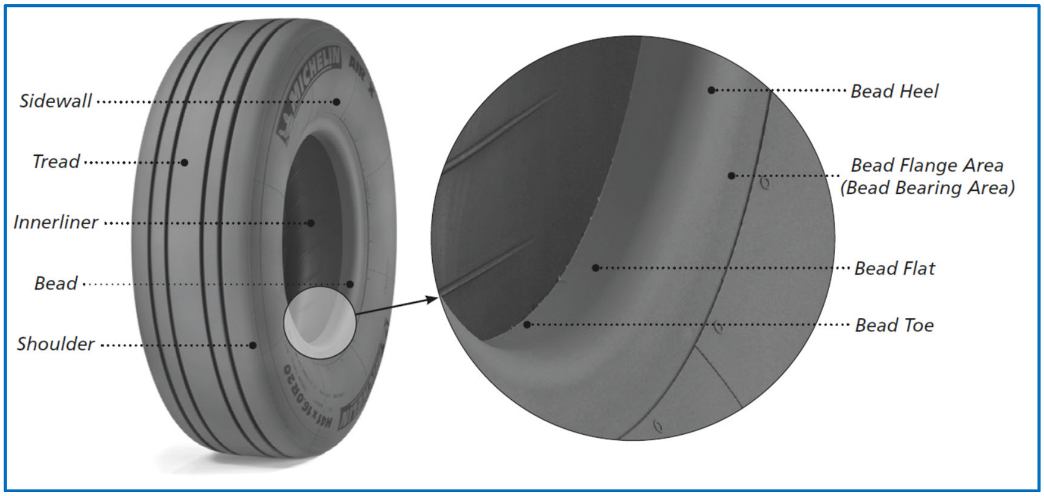


Figure 24-2 Parts of a Tyre

24.4.3 TYRE MARKINGS

Information is moulded into the rubber of tyres. It will include the manufacturer and tyre size and may include other information such as plies and various rating.

24.4.4 RATINGS

The speed rating of a tyre (for example, 225 mph) is its maximum rated ground speed (approved after completion of tests on the tyre at that speed).

The Ply Rating (PR), (for example, 22 PR), is an index which can identify the maximum rated static load that can be applied to the tyre when it is inflated to a specified pressure and is used in specified conditions of operation. It is not the number of plies.

The Load Rating (LR) is the maximum static working load that is permitted.

24.4.5 PLIES

The number and type of plies affect the tyre rigidity, load capacity and resistance to penetration. Plies are the layers of reinforcement as shown in Figure 24-1 above. They can be steel, canvas or synthetic fabric. In aircraft tyres they are often synthetic for lightness.

24.4.6 SIZE NOMENCLATURE

Two-part tyre size specification: N – D

N = nominal width of the tyre at the widest point, indicated in inches
D = nominal diameter of the tyre seat, in inches, corresponds to the wheel rim size

Example:
5.00-5 = tyre width 5"or 127 mm and tyre seat 5"
4.00-6 = tyre width 4"or 102 mm and tyre seat 6"

Two-part tyre size specification: M x N

M = nominal outside diameter of the tyre, expressed in millimetres or inches
N = Nominal tyre width in the widest point, expressed in millimetres or inches

Example:
210x65 = outer diameter 210mm, tyre width 65mm

Three part specification of tyre size: M x N – D

M = nominal outside diameter of the tyre, expressed in millimetres or inches
N = Nominal tyre width in the widest point, expressed in millimetres or inches
D = nominal diameter of the tyre seat, in inches, corresponds to the wheel rim size

Example:
380x150-5 = Outside diameter tyre 380 mm, widest place 150 mm, tyre seat 5"or 127 mm
15x6.00-5 = Outside diameter tyre 15"/ 380 mm, widest place 6" / 150 mm, tyre seat 5 "

If the "-" is replaced by the letter "R" the tyre is of radial construction.

24.4.7 INSPECTION

The surface condition of a tyre can be inspected with the tyre on the aircraft. The tread should be checked for abnormal wear. If the tread is worn in the centre of the tyre but not on the edges, this indicates that the tyre is over-inflated and the operational air pressure should be reduced. On the other hand, a tyre worn on the edges, but not in the centre, indicates under-inflation. These indications are shown in the following figure. Wear is relative to the design shape, ie should it be flat or rounded.

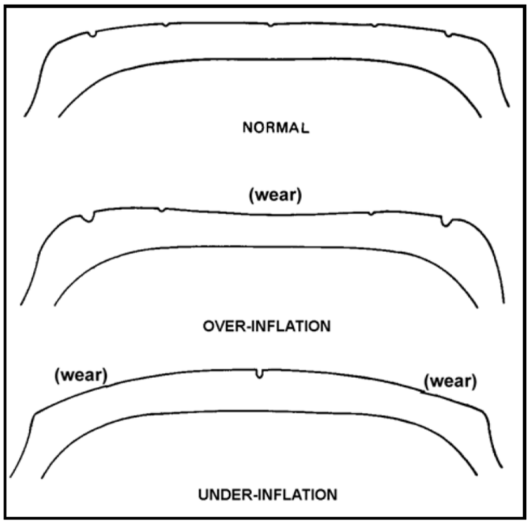


Figure 24-3 Tread Wear Patterns

The following guidelines should be used for tyre inspection:

a. **Tread Wear.** Inspect the tyres visually for remaining tread. Tyres should be removed when tread has worn to the base of any groove at any spot, or to a minimum depth as specified by the tyre or aircraft manufacturer. Tyres worn to fabric in the tread area should be removed regardless of the amount of tread remaining.

b. **Uneven Wear:** If tread wear is excessive on one side, the tyre may be dismounted and turned around, providing there is no exposed fabric. However, this may indicate some form of gear misalignment which should be investigated. But due to splayed gear and deflection due to load and landing on one wheel it is very common for dual gear tyres to wear and need turning.

c. **Tread Cuts:** Inspect tread for cuts and other foreign object damage, and mark with crayon or chalk. Remove tyres that have the following:

    i. Any cuts into the carcass ply.

    ii. Cuts extending more than half of the width of a rib and deeper than 50 percent of the remaining groove depth.

    iii. Weather checking, cracking, cuts, and snags extending down to the carcass ply in the sidewall and bead areas.

    iv. Bulges in any part of tyre tread, sidewall, or bead areas that indicate a separation or damaged tyre.

    v. Cracking in a groove that exposes fabric or if cracking undercuts tread ribs.

d. **Flat Spots:** Generally speaking, tyres need not be removed because of flat spots due to skid burns unless fabric is exposed. If an objectionable unbalance results from the flat spot, then remove the tyre from service.

e. **Beads:** Inspect bead areas next to wheel flanges for damage, especially if brake drag or severe braking has been reported during ground towing (taxiing for motorgliders), takeoff or landing.

f. **Tyre Clearance:** Look for marks on tyres, the gear, and in the wheel wells that might indicate rubbing due to inadequate clearance.

24.4.8 STORAGE

For long term storage, tyres and tubes should be kept in a cool, dry and reasonably dark location, free from air currents and dirt.

Avoid sunlight as UV rays will damage the rubber.
Avoid contact with hydrocarbon-based contaminants such as oil, petrol and grease as hydrocarbon contaminants will deteriorate rubber.

Don’t store at temperatures greater than 35°C for extended periods.

24.5 TUBES

24.5.1 GENERAL

Aircraft tyre tubes are made of a natural rubber compound. They contain the inflation air with minimal leakage. Tubes come in a wide range of sizes to match tyre sizes. Only the tube specified for the applicable tyre size must be used. Tubes that are too small stress the tube construction.

There is no mandatory age limit for an aircraft tyre tube. It should be elastic without cracks or creases in order to be consider serviceable. The valve area is prone to damage and should be inspected thoroughly. Bend the valve to ensure there are no cracks at the base where it is bonded to the tyre or in the area where it passes through the hole in the wheel rim. Inspect the valve core to ensure it is tight and that it does not leak.

24.5.2 VALVES

The valve used in nearly all vehicle tyres is known as the Schrader valve. It consists of an externally threaded hollow cylindrical metal tube, typically of brass. In the center of the exterior end is a metal pin pointing along the axis of the tube; the pin's end is approximately flush with the end of the valve body.

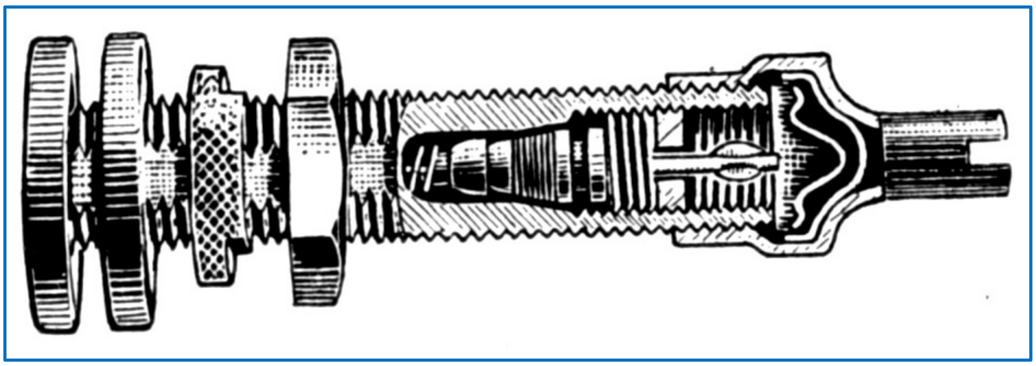


Figure 24-4 Valve Construction

Valve (stem) length and orientation is often a problem in sailplanes and must be checked and fixed so the valve does not rub on the U/C. Some valve stems need a small spacer to hold them in the correct spot – this is often a small length of plastic tube over the stem inside the rim. Tubes are available with a variety of stems and the correct one must be obtained.

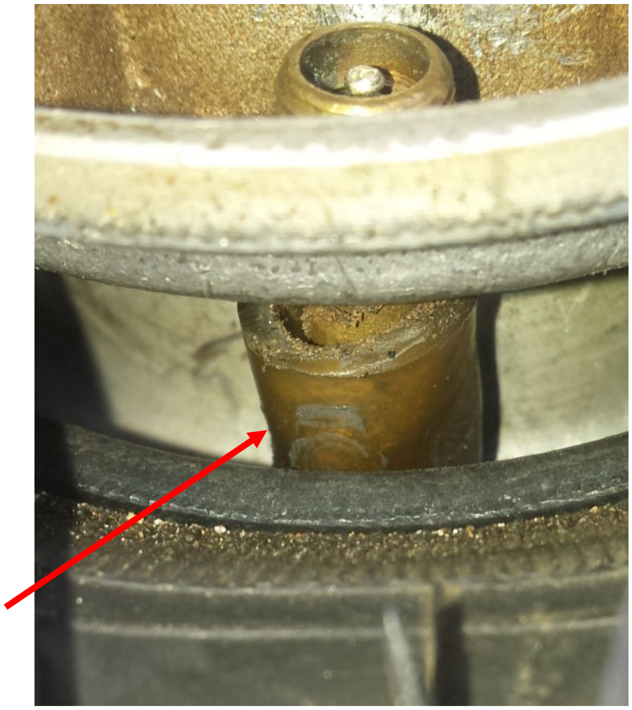


Figure 24-5 Close Up Of Valve Spacer Sleeve To Stop Valve Protruding Too Much

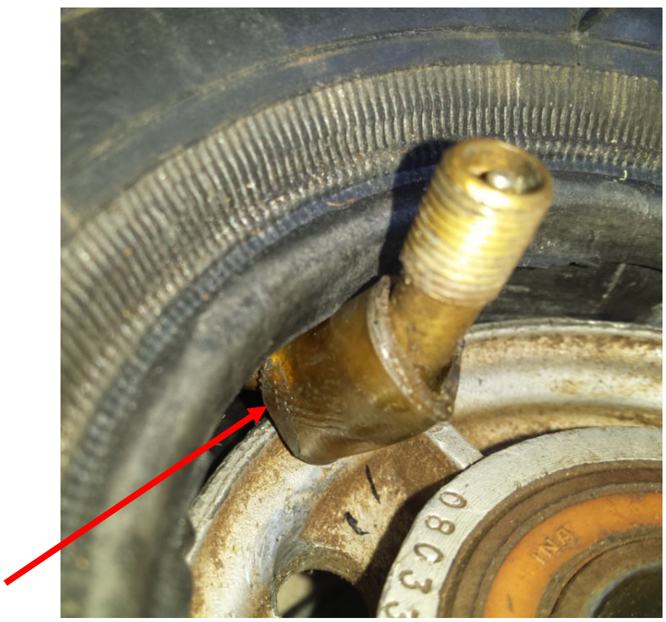


Figure 24-6 Valve Spacer Sleeve To Stop Valve Protruding Too Much

24.6 BRAKES

Most braking systems in sailplanes rely on a direct mechanical connection to the brake on the wheel. This is usually through a Bowden cable. Operation of the wheel brake lever in the cockpit causes the brake pads to be pressed against some part of the wheel to provide friction to slow the sailplane.

24.6.1 DRUM

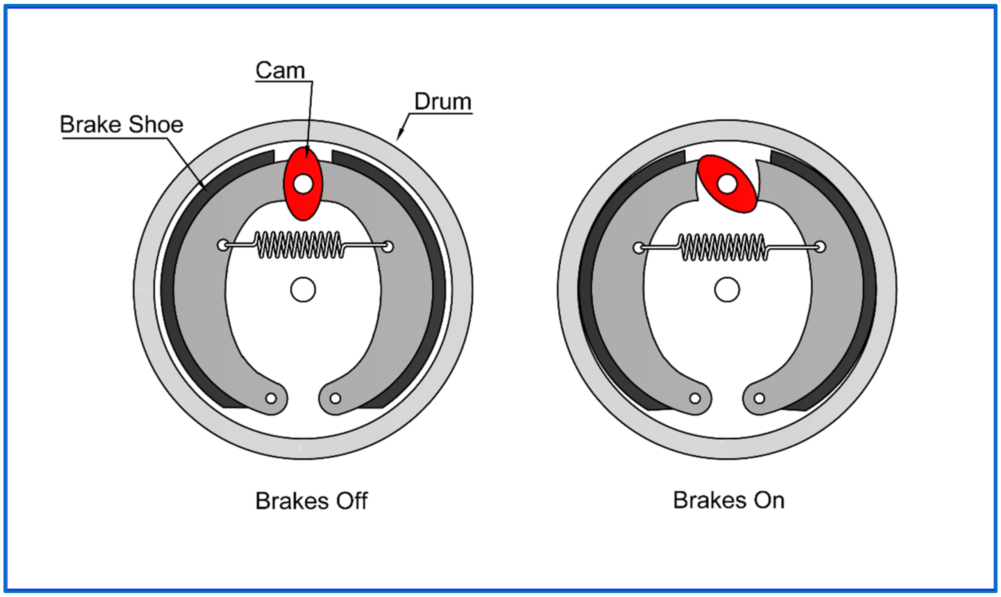


Figure 24-7 Drum Brake Mechanism

The drum brake consists of two brake shoes (pads) inside the hub (drum) of the wheel. The brake shoes are mounted on a fixed portion of the hub which does not rotate with the rest of the wheel. The fixed portion is known as the backing or torque plate. When a cam between the shoes rotates the brake shoes are forced against the inside surfaces of the wheel hub/drum which provides friction and slows the aircraft.

A return spring provides the mechanical force to allow the shoes to clear the drum when the cam is returned to the non-braking position.

With time, the friction lining material on the shoes wear and must be replaced. Caution should be used as asbestos was used in some older lining materials. If so don't blow out with compressed air.

Sailplane drum brakes are most commonly operated mechanically by Bowden cables, however some may have hydraulic cylinders in place of the cam. It should be noted that many early FRP sailplanes were designed to a standard where the brake is defined as an emergency brake only

24.6.2 DISC

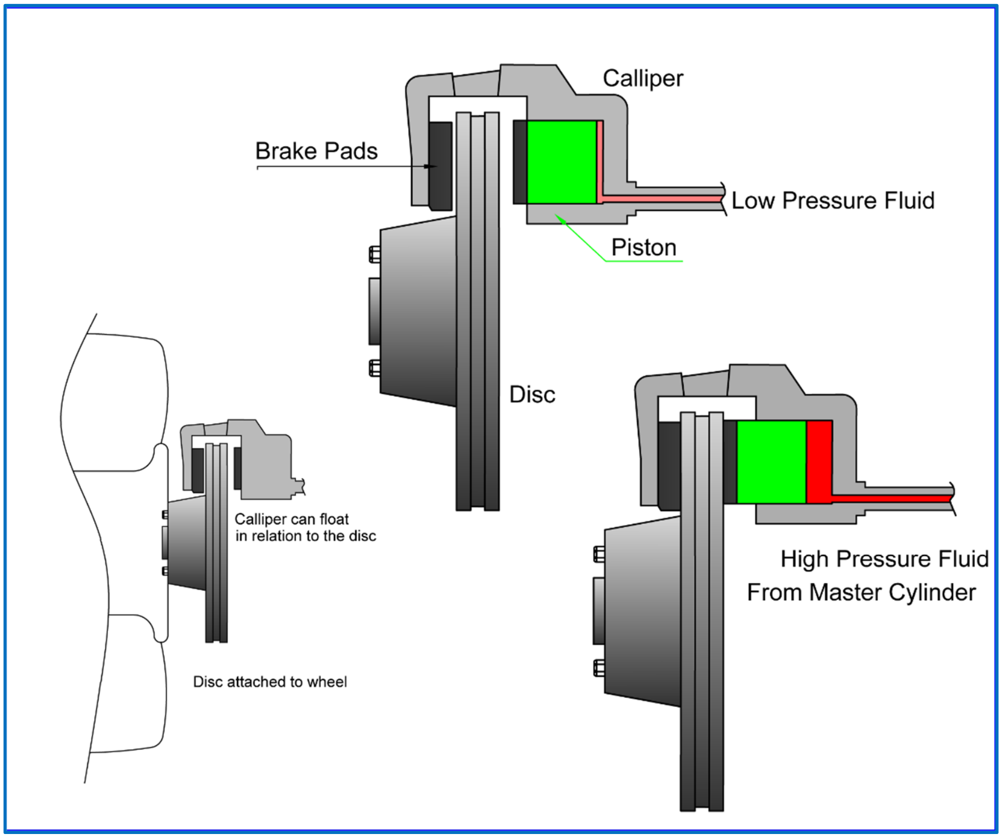


Figure 24-8 Hydraulic Disc Brake Mechanism

Disc brakes are usually hydraulically operated. They consist of a hard steel or iron disc (rotor) which is attached to the wheel. A calliper contains disc pads of friction material which are forced to rub on the brake disc to provide stopping friction. The disc calliper is attached to the airframe. However, where a calliper contains a fixed pad and a pad operated by a cylinder (as shown in Figure 24-7) the calliper may not be fixed solidly, it may float a little along the length of its mounting bolts to allow the pressure of both pads bearing on the rotor to equalise during braking.

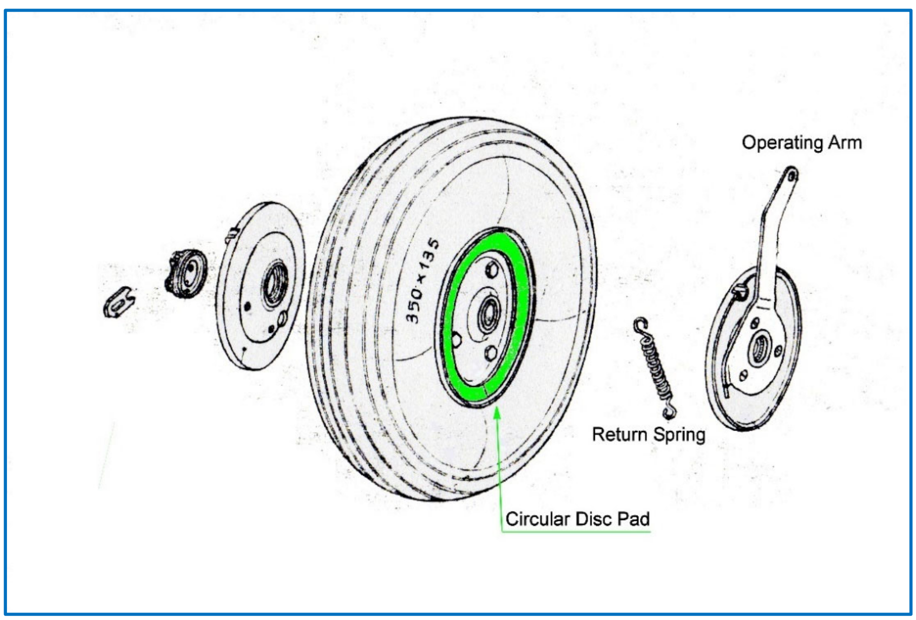


Figure 24-9 Jantar type disc brake mechanism

The Jantar is a mechanical disc brake system. It has two fixed steel discs which brake the hub on which a ring of brake pad material is bonded. It is sometimes troublesome. The main problems are:

a. Sideways movement on the axle is only prevented by the disc brake. If towed down a long sloped surface like a cambered runway then the brake is slightly on which builds up heat and damage occurs.

b. The mechanical movement method is a screw. Probably after overheating this distorts and jams and so while braking it tends to jam on bringing the sailplane to an abrupt stop.

Hints: Careful adjustment helps. Avoid overheating while towing behind a car. Finesse in using the brake is required. Car brake repairers can bond on new brake pads but remove the plastic shelled bearing as they use heat that damages the bearings.

24.6.3 HYDRAULIC BRAKING SYSTEMS

Instead of a direct mechanical connection to the wheel brake, a hydraulic system may be installed. This generally works better because it has less losses than a cable/mechanical system. It will consist of components shown in the following schematic of TOST systems. TOST and others supply kits to convert many sailplanes to hydraulic or mixed cable-hydraulic systems. These greatly improve braking both in braking force and fine control. The hydraulic system will use a master cylinder connected to the rudder pedals or brake lever (or both) to convert mechanical force to hydraulic pressure. The hydraulic pressure is then applied to the brake cylinder(s).

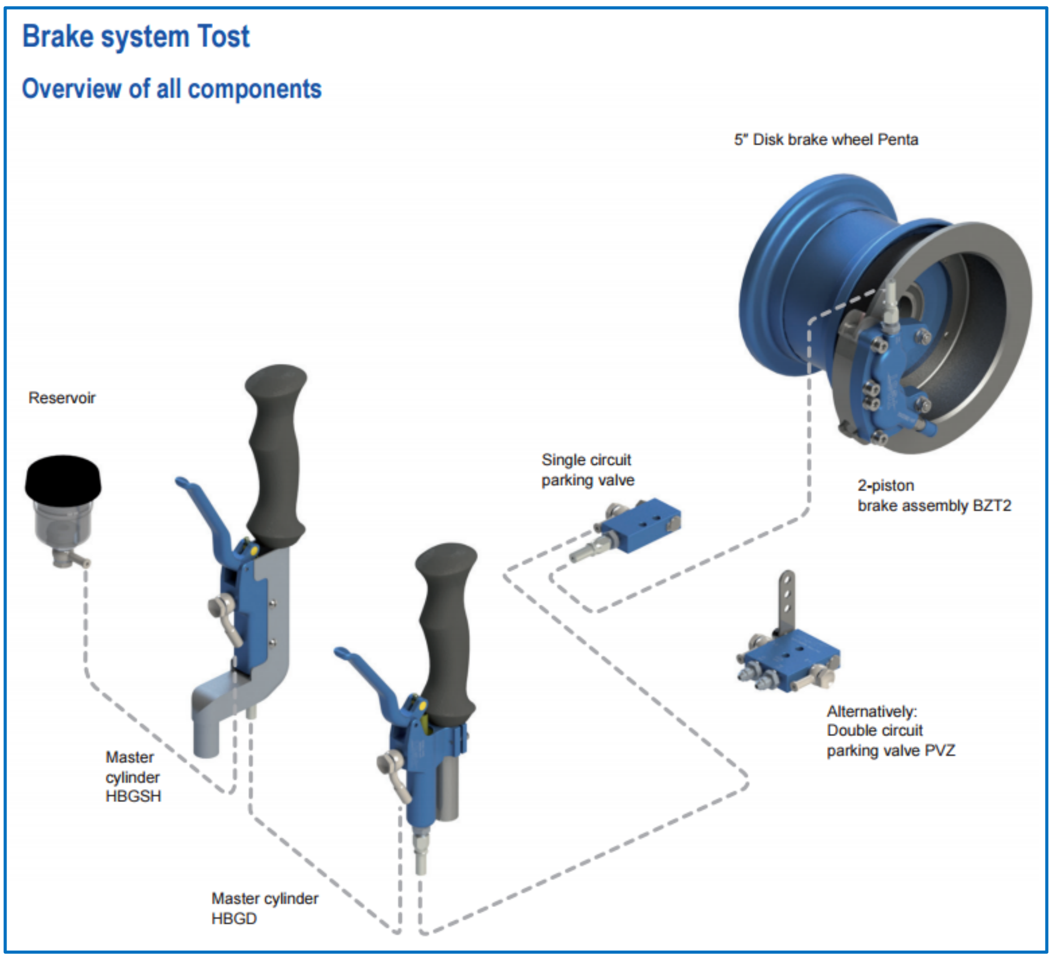


Figure 24-10 Simple Hydraulic System Schematic

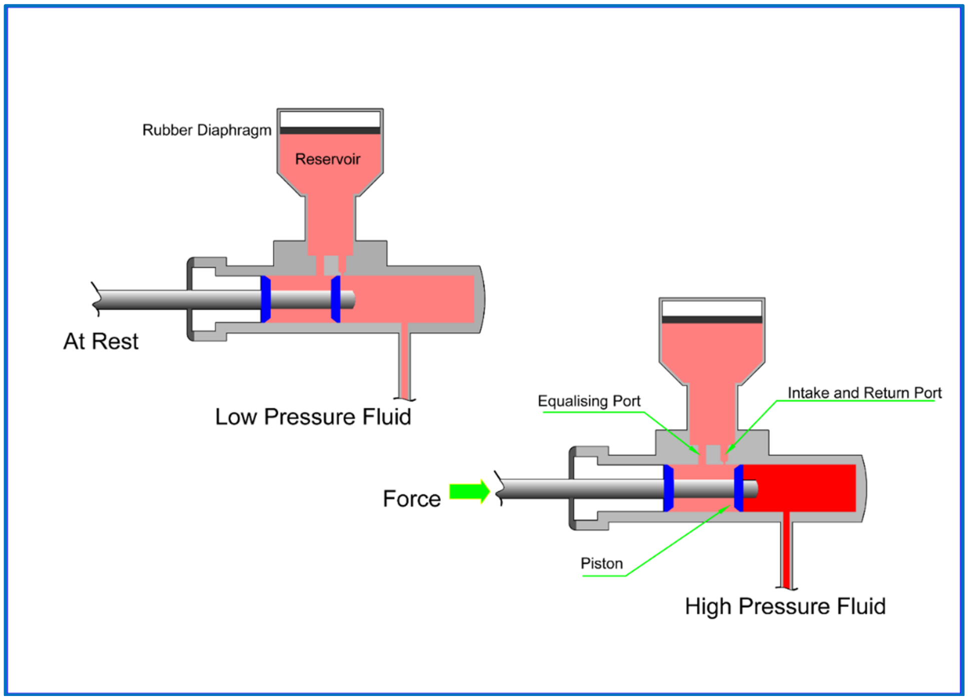


Figure 24-11 Master Cylinder Mechanism

24.6.4 HYDRAULIC LINES

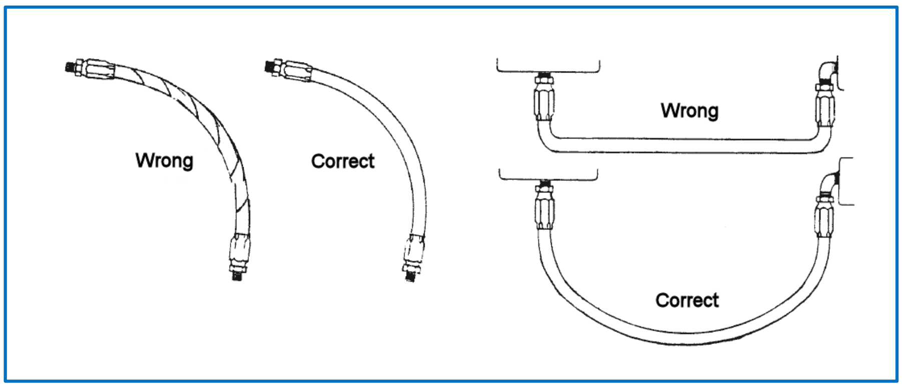


Figure 24-12 Hydraulic Hose Installations

Ensure hoses are not twisted, abrade on bulkheads, and do not have sharp radius bends. This can reduce the cross section of the hoses, and possibly reduce braking effects. It will also reduce the service life of the hoses. Twisted hoses may also loosen in service.

24.6.5 HYDRAULIC/BRAKE FLUIDS

To transfer pressure from the master cylinder to the brake cylinder(s) an incompressible fluid must be used. The fluid must also have a number of other characteristics:

a. High boiling point to prevent the heat of braking vapourising the fluid in the system. Vapour bubbles in the fluid would prevent the pressure transfer and the brakes would fail.

b. Low viscosity to allow the fluid to flow freely. The viscosity must stay constant over wide temperature ranges too.

c. Non-corrosive so that the metal components of the braking system do not deteriorate over time.

There are two types of fluids used in sailplane braking systems.

d. Brake Fluid (DOT 4)

"Brake" fluids originate from automotive systems. They are glycol based and are the more common type of fluid used in sailplanes. Don't use DOT 5 or any other.

e. Hydraulic Fluid (MIL-H-5606 or similar)
"Hydraulic" fluids originate from industrial uses and are commonly used in general aviation aircraft where the hydraulic system may extend beyond braking to include controls, suspension and other systems. This type of fluid is mineral oil based.

Note that these two types of fluids are ***not*** interchangeable. The seals, hoses and other non-metal parts of the sailplane braking system may be damaged by use of the wrong type of fluid. When seals and hoses are being replaced they must be positively identified as being the appropriate material type.

The appearance of the hydraulic system components is also no guide as (for instance) Cleveland components which normally use 5606 fluid in GA aircraft may be remanufactured by Tost to use DOT 4 brake fluids for sailplane use. The only reliable indication of the correct fluid to use is from the aircraft manual.

Automotive type brake fluids absorb moisture and may become corrosive over time. This is not as serious for steel parts but the old fluid may attack alloy components in the braking system. If the aircraft maintenance manual does not give a recommended maintenance cycle, the brake fluid should be changed and the components cleaned every 2 or 3 years. BEWARE! The rubbers may need changing every 5 years.

Hydraulic and brake fluids may have damaging effects on plastics and paint. Spills and leaks should be avoided or at least cleaned up as soon as possible. Brake fluid is water soluble, whereas hydraulic fluid is hydrocarbon soluble.

24.6.6 DIFFERENTIAL BRAKING

A system of differential braking is found in some motorgliders with dual main wheels. The brakes on the left and right main wheels can be individually operated to assist in ground steering. Usually this differential braking system is operated by use of the rudder pedals.

24.6.7 DIRECT MECHANICAL BRAKING

Some early types of sailplane have a rudimentary band braking system consisting of a metal plate/band which can apply friction directly to the tyre.

24.6.8 PARACHUTE ASSISTANCE

While not strictly part of the undercarriage some sailplanes use a tail parachute as a supplementary braking device. A detailed description of these systems is not included in this manual.

24.7 SUSPENSION

24.7.1 GENERAL

In addition to supporting the aircraft for taxi, the forces of impact on an aircraft during landing must be controlled by the landing gear. This also reduces the impact of rough taxi surfaces. This is done in two ways:

a. the shock energy is altered and transferred throughout the airframe at a different rate and time than the single strong pulse of impact, and

b. the shock is absorbed by converting the energy into heat energy

24.7.2 RIGID

The most common sailplane undercarriage design is a rigid landing gear where the wheel axle is attached either directly to the airframe or via a rigid metal frame which is part of the retract system. Shock loads transfer directly to the airframe with this design. Only the use of correctly inflated pneumatic tyres aids in softening the impact loads.

24.7.3 SIMPLE SPRINGING

Some sailplanes utilise flexible spring steel, aluminium, or composite gear legs to receive the impact of landing and return it to the airframe to dissipate at a rate that is not harmful to the airframe or occupants. The gear flexes initially and forces are transferred as it returns to its original position.

24.7.4 OLEOS/ SHOCK STRUTS

A typical pneumatic/hydraulic shock strut uses compressed air or nitrogen combined with hydraulic fluid to absorb and dissipate shock loads. It is sometimes referred to as an air/oil or oleo strut or shock absorber.

A typical aviation type shock strut is constructed of two telescoping cylinders or tubes that are closed on the external ends. The upper cylinder is fixed to the aircraft and does not move. The lower cylinder is called the piston and is free to slide in and out of the upper cylinder. Two chambers are formed. The lower chamber is always filled with hydraulic fluid and the upper chamber is filled with compressed air or nitrogen. An orifice located between the two cylinders provides a passage for the fluid from the bottom chamber to enter the top cylinder chamber when the strut is compressed. As the oleo is compressed the incompressible hydraulic fluid remains as a constant volume and flows through the orifice into the top chamber. The gas in the top chamber is compressed to a smaller volume at a higher pressure and acts like a spring.

In some cases a tapered pin is attached to the lower cylinder and protrudes through the orifice. As the strut compresses the movement of the pin reduces the orifice size to vary the rate of oil flow.

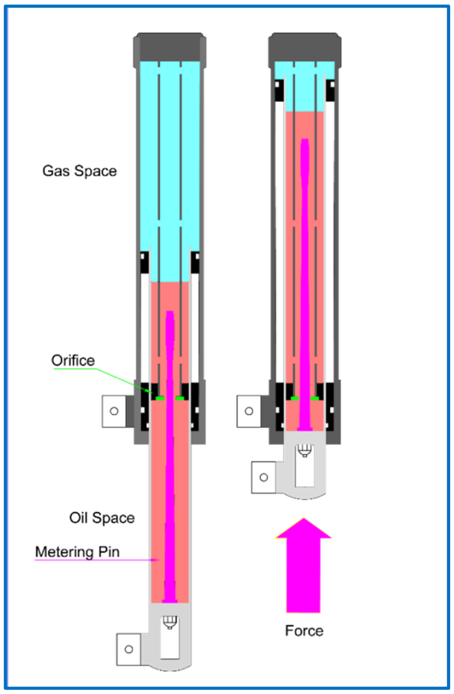


Figure 24-13 Typical Oleo Cross Section

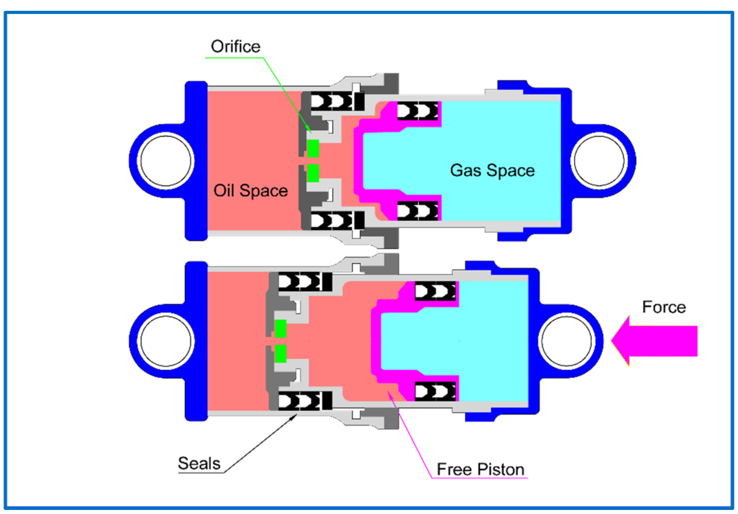


Figure 24-14 East European Type Oleo

In some east European sailplanes the gas space and the oil space are physically separated by a sub piston or cup as shown in the figure above.

The extension of the strut should be checked to see that it conforms to the distance specified by the manufacturer. If an air-oil strut “bottoms”, the gas charge has been lost from the air chamber. This is probably due to a loose or defective air valve or to defective O-ring seals.

CAUTION

Before an air-oil strut is removed or disassembled, the air valve should be opened to make sure that all air pressure is removed. Severe injury and/or damage can occur as the result of disassembling a strut when even a small amount of air pressure is still in the air chamber.

24.7.5 RUBBER OR SYNTHETIC SUSPENSION

Many modern sailplanes use compressible rubber or synthetic donuts or rods to act as springs and shock absorbers. These often specify replacement on a time basis as they do change characteristics. The correct elements need to be changed as specified. See the specific manuals, eg PW-6 and Stemme S10.

24.8 RETRACTION SYSTEMS

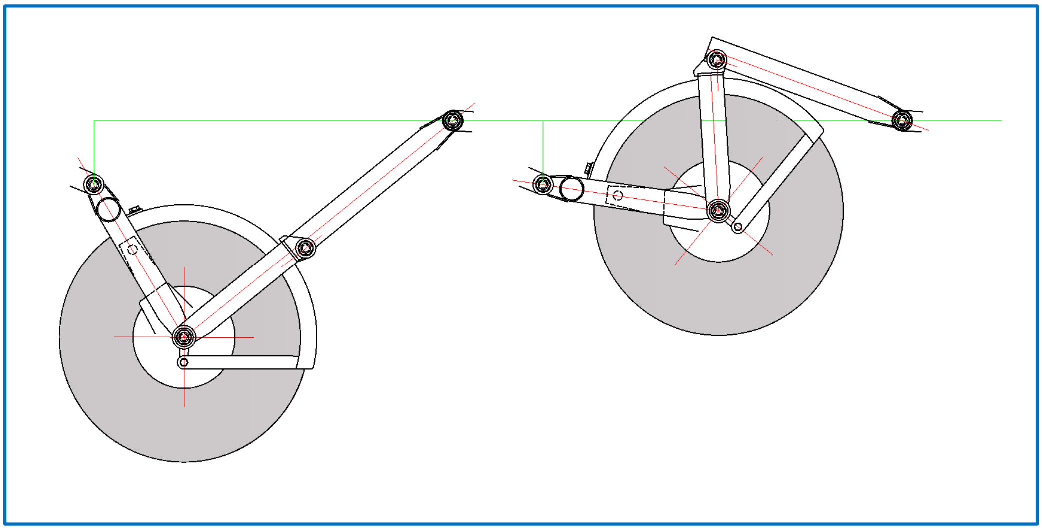


Figure 24-15 Simple Retract Mechanism With Overcentre

Retract systems in sailplanes rely on an overcentre mechanism to lock in the down position. This overcentre is usually found in the arrangement of the gear legs (see Figure 24-14). In this example, increasing weight on the wheel causes the rear leg pivot point to lock in the down position.

If the gear geometry does not achieve an overcentre when it is extended it may collapse at any time when on the ground.

24.8.1 DIRECT MECHANICAL

Nearly all sailplane undercarriage retraction systems rely on direct mechanical linkages to allow the pilot to lift the wheel. Through mechanical advantage of the retract system, the pilot extends and retracts the landing gear by operating a lever in the cockpit.

24.8.2 STORED ENERGY

Some more sophisticated aircraft, generally touring type motorgliders, may use stored energy to provide the driving force for their retraction systems. The most common system is electric, using the aircraft battery as the energy source and geared electric motors as the drive mechanism. A detailed description of these systems is not included in this manual and the particular aircraft manual should be referred to.

24.8.3 RETRACT SPRINGS/DAMPERS

Springs or dampers may be found in the undercarriage retraction system to assist the effort of the pilot to lift the weight of the wheel.

24.9 OTHER ITEMS

24.9.1 DOORS

Retract systems often use doors which close automatically after a wheel has been retracted. The door may be attached to the undercarriage leg itself as on the IS28 M2, but usually the door is hinged on the fuselage and held closed by springs or rubber shock cord. The door is displaced by the undercarriage mechanism itself.

Weak shock cord or broken/missing springs can lead to incomplete closing of the doors which can introduce a flutter issue.

In some cases the doors are connected to the undercarriage mechanism by solid linkages. This reduces the need for maintaining the door close spring tensions, but it can be difficult to set up the door closing/retract geometry precisely.

24.9.2 SPATS AND FAIRINGS

Where the undercarriage does not retract the parasite drag caused by the landing gear can be reduced by building the gear as aerodynamically as possible and by adding fairings or wheel pants to streamline the airflow past the protruding assemblies. A small, smooth profile to the oncoming wind greatly reduces landing gear parasite drag.

24.9.3 MUDGUARDS

Where a mudguard is fitted to the undercarriage the clearances to the tyre are closer than normal. Incorrect tyre size or excessive dried mud can cause the wheel to bind and may lead to damage of the tyre.

24.10 MAINTENANCE AWARENESS

The undercarriage is located in a place that makes inspecting it for normal wear and tear and damage more awkward than many other parts of the sailplane. When carrying out annual inspections or other routine maintenance the opportunity to have an especially careful inspection of the undercarriage should be taken.

24.10.1 HARD LANDINGS

Mishandled and hard landings are a common form of damage to all aircraft undercarriage systems. The undercarriage itself and the mounting structure it attaches to are designed to resist and transfer only certain mechanical loads. Where that level is exceeded some damage will result. This damage will show up in the weakest part of the wheel/undercarriage/fuselage which may not be the immediately expected location. The shock loads themselves may also damage other parts of the sailplane not directly related to the undercarriage.

Obvious results of hard landings:

a. cracked rim

b. bent axle

c. bent undercarriage legs/tubing

d. cracked welds

e. damaged mounting points in the fuselage

Non-obvious areas of damage possible after a hard landing are very diverse, depending on many factors, such as the type of construction of the sailplane, specifics of the impact and many more. For a full discussion of hard landings see BSE Chapter 25.

24.10.2 TYRE SIZE DISCREPANCIES

Tyres can vary slightly in their dimensions, depending on brand, retreads etc. While this does not pose a problem on fixed landing gear aircraft with open wheel arrangements, it may present a serious problem when installed on sailplanes with retractable landing gear or tightly confined wheels, either in a fuselage tube cage structure or in a spat.

If a different brand or type of tyre is installed on an aircraft with close tolerances in its landing gear, consideration should be given to possible tyre expansion. This can be due to high ambient temperature, heat generated from taxi and take-off, repeated landings, or heavy braking. Ensure the tyre will not expand to the point that it could rub excessively or become wedged.

24.10.3 RIM CONDITION

Rims used on sailplane main wheels are usually aluminium but some types, particularly amateur-builts, can be pressed steel. Older cast aluminium hubs are brittle, so any damage, such as from hitting a rock on landing, may crack them or break pieces off. Pressed steel is more malleable and in the same situation will dent and deform.

Tailwheel rims may also be plastic which is tougher than aluminium, so less likely to crack when new. However aging can make some plastics more brittle and plastic tail wheels should be checked for cracking and general deterioration as well. These can also be an intentional weakness and if replaced future hard landings may damage the sailplane structure.

Most sailplane rims are split types to make the changing of tyres easier, however the tyre must always be deflated before attempting to disassemble the wheel rims.

24.10.4 MOUNTINGS

The main undercarriage structure is tied directly to the structure of the fuselage to transfer landing loads to the sailplane as a whole. In a fixed wheel sailplane this may be as simple as the wheel axle passing through a suitably reinforced part of the fuselage structure. More complex arrangements, particularly where the wheel is retractable, may be through a tube structure or cast metal frame attached to the fuselage. This attachment is achieved by using bolts, or in the case of some FRP sailplanes, by bonding.

As these mounting points are virtually continuously subject to high loads when normally carrying the resting weight of the sailplane, and to impact loads when in motion on the ground these areas should be checked carefully for any stress related wear.

24.10.5 CORROSION

The main wheel is always in contact with the earth’s surface when on the ground and will pick up and spread mud, plant matter, dust and other material. This means the undercarriage is the area of the sailplane most likely to be subject to contaminants and most likely to have corrosion issues.

See BSE Section 15.5.5 for specific information on corrosion.

24.11 GUIDELINE FOR ANNUAL INSPECTION

As a guide, when maintaining a sailplane undercarriage at an annual inspection the following process can be followed:

24.11.1 DISSASSEMBLY

During disassembly, to assist with later re-assembly :

a. Beware of turning over the sailplane; manage risks it is heavy, beware hydraulic systems may ingest air.

b. Draw a diagram/ take photos

c. Secure items in labelled bags

d. Mark the axle and other components as required (up/down left/right etc)

e. Often distortion and corrosion make disassembly difficult. Use thought, lubricants/ penetrants and gentle persuasion. Don’t cause more damage.

24.11.2 CLEANING

Clean the undercarriage components removing dirt and grease as required.

Do you need to replace the brake fluid and / or clean/ fix leaks that may be causing corrosion?

24.11.3 INSPECTION

Inspection for:

a. Tyre and tube condition

b. Bent mechanical components

c. Brake lining and pads residual life

d. Over-centre locking mechanism correct adjustment

e. OLEO/gas strut condition

f. Leaks in the hydraulic system

g. Wear or fraying on brake Bowden cables

24.11.4 REGREASE

Regrease any axles, bearings or pivots with the correct type and grade of grease.

Take care to avoid contaminating the brake linings or pads

Replenish any hydraulic fluids if needed

24.11.5 REASSEMBLY

During reassembly check for:

a. Correct adjustment of the wheel brake(s)

b. Undercarriage locking correctly (up and down positions). Over-centre works correctly.

c. Safety locking of axle/nuts/bolts/pins is complete

d. Wheel doors do not jam. On each other or on the undercarriage itself

e. Wheel doors close completely with sufficient holding force.

f. Undercarriage alarm, where fitted, operates as expected.

g. Tyre valve is accessible and not likely to bind on any other structure.

h. Bleed hydraulic brakes until they have no problem air and they work well.

24.12 REFERENCES

Michelin Aircraft Tire Care and Service Manual, MAT-CSM 32-45-01, Revision E January 2016.

(Dunlop) Abbreviated Component Maintenance Manual Aircraft Tyres And Tubes, DM1172, Revision 3 February 2016.

(TOST GmbH) Betriebshandbuch Flugzeugräder, Revision 2 July 2013 (Operators Handbook for Aircraft Wheels)

(TOST GmbH) Produktkatalog, September 2013

AC 43.13-1A Change 3. Acceptable Methods, Techniques and Practices. IAP Inc., Casper, Wyoming, 1988. (Chapter 9, Section 1)

Aviation Maintenance Technician Handbook–Airframe, Volume 2, 2012. (Chapter 13)

25. INSPECTION AFTER HARD LANDINGS

25.1 GENERAL

Aircraft are designed to withstand flight and landing loads within specified limits. If the design limits are exceeded the structural integrity of the aircraft may be jeopardised and safety could be impaired. Any report or evidence on the aircraft which suggests that the design limits have been exceeded should be followed by a careful inspection appropriate to the nature of the occurrence. An Annual Inspector or higher is authorized to perform the inspection and sign it out.

The following advice is provided as guidance for this situation. It is not possible to provide precise details of inspections to be adopted after every type of incident due to the varying nature of the stress that may occur. Many forms of signs of distress and many degrees of damage occur. Hard landings happen in many ways and sometimes the pilots reaction to the situation influence the results, e.g. the pilot jerks back on the stick at the last second and smashes the tailwheel into the ground. So be open minded and look for everything.

25.2 THE MECHANICS OF HEAVY LANDINGS

There are many different methods of inspection possible and areas where those inspections may be applied to a sailplane. To assist with understanding what is most appropriate, an understanding of the forces applied to the aircraft in question is useful.

25.2.1 TAIL FIRST

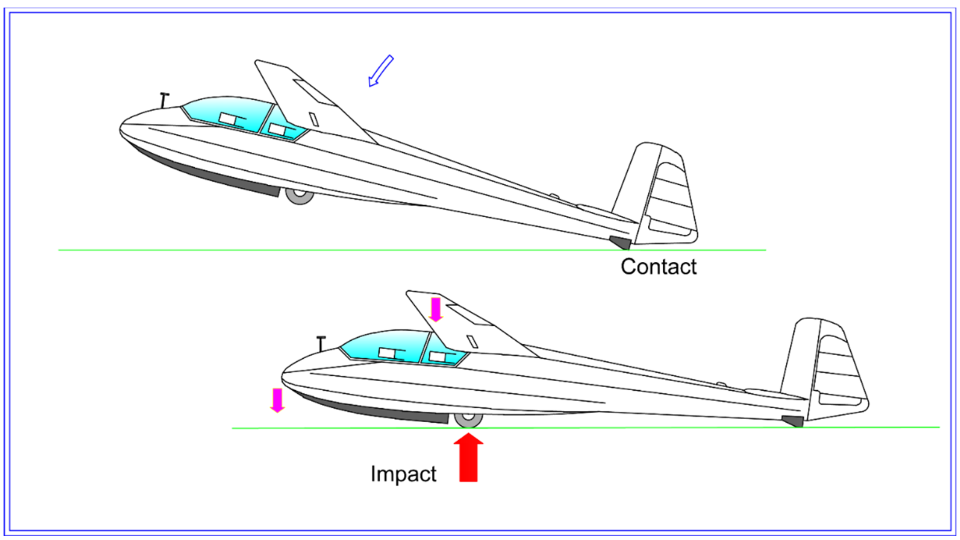


Figure 25-1 Tail First Landing

The aircraft touches down tail first which causes the aircraft to rotate around the rear contact point and impact the ground with the main undercarriage at a higher rate than normal. This can lead to:

a. Heavy impact on the mainwheel and associated structure.

b. Heavy loading at the wing roots due to wings tending to bend down.

c. Recoil of the wings upward can cause damage to the wing structure.

d. Aileron mass balances are heavily loaded both at impact, and possibly higher during recoil.

e. The pilot experiences high ‘g' loading, higher than the ‘g' load on the aircraft.

f. Highest ‘g' load will be on equipment or mass balance weights fitted into nose.

25.2.2 MAIN WHEEL FLY ON

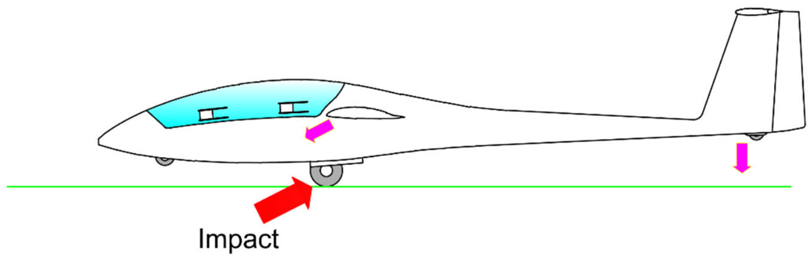


Figure 25-2 Main Wheel First Impact

The aircraft touches down on the main wheel at much higher than normal speed. This causes the aircraft to decelerate heavily with large inertia forces. This can lead to:

a. Heavy impact on wheel and structure with high loading rearward.

b. Heavy loading at wing root with wings tending to move forward under deceleration, as well as down.

c. Inertia of the tail leads to the fuselage bending down.

25.2.3 NOSE FIRST

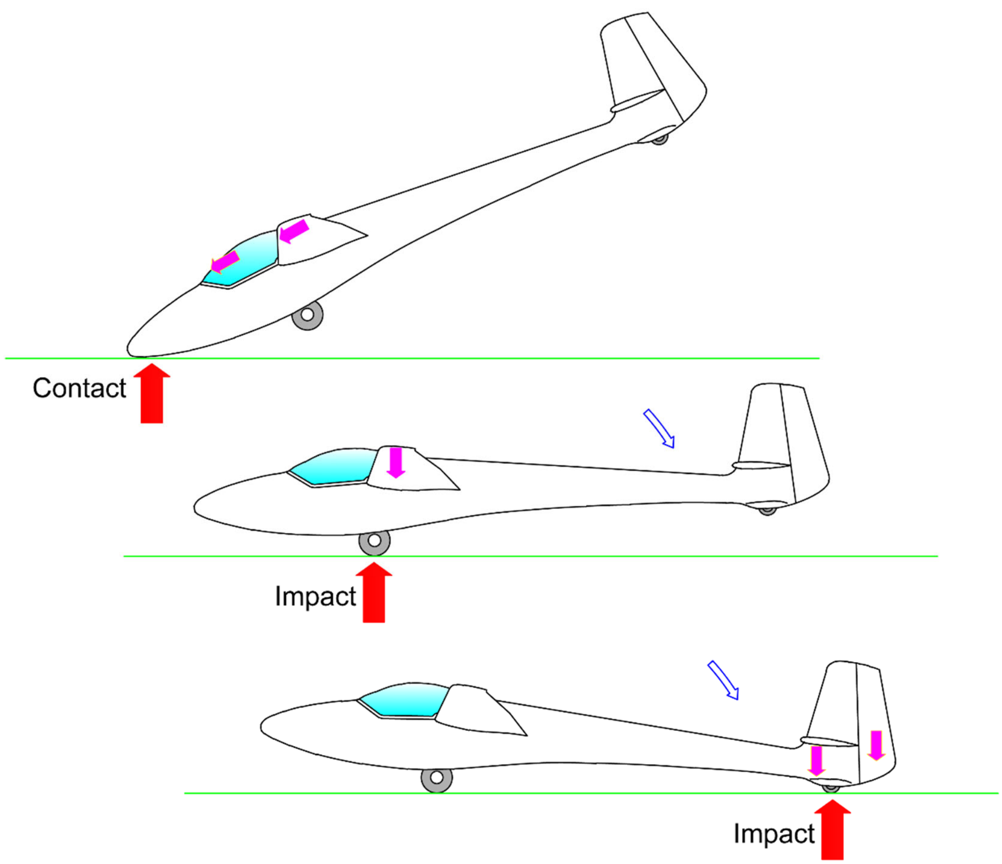


Figure 25-3 Nose First Impact

The aircraft touches down nose first. The initial contact can vary from a simple rub on the ground to full destruction of the front cockpit. Rapid loss of airspeed causes the aircraft to fall first on the main undercarriage, then subsequently on the tail. This can lead to:

a. Initial contact putting high forward loading on pilot, and all fixed equipment.

b. Wings try to keep going forward, putting their trailing edge into tension, then recoiling, putting the trailing edge into compression.

c. High forward loading on all mass balances.

d. The main wheel impact can be mild to destructive with high vertical loads on the wheel and associated structure.

e. Heavy loading at the wing root due to wings tending to bend down during main wheel impact.

f. Final impact on the tail can put high 'g' forces into the tailwheel assembly and tend to break the horizontal tailplane.

g. High loads on the rudder attachments, the elevators and elevator hinges.

25.2.4 NOSE FIRST – MAIN WHEEL BEHIND CoG

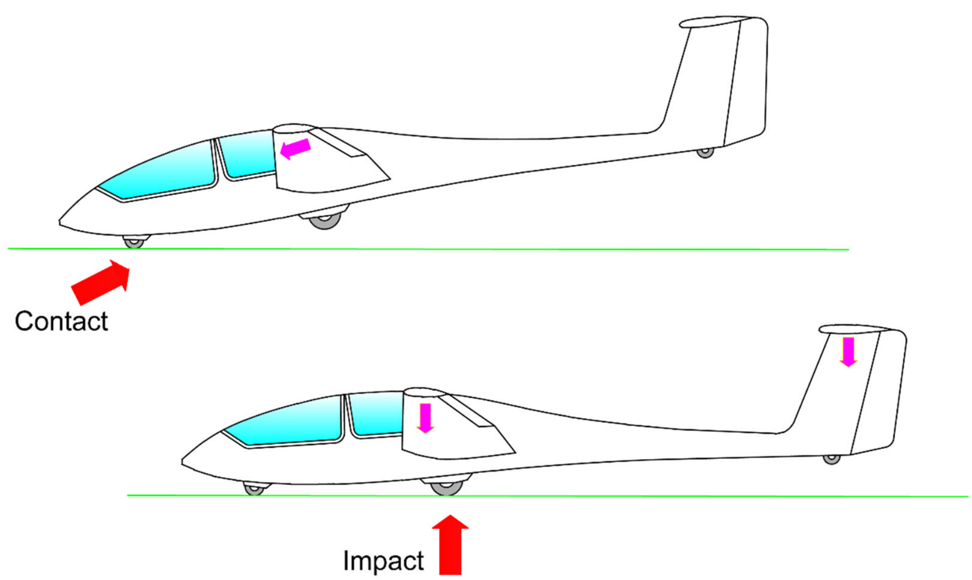


Figure 25-4 Nose First Impact – Main Wheel Behind COG

The aircraft touches down nose first similar to 25.2.3. The initial contact can vary from a simple rub on the ground to full destruction of the front cockpit. Rapid loss of airspeed causes the aircraft to fall first on the main undercarriage, but may not rotate to the extent that the tail impacts the ground. This is typical of types such as the ASK 13, Grob G 103, K7 and Kookaburra. This leads to:

a. Initial contact putting high forward and vertical loading on pilot/s and fixed equipment.

b. Wings tending to bend down and forward, then flick back.

c. Impact loads on the main wheel and its structure. High vertical ‘g' loading on fixed equipment around wheel area.

d. The tail assembly suffers high ‘g' loading ***without*** touching the ground. This causes severe stress in the rear fuselage, typically buckling the bottom rear fuselage structure.

e. High loading on horizontal tailplane tending to bend both halves down.

25.2.5 OVERBRAKING ON THE GROUND ROLL

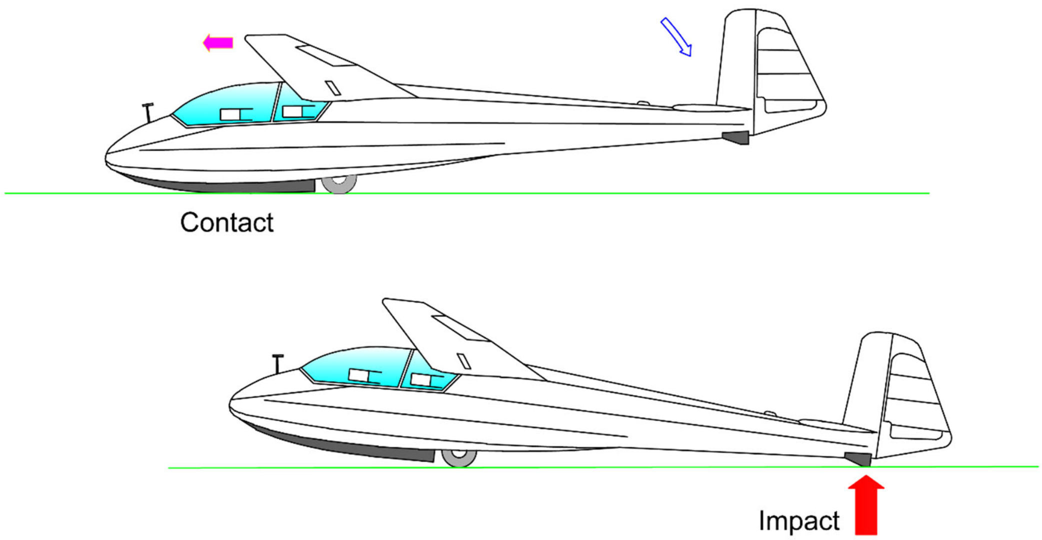


Figure 25-5 Over Braking on Ground Roll

The aircraft touches down on the main wheel, usually at higher than normal speed. The pilot then uses strong braking to intentionally decelerate the aircraft, which causes the sailplane to tip onto its nose. This is common with Blaniks, other sailplanes with heavy pilots and aircraft with good braking systems such as Jantars or older sailplanes with nose skids. The situation then becomes very like the fast fly on 25.2.2 leading to:

a. Heavy loading at wing root with wings tending to move forward under deceleration.

b. Inertia of the tail bends the fuselage down.

c. The aircraft stops and the tail drops. Sometimes up to 2 metres, severely loading the; tailwheel; rudder and hinges; rear fuselage; horizontal tail; elevators and elevator control system.

25.2.6 GROUND LOOPS

In a heavy landing the pilot ***knows*** the aircraft has been highly loaded.

But during a ground loop, even though it may be very severe, the pilot may not realise the aircraft has been overloaded.

A ground loop usually follows a pattern.

a. The wing drops into an object, ground, bush, grass etc.

b. The sailplane rotates around that tip out of control, tail up.

c. Somewhere between the start and the finish of the event, the tailwheel strikes the ground.

d. This can lead to:

   i. Extreme damage in the wing root area, dive brake box area, root end of aileron area and in the wing that strikes the ground.

   ii. The weight of the tail, especially a “T” tail, can cause the rear fuselage to “wind up”, due to the rear fuselage hitting the ground sideways. This can cause considerable damage at the base of the fin, and the tailplane to fin attachment.

25.3 THE PILOT

The thing most likely to be damaged, without necessarily a large amount of airframe damage, is the pilot.

Some sailplanes/powered sailplanes are far more dangerous in this respect than others, but all are so light in construction that any reasonable impact will be felt by the pilot.

For these reasons any pilots involved in heavy impacts or heavy landings, without apparent injury, but who subsequently experience pains or discomfort in the back should seek medical attention.

Statistics show that over 50% of persons injured in sailplanes and powered sailplanes sustain a fracture of the spine.

25.4 STRUCTURAL DAMAGE

Following any of the incidents described in 25.2, damage is likely to be found ranging from very severe to almost undetectable. The types of construction we deal with behave in different ways.

25.4.1 ALL TYPES

There are common areas of damage which should be checked for on all aircraft types after a heavy landing:

a. damage to main wing attachments

b. damage to tailplane mounting bolts/brackets

c. undercarriage wheel, gear, mounting damage

d. loosened or damaged hinges on all control surfaces

e. damage to the pilots' seat pan and harness attachments

f. instruments

g. battery mounting arrangements

There are also items which can be indicative of hidden damage after a heavy landing and should be examined further if found:

h. distortions which make canopies or hatches fit poorly or not latch properly

i. a change in control feel or full/free movement

j. general damage to the extremities of the aircraft (tips, nose and tail)

k. hydraulic leaks

25.4.2 FRP

Indications found in or damage specific to fibre reinforced plastic airframes include:

a. (a) A change of material colour around mounting pin holes, the FRP turning white which indicates failure of the resin.

b. (b) Shell structures often suffer internal delamination which is not visible from the outside.

c. (c) Internal frames become debonded from the outside shell, particularly in tailcones.

d. (d) FRP can fracture internally and return to shape without external evidence which means careful inspection is required. In FRP construction gel coat cracks can act as "tell tale", however, this property is lost if the sailplane has been repainted.

Look for:

e. delamination of wing internal skins

f. wing leading edge splits

g. spar web wrinkles and debonding

h. dive brake box damage

i. cracking at the inboard end of ailerons

j. trailing edge de-bonding

k. main wing attachment damage

l. general fuselage shell damage

m. fracture and debonding, especially at the ends of the fuselage tail boom

25.4.3 WOOD

Indications found in or damage specific to wooden airframes include:

a. Ply wood skins usually buckle diagonally similarly to metal panels, and stay buckled if over loaded by tearing fibres.

b. Glued joints can fail internally, ply can debond from ribs and frames.

c. Timber spar caps, longerons, ribs etc. are usually weak in compression, bending and splintering under overload.

d. edge failure is common, caused by "springback" of the wing structure following substantial downward and forward loading.

Look for:

e. split plywood, especially in the fuselage behind the wing root

f. damaged fuselage frames

g. fin post damage

h. wrinkles in the ply on the fuselage or wings

i. main skid damage

j. damage in the dive brake area

k. buckled/split wing trailing edges

l. fractured wing ribs

m. ply/spar delamination in the wing

25.4.4 METAL

Indications found in or damage specific to metal airframes include:

a. Mild damage often shows up as "tilted" or partly sheared rivets

b. Skin buckles between rivets indicate excessive compression loading has occurred.

c. Once metal is buckled, it stays buckled. There is no "spring back" and the torsional strength and bending strength of the structure is lost.

Look for:

d. buckling of complete panels, usually diagonally;

e. buckling of frames;

f. kinking of stiffeners.

25.4.5 STEEL TUBE

On a steel tube aircraft the wings are usually wooden and should be inspected for the same damage as detailed in 25.4.3 above.

The fuselage tubes should be inspected for bowing or buckling. Sometimes this may be subtle and using a straight edge or comparing symmetrical parts of the frame can assist. Wrinkles in the fabric surface may also indicate distortion in the fuselage tube structure.

25.4.6 MOTOR GLIDERS

As all items in the motor glider are subject to shock loads during a heavy landing it follows that items with large mass are affected the most. Consequently, undercarriage, motor mounts and firewalls should receive a particularly careful examination after any hard landing.

25.5 CASE STUDIES

GFA AD 231

An ASW 15 elevator actuating bell crank failed in flight. An inspection of the bell crank showed that an older crack most likely caused by a hard landing some years previously resulted in fatigue failure of the bell crank.

Due to the inaccessible location of the bell crank the original hard landing damage was not detected before it ultimately failed.

25.6 REFERENCES

GFA AD 231

CAAP 42L-1. Inspection of Aircraft after abnormal flight loads, heavy landing or lightning strike. CASA May 2000

26. NON DESTRUCTIVE INSPECTION

26.1 GENERAL

Non Destructive Inspection (NDI) or Non Destructive Testing (NDT) is an inspection process that allows an experienced inspector to check a part for cracks and other defects without damaging the component.

Trained sailplane inspectors holding an authorization may perform inspections using the fluorescent dye penetrant inspection. If the inspector is uncertain there is or is-not a crack experts should be called in. Other inspection processes must be performed by persons holding the appropriate authorisations.

GFA can arrange special training to increase your understanding. GFA have fluoro kits to borrow in most regions. And GFA holds some special test probes for specific ADs.

CASA authorized NDT inspectors/ technicians may perform NDT inspections and approvals for GFA sailplanes.

26.2 TYPES OF NON DESTRUCTIVE INSPECTION

There are six common NDT techniques used in aviation:

a. Visual/ optical Inspection is the most common and obvious using good light and a lens.

b. Liquid penetrant (PT)

c. Magnetic particle (MT)

d. Eddy current (ET)

e. Ultrasonic (UT)

f. Radiography (RT)

A brief description of each special method is given below for the general knowledge of inspectors. You need to know about these rather than be able to perform them. There are other methods available.

26.2.1 LIQUID PENETRANT TESTING (PT)

PT can be divided into two types: Visible Dye Inspection and the more sensitive Fluorescent Dye Penetrant Inspection.

26.2.1.1 RED DYE PENETRANT

Previously it was acceptable for sailplane inspectors to perform a Visible Dye Inspection using a Red Dye Penetrant. This method has a relatively low sensitivity to the fine defects possible in aircraft structures and is no longer considered a suitable inspection method.

WARNING
Because red dye penetrants stop fluorescent penetrants, fluorescent inspection must not be performed on parts which may have been previously inspected using red dye penetrant. If inspection of a component previously inspected with red dye penetrant is required, contact your local RTO-A for advice.

26.2.1.2 FLUORESCENT DYE PENETRANT

Fluorescent dye penetrant differs from red dye penetrant in that the dye used is fluorescent under ultra violet (UV) light. The advantage of this method is that because the dye is radiating light, it is much easier to detect than the red dye. This factor alone accounts for a significant improvement in crack detection ability especially when the defects are small.

This type of penetrant comes in a variety of sensitivities from medium to ultra-high.

Because there is a requirement for a UV light source (a Black Light) and a darkened environment for fluorescent dye penetrant, this method is only useful on parts which have been brought into a suitable viewing area. The need to purchase a black light also increases the capital costs and the setup required. However the increased sensitivity makes this the preferred method for General Aviation workshops.

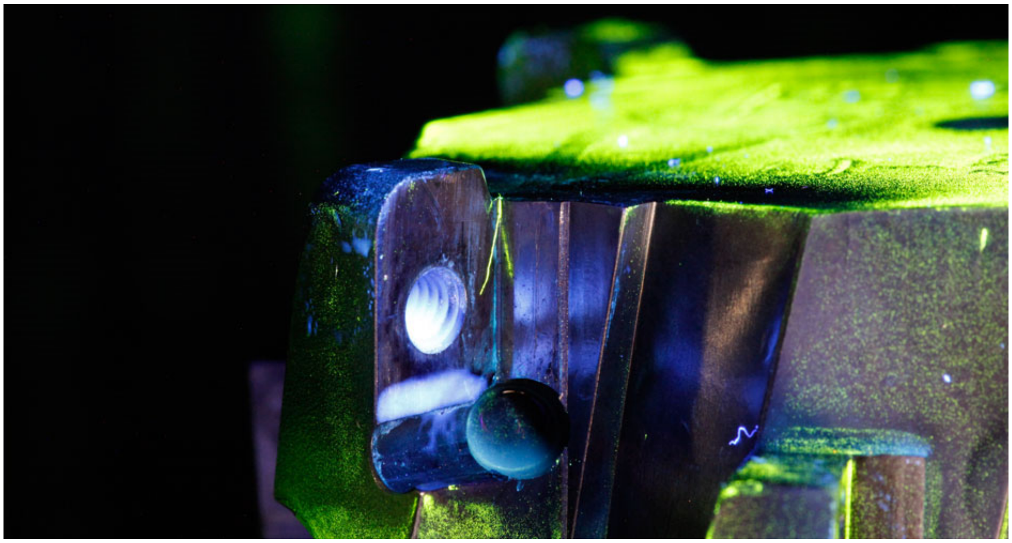


Figure 26-1 Fluorescent Dye Penetrant

26.2.2 MAGNETIC PARTICLE (MT)

Magnetic particle inspection can only be performed on magnetic materials. A magnetic field is induced in the component and wherever there is a defect the flow of the magnetic field is disrupted and a small stray field is formed. This field is detected by small magnetic particles spread over the component which then accumulate at the defect. The magnetic particles usually take the form of iron filings which may be applied dry or suspended in a light oil.

This method is the most sensitive available for ferro-magnetic materials.

Figure 26-2 Magnetic Particle Inspection

26.2.3 EDDY CURRENT TESTING (ET)

Eddy current NDI uses an induced electrical current to detect defects. Cracks in the sample produce eddies in the basic material which can be detected by a sensitive electronic probe.

Expensive equipment and a qualified NDI technician are required to use eddy current NDI and it is only used on sailplanes at fatigue sensitive spots, such as the wing root area of the Blanik to support life extension programs.

Figure 26-3 Eddy Current Testing

26.2.4 ULTRASONIC (UT)

Ultrasonic inspection involves passing high frequency sound waves (of the order 2-10 MHz) through the part and detecting the return waves which are reflected off any defects in a similar way to radar detecting an aircraft. In order to pass the sound waves into the structure, the "speaker" must be in intimate contact with the part which is usually achieved with a water bridge or a gel between the part and the speaker.

It is also possible to pass the sound waves completely through the test piece and detect the attenuation of the sound through a microphone on the other side of the part. If there is a defect within the part, there will be less sound transmitted through and the reduced sound can be used to detect the damage.

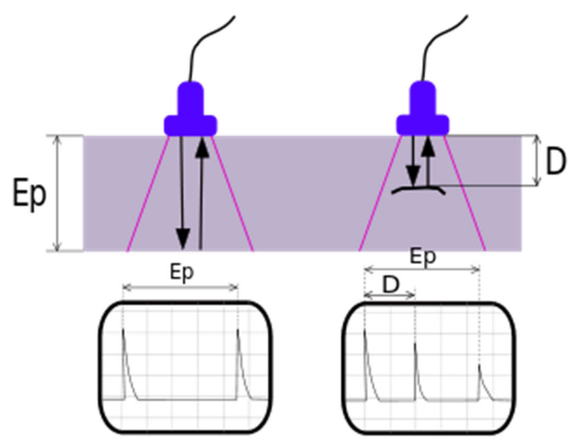


Figure 26-4 Ultrasonic Testing

Ultrasound is the prime means of NDI on composite parts during the manufacturing phase as it is less susceptible to background noise from small insignificant defects but is well suited to finding large areas of delamination which is the prime type of defect found in composites. Unfortunately ultrasound is expensive to set up and so is of little use when inspecting FRP sailplane components in the field.

The main use of ultrasound in sailplane inspection is the detection of fatigue cracks in buried items such as the root end of spar spigot pins.

26.2.5 RADIOGRAPHIC (RT)

Radiographic inspection consists of exposing one side of a part to an X-ray source and placing a photographic film on the other side. After the correct exposure time, the film is developed and the exposure on each part of the film is dependent on the density and thickness of the material in front of it. Defects effectively change the local density of the material and therefore show up on the film.

Interpretation of X-ray inspection results is very difficult and requires a skilled interpretation not to mention the health and safety requirements which must be applied.

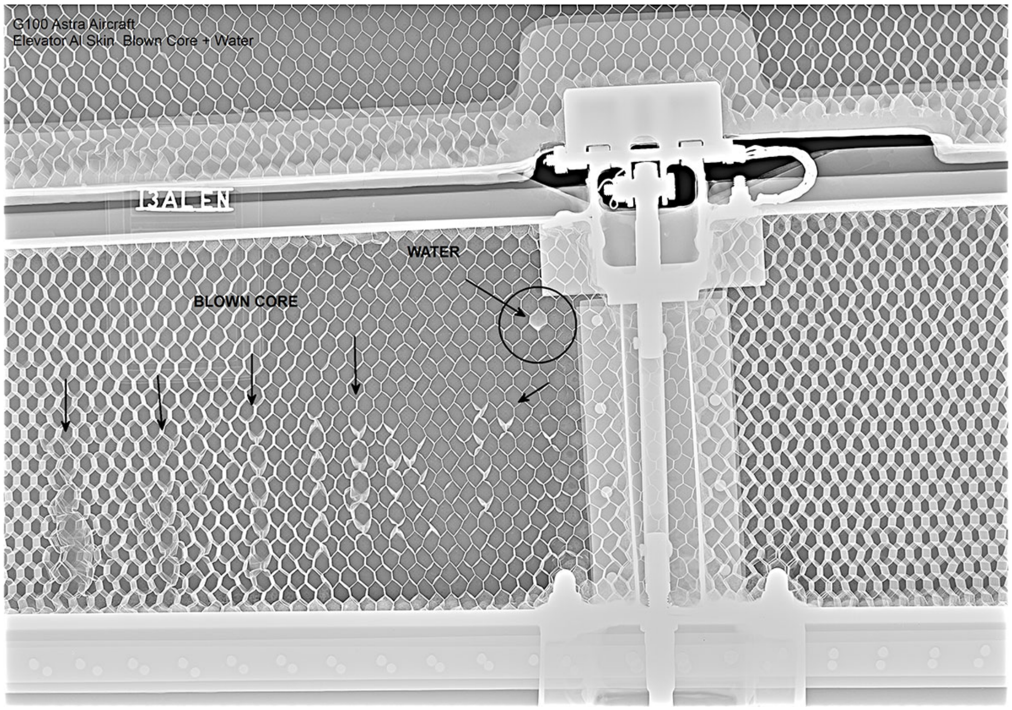


Figure 26-5 Radiographic Inspection

26.3 PROCEDURES FOR FLUORESCENT DYE PENETRANT

The procedure for performing a fluorescent dye penetrant inspection is quite simple but must be followed very closely. When testing components using fluorescent dye penetrant a positive crack indication shows that a crack is present. But if there is no indication, a crack may be present but not show up because of faulty procedures.

The following procedure is based on a commercially available fluorescent dye penetrant system. Only products from one supplier's system may be used together. The instructions on all packaging should be read thoroughly and followed explicitly. If there are any differences between the following and the instructions on the packaging, the instructions on the packaging must be followed except where noted below.

26.3.1 INITIAL CLEANING

Initial cleaning is required to remove the bulk dirt and contaminants which may affect the detection of cracks. Any paint on the area of interest must be removed at this stage. Water based paint stripper that is compatible with the sub-straight may be used, but take care to prevent contamination of the aircraft structure around the inspection area. The area shall be through cleaned at the completion of the stripper process.

Mechanical processes, such as sand blasting and machine grinding / sanding, must not be used as the action may smear / peen over the surface of the crack making the crack harder or perhaps impossible to detect. But plastic bead blasting may be acceptable.

Initial cleaning is usually performed using a basic degreaser such as petrol and then paint is removed using chemical removers. Basic cleaning may also be performed using soapy water.

26.3.2 PRE-CLEANING

Pre-cleaning is the first true step of the fluorescent dye penetrant inspection.

Spray the pre-cleaner onto the surface in question and wait approximately 10 to 30 seconds to allow any contaminants to dissolve. Wipe the component dry with clean towelling before the cleaner fully evaporates. Repeat the process until the part is clean.

Allow the part to stand for a few minutes to allow any excess cleaner to evaporate.

In a commercial environment, other cleaning methods such as vapour degreasing or ultrasonic cleaning may be available. Note: vapour degreasing is being phased out due to the ozone destroying properties of the vapour, trichloroethylene and its incompatibility with some materials. If these processes are available they should be used in conjunction with the spray cleaner to ensure the cleanest possible part.

Figure 26-6 Cleaned surface

26.4 PENETRANT APPLICATION

Check the test specimen temperature. Normal operation may be considered to be in the temperature range 15 to 40°C.

Shake the can well (any can with a stirring marble, the rattle in the can, should be shaken before use) and spray the penetrant onto the surface from a distance of 80 to 120 mm until an even but light wet coating is obtained. The part should then be allowed to stand for the appropriate dwell time.

Figure 26-7 Fluorescent dye penetrant seeps into continuity

26.5 DWELL TIME

The minimum dwell time shall be 20 minutes. If the test is under adverse conditions such as low test specimen temperature or where particularly small or tight cracks (fatigue cracks are very tight cracks) are expected then the dwell time should be doubled. The fluorescent dye penetrant should not be allowed to dry out on the part undergoing inspection.

26.6 PENETRANT REMOVAL

Excess or surface penetrant must be removed. The penetrant is removed by lightly moistening (not soaking) a clean cloth or paper towel with remover/cleaner and wiping the surface. After each wipe the cloth should be folded over to present a fresh surface to the part. This is the most critical step in the process as excessive cleaning can easily remove the dye from any cracks making them impossible to detect.

CAUTION
The cleaner must not be sprayed directly onto the surface.

Figure 26-8 Excess penetrant removed

If you have not cleaned it well enough you will see this in the next step and you can repeat the penetrant removal from the surfaces.

26.7 DEVELOPING

Shake the can well. Test spray the developer away from the job then spray the developer on to the test piece. The developer is correctly applied when there is an even, light and slightly wet coating. Excessive use of developer can mask small defects. The metal surface should still be seen through the light powder coating.

Large defects will be found almost instantly however the item should be allowed to sit for 10 minutes before a final interpretation is performed. On extremely critical inspections the developing time should be extended to equal the fluorescent dye penetrant dwell time. Continuously check the part for new developing indications.

Figure 26-9 Developer applied drawing penetrant to the surface

26.8 INDICATION INTERPRETATION

The most difficult part of fluorescent dye penetrant inspection is interpreting the indications to determine if the dye which is seen represents a true defect, is caused by a fault in the fluorescent dye penetrant process or by a section of the part which holds penetrant. A press fitted plug may cause an indication but not represent a fault. Interpretation shall be done in a darkened environment, with all white light eliminated and a suitable UV light source used for illumination of the subject part.

The intensity of the indication can be used as a guide to the size of the defect. A wide crack will contain a lot of penetrant and so produce a very strong indication while a narrow or tight crack will contain only a small amount of penetrant and so only produce a very fine indication. If a crack has been peened over during a manufacturing or cleaning process it may show as a series of small defects in a line rather than as a continuous line. Porosity in items such as castings will show up as scattered dots.

Figure 26-10 Large Crack or Opening

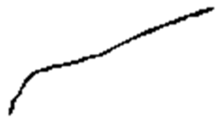


Figure 26-11 Fine Crack

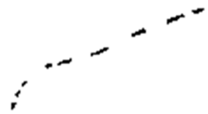


Figure 26-12 Crack Partly Closed Over

Figure 26-13 Pits or Porosity

To confirm defects the indication can be wiped off with a clean cloth lightly moistened with pre-cleaner and the part resprayed with developer. A crack will be revealed slowly whereas a scratch will not reappear. Do not repeat more than once.

The use of a different system is not permitted as different systems sometimes have incompatible chemicals which react together and destroy any indication.

It should also be noted that as inspections are repeated any defects fill with the remnants of earlier tests and indications tend to fade.

26.9 CLEANING

Once the part has been found to be defect-free the part must be thoroughly cleaned and any corrosion protection (such as paint) reapplied. Inadequate removal of the penetrant system can prevent paint adhesion and lead to future corrosion.

26.10 REFERENCES

Aircraft Reciprocating Engines. IAP Inc., Casper, Wyoming, 1993

AC43.13-1A Change 3. Acceptable Methods, Techniques and Practices. IAP Inc., Casper, Wyoming, 1988.

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NDI Familiarisation Course-GFA, Aerospace NDI Pty Ltd, 10/11/2016.

27. RADIO, ANTENNAE, FLARM AND AVIONICS

27.1 INTRODUCTION

Modern sailplanes invariably have 2-way VHF radios and ever increasingly sophisticated avionics such as FLARM, electric variometers, glide and navigation computers and flight data loggers. This equipment needs to be properly installed, tested and maintained since it provides considerable safety benefits as well as aiding the pilot's soaring performance. This chapter aims to give the basic theory and useful knowledge to enable an Annual Inspector to undertake these tasks.

This chapter should be read in conjunction with the BSE Electrics Chapter.

There are no specific inspection requirements during the Annual Inspection, other than testing the equipment is; securely installed, without risk of electrical overheating, suitably fused and is operating correctly. If FLARM is installed, the firmware and obstacle files should be checked at the Annual Inspection to ensure they are the current versions.

In this Chapter:

a. Basic radio theory is explained;

b. The characteristics of a modern VHF com radio are discussed;

c. Antennae are explained and demystified. Poor antenna connection or tuning are frequent causes of poor radio performance so best practice detail is provided;

d. A look at avionic devices in general, including information to assist installation and inter-connection.

e. FLARM, its installation and maintenance are discussed as they are an important safety aid to see and avoid other similarly equipped aircraft.

Throughout this chapter the term "VHF Com radio" means the 2-way VHF aircraft band communications radio, elsewhere sometimes referred to as Com, Radio or Transceiver. The term "Antenna" (plural = "Antennae") is the receiving and/or transmitting element attached to a radio, elsewhere sometimes referred to as an aerial.

Acknowledgement: The Antenna section contains content modified from the "XCOM Dummies guide to aircraft antennae 2007".

27.2 RADIO BASICS

27.2.1 RADIO WAVES

Radio waves are a type of electromagnetic radiation. Electromagnetic radiation is transmitted in waves of particles in a broad range of wavelengths and frequencies known as the electromagnetic (EM) spectrum. The spectrum is generally divided into seven regions in order of decreasing wavelength and increasing energy and frequency. The common designations are: radio waves, microwaves, infrared (IR), visible light, ultraviolet (UV), X-rays and gamma-rays.

The radio wave region of the spectrum is divided into 9 bands as follows:

Table 27-1 Radio Band Frequencies

Band	Frequency Range	Wavelength Range
Extremely Low Frequency (ELF)	<3 kHz	>100 km
Very Low Frequency (VLF)	3 to 30 kHz	10 to 100 km
Low Frequency (LF)	30 to 300 kHz	1 m to 10 km
Medium Frequency (MF)	300 kHz to 3 MHz	100 m to 1 km
High Frequency (HF)	3 to 30 MHz	10 to 100 m
Very High Frequency (VHF)	**30 to 300 MHz**	**1 to 10 m**
Ultra-High Frequency (UHF)	300 MHz to 3 GHz	10 cm to 1 m
Super High Frequency (SHF)	3 to 30 GHz	1 to 1 cm
Extremely High Frequency (EHF)	30 to 300 GHz	1 mm to 1 cm

The frequency band allocated internationally for aircraft communications, and used by sailplanes, is referred to as the “Airband”. It lies in the VHF band and is specified as 118.000 MHz to 136.975 MHz.

Commercial and general aviation aircraft flying in remote areas will likely also be fitted with HF radio which has longer range than VHF.

27.2.2 WAVELENGTH AND FREQUENCY

The wavelength is the distance between peaks or troughs within a single oscillation of a transmission. Imagine a wave moving across the water - as each wave hits the shore, the water rises and falls, and there are the peaks and troughs in the height of the water. A radio signal travels in the same way and the wavelength is simply the distance between two consecutive peaks or troughs.

Frequency is simply the number of waves emitted per second. A frequency of 118.000 MegaHertz (MHz) means that 118 million waves are emitted each second. Now, if more waves are emitted each second, then they must be closer together, so this means that the higher the frequency the shorter the wavelength.

27.2.3 HOW FREQUENCY AND WAVELENGTH ARE RELATED

Electromagnetic waves always travel at the speed of light (299,792 km per second). This is one of their defining characteristics. In the electromagnetic spectrum there are many different types of waves with varying frequencies and wavelengths. They are all related by one important equation: Any electromagnetic wave's frequency, multiplied by its wavelength, equals the speed of light.

Frequency of oscillation x Wavelength = speed of light

We can use this relationship to figure out the wavelength or frequency of any electromagnetic wave if we have the other measurement. Just divide the speed of light by whichever measurement you have and then you've got the other.

$$\text{Wavelength} = \frac{\text{Speed of Light}}{\text{Frequency of Oscillation}}$$

$$\text{Frequency of Oscillation} = \frac{\text{Speed of Light}}{\text{Wavelength}}$$

Figure 27-1 Radio Wave and Frequency Equations

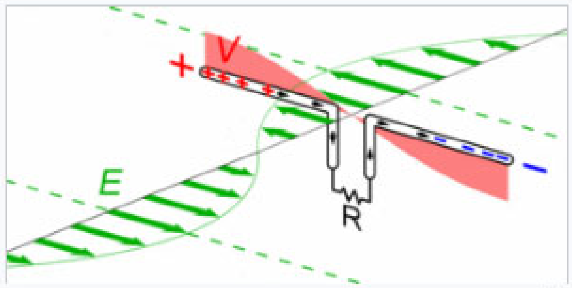
Since the frequency range for the aircraft band is from 118.000 MHz to 136.975 MHz, then the aircraft band wavelength is approximately 2.2 metres. This wavelength is an important dimension as it dictates the size of antenna required, though fortunately a full wavelength is not needed.

27.2.4 USING RADIO WAVES

It is a basic fact of physics that when electrons move as an electric current in a wire, an electromagnetic field is created around that wire thus radiating energy in many directions. Similarly, if a wire is placed in an electromagnetic field of waves, the field will cause electrons to flow in the wire.

Wikipedia has an excellent animated representation of how electromagnetic waves cause a current to flow in an antenna. See: https://en.wikipedia.org/wiki/Radio_wave

A screen shot of this is shown below at Figure 27-2



Animated diagram of a half-wave dipole antenna receiving a radio wave. The antenna consists of two metal rods connected to a receiver *R*. The electric field *(E, green arrows)* of the incoming wave pushes the electrons in the rods back and forth, charging the ends alternately positive *(+)* and negative *(−)*. Since the length of the antenna is one half the wavelength of the wave, the oscillating field induces standing waves of voltage *(V, represented by red band)* and current in the rods. The oscillating currents *(black arrows)* flow down the transmission line and through the receiver (represented by the resistance *R*).

Figure 27-2 Half-Wave Dipole Antenna

So to communicate with radio waves we start by using a crystal-oscillator controlled frequency synthesiser to accurately create electric current waves at the desired frequency within the Airband. This is referred to as the carrier wave. Signal information (eg a voice message) is then added to the carrier wave by modulation (see next section). The radio frequency electric current waves are transferred by special screened connecting cable (which minimises the escape of energy as electromagnetic waves) to a carefully tuned antenna which maximises the conversion of the electric current waves into electromagnetic waves of the desired frequency. The transmitted electromagnetic field travels from the antenna in many directions and at the speed of light.

If another antenna is placed in the electromagnetic field, then a small electric current will be generated in the antenna wire at a frequency corresponding to the transmitted wavelength. The signal electric current produced is very small but can be maximised by tuning the length of the antenna to the wavelength of the electromagnetic wave and also matching the antenna polarisation (see later section) with the transmitter polarisation. The radio frequency electric current is conveyed by screened cable (which minimises the escape of energy as electromagnetic waves and introduction of interference) to the radio. At the radio, the radio frequency signal is amplified and processed (demodulated) by the radio to leave only the signal information (eg voice message) as an output.

27.2.5 MODULATION

A “carrier” wave, as discussed in the previous section, does not contain any message information. The simplest way to convey a message is to key on/off the carrier wave, eg Morse Code, but this is inconvenient and inefficient. However, this is still the way that pilots can turn on runway lights at some airfields just by keying their VHF com radio a few times in regular succession.

In order to convey a message by radio, the carrier wave at the transmitter needs to be combined, referred to as “modulated”, with the analogue voice or digital data message signal. Then at the receiver, the carrier wave needs to be “demodulated” (eg a low pass filter) to recover the message signal.

The two most common ways to modulate the carrier wave with a message signal are:

- Amplitude modulation (AM). The power, or amplitude, of the signal is varied, or modulated, at a rate corresponding to the frequencies of an audible signal such as voice or music. AM radio has a long range, particularly at night, but it is subject to interference that affects the sound quality. When a signal is partially blocked, the volume of the sound is reduced accordingly. Aircraft band voice communications uses AM.
- Frequency modulation (FM). The amplitude of the signal remains constant while the frequency of the carrier wave is varied slightly higher or lower at a rate and magnitude corresponding to the audio or data signal. This results in better signal quality than AM because environmental factors do not affect the frequency the way they affect amplitude, and the receiver ignores variations in amplitude as long as the signal remains above a minimum threshold.

27.3 VHF COM RADIOS

A VHF Com Radio is a combined Airband radio transmitter and receiver in one package with a single antenna. It operates in half-duplex mode in that it is either receiving or transmitting but not both at the same time. By default, the radio is in receive status unless the operator activates transmit.

There are numerous brands of aircraft radios on the market. Since they all must communicate with each other, they must carefully comply with international technical standards. Over time, the physical form, technical features and methods of operating the different brands of radios commonly used in sailplanes have become very similar but are still different so the manufacturer's user/installation manual is the primary source of information.

Hand-held VHF Airband com radios are readily available but their range is usually far less than a well installed radio and, as a loose object in the cockpit, they may be an inflight hazard.

An installed VHF com radio system usually comprises the following components and these are discussed in the following text:

a. VHF com radio unit

b. Microphone and Press To Talk (PTT) switch

c. Loudspeaker

d. Antenna

e. Antenna-Radio cable

f. Wiring harness (to connect the above components)

27.3.1 GOLDEN RULES - WARNING!

Before going any further, there are a few Golden Rules when working with radios that need to be observed:

a. DO NOT transmit without an antenna connected that is suitable for the radio's frequency operating range.

b. DO NOT transmit with a damaged coax cable.

c. DO NOT transmit with a disconnected coax cable

d. DO NOT transmit when the antenna is grossly out of tune i.e. SWR greater than 3:1

Failing to comply with any of the above may cause the reflected power (ie power normally radiated by the antenna) to severely damage the radio.

27.3.2 THE VHF COM RADIO

Most countries divide the 19 MHz of the Airband into 760 channels of 25kHz bandwidth and use amplitude modulation voice transmissions, on frequencies from 118–136.975 MHz, in steps of 25 kHz. Hence the product name of many VHF com radios includes the number "760".

In Europe, to create more available channels each ‘760 channel’ has been further divide into three channels of 8.33 kHz bandwidth, thus permitting 2,280 channels. These 8.33kHz radios are compatible with 25kHz spaced frequencies. At the time of editing, Australia has no published plan to use the new channels created by 8.33kHz bandwidth.

Aircraft VHF radio communications worldwide uses amplitude modulation. A typical sailplane radio has an output of 5-10 watts Radio Frequency (RF) output.

The usual physical form of modern VHF com radio found in sailplanes is a rectangular box typically 60 x 60 x 200mm. They are designed to be installed in a standard 57mm (2 ¼”) circular instrument panel hole (from behind the panel) and secured using 4x mounting screws through the panel.

Figure 27-3 Example VHF Com Radio Panel Mounted

Some manufacturers offer a remote-controlled version which allows the controller “head” to be installed in instruments panels lacking depth whilst the main box is installed elsewhere. Eg Becker RT6512.

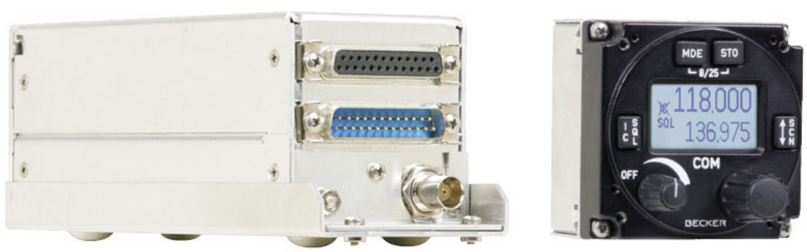


Figure 27-4 Remote VHF Com Radio and Controller Head

It is best practice to install the radio with its own dedicated fuse/circuit breaker. The manufacturers’ recommended value is often 3A but check with radio’s user/installation manual.

The radio case is usually metal and often has its own grounding connection which is important to minimise interference.

In a 2-seat tandem sailplane, the VHF com radio should be fitted in the panel of the cockpit used for solo flight, usually the front cockpit. This has the unfortunate disadvantage that an instructor in the rear seat is unable to adjust the radio frequency/volume in flight. If this is an important issue, then a rear seat ‘remote radio head’ which connects to the main radio may be a suitable solution (Eg Trig TY91).

27.3.3 MICROPHONE AND PTT

A microphone, colloquially called a mic or mike, is a transducer that converts sound into an electrical signal.

There are two types of microphone commonly used in aviation and many radios can be set to accommodate either. Care is needed to ensure the type of microphone used is suitable for the radio and the radio properly configured. The two types of microphone are:

- The dynamic microphone. A coil is glued to the rear of a membrane, and there is a strong magnet surrounding this coil. When sound waves hit the microphone, the membrane moves to the rhythm of the sound waves, and the coil on its back moves along with it. The relative movement of the coil within the stationary magnetic field induces a small signal voltage in the coil. (This is effectively a loudspeaker in reverse). The output signal level is low. Some brands of VHF com radios have a special input connection and internal amplification for this type of mic. Other brands require an add-on mic amplifier to be used or deem this type not suitable.
- The electret microphone (a statically pre-charged form of condenser microphone). This uses a vibrating diaphragm as a capacitor plate that varies the capacitance in sympathy with the sound wave. This is probably the most common microphone type in use in aviation. They are small in size and can have noise cancelling capability. They are a high signal device and thus do not normally require amplification. It is important to wire an electret microphone with the correct polarity as it must have a voltage bias applied to it by the radio.

Any mismatch in the antenna tuning can set up standing waves currents along the outside of the antenna coax which are capable of electromagnetically inducing unwanted signals into microphone wires. This is the cause of many of oscillation and feedback problems. To protect against interference:

- Do not run the microphone cable alongside the antenna coax, keep them separated as much as possible, and;
- Use screened cable between microphones and the radio should be via screened cable where the screen is grounded on one end only.

It is normal for the microphone to be mounted on the end of a flexible gooseneck and to activate it with a PTT (Press To Talk) button switch on the control stick. This means the pilot can position the microphone near his mouth, has both hands available to fly the aircraft and can activate the radio via the PTT without letting go of the control stick. The PTT cable where it enters or is attached to the control stick should be checked at each Annual Inspection as it may be subject to fatigue as the stick is moved.

It can be convenient for maintenance to connect the microphone/gooseneck to the in-fuselage wiring via a good quality connector, such as a miniature DIN 3-pin, maintaining the screening through the connector. This enables easy disconnection and removal for maintenance.

In two seat sailplanes with a single radio, the radio usually has separate input pins for each microphone and each PTT. When two microphones are used, some radios require the microphones to be of the same type ie matched, whilst some radios have different inputs and/or internal software configuration to allow un-matched microphone pairs. Read the installation manual carefully to ensure a valid configuration.

27.3.4 LOUDSPEAKERS

Loudspeakers convert electrical energy into sound waves using an electro-magnet to excite and vibrate a diaphragm. A speaker is described by its impedance (usually 4 ohms or 8 ohms), power handling capability (typically 5 watts) and its physical size. The speaker’s impedance must match and the power rating match or exceed the radio/device’s specification.

Note: Impedance = resistance + reactance (due to capacitance and induction created by alternating current signals).

Adding a second speaker in series or parallel will result in a different impedance to the individual speakers (in accordance with resistive network theory) and is best avoided. In a two-seat tandem sailplane with a single speaker, it is usually best to mount the speaker in or on the rear instrument panel so as to position it between the two pilots where both can similarly hear a reasonable volume setting.

Do not ground wires feeding loudspeakers unless the radio installation instructions state this is required.

Do not connect speakers to headphone outputs or headphones to speaker outputs.

You cannot simply connect multiple input sources to the same speaker. Whilst there are electronic mixer/amplifiers that can combine multiple input sources into one output, this is done at low signal levels prior to the main amplification. It is thus normal in sailplanes to have separate speakers for the radio and electronic variometer(s).

All speakers contain a powerful magnet that can affect a magnetic compass. It is best to mount it as far away as practical from the compass to avoid erroneous compass readings. After a new radio installation, you should re-swing your compass, including radio transmit and receive operation, to confirm the compass is not unduly affected.

27.3.5 RADIO WIRING HARNESS

Connections to modern radios are usually via a male sub-miniature D socket (often 15 or 25 pin) on the rear of the radio. This socket usually provides all connections except the antenna and a case/chassis ground. This enables the radio to be easily disconnected and removed from the sailplane in the event of requiring service.

Some manufacturers provide a matching female D plug with pre-soldered wires as a wiring harness. Other manufacturers provide a wiring diagram and perhaps an unwired male socket for the installer to solder wires to.

There is no common standard shared by manufacturers for the wiring of the connectors used in radio wiring harness. If you replace a radio with a different model or brand, even if the new radio looks like it will simply plug into the existing harness, you must read the installation manual and ensure the correct wiring is configured at the connector pins or you may damage the radio.

An example of a VHF com radio wiring harness and it’s wiring diagram are shown below at Figure 27-5 and Figure 27-6 (acknowledgement to Microair):

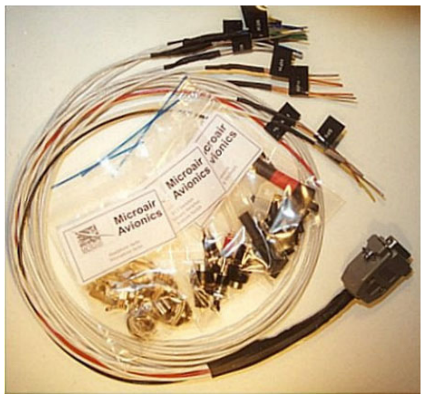


Figure 27-5 VHF Com Wiring Harness

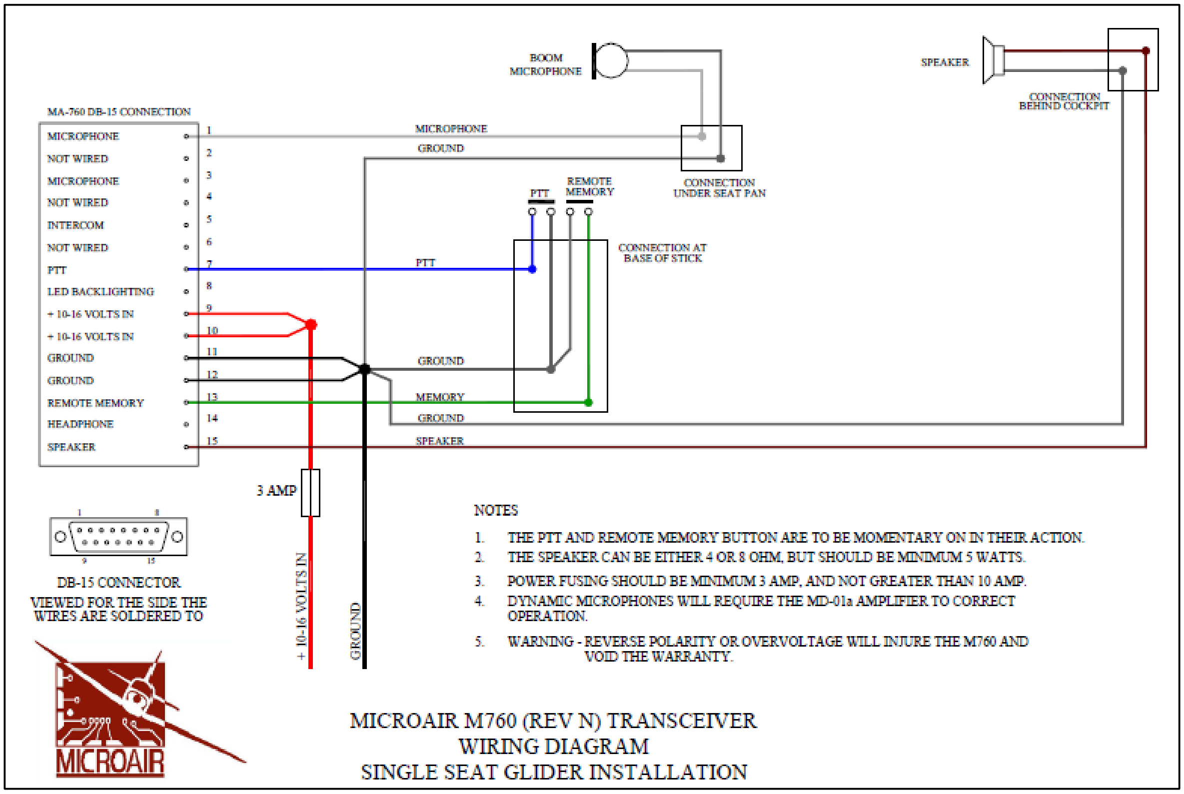


Figure 27-6 VHF Com Example D-Plug Wiring Diagram

27.4 ANTENNAE

27.4.1 ANTENNA BASICS

An antenna is a transducer that enables:

a. Transmission by converting radio frequency electric current into electromagnetic waves that are then radiated into space, or

b. Reception by converting electromagnetic waves into radio frequency electric current

An antenna consists of an active/driven element and a ground plane element. In physical form, antennae are either a dipole antenna (two conducting elements are clearly visible) or a monopole antenna (one active element is visible and the other, the ground plane, is not so obvious).

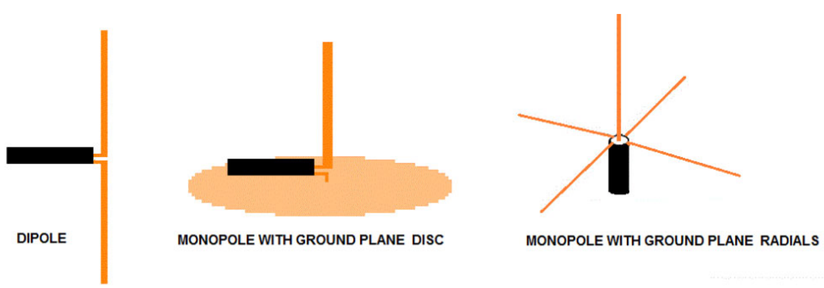


Figure 27-7 Forms of Antennae

The physical length of the antenna's active element needs to be matched/tuned to the frequency range of use. Antenna lengths of 1, ½, ¼ or 1/8 of the wavelength of the mid frequency of the required band are all suitable. Generally, the longer the length of antenna, the greater output strength. For practical reasons, the optimum length of a sailplane antenna's active element should match one quarter of the wavelength of the frequency being used.

The ground plane element of an antenna should be of similar equivalent electrical size to the active element. Where the two elements are physically aligned as a 'dipole', they are usually described as half-wave dipoles as each element is ¼ of a wavelength. Monopole antennae, such as a whip antenna, are usually described as ¼-wave whip but must still have an equivalent ground plane.

The ground plane (sometimes referred to as the counterpoise) is simply the 'grounded' side of the antenna. All antennae require a suitable ground plane but there are several different ways of achieving this for a monopole antenna, such as:

a. Use the aircraft skin (on metal aircraft)

b. Use a foil or aluminium sheet inside the aircraft

c. Use wires radiating from the base of the antenna

d. Use a tuned coil of wire built into the base of the antenna

27.4.2 ANTENNA POLARISATION

The term "Polarisation" simply refers to the orientation of the electromagnetic radio wave being transmitted from the antenna. A vertical antenna radiates a vertically polarised signal and a horizontal antenna radiates a horizontally polarised signal. For good communication, the transmitting and receiving antennae need to have the same orientation.

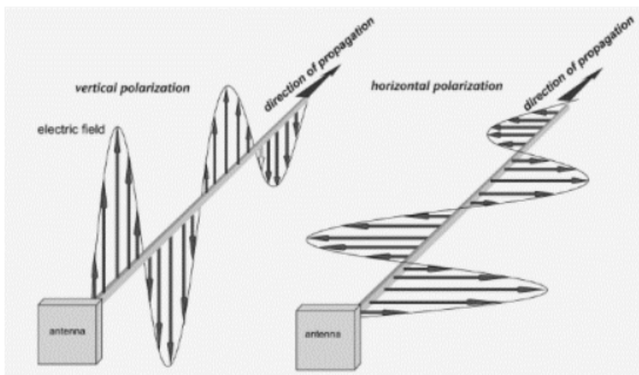


Figure 27-8 Antennae Polarisation

For aircraft band frequencies, vertical polarisation is the standard. Thus, a sailplane's antennae radiating element should be mounted so as to as near vertical as possible with the sailplane in a straight and level flight.

An Airband radio with a vertical antenna is omni-directional in that theoretically it transmits/receives equally in all horizontal directions. However, the structure of the sailplane may degrade the signals in some directions eg a tail-mounted antenna may have a weak zone in the forward direction.

27.4.3 TYPES OF AIRCRAFT ANTENNA

There are several different types of antenna available for aircraft. Some are expensive, some are cheap, some are designed to be used externally and others are designed to be used internally ie inside the aircraft structure. All Airband antennae have a designed input impedance of 50 ohms

For practical reasons, most modern GRP sailplanes have a vertical half-wave dipole built into the vertical stabiliser during construction. Accessing such an antenna or the point of connection of the cable to the antenna is likely to be very difficult, however such antenna installations are generally very reliable. To prolong the life of a tail antenna, do not pull or strain the antenna cable.

There are hundreds of antennae on the market with many different features but they can be split into the f major groups shown in the table below:

Table 27-2 Antennae Groups

<u>Internal dipole antennae</u> - The most common dipole is the half wavelength dipole antenna which has two 1/4 wave 'elements' placed end to end with the connection point at the centre.	
<u>Fibreglass or stainless-steel whip antennae</u> —these are 1/4 wave antennae most suited to ultralight aircraft, sailplanes, sport aircraft, etc.	
<u>Fibreglass rigid antennae</u> - more expensive 1/4 wave antennae like the Comant 121 model which offer extremely good SWR readings across the entire aviation band and offer excellent performance. Often seen on GA aircraft.	
<u>Base station antennae</u> - usually longer in length than standard 1/4 wave antennae, most base station antennae are 1/2 wavelengths being approximately 1.2 m long plus a base section. They are normally 'ground plane independent' (meaning that the ground plane is 'in-built') and are mounted vertically on towers or the side of buildings. Due to their bulk they are not suitable for sailplanes.	

27.4.4 WHIP ANTENNAE

In metal aircraft, a whip antenna can be grounded through the antenna mounting screws into the airframe. In which case, it is important to obtain a good electrical bond where the antenna is mounted by ensuring the area is free of paint and debris. With many antennae, a backing plate is placed in the aircraft interior with the antenna connected by mounting screws through the aircraft skin. The backing plate must obtain a good electrical ground to the aircraft skin by removing the paint. The electrical ground can be checked by placing a multi-meter between the antenna mounting screw and the aircraft skin. The reading should be no greater than 0.003 ohm

Wood/fabric sailplanes and modern GRP sailplanes lack a metal frame or body and thus create challenges when trying to ground a whip antenna. To ensure good communications, care must be taken to provide an adequate ground plane. For best performance the ground plane should be horizontal and have a radius of at least one quarter wavelength of the antennae operating frequency, or as large as practical.

Internal antennae and ground planes will not work inside sailplanes with carbon fibre reinforcement in the fuselage. Such sailplanes usually deliberately have no carbon fibre in the stabiliser and/or rudder so that a dipole antenna can be installed there.

The location of an antenna on any aircraft is very important. VHF transmissions are line of sight and any object in the transmission path like the tail plane, other antennae, people or carbon fibre reinforcement will reduce the performance of the antenna in the direction of the interrupted line of sight. In a perfect installation the antenna would be located on a flat surface centrally located in the middle of a ground plane. Unfortunately, this is not always possible and the best position must be a compromise for each individual aircraft type.

On powered sailplanes, antennae should not be mounted anywhere near an engine exhaust.

27.4.5 CONNECTING THE RADIO TO THE ANTENNA

You cannot use normal parallel-pair wire cable to connect a radio with the antenna – you must use a coaxial cable, often referred to as 'coax', where one conductor forms a concentric "shield" around a central core conductor. This cable provides a pathway for the transmission signal and needs to have physical properties that provide the best possible performance regarding low loss of signal and exclusion of interference.

In most cases, newly constructed sailplanes come ready installed with an antenna and connecting coax cable or a purchased antenna comes with a coax cable deemed suitable by the antenna manufacturer or supplier. However, there may be times when a coax cable must be replaced or extended, so the following text is provided to aid understanding and selection of suitable cable.

27.4.6 COAXIAL CABLE

Coax cable has a centre wire, a dielectric/insulation layer, a concentric outer braid/foil shield and an outer protective jacket (see diagrams below). The centre wire carries the signal to/from the antenna and the outer shield cancels any electromagnetic radiation and suppresses external interference that might degrade the transmission signal quality.

Every coax cable exhibits capacitance between the centre wire and the braid, and also inductance along the length of the cable. For coax cables at radio frequencies, the capacitance typically dominates the impedance value and is thus often stated in a cable's specification.

Understanding Impedance

In direct current circuits the relationship of current (I), voltage (V) and resistance (R) is defined by Ohm's Law $V = I \times R$. However, with alternating current (such as radio frequency signal fluctuations) in circuits, there is further opposition to the current changes due to the effects of capacitance and induction known as reactance.

So in alternating current circuits, the relationship equation becomes $V = I \times Z$ where Z is called Impedance and measured in ohms (symbol is Ω). Impedance is the resistance plus the reactance (due to capacitance and induction). The value of reactance depends on the frequency of the signal as well as the value of the capacitance and induction.

Coax cable is classified by its "characteristic impedance". The characteristic impedance of a uniform transmission line is defined as its input impedance when its length is infinite. Characteristic impedance is determined by the geometry and materials of the transmission line and, for a uniform line, is not dependent on its length. The importance of this for radio communications is that for maximum power transfer the radio output impedance, coax cable characteristic impedance and antenna impedance must all match. VHF com radio coax cables must have a characteristic impedance of 50 ohms. Do not use TV coax, which has a characteristic impedance of 75 ohms, in sailplanes.

Aside from the characteristic impedance, the most important electrical parameter of coax is probably the signal loss (sometimes referred to as "attenuation") per metre. Signal loss in the cable means that a fraction of the radio's output fails to reach the antenna or else that the received signal at the antenna is diminished by the time it reaches the radio. Ideally, we want to choose a cable with low loss. Signal loss is usually expressed as decibels (dB) per 100m. Decibels is an exponential scale, not a linear scale, so for example a 3dB loss is equivalent to a reduction to 50% of the input signal level and a 10db loss is equivalent to a reduction to 10%.

There are several factors that influence the signal loss in a coax cable, the key ones being:

a. Cross section area and number of stands in centre wire. The bigger the diameter the better the conductivity but heavier the weight per metre. Theoretically a solid core centre wire has greater cross section than a stranded core and so less loss. Stranded cores however are more flexible so less inclined to break.

b. Dielectric/Insulator thickness and material.

c. Quality of braiding shield. The fewer gaps in the braiding the less loss of signal and possibility of interference. This is often specified as the percentage of coverage – the higher the percentage the better. Copper braid may be further improved by coating with silver. Two layers of braid are sometimes used as it results in fewer gaps. Foil is an alternative to braid and has no gaps but is relatively fragile. Composite shields comprising a layer of foil covered in a layer of braid are available.

For sailplanes, the length of run of the coax cable is relatively short (so the length related loss is usually fairly small), the RF transmit power is relatively low (4-10W), we need to minimise the weight and choose a durable flexible cable which will have a long life. In practice this means we are seeking a good quality 50-ohm low loss coax of approx 5mm outside diameter. There is a bewildering choice in the market!

At first glance there appears to be a standard for coax cables (originating from the US military in the 1950s), all commencing with the designation "RG". For example, RG58 is a 50 ohm (Ω) coax with an outside diameter of approx 5mm. But the RG standards are no longer officially maintained and have been superseded in the US by MIL-C-17. Manufacturers may also put to market products that do not match precisely these standards but may be fit for sailplane use.

The following table summarises a number of appropriate RG specifications for 50 ohm coax and a couple of manufacturers' products that might be considered for sailplanes:

Table 27-3 Typical Specifications of Suitable Coax

Type	Code or brandname	Centre conductor / Shield	Typical Loss/100m @ 100MHz	OD mm
Single shield	RG58/U	Solid / Braid	15.0	5.0
	RG58A/U	Stranded / Braid	17.0	5.0
	RG58C/U	Stranded / Braid (non-contaminating jacket")	17.0	5.0
	RG8X (Mini 8)	Stranded / Braid	10.1	6.1
Double shield	RG142U	Solid / double Braid	10.8	5.0
	RG400	Stranded / double Braid	10.8	5.0
Low loss	LMR195	Solid /Foil + braid	12.0	5.0
	Hyperflex 5	Stranded /Foil + braid	8.2	5.0
	Airborne 5	Stranded /Foil + braid	9.4	5.0

d. "Non-contaminating jacket" meaning: Over time, exacerbated by UV and heat, the migration of plasticiser from a PVC jacket into the polyethylene core of a coaxial cable causes contamination which can significantly alter the high-frequency transmission characteristics of the cable. A non-contaminating jacket is less prone to deteriorate in performance overtime.

When comparing signal loss factors, it is important to use consistent units of measure and ensure the frequency at which the attenuation is measured is close to the Airband range.

Coax cable similar to RG58 is available with an aluminium foil shield instead of a wire braid. Theoretically foil, having 100% coverage compared to braid having gaps between the braids, has less loss and is therefore superior. However, foil alone cannot be soldered and if crimped the foil may be damaged by bending. There are also double shielded cables, that have a braid shield and also a foil shield, which offer excellent shielding and practicality.

For motor sailplanes with unshielded ignition systems, it is preferable to use RG400 or RG142/U which is a double shielded coax, or a branded low loss coax, since the extra shielding will reduce interference noise due to the ignition system.

Figure 27-9 Shielded Coax

If choosing a coax to connect a base station with an antenna over 8m away, you might consider a thicker coax cable, say 10mm outside diameter so as to minimise the losses and because size/weight is not an issue.

It is good practice and gives the best performance if the coax cable is kept as short as possible. Avoid sharp bends, do not coil the coax cable to create loops and do not run the VHF antenna coax alongside a transponder coax to avoid interference problems.

Once the coax is installed, it generally lasts the life of the aircraft so skimping on a few dollars during installation does not make good sense. You should purchase the best quality coax and connectors that you can afford and ensure that they are correct for your avionics installation.

If it is required to extend an existing coax cable, do not attempt to solder or crimp an add-on length to the existing cable as such a joint would most likely be a cause of signal loss. It is best to have male BNC plugs on the ends of the cables to be joined and use a female-female inline connector to join them.

Figure 27-10 Female-Female Coax Connector

Potential suppliers of suitable coax cable and connectors in Australia are:

a. Altronics

b. Jaycar

c. radioparts.com.au

d. rfsolutions.com.au

e. zcg.com.au

f. commswestdistribution.co.au

27.4.7 VHF COM RADIO ANTENNA CONNECTORS

When a coax cable needs to be connected to either the antenna or to the radio, it is usually done with a BNC (bayonet) connector or occasionally a TNC (threaded) connector. These connectors are light, mechanically strong and reasonably weatherproof. There are numerous manufacturers to choose from. Right angled versions are available which can be useful where there is a depth issue behind the panel. They are available in crimped or soldered versions. There are also solderless/crimp-less versions but these are not good enough for radio frequency use.

If using coax other than standard RG58, then check that the connector matches the coax diameter else the crimp or securing gland (on a soldered connected) may be the wrong size.

Figure 27-11 RG58 BNC bayonet (crimp) 50 ohms

Figure 27-12 RG58 TNC screw on (crimp) 50 ohms

Figure 27-13 RG58 BNC bayonet (crimp) right-angle 50 ohms

Notes: BNC = Bayonet Neill–Concelman. It features two bayonet lugs on the female connector; mating is fully achieved with a quarter turn of the coupling nut.
TNC = Threaded Neill–Concelman. This has a screwed coupling nut.
RG59 connectors are designed for 75 ohm cables and should not be use with VHF com radios.

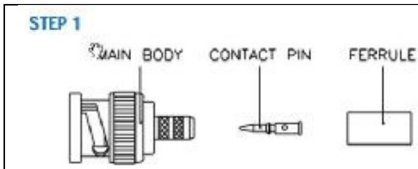
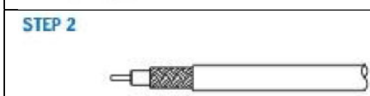
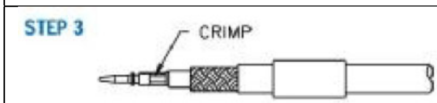
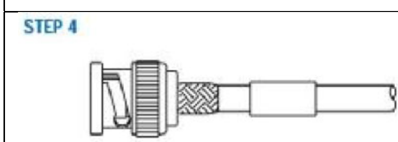
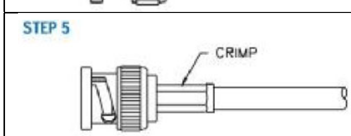
27.4.8 MAKING A COAX PLUG CRIMP CONNECTION

It is a common error to apply too much heat when soldering and this can damage both the plug and the cable, therefore a crimped connection is usually the best solution. Properly made crimped connections are very reliable and strong, offering years of service in the field.

Crimped connections need to be performed with the correct size and profile crimping tool. An example is shown in the figure right. The table below describes the process steps.

Figure 27-14 Typical Ratchet Crimpers

Table 27-4 The steps for making a crimp connection on a BNC or TNC connector

	**Step 1.** Layout all the parts required for a crimped connection.
	**Step 2.** Strip back the outer cable shield to expose the braid and also strip back the dielectric/insulator to expose the cable core. Experimentation on a practice piece may be required to establish how much strip back.
	**Step 3.** Slide the ferrule over the cable, out of the way for now. Position the contact pin on the exposed cable core and then crimp the contact pin in place.
	**Step 4.** Insert the cable into the rear of the BNC connector until you hear the contact pin click into position.
	**Step 5.** Slide the ferrule back down the cable until it is firmly seated on the base of the BNC and crimp into position using an appropriate size crimping tool.

Finally, check the coax cable and BNC fitting for physical security and electrical continuity to make sure the connection has been completed correctly.

27.4.9 ANTENNA PERFORMANCE

The Voltage Standing Wave Ratio (VSWR), or SWR for short, of an antenna is a measure of how efficiently the radio is radiating the energy it produces when it transmits. It is represented as a ratio and is generally, all though not accurately, referred to as the ratio of emitted power to reflected power within an antenna.

You don't need to know what it actually is in order to measure it; you just need an SWR meter to get three simple readings.

Every new antenna installation in an aircraft, regardless of the quality of the antenna, should be checked with a SWR meter before first flight. For existing antenna installations, if faults are suspected with the radio or antenna then a SWR test may help verify the issue.

SWR meters are readily available in electronics shops and on the internet. Make sure the meter covers the Airband frequency range and comes with the appropriate connectors.

Here is what you need to know:

a. The scale on a SWR meter reads from 1 to infinity. The smaller the number, the better the SWR reading and the antenna will perform. The scale is not linear, it is logarithmic. From 1 to 3 covers more than half of the scale on a SWR meter. The remainder covers 3 to infinity.

b. The ideal number to aim for on the SWR meter is 1:1 (pronounced 1 to 1) but this is rarely achieved. This means all the energy is being radiated and none being 'reflected' back into the radio. Less than 1.5:1 is very good. A SWR of 2:1 or less is OK. It is generally regarded that a SWR reading of less than 2.5:1 is acceptable for aviation use, but the intention is to get the SWR as low as possible.

c. A SWR reading of more than 3 may be hazardous to a radio. This is often marked in red on the SWR scale. Because of the logarithmic scale, you don't have to be far into the red before you are into the big numbers!

d. The Airband covers a very wide range from 118.000 MHz up to 136.975 MHz. For any given frequency there is a corresponding wavelength and one ideal length of antenna. Because we are changing frequencies often, it stands to reason that the actual length of our antenna must be a compromise since we can't keep changing the length of the antenna every time we change frequency. Most aircraft antennae are tuned in the middle of the Airband frequency (usually 127 MHz) and we accept a compromise of the SWR reading at frequencies above and below this middle frequency.

e. In practice the size and shape of the antenna's ground plane can also affect the SWR of an antenna. (no ground plane = high SWR)

f. ATC radio transmissions are vertically polarised, as described earlier. This means that your aircraft antenna should be installed so as to be more vertical than horizontal for best performance.

27.4.10 THE EFFECT OF ANTENNA DIAMETER/WIDTH ON PERFORMANCE

Generally, a larger diameter/width antenna will give a broader band performance. That is, an antenna that is large in diameter or flat and wide like the internal dipoles, will give a much better broadband performance than a thin stainless-steel whip antenna. When a thin stainless-steel antenna is tuned to 127 MHz (roughly the middle of the aircraft band) the maximum broadband performance it can give is around 5 MHz (ie 2.5MHz either side of 127 MHz) whereas larger diameter antennae can give broadband performance over 10 MHz range.

The following two graphs are a good indication of how a wider diameter antenna can generally provide better performance. The graph on the left-hand side shows a performance chart for a Mobile 1 base station antenna.

Reading the graph at 118 MHz shows a SWR of less than 1.6:1, at 126 MHz it is 1:1 and 136 MHz it is around 1.7:1 making this a fantastically performing antenna across the entire Airband range.

The graph on the right however shows a stainless-steel whip type antenna which is tuned to 124 MHz where it has a SWR reading of around 1.1:1 which is great. Unfortunately, at 129 MHz the antenna is already above our upper limit of 3:1 SWR and the same at the lower frequency of around 121 MHz. What this means is the stainless-steel whip type antenna will perform really well at around 124 MHz but its performance drops off quickly when the radio is moved off this frequency. This antenna should not be used for any frequencies lower than 121 MHz or higher than 129 MHz because of the risk of radio damage.

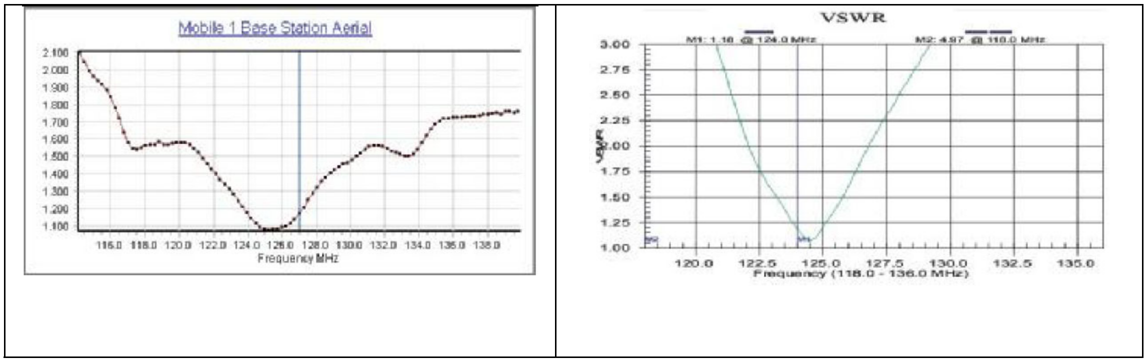


Figure 27-15 Example SWR Results Graphs

27.4.11 USING A SWR METER

Connect the antenna BNC plug to the side of the SWR meter marked antenna. Connect the radio to the side of the SWR meter marked transmitter. In other words, the SWR meter is connected between the radio and the antenna.

Figure 27-16 SWR Meter Between Radio and Antenna

Rig the aircraft and move it well away from hangars. Conducting SWR tests inside a hanger is a complete waste of time because the meter will measure the signal bouncing off the metal from the hangar and give a high reading!

Firstly, set the first frequency to 118.000 MHz and calibrate the SWR meter by doing a brief transmission on the calibrate setting and adjust the power needle to the 'set' position (100% full scale deflection) using the knob on the front of the meter. Make sure the frequencies you use are not in use at your location.

If you have the most common SWR meter which is a single dial meter, you will have to switch between calibrate and SWR operations and note the readings.

Note: You don't need to talk to anyone; in fact you don't even need your headset plugged in. You are just measuring the efficiency of the 'carrier wave', not the modulation (voice signal).

Then repeat the operation above on 127.000 MHz and again on 136.975 MHz. This will give us three SWR readings across the entire aircraft band. One reading is at 118.000 MHz, the second reading at 127.000 MHz and a final reading at 136.975 MHz.

A typical example set of SWR readings follows:

118.000 MHz = 2.3 :1

127.000 MHz = 1.5 :1

136.975 MHZ = 2.8 :1

From these three readings we can see that the antenna is best at 127 MHz, it is not too bad at 118 MHz but the SWR readings get high at 136 MHz. This tells you that the antenna is going to perform better in the central and lower frequencies than it is at the top of the frequency range.

In this example the antenna is not perfect especially at 136 MHz but it will do the job.

We would like to get a better reading and to do this ideally you would tune the antenna. However, many sailplane antennae are built-in during manufacture, are inaccessible and thus untuneable. We should take comfort that the antenna was carefully selected by the sailplane manufacturer to be suitable and provided the Airband frequency range has not changed, it should be adequately tuned.

If a SWR test suggests that an installed antenna is poorly tuned, then the most likely cause is the connecting cable or the deterioration of the connection (eg strain induced disconnect or corrosion) of the coax to the antenna. Accessing the latter may be challenging.

27.4.12 HOW TO TUNE ANTENNAE

Many of the more expensive add-on antennae come pre-tuned and it is pretty much impossible to make tuning changes to the antenna. Some of the cheaper antennae however have the ability and the requirement to be tuned in each installation. The procedure for tuning is:

a. If it is a whip antenna, screw the antenna onto the antenna base as far as it will go and ensure you have a suitable ground plane with good electrical contact. A poor ground plane will cause your antenna to be grossly out of tune and cannot be remedied by tuning the whip as described below.

b. Note the SWR readings at the three frequencies 118.000, 127.000 and 136.975 MHz. To get correct readings, keep people and metallic items away from the antenna.

c. The higher the frequency, the shorter the required antenna length. You should try to adjust towards the frequency with the higher SWR, so in the previous example we need to adjust towards the higher frequency (136.975). This means we need a shorter antenna, so we can trim one or two millimetres off the top of the antenna and recheck the SWR.

d. If the SWR is higher on the lower frequency, then (the lower the frequency the longer the antenna) we need to lengthen the antenna.

e. Take care - it may not be possible to get 'flat line' in all cases. If the SWR reading starts to increase again before reaching 1:1, then you have gone too far, so stop cutting

f. When you have the best SWR reading you can, remove the meter and reconnect the coax directly to the radio. Go for a fly and get a proper radio check

27.5 AVIONICS

27.5.1 AVIONICS INTRODUCTION

Aside from VHF com radios, modern sailplanes frequently have an array of avionics installed in the instrument panel such as:

a. FLARM – other aircraft detection, relative location display and collision hazard warning

b. Electric variometer

c. GPS navigation

d. Map display

e. Flight computers

f. Track and height logging

All these devices require power, some require antennae or sensors and often they also require interconnection to transfer data.

Pilots may choose to supplement the installed avionics with portable/temporarily fitted personal devices (eg Oudie) running flight computer software and flight loggers (eg Nano). Whilst these can often function independently, pilots may wish to connect them to the sailplane’s power system and exchange data with installed avionics.

Whilst there are trends towards devices with integrated multiple functions, and Bluetooth radio is sometimes a connection option, it looks likely that sailplane cockpits will continue to require the physical interconnection of multiple devices for many years.

Fortunately there are some standards and conventions in use and manufacturers usually provide good documentation. However, unless well planned, installed and recorded in the Maintenance Logbook, this avionics interconnectivity can mean a “spaghetti” of wiring which is difficult to understand and fault find.

Transmitting (more than 1-2 sec for test purposes) without an antenna connected or with an antenna grossly out of tune could damage the radio. The energy produced by the radio when in transmit mode needs to radiate (and hence dissipate heat). If it is unable to do so (for whatever reason) it will be reflected back into the radio and likely damage the power amplifier circuit.

27.5.2 IGC STANDARDS FOR DOWNLOADING FLIGHT DATA

A number of years ago, the International Gliding Commission (IGC) devised standards for the connectors and fittings for downloading flight data. These are published as "Technical Specification for GNSS Flight Recorders". Extracts from the Second Edition with Amendment 4a - 10 April 2016 follow below.

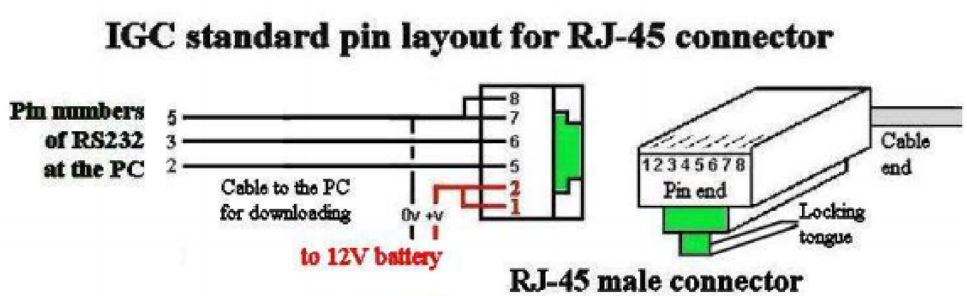
Whilst this IGC standardisation has been helpful, unfortunately the IGC appears to have deviated from the conventional RJ45 plug/socket numbering convention which can cause confusion. The key relevant parts of the IGC Standard are shown in the Figure below:

> 6.4 Connectors and Fittings for downloading Flight Data. IGC-approved types of connectors for downloading flight data are listed in Appendix F. Where a PC is used for downloading, either the RJ45 or USB connector is recommended because standard wiring to these types includes both power and data download facilities. The IGC standard connections for the RJ45 are given in Appendix F and the USB connections are to the international standard.

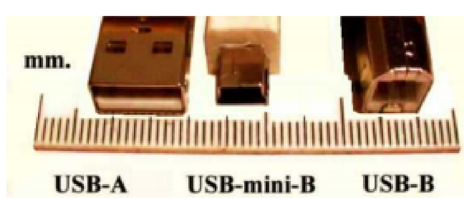
> F1 Connectors and Fittings for downloading Flight Data. IGC-approved types of connectors or fittings on the recorder case for downloading flight data are listed below. Many FRs have connectors for storage devices such as an SD card (including micro-SD), USB memory sticks, etc., and do not need a PC connection, particularly for downloading after flight.

F3 8-pin RJ-45 connector. This is a female 12 x 6 mm RJ-45 socket with 8 connections. It is also used for ISDN and Ethernet connections (but with different pin allocations). In the IGC layout, with the male plug end held towards the observer and the pins uppermost, the locking tongue underneath and the cable running away from the observer, pins are numbered 1-8 from left to right. IGC functions are listed below and also in the diagram that follows.

RJ-45 Pins	Function
1&2	Volts +
3&4	Spare, for future application with GFAC approval
5	Data out
6	Data in
7&8	Earth (Volts -ve)



F4 USB connectors. The connector on the recorder case may be a female Universal Serial Bus (USB) B-type receptacle, for connecting the recorder to a PC through a standard USB-B to USB-A cable. Wiring to the connector on the recorder case shall be to the USB standard (see www.usb.org). The recorder port shall be compatible with USB 1.1 and USB 2.0 devices. On the recorder, the receptacle shall be either a full-size USB series B receptacle (for which the male is about 8 x 6mm) or the 5-pin USB series mini-B receptacle for which the male is about 6 x 3mm with angled ends. See the photo below:



F7 "Grandfather Rights" for RJ-11 telephone connector with 6 pins. The RJ-11 was an IGC-approved connector but was withdrawn for new types of recorder by Amendment 6. This was because it had been found that after repeated use the locking tongue can break off, leading to the use of sticky tape or other methods to secure the connector to the recorder. The larger and stronger RJ-45 is a significant improvement over the RJ-11 because it is stronger, has more pins and its cable is (normally) shielded. The details of the RJ-11 pin layout continue to be included below so that users of equipment with RJ-11 connectors that has "Grandfather Rights" know what pin layout to use when making up connectors for download of data. The IGC RJ-11 system used a female 9 x 6 mm RJ-11 socket on the recorder with pin assignments as follows:

RJ-11 Pins	Function
1	Volts +
2	Spare (For future application (FFA) with GFAC approval. (Some recorders use this for an external LCD)
3	Spare (remarks as for pin 2)
4	Data out
5	Data in
6	Ground

Figure 27-17 Figure 27-1 Extracts from IGC standards

27.5.3 INTERCONNECTION OF AVIONICS

Avionics interconnection can comprise:

a. Power: May be 12V (nominal aircraft battery voltage), 5V (ie USB voltage level) or 3.3V (data logic and LED display voltage level)

b. Data exchange: Signal inputs/outputs. Several different formats exist.

c. Sensors (eg outside air temperature, airbrake status): These could be digital or analogue

d. Antennae

e. Pneumatic ie Pitot, static, TE. This is not covered in this chapter.

Whilst there is an IGC standard for cable and connectors used with Flight Loggers and Personal Digital Assistants (PDAs) such as Oudie, Kobo and Nano, these standards are not always universally applied and some manufacturers may occasionally use their own variations. Some of these are made for other uses and modified to carry out a sailplane function.

The interconnection of avionic devices is relatively simple if you follow manufacturers' suggested installation configurations and use the purpose made cables and connectors available from the suppliers. If you choose to implement an unpublished configuration, make your own cables, repair cables or want to incorporate existing legacy equipment, then proceed carefully with caution as you can easily damage avionics if incorrectly connected.

There are numerous different standards for how digital signals are passed along cable and, clearly, compatibility is essential. Therefore, if you are attempting a non-standard configuration, the interconnection of data may require more than just a simple plug/socket cable converter, eg the data signal may need to be converted to different signal levels or format.

It can be difficult to shorten many types of pre-made connectors because of the tools, parts and skills required to re-terminate the cable's cut end. Therefore, it is best to buy the appropriate length of pre-made cable. Some cables may be available in customed lengths from specialist suppliers. If a cable is unavoidably too long, then carefully coil and tie-wrap the surplus. But be aware that coiled or even close parallel cables act as antenna and may transfer/receive spurious signals. Be wary of what you cable tie together and where you create coils. As a general rule, keep all cables away from the radio antenna coax, some multiplexed data cables and engine ignition wiring.

Beware of voltage compatibility between devices and do not wire two supplies of different or even the same voltage to one device unless the device explicitly requires it. For example: The PowerFLARM may be supplied with 12V via its D-connector or via its RJ12 socket. If you connect the PowerFLARM to a LXNAV S100 via the RJ12 socket you will connect the required 12V and you should not connect the power leads via the D-connector. However, if you want to fuse the PowerFLARM separately to the S100, then you should power it via the D-connector but must modify the RJ12 lead such that the 12V pin is not connected.

You need to carefully consider socket and plug pinout details. Only the USB connector international standards have compliance from most manufacturers. For example; compare the published LXNav S100 RJ45 socket (labelled PDA) pinouts with the IGC standard for the RG45 connection cable to flight recording devices as shown below. Clearly these are not directly compatible. A special cable from LXNav is available to convert the LXNav RJ45 PDA socket to a fully standard compliant mini-USB-A plug.

RJ-45 Pins	Function
1&2	Volts +
3&4	Spare, for future application with GFAC approval
5	Data out
6	Data in
7&8	Earth (Volts -ve)

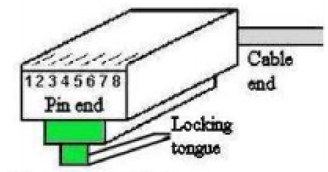


Figure 27-18 IGC standard RJ45

Pin Number	Description
1,2	Ground
3	(output) Transmit from LXNAV S8XRS232 (e.g. Computer, IPAQ38/39xx)
4	(input) Receive to LXNAV S8XRS232 (e.g. Computer, IPAQ38/39xx)
5	(output) Transmit from LXNAV S8XLV-TTL (3.3V) (e.g. Oudie, HP302, HP31x)
6	(input) Receive to LXNAV S8XLV-TTL (3.3V) (e.g. Oudie, HP302, HP31x)
7,8	5V OUTPUT (maximum 1A)

Figure 27-19 LXNav S100 PDA RJ45

If you buy pre-made RJ45 to RJ45 cables, be careful that you buy “straight through” cables unless you have identified that you specifically need “crossover” data cables.

Bluetooth radio is becoming more common as a means of connecting PDAs to FLARM and navigation avionics. Refer to the device manuals for set up instructions.

To aid future maintenance, it is strongly recommended that details of the avionics interconnection is included on the sailplane’s electrical wiring diagram. An example follows:

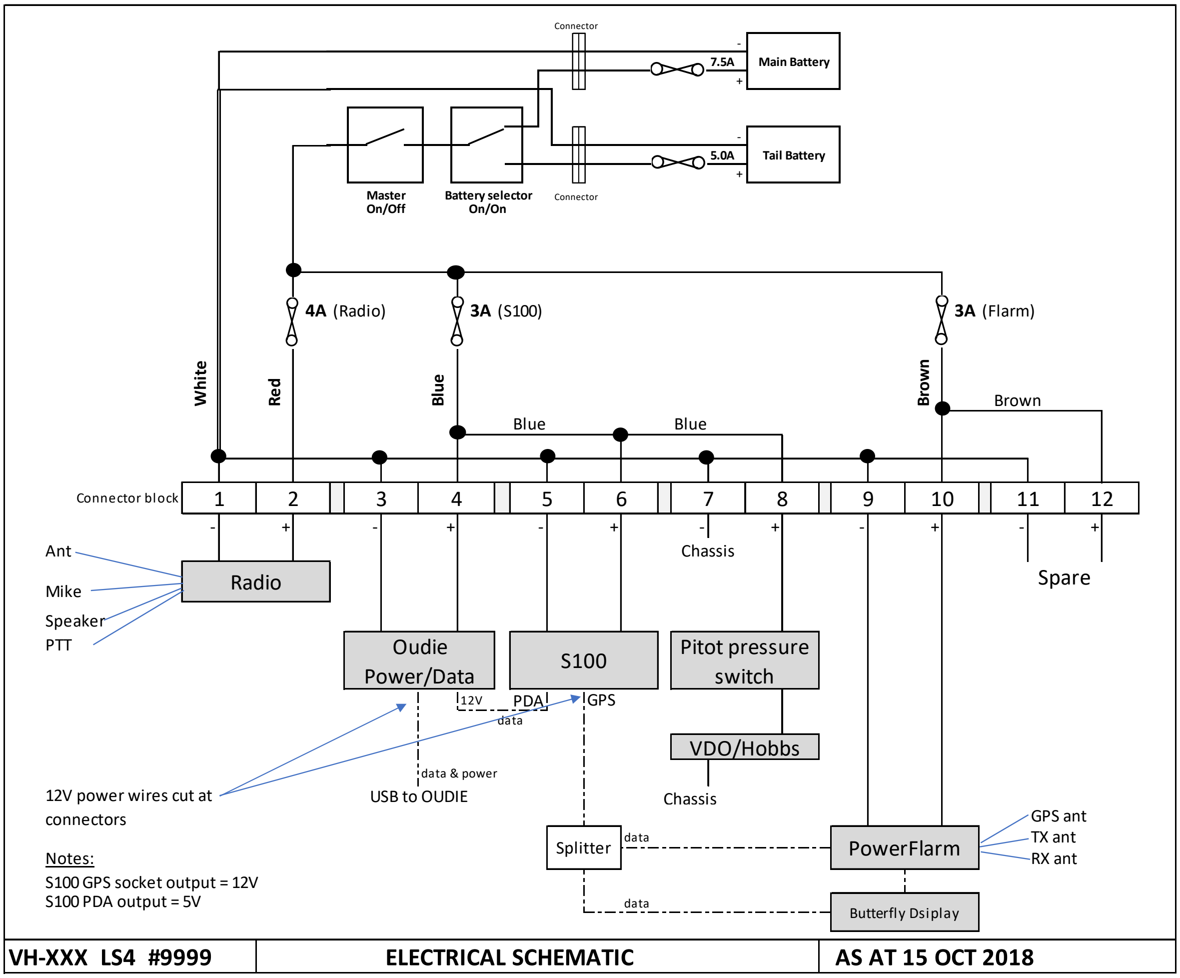


Figure 27-20 Electrical Schematic with Data Interconnection Shown

27.5.4 DATA SIGNAL INTERCONNECTION

Computer equipment and modern avionics pass information and instructions between devices in a time series of digital bits (ie a binary logic format comprising “1” and “0”). Information is arranged into packets which are framed to identify the beginning and end of the data and usually includes an error check.

The transfer of digital data between devices basically (this is a greatly simplified explanation!) requires two things to be shared at the sending and receiving nodes:

a. A common language - the way that the information is encoded and structured into packets of data. A good example frequently used in sailplane avionics is the National Marine Electronics Association (NEMA) protocol for encoding GPS data. Avionic manufacturers may incorporate such international standard formats within their own message packets or create their own unique protocols.

b. A common interface – including the physical way the data is represented, the rate of data transfer and the physical interconnection of the sending and receiving nodes. Examples commonly used in sailplanes are: RS-232, TTL, USB, CAN-Bus and Bluetooth.

The rate at which information is transferred in a communication channel is known as the baud rate. In the serial port context, as an example "9600 baud" means that the serial port can transfer a maximum of 9600 bits per second. The most commonly used baud are 1200, 2400, 4800, 9600 and 19200, up to 128,000. Obviously, the connected devices must be able to operate at the same rate and sometimes they need to be set to a specific rate for compatibility. The higher the baud rate, the more sensitive the equipment is to the quality of the cable and installation.

The following sub-sections explain a few of the different ways that data can be represented on wired connections. Unless devices use the same format for data, they cannot directly communicate with each other and an interface/converter (with active circuits rather than just a cable) may be required.

27.5.5 RS-232 (TRUE AND TTL)

RS-232 originated in the 1960s but is still one of the most widely used interface standards and is often found in avionic devices. The RS-232 standard defines how data is transmitted in a serial stream but does not describe the content. It defines the framing and the timing. It also defines the signal voltage levels.

The RS-232 standard defined numerous roles for connecting wires which originally required a 25-pin connector but for most purposes a 9-pin connector was found satisfactory and for many years was a standard port on personal computers.

RS-232 uses single-ended signalling in that the transmitter generates a voltage on a single wire that the receiver compares with a fixed reference voltage relative to a common ground connection shared by both ends. Two-way communication requires two wires and ground. A minimal "3-wire" RS-232 connection therefore consists only of transmit data (Tx), receive data (Rx) and ground and is commonly used when the full facilities of RS-232 are not required. Note the Tx to Rx cross-over.

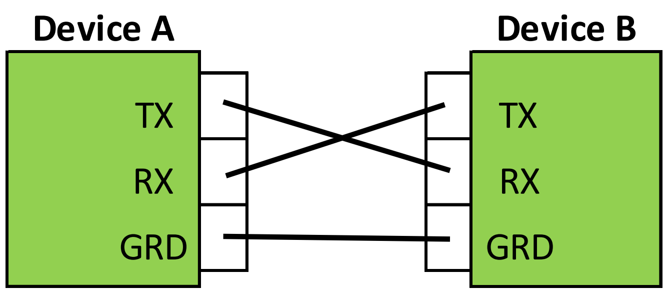


Figure 27-21 Tx to Rx Cross-Over

Because RS-232 has its origins in the 1960s, the signal voltage levels required were relatively high so as to power electromechanical devices. Thus the “True” RS-232 standard defines logic ‘1’ as a low level -3V to -15V, while high level +3V to +15V is defined as logic ‘0’. The dead area between +3V and -3V is designed to absorb line noise. However, with that development of transistors and integrated circuits, which typically operate at 3.3-5V, the True RS-232 signal voltages became unnecessary and unavailable and thus “TTL RS-232” evolved.

TTL RS-232 means that data is transmitted using the framing and timing of RS-232 but uses voltage levels compatible with TTL logic chips. The reason for doing this is that it eliminates the requirement to uplift the signal voltages between devices which would add cost and offer no benefit over short distance connections between TTL devices. TTL RS-232 signal levels always remain between the limits of 0V and Vcc (usually 5V or 3.3V). A logic high ('1') is represented by Vcc, while a logic low ('0') is 0V. This was the format used on personal computers up until USB sockets became dominant.

27.5.6 USB – DIFFERENTIAL SIGNALLING

The Universal Serial Bus (USB) standard dates from 1996 and has evolved since into a widely used standard. There are numerous types of USB connectors, the most common one used in avionics as the means of communicating with PDAs is the mini-USB-B, illustrated later.

USB uses Differential Signalling which is a method for electrically transmitting information using two complementary signals, labelled D+ and D-. This technique sends the same electrical signal as a differential pair of signals, each in its own conductor. The pair of conductors is usually twisted together to reduce interference. The receiving circuit responds to the electrical difference between the two signals, rather than the difference between a single wire and ground. In this way any interference/noise induced in the cable is effectively eliminated.

Transmitted signal levels are 0.0–0.3V for logic “0”, and 2.8–3.6V for logic”1”. Note that the communication over D+ and D- is half-duplex, in other words it is either send or receive on the same pair of wires with the devices at either end managing the data flow.

27.5.7 CAN-BUS

A CAN (Controller Area Network) Bus is a standardised means of interconnecting power and data between a number of intelligent controller devices along a cable defined as the bus. In practice it can look like a "daisy chain" in/out topology but, in reality, devices "T" off the bus, ie one pair of wires goes from one to the next device and can include many devices, and more can be added later. Each intelligent controller device monitors the bus for any coded messages intended for it and can also send encoded messages to other specified controllers. It is used extensively in modern automotive vehicles and an enhanced version is used in aviation.

In the sailplane world at the time of writing, LXNav uses a CAN-Bus to connect an S80x/S10x to a S8xD/S10xD second cockpit repeater. Physically the connection is a general purpose, multi-core cable with sub DE-9 connectors (male one end, female the other end). Two wires are used for data, one wire for ground and usually a wire providing power for the devices connected to the bus (obviously one device must be the source of the power). Loops of ground or power wires must be avoided to avoid electromagnetic interference and variations in signal levels.

The type of signalling used is complex and beyond the scope of this document.

With CAN-Bus it is important that the far end of the bus is correctly terminated to ensure the integrity of the data signal. Termination is a resistor but is often plugged on the end connector for convenience. The LXNav CAN-Bus terminator looks like a blank D-plug but contains the required bleed resisters on the data lines.

27.5.8 CONNECTORS

27.5.8.1 SUB MINIATURE D-CONNECTORS

The D-sub connector contains two or more parallel rows of pins or sockets usually surrounded by a D-shaped metal shield that provides mechanical support and ensures correct orientation.

These connectors are often used for VHF com radio connection.

Figure 27-22 Male DE-9 Connector (often called a DB-9)

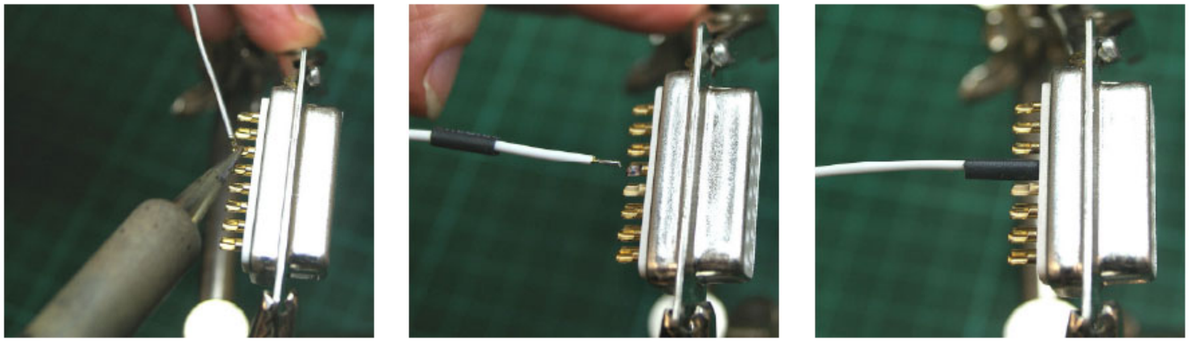
Strictly, the part-numbering system uses D as the prefix for the whole series, followed by one of A, B, C, D, or E denoting the shell size, followed by the number of pins.

Each shell size usually corresponds to a certain number of pins or sockets: A with 15, B with 25, C with 37, D with 50, and E with 9. For example, DB-25 denotes a D-sub with a 25-position shell size and a 25-position contact configuration. However, "high density" configurations are also available such as the DE-15 (often called a VGA connector) which has the same physical size as the DE-9 but has 15 pins arranged in 3 rows of pins rather than 9 pins in 2 rows.

In practice, the original naming pattern is not always followed due to an ignorance of the fact that B represented a shell size and also historic mislabelling. Hence it is now common to see DE-9 connectors sold as DB-9 connectors. So "DB-9" nearly always refers to a 9-pin connector with an E size shell.

The DE-9 is sometimes called a "RS-232 serial" connector. The LXNAV CAN-BUS uses DE-9 connectors.

When making soldered connections to D-connectors it is easiest to "tin" the wire and "tin" the connector's pin cups with solder before soldering them together. Best practice is to slip a piece of heat shrink on the wire before soldering and then shrink it over the soldered joint. See illustration below (from Microair M760 User and Installation Manual):



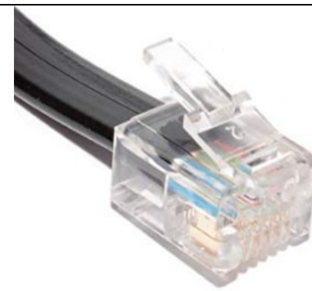
Tinned Solder Cup | Solder Wire to Cup | Heatshrink

Figure 27-23 Soldering a Connector

27.5.8.2 RJ12 AND RJ45 CONNECTORS

RJ12 and RJ45 plugs and sockets are a common way of connecting both data and power between avionic devices. RJ stands for Register Jack. The most frequently seen types are:

Table 27-5 RJ Connector Types

RJ11 = 6 pins but only 4 pins connected **RJ12 = 6 pins and 6 pins connected. (Sometimes called RJ25** Both have the same size plug/socket (9 x 6 mm) and six pins but the difference is the number of connected pins. They are commonly used for telephones and data. Unfortunately, the locking tab is prone to breaking off resulting in it either not locking or being difficult to unlock.	
RJ45 (8-pin connector) The physical size (not including the tab) is 12 x 6mm. This is also commonly used for Cat 6 Ethernet where it has 4 pairs of twisted wires.	

Fitting RJ12 and RJ45 male plugs onto cable is relatively straight-forward but requires care. Special crimpers are needed and are readily available from good electronics shops or on the internet. It is not generally necessary to make up leads with inline female sockets. If one is needed, it is easiest to crimp on a male plug and use a female-female connector.

According to the original ACTA standard, the pins on a socket are numbered 1-8 with the tab key underneath. But note that the IGC standard does not comply with the ACTA numbering standard as shown below. So be very careful.

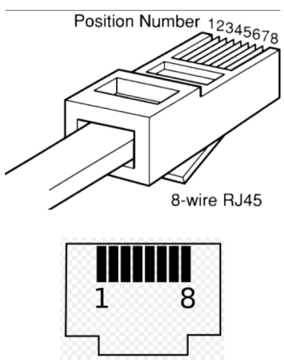


Figure 27-24 ACTA numbering standard

RJ-45 Pins	Function
1&2	Volts +
3&4	Spare, for future application with GFAC approval
5	Data out
6	Data in
7&8	Earth (Volts -ve)

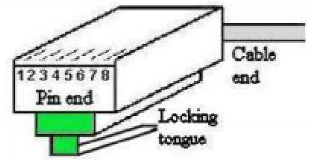


Figure 27-25 IGC standard for RJ-45 pins

It is usually possible for a RJ12 plug to fit into a RJ45 socket but it is not recommended. Often the tab key will centrally locate the RJ12 plug pins 1-6 over the RJ45 socket pins 2–7. And in many uses of the RJ45, wiring diagrams show that the two outer pins (pins 1-2 and 7-8) are shorted to each other on both sides of the socket/plug, so the outer pins 1 and 8 are redundant. But this cannot be relied upon and the RJ12 plug casing may damage pins 1 and 8 of the RJ45 socket.

See PowerFLARM Core (RJ45) and FLARMmouse (RJ12) example below which shows how pins 2-7 of the RJ45 connector match pins 1-6 of the RJ12 connector.

The 8-pin RJ45-socket is in accordance with IGC GNSS FR specifications, except for pin 3. Pin numbering follows IGC's convention (http://www.fai.org/gnss-recording-devices/igc-approved-flight-recorders):

1: +12 to +32 V DC power supply
2: +12 to +32 V DC power supply
3: Core supplies +3 V DC for display
4: GND
5: TX, Core sends (RS-232)
6: RX, Core receives (RS-232)
7: GND
8: GND

Figure 27-26 PowerFLARM Core RJ45

Pin number	Description
1	(Power input) 12VDC
2	(Power output) 3.3VDC (200mA)
3	GND
4	(output) Data out RS232 – transmit line
5	(input) Data in RS232 – receive line
6	Ground

Figure 27-27 FLARMMouse RJ12

27.5.8.3 USB CONNECTORS

The IGC standard recognises the USB- A and mini-USB-B connectors. USB-A is found on most PCs and notebook computers. Mini-USB-B sockets are used on Oudie, Nano and many other Personal Digital Assistant (PDA) devices because of its small size. This type of connector is easily identified by its bent sides.

Figure 27-28 Mini-USB - B Plug

The standard pinout for the Mini-USB-B is:

Table 27-6 Mini-USB-B Pinout

Pin	Name	Description	Colour
1	V_{CC}	+5 VDC	Red
2	D-	Data -	White
3	D+	Data+	Green
X	ID	May be N/C GND or used as an attached device presence indicator (shorted to GND with resister)	
4	GND	Ground	Black

Note that according to the USB standard, pins 2 and 3 (Data- and Data +) are both used for a single channel bi-directional differential signalling. (This is not one wire for data out and the other for data in).

Pin X is usually unconnected or grounded. However some manufacturers of devices have designed their device's USB port to adopt a "secret" RS-232 mode when a voltage Vcc (eg 5V) is applied to the socket's X pin. The USB port will still operate to the USB standard if the X pin is not connected or at Ground. This avoids the need for an external RS-232 to USB converter. In other words:

When pin X="0" : device USB port is in standard USB mode where pin 2 is D- and pin 3 is D+

When pin X="1" : device USB port is in duplex TTL RS-232 mode where pin 2 is Tx and Pin 3 is Rx.

There are several other types of USB connectors defined by the international standards. Interconnecting plugs/cables are generally easily available.

The USB-mini-B is not a strong plug. The wires in the device are often broken off and are hard to fix as it is surface mount technology. If the device becomes intermittent then this is likely the problem. It is best to support the connector to avoid bending and tugging.

27.5.8.4 OTHER CONNECTORS

There are numerous other types of connectors such as SMA and MCX in use by avionics manufacturers. A good guide to cables and connectors can be found at: www.telcoantennas.com.au.

Serial connections and connectors is a rapidly evolving system as it is commonly used on modern devices such as smartphones. New connectors are available for Apple and Android devices that are stronger and can be inserted either way. Eg. USB-C is a smarter connector that can serve more functions at higher speed. If you come across other devices/connectors then they will likely be documented on the internet. A converter plug or cable can connect a B to a C but it will only operate at the B capabilities.

27.6 FLARM

27.6.1 FLARM INTRODUCTION

FLARM is an electronic system for sailplanes used to selectively alert pilots to potential collisions between other aircraft similarly equipped with FLARM. It is becoming increasingly popular in Australia and worldwide. FLARM is a portmanteau of "flight" and "alarm". FLARM is a Swiss company that has licensed other manufacturers to use its technology. FLARM devices have low power consumption and are relatively inexpensive to purchase and simple to install.

FLARM obtains its position and altitude readings from an internal GPS and a barometric sensor and then broadcasts this together with forecast data about the future 3-dimensional flight track. At the same time, its receiver listens for other FLARM devices within range and processes the information received. Advanced motion prediction algorithms, optimised for sailplanes (eg whilst in thermal 'gaggles'), predict potential conflicts for up to 50 other aircraft and alert the pilot using visual and aural warnings.

During the initial installation of a Flarm, the device setup with the aircraft's details so that the identity of the sailplane is transmitted to other users.

In areas where the Open Glider Network ground receiving stations have been set up, it is possible to monitor Flarm based sailplanes via the internet on the live.glidernet.org website and other sites such as flightradar24.com. If the sailplane information has been correctly setup in the FLARM and registered with OGN, the registration code and aircraft type will be displayed anyone with internet access. This is a convenient way to check a FLARM GPS and data transmit functions.

Most FLARM devices automatically record sufficient flight data to satisfy the requirements of a Position Recorder, storing data files in the required IGC format. Some are IGC approved Flight Recorders. Consult the device user manual to discover how to extract the IGC file.

The main limitation of FLARM is it only 'sees' other FLARM equipped aircraft and so non-equipped GA aircraft and sailplanes are not seen. Most GA aircraft do not and will not install FLARM because they are mandated to use similar purpose but expensive higher power devices like transponders and ADS-B.

FLARM has developed a version which also includes ADS-B and transponder detection but not transmission. A Mode-S transponder with ADS-B capability is an international standard broadcast surveillance system in which an aircraft automatically transmits to a ground station and other air traffic its identity, precise location, altitude, velocity and other information. In Australia (as at Dec 18), ADS-B is required only for aircraft operating under instrument flight rules (IFR) but offers substantial benefits for visual flight rules (VFR) pilots as it provides in-cockpit visibility of all transponder equipped aircraft. Use in sailplanes is currently low but as the cost of this equipment falls it will likely become more common in sailplanes, especially those flying at or near GA airfields. Further information is on the CASA and Air Services Australia web sites.

All FLARM devices can be connected to dedicated FLARM displays or compatible navigation devices to give visual and aural warnings and also show the relative bearing and altitude of conflicting traffic. Some show position using a simple pattern of LEDs and others use a map format. Licensed manufacturers produce a range of integrated FLARM devices, dedicated displays and display integration into their avionic products. Eg FLARM data may be supplied to and displayed by other devices such as: Oudie and LXNav S80/S100.

Most FLARM displays also have a 'Nearest mode' which displays the closest sailplane equipped with FLARM. This is not a warning of potential conflict but is an aid to situational awareness. Nearest mode can be switched off if not wanted.

The range of FLARM devices on the market changes rapidly. Note that FLARM frequency ranges are the same in USA and Australia but different in Europe. For illustration purposes, some popular products in Australia as at December 2018 are:

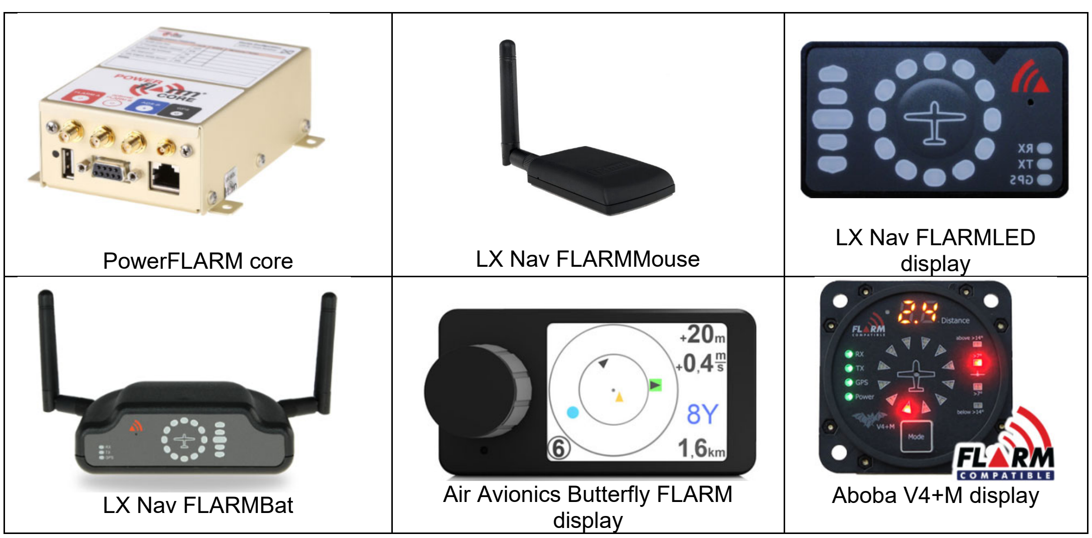


Figure 27-29 Example Flarm Devices

27.6.2 GPS ANTENNA

FLARM has an internal GPS receiver to know where you are and a computer to determine expected future track. Timing signals are picked up from a network of geostatic satellites by the GPS antenna and computed to determine position and altitude.

The GPS antenna is usually internal to the device case or an external small square block connected with a cable to the FLARM device. Do not share/split an antenna output with another device.

If using an internal GPS antenna, then the whole top of the unit must have a clear view of the sky. If using an external GPS antenna, then the top of the antenna must have a clear view of the sky and remember to set the internal DIP switches if required in the manual.

Figure 27-30 GPS External Antenna

If the GPS antenna is buried behind the instruments or has fallen on its side, the FLARM systems knowledge of your position and course will not be accurate and collision prediction warnings may be impaired.

The FLARM unit has a GPS status LED that will be green (or off on some old units) when good signals are received from the satellites and the position is calculated. When the unit is first turned on it will be red but after a minute or so, and before you take off, it needs to be green (possibly off but not red).

27.6.3 DATA ANTENNA

FLARM uses a very low powered radio data link to communicate with other FLARM's, so it's important that the corresponding data antenna is set up correctly. The data antenna can be either a small pole antenna or a loop antenna (now discontinued) stuck on the inside of the canopy.

In Australia, FLARM uses a data communication frequency in the range 917.0 MHz – 926.6 MHz. So the mid-band wavelength is approx 0.325m. A half-wave dipole antenna is thus approx 180mm tall.

Orientation of this antenna is important as all antennae are directional to some degree. The pole type antenna must be vertical to communicate in the directions of interest. If it has fallen over or bent forward, then there might be blind spots in your coverage and reduced range. There should also be no metal or carbon obstructions blocking the "view" of the data antenna to the other sailplanes. This usually means the best position for the data antenna is again on top of the instrument panel.

Figure 27-31 Flarm Antenna on Top

The data antenna may not be very robust and numerous faults have been found to be caused by broken antennae. Regularly give the antenna a visible inspection and replace it if damaged in any way. Also replace it if you are not receiving anybody or others claim they cannot see you. The half-wave antennae are better than the short stubby ones. The stick-on loop antennae were prone tend to break the tracks near the connector.

As FLARM transmitted signals are very weak, it is easy for external interference to affect the performance. The frequencies used by phones and the FLARM are close enough in the spectrum to cause some blocking in the FLARM (850MHz and 900MHz compared to the 921MHz for FLARM). Mobile phones in close proximity will likely degrade the sensitivity of FLARM and pilots should thus turn theirs off when in the air. The sailplane's VHF radio may also interfere when transmitting but the frequency is further away and thus less prone to interfere. Also, you can control when transmit on the radio but a mobile phone transmits automatically and frequently to the network.

The data link frequency for Australia is different to Europe and if set to the wrong frequency the FLARM will be useless. Visiting pilots with FLARM that has been used overseas should check the frequency. The FLARM tool software can be used to check and change all the settings including the frequency. This is software that runs on a PC and plugs into the power/data port. The latest FLARM versions have automatic frequency setting according to the location determined by the device's GPS.

Early FLARMs were thought to have an issue with static electricity destroying the receiver front end. For a small cost, the unit could be returned to the manufacturer for additional cost protection to be installed.

The data receive green LED on the FLARM will indicate when it is receiving a signal from another FLARM. Before take-off, it's a good idea to check the light is on if there is a sailplane or tug with FLARM in the vicinity.

FLARM requires regular software updates otherwise a unit may become incompatible with other FLARMs and collision detection may be ineffective. The updates are free and are easy to do if your FLARM has a SD card. If no SD card, then there should be a method of upgrade via connection to a PC, consult the manual. The software should be checked at every Annual Inspection.

27.6.4 FLARM REMOTE DISPLAYS AND INTERCONNECTION TO OTHER DEVICES

A FLARM device transmitter/receiver device may have an inbuilt display and/or provide data to one or more remote display (eg FLARM Butterfly), navigation equipment (eg LXNav S100) or PDA (eg Oudie) devices for display. These display devices may present information slightly differently, but the basic alarm status warnings should trigger simultaneously as the collision vector analysis is done by the FLARM.

Correct connection and configuration of the FLARM with displays or/or other devices is essential. Once you have a working setup, it is good practice to record the details in the aircraft's logbook for future reference.

Key things to consider are:

a. Data physical connection. Serial data communication between FLARM devices is achieved via data/power cables with RJ12 sockets or Bluetooth on some devices. Avoid unnecessarily long cables.

b. Multiple displays connect to one FLARM. Where two or more FLARM displays/devices are to be driven by cables from a single FLARM, then care must be taken to avoid data collision issues (ie only one display should be in control of the FLARM).

   - Some displays have a Master/Slave software setting (only one display should be set to Master).
   - Some equipment may need a special RJ45 'Y-splitter' that has one port that allows data in both directions between the FLARM and display and the 2nd port only sends data from the FLARM to the other display.

c. Power connection. All devices involved need to be powered and this is achieved either by a dedicated power connection or via the data/power cable. Some devices can operate from 3V via one socket or 12V from another socket, however inputting power via both may damage the unit. Sometimes special data/power leads will be required which have been assembled without the standard power connection. Take care to read the user manuals.

d. Device configuration. Some devices require hardware 'dip' switches or software settings to be configured to match the devices they connect with. Devices are often supplied with default settings, such as data baud rate, which may not always be compatible. Consult the appropriate user manuals and look for compatible settings. Some devices may revert to the default settings if a key sequence is accidentally pressed or the device is subjected to power spikes. If faults appear, check the settings are still compatible.

27.6.5 REVIEWING FLARM PERFORMANCE

Valid collision warning alerts are only generated if FLARMs in all equipped aircraft are working properly. Unfortunately, there is no simple test a pilot can do to verify his/her aircraft's FLARM is working properly before takeoff. The status indicator lights only give some of the status and are not an end to end check.

If the sailplane is equipped with a Flarm display device that provides a map plot and you can physically see sailplanes that you know have FLARMs, then they should show on the plot. If you are with multiple sailplanes turning in a thermal, then you may get a warning from one of them. If you don't get indications or warnings when you would normally expect to get them, then check your equipment is functioning correctly.

There is a FLARM web page (http://www.flarm.com/support/analyze) where you can upload a FLARM IGC data file and get an analysis of the received range information for a flight. Flights to be analysed must have at least a duration of 30 minutes and contact with 5+ other FLARM equipped aircraft during the flight to enable a valid analysis.

The radio range analysis below shows poor performance later traced to a broken data antenna:

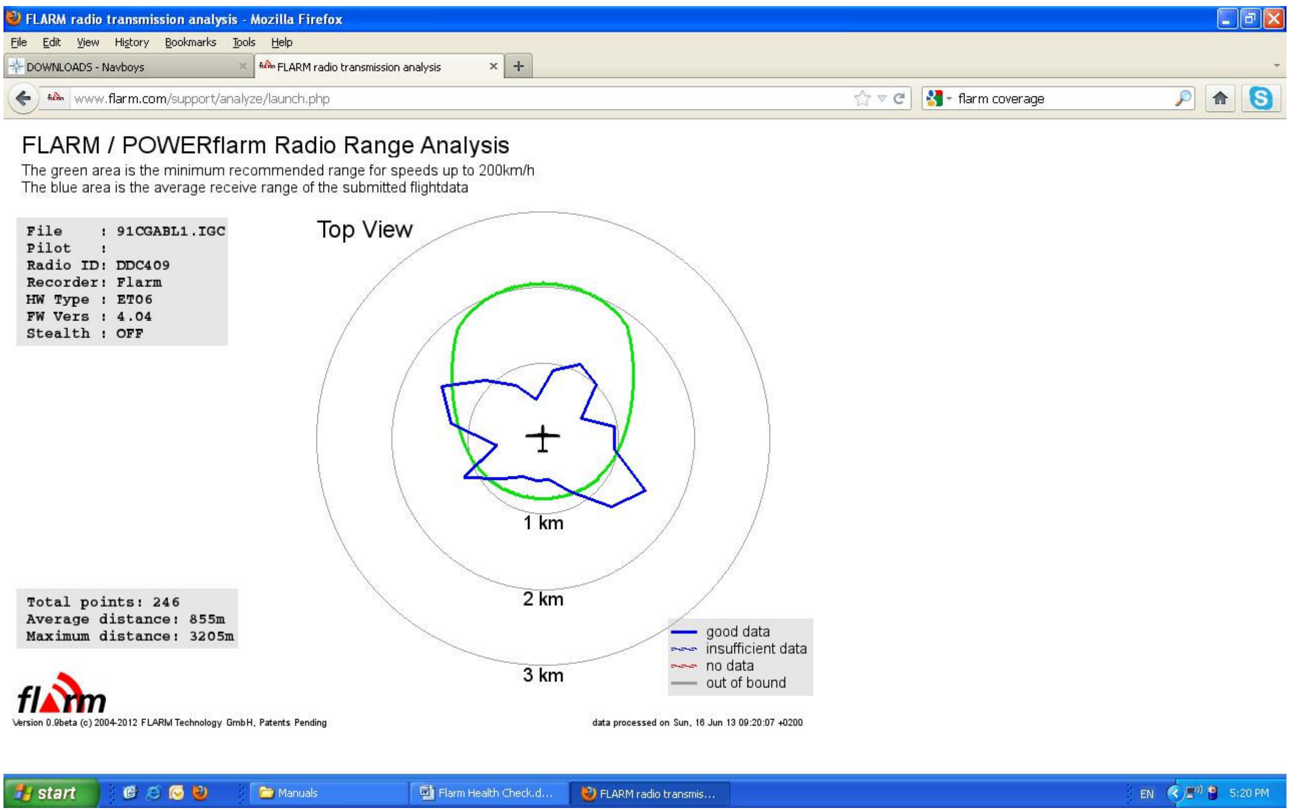


Figure 27-32 Flarm Range Analysis Diagram

Remember FLARM only detects other FLARM equipped aircraft so it's important that owners of all FLARM equipped aircraft maintain and check their installations regularly.

27.6.6 FLARM MAINTENANCE/FAULT CHECKLIST

The following check list will help ensure FLARMs are operational:

a. Check the GPS antenna is facing the sky and clear of everything.

b. Check the data antenna is vertical and clear of everything.

c. Check the data antenna is not damaged in any way.

d. Check the software is up to date.

e. Check the frequency is set up for Australia if the FLARM has come from overseas.

f. Check your display is set up correctly. (Sequentially flashing status lights means it is not getting messages from the FLARM and possibly a wrong data baud rate setting)

g. Check the GPS status light goes green before takeoff.

h. Check the receive light occasionally goes green when another FLARM is nearby.

i. In the air, check you are receiving other FLARMs by staying in nearest mode for a while.

j. In the air turn off your mobile phone to avoid interference with the FLARM.

k. Upload the FLARM IGC file to the FLARM web site if you have had lots of FLARM traffic during a recent flight and see what range you are getting.

l. Have all the other sailplanes flying at your location completed the above checklist and have operational FLARMS?

27.7 MODIFYING INSTRUMENT PANELS

A well designed and constructed instrument panel is a delight to see and use. The configuration and layout of a sailplane's instrument panel should be an aspect of careful consideration by the purchaser of a new sailplane and an owner contemplating modification.

Inevitably during the life of the sailplane, the availability of new avionic devices and pilot choices will mean that additions and modifications are made to the instrument panels. This can be more challenging than starting from a totally blank panel since a new instrument may be a different size compared to what it replaced and sailplane instrument panels have numerous physical and electrical constraints.

MOSP3 allows owners to modify instrument panels with due care and subject to approval by an Annual Inspector (refer Section 18.7). Obviously, there are minimum instruments requirements (as specified by the manufacturer) and all critical instruments like the altimeter and ASI must be serviceable. Be wary of introducing structural changes, weight and balance change and crashworthiness. You must document all changes in the maintenance logbook and have then signed off by a qualified and competent Annual Inspector.

Instrument panels are usually made of aluminium or glass fibre. Do not use steel or wood (unless the sailplane is a wooden sailplane) when constructing or modifying an instrument panel. Instruments panels are usually coloured flat black or flat dark grey because this provides the best background contrast for the instruments to be seen and avoids light reflections.

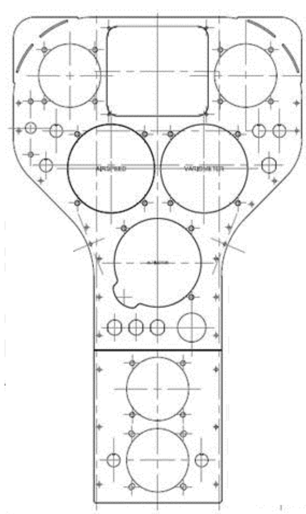


Figure 27-33 New Aluminium Panel Cutting Design

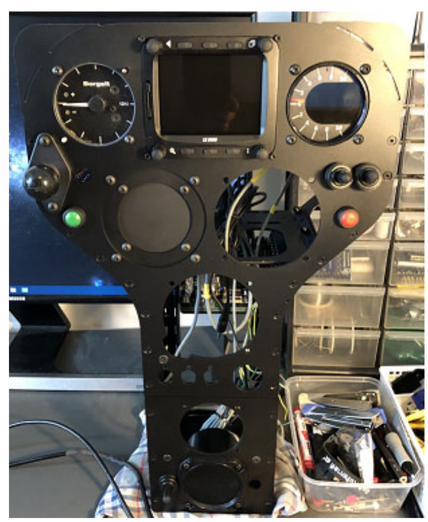
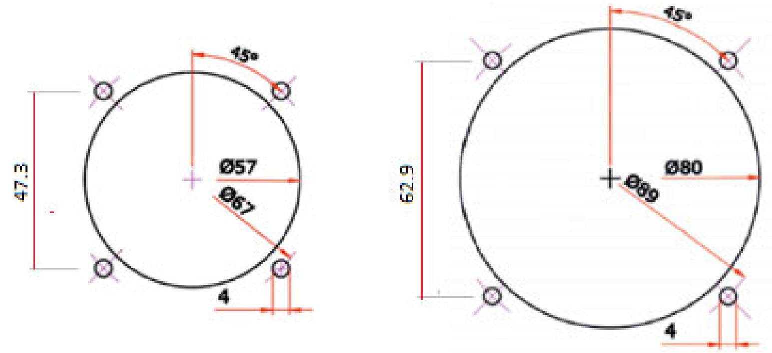


Figure 27-34 Instruments Being Fitted to a New Panel

27.7.1 PANEL STANDARD INSTRUMENT SIZE CIRCULAR HOLES

Most sailplane radio, avionics and pitot/static instruments are designed to be installed in aviation instrument standard 57mm (2¼") or 80mm (3⅛") diameter holes with a standard x4 securing screws layout as shown below (not to scale):



57mm (2¼") **80mm (3⅛")**

Figure 27-35 Standard Aircraft Instrument Panel Hole Templates

Instrument securing screws are typically 4mm diameter but some manufacturers use other small metric or imperial (eg UNC) sizes. Some instruments may require one or more of the securing screw holes to be larger for control knob spindles. Some instrument panels use countersunk 'flat' screws to give a flush panel appearance.

27.7.2 INSTRUMENT FASTENERS

Many modern avionic instruments have pre-tapped holes in their bodies, so the manufacturer supplied or specified screws should be used. Note that often there is stated a maximum length of screw penetration into the instrument body – do not use overly long screws as you risk damaging the instrument.

27.7.2.1 FASTENER MATERIAL AND COLOUR

Aircraft instrument panel screws and the accompanying washers and nuts have historically been made from non-ferrous materials such as brass, aluminium or plastic (eg nylon) which are not magnetically susceptible and thus do not interfere with the aircraft compass. One downside of non-magnetically susceptible fastenings is that you obviously cannot use a magnet-on-a-stick to pickup any dropped washers or nuts under the panel.

Steel screws (especially if they have become magnetised) that are in close proximity to a compass, may disturb the earth's natural magnetic flux sufficiently to cause the compass to misread. The amount of error is difficult to predict, is unlikely be constant on all bearings and may not be significant. Since sailplane pilots rarely use their aircraft compass for dead reckoning navigation over long distances, a small amount of compass inaccuracy is usually acceptable.

If magnetically attractive (eg steel) screws are added or removed from a panel, then the compass accuracy should be checked before the sailplane returns to service. Significant compass errors attributed to steel screws may require their replacement with non-magnetically susceptible screws.

Brass, aluminium and plastic screws are prone to the threads or drive heads stripping as the materials are relatively soft. Stainless steel has become more commonly used for instrument fasteners because of its strength and is considered to have low magnetic attraction.

Note that '300 series' (ie 304 and 316) stainless steel is naturally not susceptible to magnetism but may become somewhat attractive to magnetic during cold forming manufacturing processes involving compression such as rolling, bending and stamping which changes the crystalline structure of the material. 304 (often referred to as A2) stainless steel is more prone to this than 316 (often referred to as A4 or marine grade). In general then, stainless steel small screws, nuts and washers are not usually magnetically attractive.

Panel screws are usually black to match the most common panel colour. Depending on the material, the black surface colour is created by annodisation (eg passivated black zinc-nickel), chemical staining or processes causing a surface coating of black oxide. Note that black oxide is usually coated with oil or wax to prevent brown rust forming, thus steel and sometimes 304 grade stainless steel screws may show rust. Of course, it is possible to DIY paint natural colour screws to the desired colour but the coating may not last long. A light sanding of the head and degreasing will prolong the paint adhesion.

Where an instrument has non-threaded lugs for fixing to the panel, then screws with washers and some form of locked nut (eg locking washer and plain nut or else an elastic nut) must be used. Brass elastic nuts in sizes suitable for instrument screws are rare. It is common practice to use stainless steel elastic nuts with brass screws. There is little risk of galvanic corrosion as the two metals are relatively close together on the anodic index.

27.7.2.2 FASTENER THREAD STANDARD, HEAD TYPE AND DRIVE TYPE

Historically many American made aircraft and aircraft instruments have used small diameter American UNF and UNC standard screws and thus such screws are readily available from most aviation parts suppliers, including in Australia. However most modern sailplanes and sailplane instruments are now manufactured using metric fasteners. Unfortunately, the two screw standards are not compatible as can be seen in the table of specifications of commonly used instrument panel screws shown in the Table below:

Table 27-7 Specifications of common UNC and Metric instrument screws

Size	Description	Major diameter (mm)	Threads per inch
4-40	#4 gauge, UNC 40 TPI	2.845	40
M3	3mm x 0.5 pitch (coarse)	3.0	50.8
M3.5	3.5mm x 0.6 pitch (coarse)	3.5	42.3
6-32	#6 gauge, UNC 32 TPI	3.505	32
M4	4mm x 0.7 pitch (coarse)	4.0	36.3
8-32	#8 gauge, UNC 32 TPI	4.166	32

M3.5 screws at first sight look to be the same as 6-32 but they have different thread pitch/TPI. M3.5 screws are not widely available in Australia. Australian mains 230V electrical general-purpose outlets (ie electric wall sockets) use screws described by some manufacturers as ‘M3.5 x 0.8 pitch’. Since 0.8 pitch is equivalent to 32 threads per inch, then you’ll see that in fact they are UNC 6-32 screws.

Screws come in a range of head types (shown below) and drive types eg slotted, cross drive (Philips/Pozi), hexagonal socket. The most common form used on instrument panels is pan head cross drive, though panhead with internal hexagonal socket drive is gaining popularity due increasing availability.

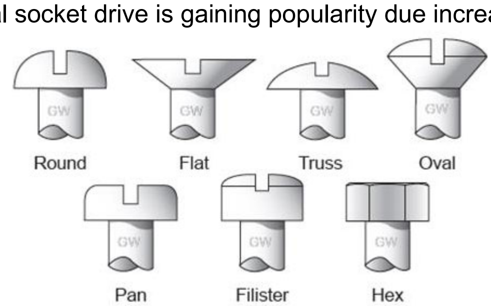


Figure 27-36 Screw Head Types

Flat head screws, often referred to as countersunk screws, give a flush finish. If considering this type of head, note:

a. UNF/UNC flat head screws usually have a head angle of 100 degrees, as is normal for most aviation rivets. Metric flat head screws to DIN standard have a head angle of 90 degrees. Nearly all Australian DIY and tool store sourced counter sink drills are 90-degree, which does not provide a good seating for screw heads with 100-degree angle.

b. It can be difficult to control the depth/width and concentricity of the countersink drilling using a handheld drill. If you wish to use this style, you may need to source a combined pilot hole/countersunk drill and some form of drill depth control. The right tools, experimentation, consistency and practice will be needed to get a good result. Pan head screws are much easier!

UNC/UNF instrument screws are often listed under their 'MS' designation or the now superseded AN designation. The following table shows some of the commonly used standards:

Table 27-8 UNC/UNF Screw Standards

MS	AN	Description
	AN 515B	Black Brass, Round head, slot or cross
MS 35214		Black Brass, Pan head (#4, #6, #8 screws)
MS 24693-BB	AN 507B	Black brass flat head, cross

Metric screws are often listed under their DIN or ISO designation as follows:

Table 27-9 Metric Screw Standards

DIN	ISO	Description
963	2009	Slot drive, flat head
965	7046	Cross drive, flat head
85	1580	Slot drive, pan head
7985	7045	Cross drive, pan head
7380	7380	Hex internal socket drive, pan head

Winter Instruments products are now supplied with 4mm black aluminium and previously M4 black brass screws. These screws may be available from the Aircraft Spruce or the Australian Winter agent, MrSoaring.com.

Black metric stainless steel screws are usually 304 (A2) grade with black oxide. They can be difficult to source in pan head cross drive but are readily available on the web with hex internal drive.

If not magnetically attracted fasteners are essential for the installation, then probably the ultimate choice is black metric 316 (A4) grade pan head cross drive stainless steel but there are few suppliers in the world. At the time of writing, there is no known stockist in Australia but Accu.co.uk had these available.

Many Australian fastener companies supply M4 steel (magnetically attractive) screws with black oxide finish with slot, cross and hex internal socket. The quality of finish can vary greatly between suppliers and manufacturers.

Steel (magnetic) pan head cross drive screws with zinc-nickel black passivated finish are available from a few sources such as: RS, Element14, BoltandNut.com.au. The quality of the blackening varies.

27.7.3 INSTRUMENTS WITH UNTHREADED ATTACHMENT LUGS

Some instruments, particularly older instruments, have lugs with holes rather than pre-threaded holes. In this case there is some freedom of choice of imperial/metric and fastener size. In most cases a washer will be required at the nut end of the screw to spread the load. A locking washer and nut, or else an elastic nut, should be used. When installing or removing this sort of hardware, consider how you can stop items dropping down inside or under the control panel. Placing a cloth to catch dropped items may save many minutes of frantic searching!

With this style of instrument, the installation can be made much easier by using a 'nut ring' which is frame (aluminium or plastic) with rivnuts. This eliminates the washers, locking rings and washers – so less risk of dropping hardware into the bowels of the instrument panel. They are readily available for 4-32 screws but none were found in M4 at the time of writing. It would be relatively easy, but time consuming, to DIY fabricate one with basic hand tools.

Some instruments can be converted to screwed lugs by inserting stainless steel helicoils. These spring-like fitments are usually used to repair damaged threads and low cost kits are available on the internet. The lug hole must be drilled to a special size (eg 4.2mm for an M4 x0.7 pitch thread) and then a screw thread cut with the corresponding special size/pitch tap. The helicoil is then screwed in with a special tool. After this process has been completed, the inside of the helicoil acts as the thread for a standard (eg M4) instrument securing screw.

 **Figure 27-37 Helicoils**	 **Figure 27-38 Nut Ring (example from Wings & Wheels USA)**

27.7.4 BLANKING OR DOWNSIZING AN EXISTING INSTRUMENT HOLE

Pre-cut, drilled/punched and painted blanking plates and downsizing plates are readily available from avionic suppliers made from aluminium or plastic. Alternatively, they can easily be fabricated from aluminium sheet or even 3-D plastic printed. Do not use steel as it is heavy and magnetically attractive.

Small unwanted holes can often be covered up with a label or placard (eg local radio frequencies). Unwanted holes in GRP panels can be blanked out by careful adhering a thin mat of glass fibre behind the panel and filling the hole with resin/beads.

27.7.5 ADDING OR ENLARGING HOLES IN INSTRUMENT PANELS

Large circular holes for radios and instruments may be cut by using several methods:

a. Water jet or laser jet cutting or CNC routing. This will give a very accurate cut precisely as was planned on the CAD (Computer Aided Drawing) file you agreed with the specialist workshop. It requires the panel to be stripped and taken to a specialist workshop.

b. Die/punch cutter. These work by shearing the material, they do not rotate. They make an accurate and neat hole. They can be used with a panel partially dismantled in a cockpit and create little mess. They are readily available in USA but the sizes are uncommon in Australia. You may find a LAME, or aircraft home builder has a set and can provide a service or loan/rental of this tool.

Figure 27-39 Reversible cutter for 2-1/4" and 3-1/8" panel holes

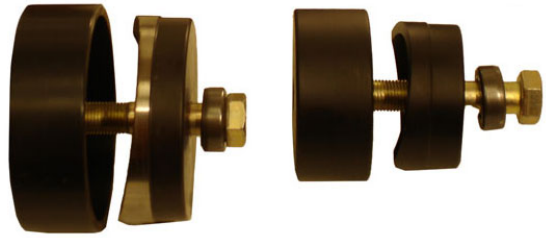


Figure 27-40 Single size punches

c. The correct sizes are available in good tool stores and on the internet, sometimes listed under the imperial size. Beware of the course cut (few teeth per inch) models and cheap versions which may not form a complete circle of teeth or be truly circular. Hole saws require a central pilot hole and a slow drilling speed. Very even and gentle pressure perpendicular to the panel face is needed to avoid the teeth “grabbing”. Trial and practice are recommended on scrap material first as it is easy to mess up a hole which may ruin the entire panel. You have been warned!

Figure 27-41 Fine cut (many TPI), continuous circle cutter (pilot drill not shown fitted)

Figure 27-42 Course cut (few TPI) cutter

d. Routing or hole drilling, finished by hand filing. This method, when performed with care and patience, can achieve good results at minimum cost. It may be the only option when enlarging an existing hole.

- Careful marking out and accurate initial centre punching of the hole is critical. Scribed circles directly onto the material with dividers is generally more precise than pencil/compass onto the bare face or masking tape.
- Remove the bulk of the material by drilling chains of small holes and using a hacksaw. With GRP, a rotary burr can be used. Use a vacuum cleaner to collect the dust as you cut.
- Finish to dimension using a half-round smooth grade file. (Note: Files are usually classified by cut grades: 1st cut = Bastard, 2nd cut = Second or Medium, 3rd cut = Smooth).

Enlarging a 57mm hole to 80mm can be challenging to mark-out and cut. To assist with marking out, screw an old blanking plate (or piece of aluminium sheet) in position. To establish the centre position of the old hole, draw bisecting lines through the mounting hole centres. If the new 80mm hole is not concentric with the old 57mm hole, carefully consider the position of the existing mounting screw holes to ensure they are within the 80mm hole.

Be careful not to remove too much material from the panel such that its structural integrity is compromised.

The small mounting holes for instruments (usually approx 4mm) need to be carefully positioned. Either carefully mark out and centre punch the locations or else use a proven template. A strategy for a precision fit of the securing screws is to drill the holes undersize, say 3mm, place the avionic device in the opening and observe how the securing holes align. Then open out the sides of the securing holes to match the location of the instrument’s holes using a needle file.

Before cutting a new or enlarged instrument hole:

a. Check there is enough space for the intended radio or instrument behind the panel. Carefully consider the full volume of the radio/instrument (ie width, length, corners, space for connectors). Check that there is not interference when the panel cover/cowling is replaced.

b. Carefully mark out the position of the hole and screw holes. Measure twice, cut once!

c. If cutting by hand, consider making an aluminium sheet template to use as a guide for cutting accuracy. Making the template is good practice at marking out and cutting.

d. Remove other instruments or carefully protect them from vibration, dust and swarf. If cutting fibreglass, use a vacuum cleaner to remove the dust as you cut.

e. After cutting a hole, consider if the raw edge of the cut material will be visible. If so, then it is best to paint (or use a permanent marker pen) the edge before fitting the instrument.

Even using computer drawn plans and computer-controlled cutting does not guarantee perfect results first time. Consider making a prototype from a cheap panel of clear Perspex. Fit all the instruments. Make sure the layout suits you. Identify clashes and fix these. Eg the edges of instruments touch or interfere on the edge, or a screw does not fit. Some types of instrument (eg altimeters) require special cut-out shapes – match yours exactly. Adjust the CAD drawing until perfect. Then get the final panel cut.

Holes for switches and fuses are often in the range 10-16mm diameter which are difficult to cut in thin material using conventional twist drills. Clamping a block of wood behind the area being drilled will improve results and remember that the bigger the drill, the slower the RPM needed.

Good results in sheet materials can be achieved using a slotted/spiral cone drill, or else careful use of a round file starting from a small hole.

Figure 27-43 Cone Drills

27.7.6 INSTRUMENT PANEL LABELLING

Sailplane manufacturers may specify mandatory placard and labelling requirements in the pilot handbook. This may include full size pictures of what is required.

Don’t forget that a fireproof (brass or stainless) engraved placard showing the aircraft registration is mandatory (ref GFA AN 84) inside the cockpit and preferably in sight of the pilot. This is normally attached to the instrument panel. At the time of writing, engraved brass plates are available from the GFA shop.

There are several methods of labelling instrument panels, including:

a. DIY computer printed adhesive labels. This method may be used to easily reproduce manufacturers’ placards and pictorial labels. Depending on the label material and/or ink permanency, a transparent covering may be required.

b. Transfers/decals. Either standard sets or custom made. Professional builders of instrument panels often use this technique. A coat of clear matt varnish/lacquer is often applied on top to add protection.

c. Pre-printed stick on labels. Sets of printed labels are available for common general aviation aircraft and also generic sailplane pictorial labels (eg release, airbrake).

d. Engraving or laser etching. Either directly onto the panel or placards which are stuck on the panel. This requires specialist equipment or finding a competent service provider. It may be worth considering if building a new panel.

e. Stick-on thermally printed tape. Relatively inexpensive handheld thermal label printers are available (eg models by Brother and Dymo) that print text, numbers and symbols onto special adhesive backed tapes. They can be used to create custom labels in a variety of print sizes with a choice of several tape widths. White print on black tape, with works well on black instrument panels. The appearance can be enhanced by trimming excess blank tape from the top, bottom and ends of the label. Take care to make sure they are straight – identify and align with a valid horizontal or vertical datum line on the panel.

Thermal printers are also available with the capability of printing text and numbers on heat shrink which is a good way of labelling wires and cables. So if thinking of buying a thermal label printer, consider spending a little more to gain this capability.

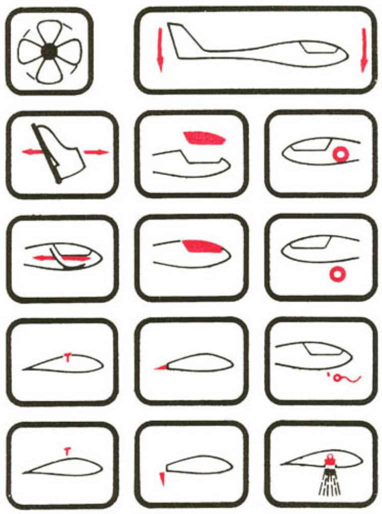


Figure 27-44 Example of Stick on Labels

Figure 27-45 Example Thermal Label Printer

27.8 VHF COM RADIO FAULT FINDING GUIDE

The following table is a general aid for fault finding. The user/installation manual for the installed radio is likely to have a section on fault finding and should be referred to.

Table 27-10 Radio Fault Finding Guide

Symptom	Possible causes	Checks
Radio shows no indication operating when the master switch is switched on	No power to radio	Check: battery present and charged, main battery fuse ok, radio external fuse ok, radio internal fuse/breaker ok Use a multi-meter to check voltage at radio.
No TX indicated on radio when PTT pressed	PTT cable not connected to radio or PTT switch failing to make a closed circuit. Battery voltage low, voltage drop or no power connected to radio.	Check connections of power and PTT. Check PTT switch is functional Check battery charged. Check voltage at radio when in transmit mode.
Radio indicates TX but other stations do not appear to receive.	Transmitting on wrong frequency or out of range. Your radio volume is turned down (you are transmitting, other stations are	Check correct frequency set Turn volume up to full Check connections. Try using a known good mic.

	receiving but you are not hearing the other stations' responses) Microphone faulty or poor connection. Antenna poor connection or antenna not tuned. Excessive voltage-drop when transmit power required due to small cable cross-section or high resistance connections.	Check connections. SWR test. Check all power supply connections. Measure voltage at radio when in transmit mode. Consider if power cable cross section is sufficient.
Carrier wave only received by other stations or weak signal	Microphone faulty or poor connection. Microphone type not set up properly in radio or incompatible. Poor microphone use technique. Voltage low due to battery or voltage drop	Check connections Check microphone is compatible with the radio, connected to correct input and radio software settings correct. Try microphone close to mouth and speak directly into it. As above
Speaker output is not working	Speaker not connected or not impedance matched to radio output. The radio's speaker function is not turned on or volume is turned down.	Check speaker connected and volume turned up
"Hot mike", ie prolonged transmissions,	PTT sticking or short circuit in PTT circuit. Pilot tense.	Check PTT switch function and circuit integrity. Pilot needs to relax.
Receiver noise is always present.	The noise suppression function (squelch) of the noise is not set properly or is not working. Some avionic or portable device is producing a relatively high level of electromagnetic interference.	Try to suppress the interference by adjusting the squelch to a higher value. Note, that a higher value causes a reduced sensitivity. Remove mobile phones, portable devices and power charges to identify and eliminate interference source. Reduce the interference emitted by the avionics near the radio and antenna by improving: shielding, distance, grounding or use of ferrite suppression cores.
The Antenna SWR exceeds 3:1.	Possibly caused by a defective or insufficient ground plane for the antenna.	Check for sufficient size of the ground plane and make sure there is no mechanical defect on the antenna.
	The impedance of the antenna cable deviates significantly from 50 ohm.	Make sure the used antenna cable has 50 Ω impedance and the cable is not pinched or kinked on its way from the radio to the antenna.
	Possibly caused by a fault on the BNC connectors of the radio-antenna cable.	Check for proper crimp/solder work on the BNC connectors

28. L'HOTELLIER CONNECTORS

L'Hotellier connectors are used in a wide range of sailplanes as a flexible joint and means of quick connection / disconnection of flight control systems for rigging and de-rigging purposes. This Chapter details the essential daily checks, periodic inspection and maintenance requirements for L'Hotellier connections that ensure the integrity of the control system and thus the safety of the sailplane and pilot.

This BSE chapter was first published in November 2021 and supersedes GFA AD177 Issue 7 and AD178 which were then cancelled.

28.1 BACKGROUND

L'Hotellier is a French manufacturing company based in Anthony, France. As at the date of creation of this document, L'Hotellier is part of Collins Aerospace and there is no appointed company agent in Australia for purchase of parts and no product information posted on the internet.

Orders for components placed directly with L'Hotellier are subject to large minimum order quantities and long lead times. Some L'Hotellier component stock is held in Australia by Morgy's Sailplane Works (Waikerie SA) and Maddog Composites (Dinmore QLD). Otherwise, L'Hotellier components can usually be obtained via the sailplane's manufacturer or their Australian agent.

28.2 DESCRIPTION OF L'HOTELLIER MECHANISM

L'Hotellier connectors enable linear (push/pull) forces to be transmitted but not rotary forces. They are commonly found connecting aileron, elevator and airbrake control linkages in sailplanes built between approx 1975-2000.

L'Hotellier connectors comprise a ball and a matching spherical socket into which the ball is inserted and held by a plunger. The plunger is locked into position by a spring-loaded wedge tab or else a spring-loaded cam. Depressing the wedge or cam enables the plunger to slide and thus the socket opens to allow the ball to be insert or removed from the socket.

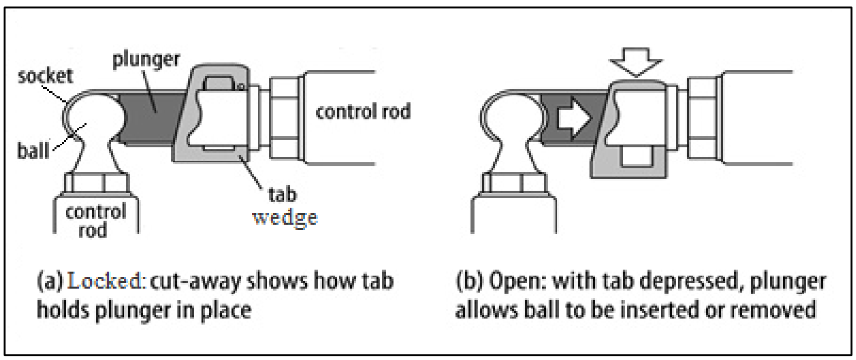


Figure 28-1 L'Hotellier Mechanism (standard 90⁰ Type 41 connector)

There are 3 types of connection:

a. 'Standard' 90-degree swivel joint. The axis of the ball shaft is at approximately 90 degrees to the axis of the socket shaft. Eg this is the configuration used to connect an Astir elevator.

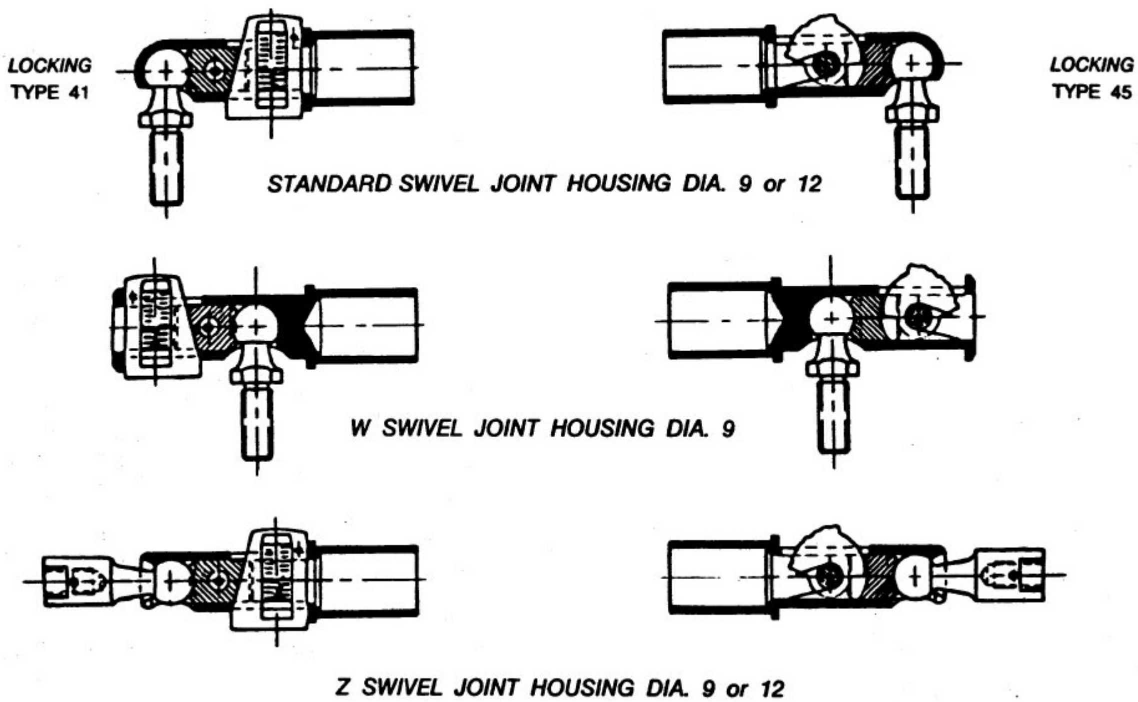
b. 'Z' swivel joint. This has the axis of the ball shaft and socket shafts approximately inline. Eg this is the configuration used for Astir ailerons and dive brakes.

c. "W" swivel joint. There are no known applications of this in sailplanes in Australia.

There are 2 types of socket lock mechanism:

a. Type 41 with a sliding wedge lock mechanism. This is the most common type found in sailplanes in Australia.

b. Type 45 with a rotating cam lock mechanism. There is a small number of these in sailplanes in Australia.



Drawing from l'Hotellier datasheet (with some captions removed)

Figure 28-2 Types of L'Hotellier Connectors

NOTE

GFA AD178 10/06/1980 identified that some sailplanes in Australia had erroneously had 'Z' inline swivel sockets installed in 90-degree joints. In this case the coupling is subjected to more rapid wear due to the reduced bearing surface at the open end of the socket which can lead to a wear pattern that grips the ball, restricts flexibility and could cause failure of the ball shank. Immediate inspection and, if necessary, replacement was required.

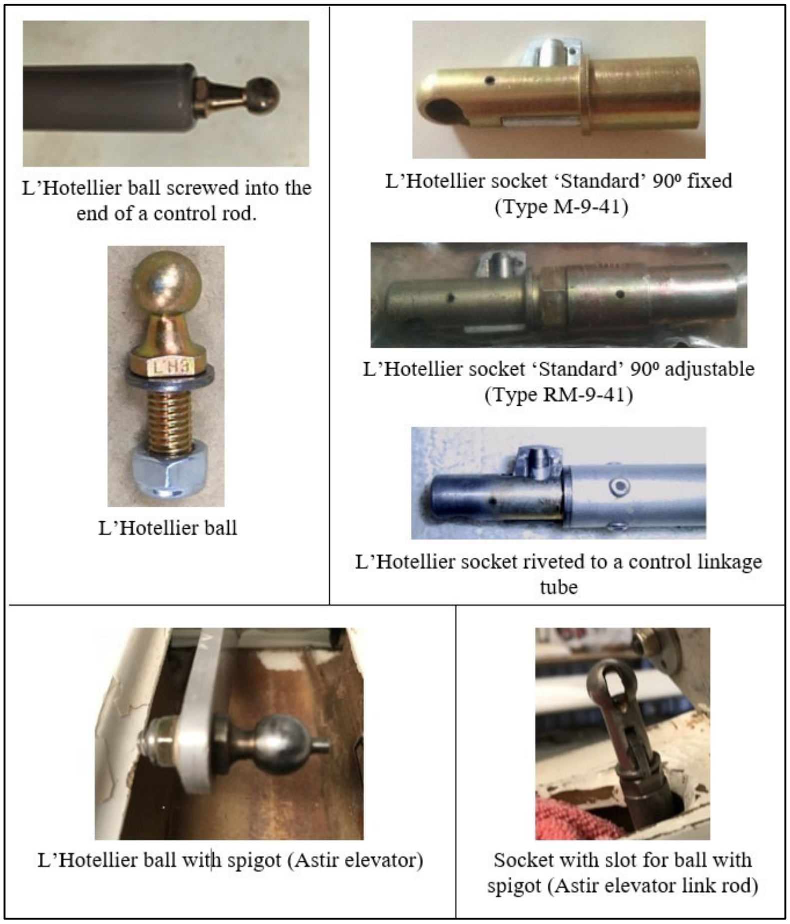
L'Hotellier ball variants are available with a spigot on top of the ball which require a special socket with a slot. These are only used in the 'Standard' (90 degree) configuration. Eg connecting the elevator of an Astir. Do not use these anywhere other than specifically where the sailplane manufacturer has designed for them to be used.

L'Hotellier sockets are available with several types of shaft:

a. Type K or M: Fixed length, for tube – These are attached to control rods directly with rivets, glue or both.

b. Type N: Adjustable length, for threaded rod - not known to be used in sailplanes

c. Type RK or RM: Adjustable length (with lock nut), for tube – These are attached to control rods directly with rivets, glue or both.



L'Hotellier ball screwed into the end of a control rod.

L'Hotellier socket 'Standard' 90º fixed (Type M-9-41)

L'Hotellier socket 'Standard' 90º adjustable (Type RM-9-41)

L'Hotellier ball

L'Hotellier socket riveted to a control linkage tube

L'Hotellier ball with spigot (Astir elevator)

Socket with slot for ball with spigot (Astir elevator link rod)

Figure 28-3 Various L'Hotellier Fittings

28.3 SAFETY INCIDENTS INVOLVING L'HOTELLIER CONNECTORS

Since 1980 there has been a steady run of incidents and accidents, including fatalities, caused by unintended disconnection of L'Hotellier coupling. The couplings have been found to disconnect for the following reasons:

a. Incorrect assembly during rigging. Either not connected at all or only partly engaged resulting in separation of the control linkage whilst in flight.

b. Disconnection in flight of controls which have been correctly connected. In most cases this has been due to weak latch springs. The use of an approved form of safety locking device, such as a safety pin, is now mandatory to prevent this.

c. Fracture of the ball coupling at the top of the threaded section at the neck immediately under the ball.

The frequency of incidents and adverse outcomes has lowered over time as a result of better knowledge and improved maintenance procedures with these connectors.

28.4 SAFETY LOCKING

It is mandatory that all L'Hotellier couplings in sailplanes on the Australia register must have a means of safety locking the wedge or cam. The manufacturers approved safety locking methods will normally be shown in the Flight/Maintenance Manual or manufacturer's Technical Note or an EASA Airworthiness Directive.

28.4.1 SAFETY LOCKING PINS

In the absence of a sailplane manufacturer's specified safety method for the L'Hotellier couplings, the GFA approved safety locking method is to use safety pins or safety wire through a small hole in the wedge/cam as shown in Figures 28-4 and 28-5.

It is recommended that each safety pin be tied to part of the fitting by thin nylon cord or similar to avoid loss.

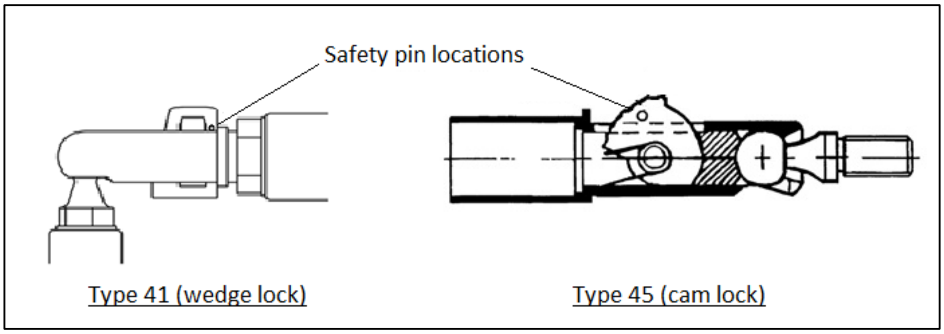


Figure 28-4 Safety Pin Hole Locations

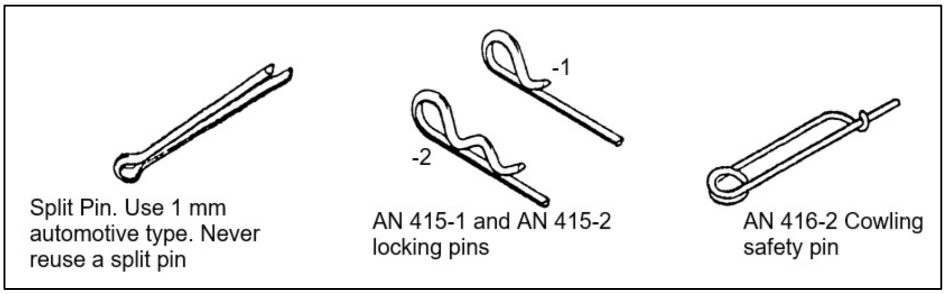


Figure 28-5 Types of Safety Pin

There are other safety locking methods, suitable for wedge locks (Type 41 connectors), fitted by some manufacturers and / or approved by some sailplane manufacturers for retrofit.

Whilst it may be possible to retrofit the above safety locking mechanisms, they are significantly bulkier than safety pins/wires. Therefore, unless approved by the sailplane manufacturer, each locking method must be specifically approved by GFA for use in a particular aircraft type.

Should a sailplane equipped with L'Hotellier connections be found not to have one of the above methods of safety locking or an alternative method approved by GFA for the specific sailplane, then the sailplane is deemed unairworthy and is to be grounded immediately. This is a Major Defect which shall be entered into the Maintenance Release and requires rectification before further flight.

28.4.2 SCHEMPP-HIRTH SAFETY SPRINGS

These springs are fixed to the socket body using an existing hole. One end of the spring aligns with and is inserted into the safety hole in the wedge when it is locked. Left and right hand versions are available.

CAUTION

The Schempp-Hirth safety springs rely on positive spring force to keep the end of the spring in the wedge safety hole. If the spring is overextended to unlock the connector, it can permanently bend the spring such that it wants to remain open. In these circumstances vibration and movement could cause the spring to open in flight.

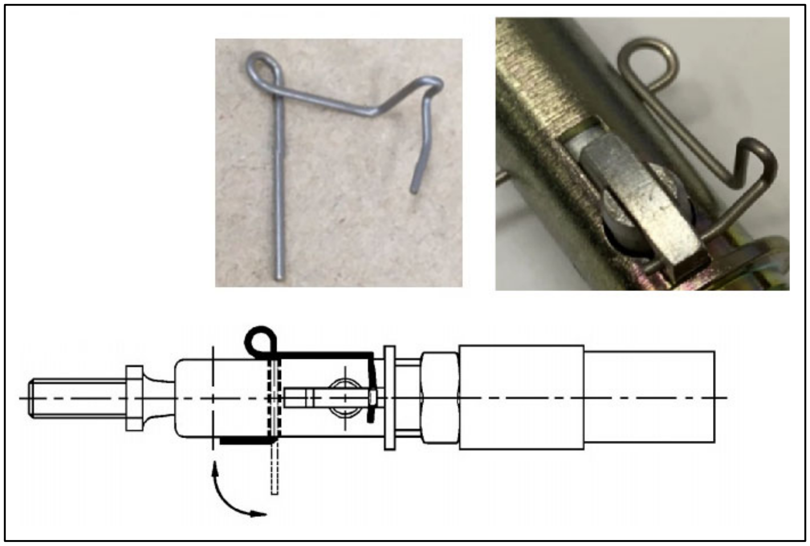


Figure 28-6 Schempp-Hirth Safety Locking Spring

28.4.3 UERLING TYPE SLEEVES

These ‘add-on’ sleeves are designed to stop the ball being removed from the socket by physically obstructing any disconnect motion. They are only suitable for Type 41 inline (Z-swivel) connectors.

For installation, the sleeves must be slid axially onto the L’Hotellier socket shaft - they must not be installed by clipping radially onto the socket shaft. Radial clipping requires excessive opening of the sleeve and may lead to cracks and ruptures due to over stressing such that the sleeve cannot function properly anymore.

Early Uerling sleeves, as fitted to LS3 sailplanes, were a red colour, fairly flimsy and required replacement every two years. It was mandated by LS (ref TM3049) that these be replaced with thicker, white colour, sleeves. There should be no red Uerling Type sleeves currently in use in Australian sailplanes.

More modern LS ‘Uerling type’ sleeves are made from white nylon / plastic and are much more solid than the red ones, see Figure 28-8. These do not have to be replaced after fixed life period, but must be inspected annually for deterioration and functionality.

In some old Grob documentation there is reference to ‘Securing Sockets S26’ which it is believed were an Uerling type sleeve. However, these are not now available for purchase from Linder.

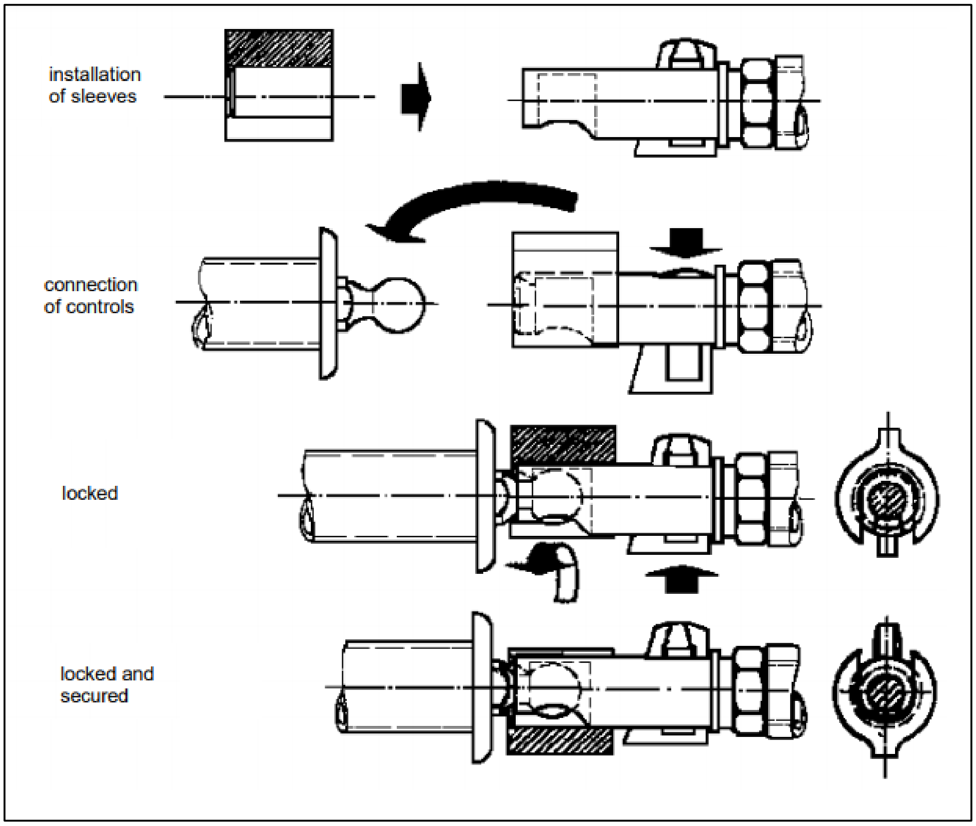
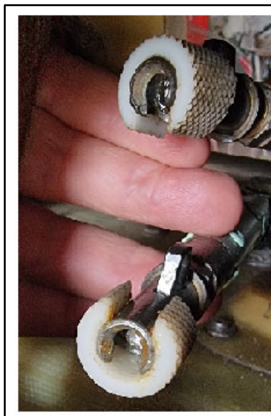


Figure 28-7 Uerling Type Safety Sleeves in Operation



Unsecured (top)
Secured (bottom)

Inline connector secured with an Uerling type safety sleeve stopping the ball detaching from the socket.

Note the sleeve does not cover or preventing movement of the locking wedge

Figure 28-8 LS White ‘Uerling Type’ Sleeve

28.4.4 WEDEKIND SAFETY SLEEVES

Wedekind safety sleeves are permanently fitted onto Type 41 inline (Z-swivel) socket shafts. They are sprung loaded and function by preventing the wedge from moving out from the locked position.

The ball must be fully inserted into the housing to allow the plunger and wedge to function correctly and lock the ball in position. The securing sleeve must then cover the wedge lock plate for a minimum of 3mm (ref Grob TM306-32).

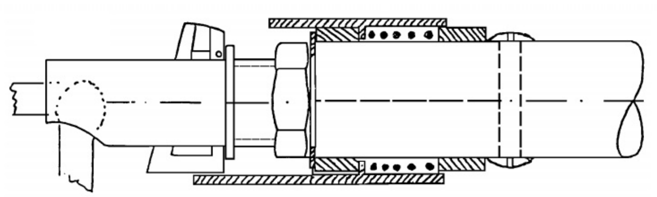


Figure 28-9 Wedekind Safety Sleeve Cross-Section

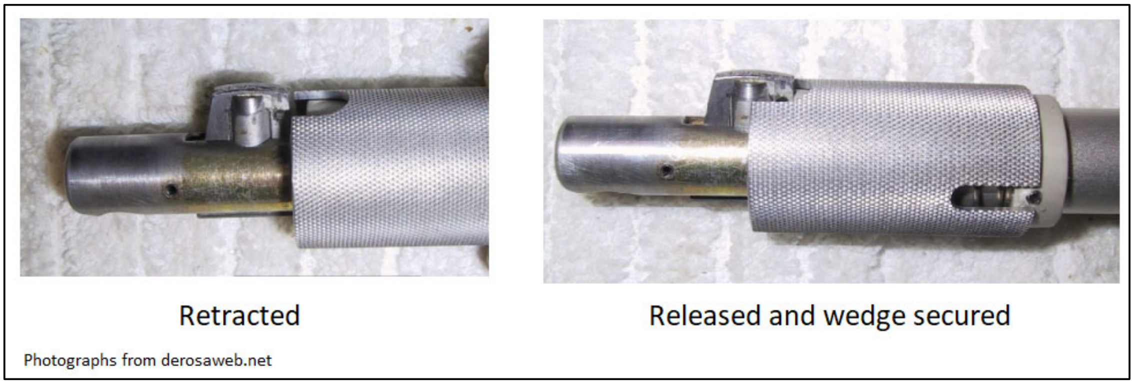


Figure 28-10 Wedekind Safety Sleeves Shown In Retracted And Wedge Secured States

28.4.5 LS SAFETY SLEEVES

These sleeves are permanently fixed on the ball side of the coupler. They are sprung loaded but needed to be screw-twisted over the joint so as to prevent the ball from leaving the socket. They are only suitable for Type 41 inline (Z-swivel) connections. Eg as used on the LS4.

Figure 28-11 Control Rod With L'hotellier Ball and LS Safety Sleeve

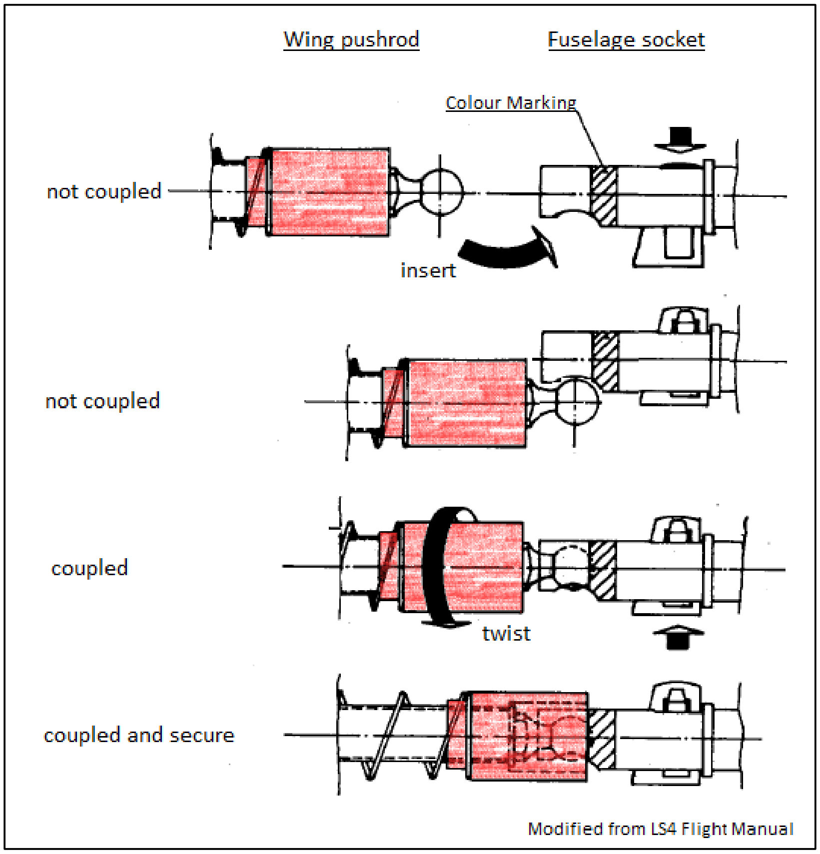


Figure 28-12 Diagrams of LS Safety Sleeve Operation

> **NOTE**
>
> The twist motion to secure is anti-clockwise when looking at the end of the rod with the ball. Therefore, when checking a sailplane, the left-wing connector may appear to twist in the opposite direction to the right-wing connector.

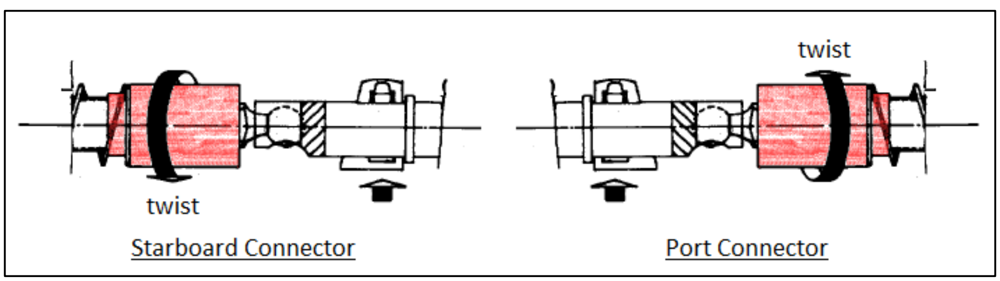


Figure 28-13 Aileron Connectors Direction of Twist of LS Safety Sleeves (Viewed Looking Aft)

28.5 INSPECTIONS AND PERIODIC MAINTENANCE REQUIREMENTS

The mandatory inspections and mandatory periodic maintenance are specified in MOSP 3 Section 13.4.

28.6 DAILY INSPECTION

Daily inspection and the connection / disconnection of L'Hotellier couplings, fitting safety pins and lubrication of the coupling must be performed by qualified Daily Inspectors who are familiar with the type of L'Hotellier and safety method fitted.

In most sailplanes it is difficult to see the L'Hotellier connectors in their normal locations as they are often hidden from view behind spars. Touch / feel is often the sense used to make the connection and establish it is locked together and the safety mechanism has been applied. Torches, mirrors, smartphone cameras and endoscopes may be useful tools to assist visual inspection. Inspectors should thoroughly familiarise themselves with how the connectors look and feel whilst the sailplane is derigged.

The actions to be taken during the Daily Inspection of the L'Hotellier connectors are:

Action A: Check Maintenance Release for Periodic Maintenance Requirements. Part 1 of the sailplane's Maintenance Release (MR) must be checked for the periodic maintenance requirements applicable by Total Time In Service (TTIS) or date. Any required maintenance due by virtue of the stated TTIS or date must be completed prior to the next flight.

Action B: Ball and Socket Installation Integrity. Inspect and check for defects such as looseness of balls, loose locking nuts, broken tab washers, worn threads etc. Any of these defects will allow the L'Hotellier connectors to wind out or loosen. Any looseness can cause bending failure and cracking of the shank at the underside of the flange. This sort of defect is significant and must be treated as a Major Defect and the sailplane not be flown until evaluated and rectified by an Annual Inspector.

Action C: Ball Correctly Engaged in Socket. The correct and incorrect assembly of the couplings must be pointed out by Daily Inspector Examiners and understood by Daily Inspectors. This is shown in Figure 28-14.

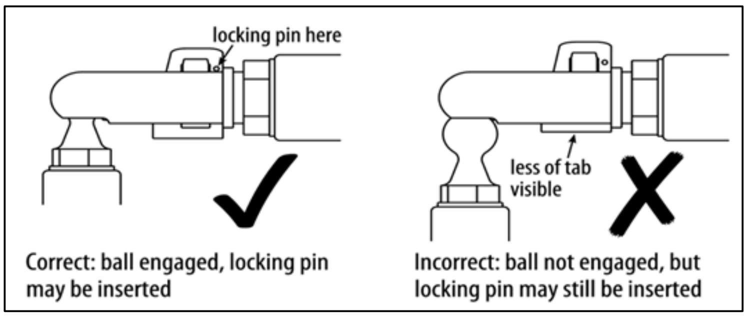


Figure 28-14 Correctly and Incorrectly Assembled Couplings

Daily Inspectors must be aware that it is possible to connect these couplings incorrectly. The ball may not be fully seated as shown in Figure 28-15.

Method: The inspector should physically try to pull the ball from the socket to ensure it is fully inserted and held by the plunger.

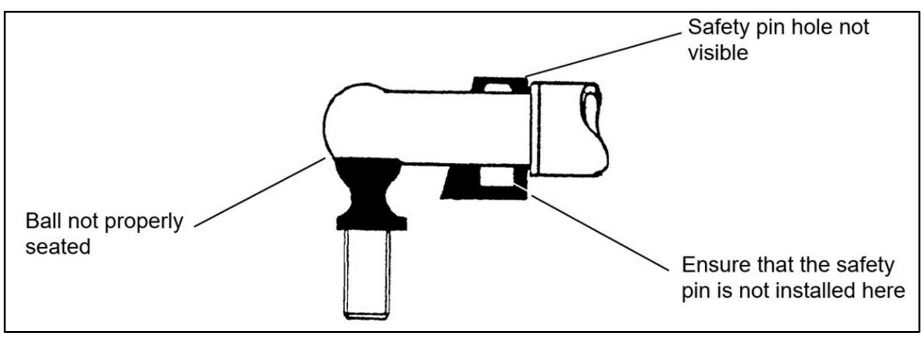


Figure 28-15 Incorrectly Assembled Coupling

Action D: Safety Locking. The presence and effectiveness of the safety locking must be checked at each Daily Inspection.

Method: Visually or by touch, establish that the safety locking is present and has been correctly applied. Where possible, the cam/slide should be pushed to ensure it is impossible to move the cam/slide enough to open the coupling.

Action E: Positive Control Check. Positive control checks should be carried out every time a sailplane is subject to a Daily Inspection. It is also essential for positive control checks to be carried out every time a sailplane is rigged (assembled for flight). This is advised even if there is automatic control connection.

Method: Taking care not to apply excessive force, each control surface should be restrained while an attempt is made to move the control, and the direction of motion checked. It only takes a couple of minutes for a helper to advise the Daily Inspector whether movement of the cockpit controls generates the correct responses at the control surface. A positive control check can reveal connections that have only partially been engaged.

28.7 PERIODIC LUBRICATION

The lubrication intervals are specified in MOSP 3 Section 13.4.

The locking wedge should be cleaned but not lubricated.

Where periodic lubrication is impractical due the aircraft's construction, alternative arrangements may be approved by the CTO/A on written application by the Registered Operator.

Lubrication may be undertaken and signed-off in Part 1 of the Maintenance Release by a Daily Inspector. Because the control linkage has been disconnected to enable the lubrication, a duplicate inspection and signature by another Daily Inspector is required regarding the reconnection,

On completion of lubrication, it shall be recorded and signed off in the Maintenance Release and the next due date / TTIS for lubrication shall be calculated entered in the Maintenance Release by the inspector actioning the lubrication.

A high-quality grease may be used for flight in non-freezing conditions. Flight in sub-zero temperatures (e.g. high altitude wave flying) requires the use of low temperature aviation greases such as Aeroshell 7 or Mobilgrease 28.

28.8 ANNUAL INSPECTION AND PERIODIC MAINTENANCE

L'Hotellier couplers may be subjected to ball wear and ball stem/thread fracture due to incorrect adjustments elsewhere in the control linkages. Annual Inspectors must check for:

a. Excessive pilot effort to lock / unlock airbrake systems.

b. Proper out-travel stops close to the pilot in the airbrake systems so as to prevent ball stems bending and cracking when the airbrake is fully functioned during pre-flight cockpit checks.

c. Free play within manufacturer's limits

Annual inspection and periodic maintenance (other than lubrication) of L'Hotellier connectors may only be performed by qualified and current Annual Inspectors. In addition to the daily inspection checks (Actions A-E above) and periodic lubrication requirements, the following actions are required:

28.8.1 SAFETY LOCKING

Check there are safety locking mechanisms present and functional for all L'Hotellier connections fitted on the sailplane. If the sailplane manufacturer's operating manual does not describe a L'Hotellier safety locking mechanism, then the safety pin method described in this chapter must be applied or else an alternative method fitted as approved by GFA for the specific sailplane under inspection.

28.8.2 BALL WEAR

All balls must be checked for wear, as per Figure 28-16, at 500-hour intervals and during Annual Inspections, whichever comes first.
The maximum out-of-round dimension A minus B or B minus A is 0.1 mm
Also check the ball thread (no damage is acceptable) and the base of the ball for cracks.

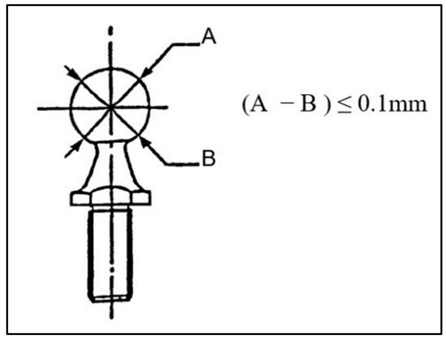


Figure 28-16 Ball Wear Measurements

The fit of the ball in the fitting can be checked by unbolting the ball from the control system and installing it in the coupling and attempting to rotate it. Any variation in the torque needed to rotate the ball is an indication of wear and ball replacement should be considered.

The collar of the ball must be perfectly set on its base. See Figure 28-17 below.

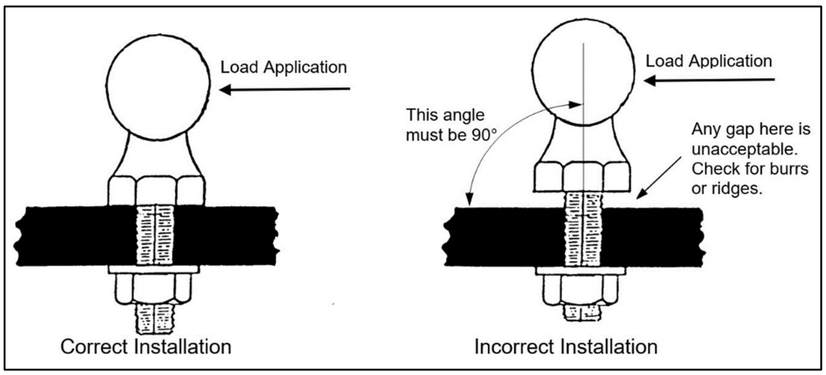


Figure 28-17 L'Hotellier Ball Collar Installation Requirement

28.8.3 COUPLING CLEARANCE AND WEAR

At each Annual Inspection, the projection of the Type 41 wedge locking plate must be checked as per Figure 28-18. This measurement is an indication of the combined wear of the ball and socket. If replacing the ball does not bring the extension back into tolerance, then the socket is excessively worn and must be replaced.

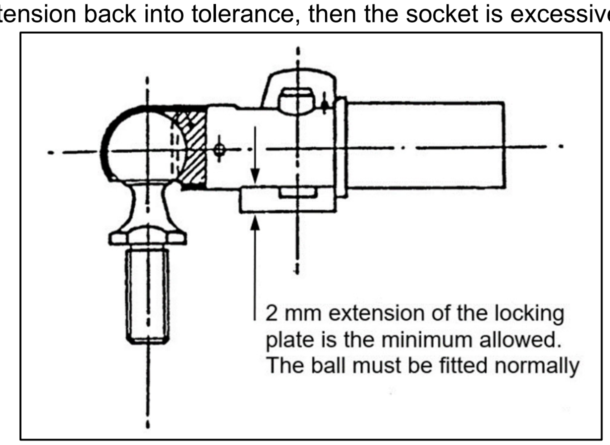


Figure 28-18 Locking Plate Extension

Some sailplane types were originally fitted with aluminium alloy socket fittings. These must be checked at each Annual Inspection for socket wear and when replaced, replacement is to be with a steel alloy assembly.

28.8.4 LATCH SPRING CHECK (TYPE 41)

At each Annual Inspection, clean the coupling and measure the force required to initially move the sliding latch (pre-load) and the maximum force just before the latch reaches its natural stop.

The pre-load should be approximately 600g and the force when the latch is fully out is approximately 1000g. Significant variance to these figures indicates a weak spring which may not secure the coupling and thus replacement of the socket unit is required.

Note: Faulty latches have been found with zero pre-load and a maximum load of 300g.

28.9 1000 / 3000 HRS TTIS PERIODIC MAINTENANCE

The replacement intervals are specified in MOSP 3 Section 13.4.

Balls and sockets removed due to time in service or not to specification, must be deliberately made unusable and disposed of to prevent accidental further use.

Replacement of balls and/or sockets shall be recorded in the sailplane's logbook including:

a. Details of the part number, description, supplier source and any manufacturer batch information provided

b. The next due TTIS or date of required maintenance or replacement.

c. The date of replacement, the signature and GFA number of the Annual Inspector approving the work.

28.10 ANNUAL INSPECTION DOCUMENTATION

28.10.1 LOGBOOK ENTRY

The sailplane's logbook entry for the Annual Inspection is to record that the inspection requirements of this chapter have been completed and any remedial action taken. The entry must also detail the future periodic maintenance requirements as follows:

a. The next 50-hour lubrication is required by Total Time in Service (TTIS).

b. The TTIS by which a 500-hour wear inspection must be completed.

c. The TTIS by which L'Hotellier balls must be replaced. Note there may be more than one such entry if more than one size of ball is installed and/or similar size balls are installed in different control circuits and have been changed at different times.

A record of ball measurements and latch spring tensions should be added to the sailplane's support documentation.

28.10.2 MAINTENANCE RELEASE DOCUMENTATION

The Reoccurring Maintenance Items page of the Maintenance Release of a sailplane equipped with L'Hotellier couplings must be endorsed with the periodic maintenance requirements identified at the Annual Inspection documentation as detailed above.

Item No	Maintenance to be Performed. Items which may be performed by Daily Inspectors must be marked 'DI'		Due Date or Time in Service	Maintenance Certified by: (with member no)	Date Completed
1	REPLACE NOSE TOST MAIN SPRING		4542 LAUNCHES		
2	CHECK RUDDER CABLES EVERY 200 HRS		2402 HOURS		
3	CLEAN AND LUBRICATE L'HOTELLIERS		03 APR 2022 OR 2252 HRS OR NEXT RIGGING	ABradshaw 2250 HOURS	21 FEB 2022
4	CLEAN AND LUBRICATE L'HOTELLIERS		21 AUG 2022 OR 2300 HRS OR NEXT RIGGING		

Maintenance Authority is your signature, name and membership number

Figure 28-19 Example of Entries in Maintenance Release Part 1

Since these actions may be completed before the stated due date / TTIS, the subsequent check / action date / TTIS is best not written into the MR in advance. When the action is completed, the inspector should enter when the next periodic maintenance action is due.

28.11 MAINTENANCE ACTIONS

28.11.1 TYPE 41 SOCKETS (WITH WEDGE LOCK) SAFETY HOLE

Type 41 sockets were originally manufactured with a 1.0 mm ∅ 'witness' hole that visually confirmed the coupler was locked. L'Hotellier later changed this to a 1.2 mm ∅ hole for inserting a safety pin. Sockets with witness holes of only 1.0 mm ∅ may be redrilled to 1.2 mm ∅.

28.11.2 TYPE 45 SOCKETS (WITH CAM LOCK) SAFETY HOLE

All cam style L'Hotellier sockets are to have a hole for a safety pin. Safety pins must be inserted before flight. Early manufactured cam style couplings did not have a safety hole, but GFA AD177 Issue 5 dated 12 May 1998 required that all such couplings be inspected and modified by 31 July 1998.

If a cam style coupling is found without a safety hole, it is to be modified by drilling a hole as shown in Figure 28-20 using the following procedures:

a. Remove the connector from the aircraft.

b. Fit a coupling ball so that the coupling is in the connected state.

c. Drill a 1.3 mm ∅ hole as show in the Figure below. Clean the coupling and ensure no swarf remains.

d. Reinstall the couplings. Ensure that any locknuts are tight.

e. Check the control surface deflections and freeplay of all control circuits which have been disturbed.

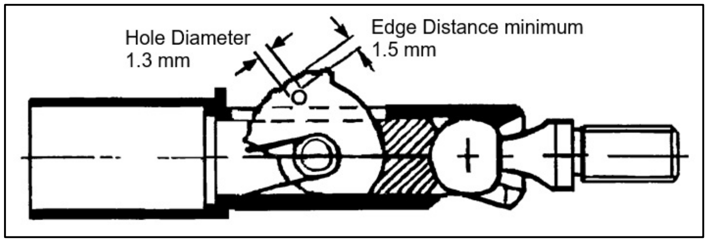


Figure 28-20 Drilling Safety Pin Hole in a Type 45 Cam Locking Socket

Once the holes have been drilled, safety pins or lock wire must be fitted. When fitting the pins for the first time, clearance around the fitting must be checked as some designs do not permit the installation of the safety pins due to fouling with the adjacent structure and in these instances locking wire must be used.

Each safety pin installation must be checked for clearance from the surrounding structure and control systems through the full travel of each control system.

28.11.3 INSTALLATION OF BALLS WITH REDESIGNED THREADS

GFA AD177 Issue 6 identified that L'Hotellier had redesigned some of the balls to remove the undercut thread and introduce a small length of shank. Figure 28-21 shows the original and the replacement designs.

The part number designation of the balls with redesigned threads is believed to be 961S-150-150.

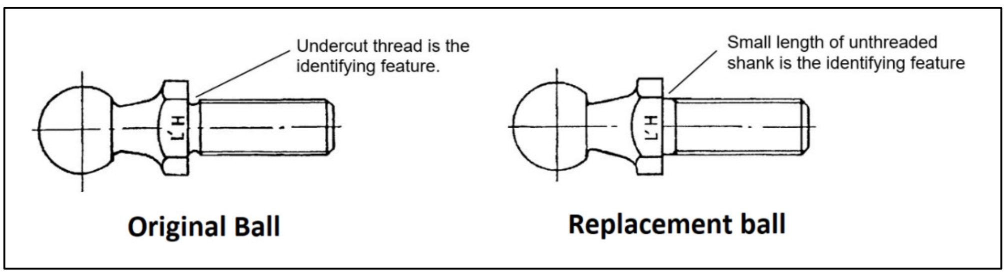


Figure 28-21 L'Hotellier Ball Redesigned Thread

Because of the redesigned thread, the mounting brackets must be modified to accept the new thread. Where the ball is mounted at 90° as shown in Figure 22 below and there is a nut on the ball, then the plate may be drilled out to accept the 961S ball.

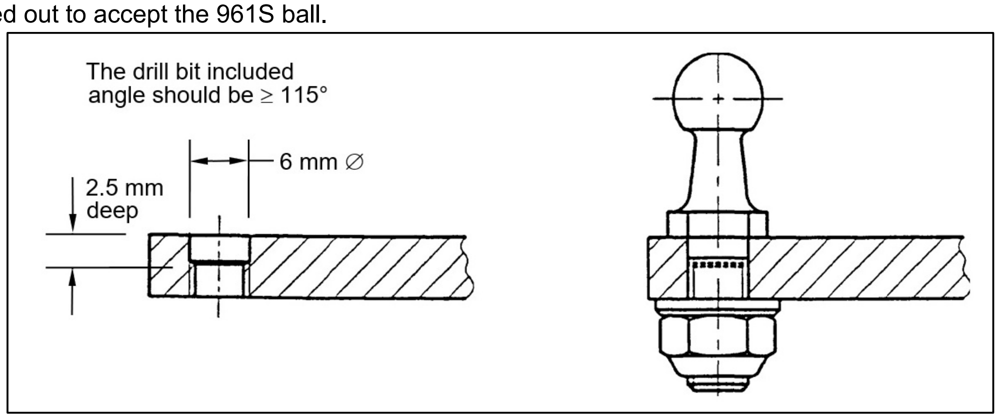


Figure 28-22 Modified Mounting for 961S-150-150.L3 Ball

The ball may be installed in push rod end fittings by installing 2.5 mm of washers under the ball flange. Because this changes the geometry of the control system the control deflections or dive brake locking forces must be checked and adjusted to bring them back into tolerance.

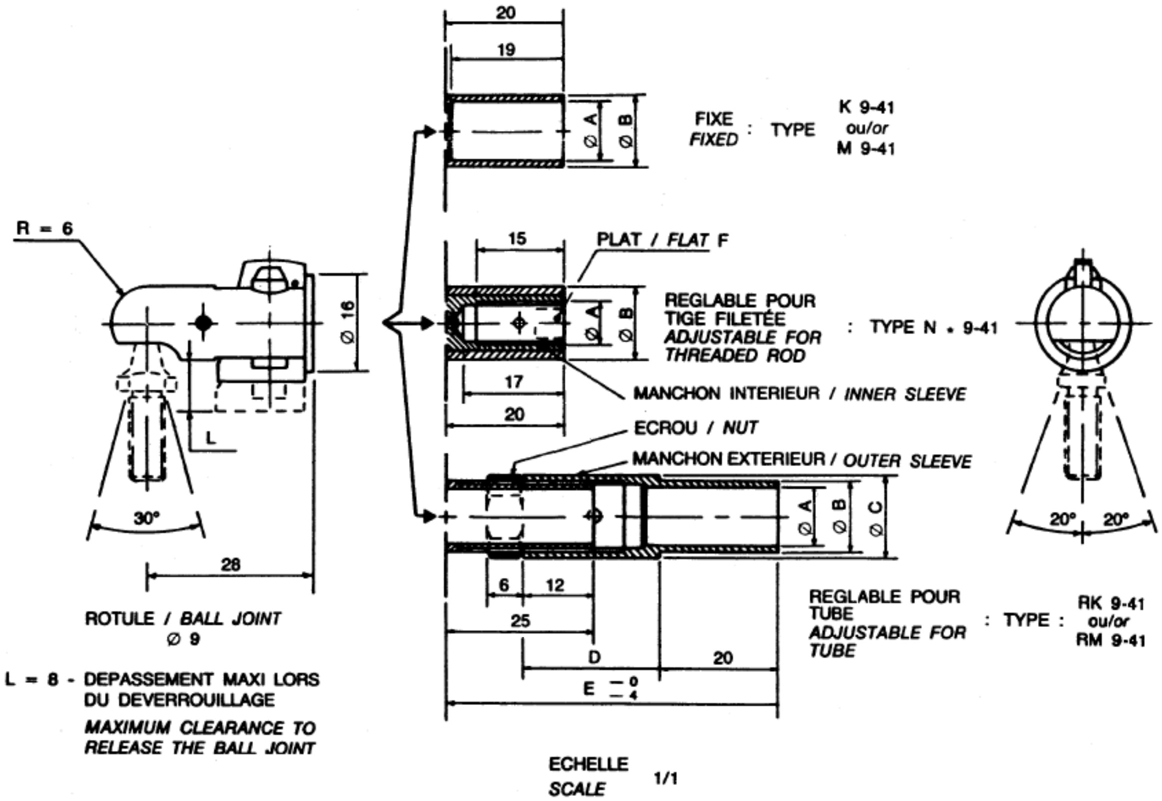
The installation of 961S-150-150.L3 balls in any other designs requires formal design approval from GFA.

28.12 EXTRACTS FROM L'HOTELLIER PRODUCT GUIDE

TYPE K-M / N* / RK-RM 9-41

LOGEMENT NORMAL DE LA ROTULE
STANDARD SWIVEL JOINT HOUSING

N * = N6, N7 ou/or N8 VOIR LE Ø DU TARAUDAGE DANS LE TABLEAU
SEE THE TABLE BELOW FOR TAPPING DIAMETER



MATIERE/MATERIAL			K	M	N 6	N 7	N 8	RK	RM
DIMENSION / DIMENSION		A	10	12	M6 × 100	M7 × 100	M8 × 100	10	12
		B	12	14	12	12	13	12	14
		C						14	16
		D						23	19
		E						56	52
		F			11	11	12		
MASSE WEIGHT	A-U4G	1	15,50	16,00	19,50	18,75	19,25	23,10	25,20
	XC 38	2	26,50	27,50	36,75	35,25	36,25	49,10	54,10
	35NCD6	3							

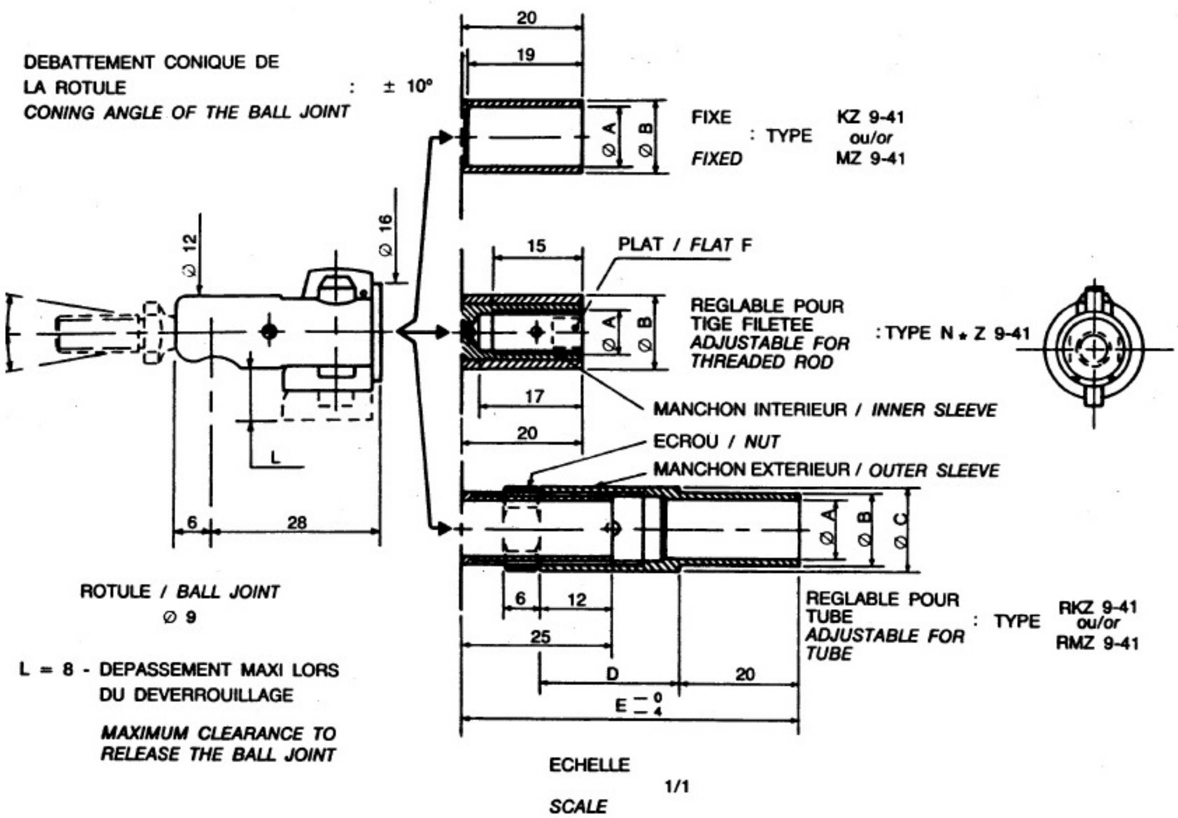
TYPE K-M / N* / RK-RM Z 9-41

LOGEMENT EN Z DE LA ROTULE

Z SWIVEL JOINT HOUSING

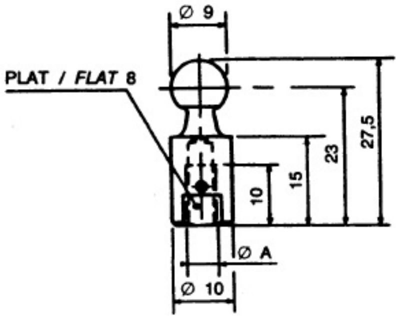
N * = N6, N7 *ou/or* N8 VOIR LE Ø DU TARAUDAGE DANS LE TABLEAU

SEE THE TABLE BELOW FOR TAPPING DIAMETER

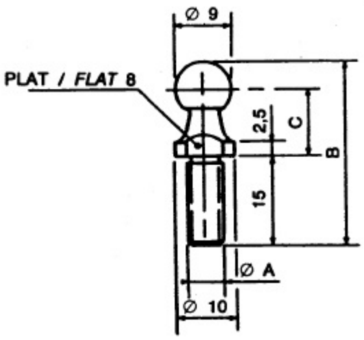


		TYPE						
		K	M	N6	N7	N8	RK	RM
DIMENSION / *DIMENSION*	A	10	12	M6 × 100	M7 × 100	M8 × 100	10	12
	B	12	14	12	12	13	12	14
	C						14	16
	D						23	19
	E						56	52
	F			11	11	12		
MASSE *WEIGHT*	XC 38 — 2 / 35NCD6 — 3	26,50	27,50	36,75	35,25	36,25	49,10	54,10
MATIERE/*MATERIAL*								

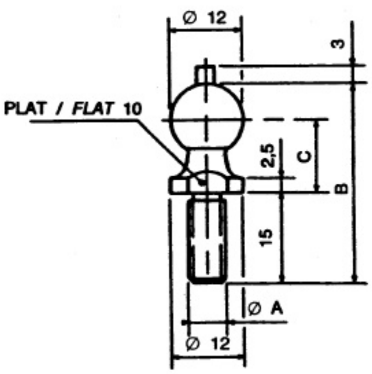
ROTULES
BALL JOINT



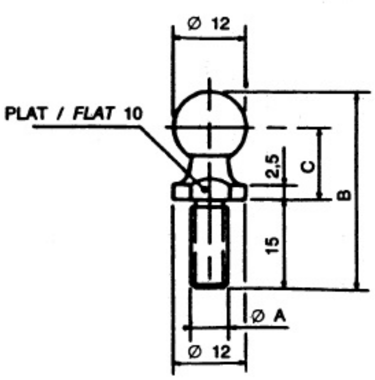
MATIERE / *MATERIAL* 35 NCD 6 PROTECTION/*FINISHING*: CADMIE BICHROMATE		
REF. P/N	Ø A	MASSE WEIGHT
95 M	M 5 × 0,80	11,00
96 M	M 6 × 100	10,50
97 M	M 7 × 100	9,50



	MATIERE / *MATERIAL* 35 NCD 6 PROTECTION / *FINISHING* : CADMIE BICHROMATE				
	REF. P/N	C	B	Ø A	MASSE WEIGHT
	952 M	12	31,5	M 5 × 0,80	7,50
	955 M	15	34,5	M 5 × 0,80	8,50
NF L 35-452	961 M	11	30,5	M 6 × 100	8,00
	965 M	15	34,5	M 6 × 100	9,00



MATIERE / *MATERIAL* 35 NCD 6 PROTECTION / *FINISHING* : CADMIE BICHROMATE				
REF. P/N	C	B	Ø A	MASSE *WEIGHT*
262 M	12	33	M 6 × 100	13,00
265 M	15	36	M 6 × 100	14,50
282 M	12	33	M 8 × 125	15,50
285 M	15	36	M 8 × 125	16,50



	MATIERE / *MATERIAL* 35 NCD 6 PROTECTION / *FINISHING* : CADMIE BICHROMATE				
	REF. P/N	C	B	Ø A	MASSE *WEIGHT*
	1262 M	12	33	M 6 × 100	12,70
	1265 M	15	36	M 6 × 100	14,20
	1282 M	12	33	M 8 × 125	15,20
NFL 35-452	1285 M	15	36	M 8 × 125	16,20

28.13 HISTORY OF AIRWORTHINESS REQUIREMENTS REGARDING L'HOTELLIER CONNECTIONS

28.13.1 GFA AIRWORTHINESS DIRECTIVES

AD177 Issue 2, 24/5/1983. Combined all known inspection, replacement and maintenance actions required to ensure safe operations of L'Hotellier couplings.

AD177 Issue 3, 18/4/1990. Represented the experience generated since 1983 from the application of Issue 2 requirements.

a. Correct lubrication prevents ball wear. Correct installation will help to prevent fracturing of the threaded part of the ball.

b. Excessive pilot effort to lock/unlock airbrake systems is a major contributor to ball wear and ball stem/thread fracture. When rigging an airbrake system, the sailplane manufacturer's recommended procedure, including freeplay limits, must be followed.

c. Lack of proper out-travel stops close to the pilot in airbrake systems can cause ball stems to bend and crack when the airbrake is fully functioned during pre-flight cockpit checks.

d. Balls with threaded shanks larger than 6mm diameter need not be replaced at intervals less than 3000 hours, as recommended by the L'Hotellier coupling manufacturer.

AD177 Issue 4, 30/10/1991. Added an additional check on the condition of the springs.

AD177 Issue 5, 12/5/1998. Required Type 45 couplings with a locking cam to have safety pins installed and the maintenance requirements updated to reflect the latest information from L'Hotellier.

AD177 Issue 6, 25/1/2001. Changes the requirements for lubrication of the couplings.

AD177 Issue 7, 9/5/2001. Corrects an erroneous part number for replacement L'Hotellier coupling balls. Superseded by chapter in BSE.

AD178 Issue 1, 10/6/1980. Check for and remedy incorrect type of L'Hotellier socket fitted (inline socket incorrectly used for 90-degree joint).

28.13.2 OTHER REFERENCES

Glasser-Dirks Technical note No. 826/24.

LBA ADs 1993-001/3 and 1994-001/2

Grob Service Bulletin TM306-32 & TM315-57 regarding use of Wedekind sleeves and Securing Socket S26 in G102 and G103 sailplanes

L'Hotellier Maintenance Instructions 10.01 dated 03/94.

29. GLOSSARY OF ABBREVIATIONS AND TERMS

AAF	Airworthiness Administration Fee – the fee payable to GFA for the issue of the Annual Inspection Kit , the documentation that supports a sailplane's annual "Form 2" inspection.
AC	Aerodynamic Centre - the point on a wing aerofoil where the pitching moment produced by the aerodynamic forces is constant with angle of attack.
AD	Airworthiness Directive – a document detailing mandatory actions for the continuing airworthiness of the sailplane usually generated in response to some technical issue such as a serious defect requiring rectification advice from manufacturer
AI	Annual Inspection. Often referred to as a "Form 2 Inspection"
AN	Airworthiness Advice Notice - a GFA document providing non-mandatory airworthiness advice.
AN bolts	Army Navy bolts – A specification system for bolts originating in America.
AIP	Aeronautical Information Publication - as issued by Airservices Australia.
ASI	Air Speed Indicator
ATSB	Australian Transport Safety Bureau - the national body responsible for civil aircraft accident investigation being an independent Commonwealth Government statutory agency.
BA bolts	British Associate bolts - A specification system for bolts originating in Britain
BCAR	British Civil Airworthiness Requirements - the standard to which many British and some Australian sailplanes have been certificated. Now largely superseded by EASA and OSTIV standards.
Boom	The upper & lower spanwise beams of a sailplane main spar which carry the main bending loads acting on the wing. Also called a spar cap.
Box spar	A spar constructed of two booms top and bottom joined together by shear webs on both the front and rear of the booms thus forming a box in cross section.
BS	British Standard – a system of standards now mostly replaced by international or European standards
BSE	The GFA publication Basic Sailplane Engineering
CS-22	Certification Specifications for Sailplanes and Powered Sailplanes CS-22 issued by EASA.
CASA	Civil Aviation Safety Authority.
CAR	Civil Aviation Regulation.
CAO	Civil Aviation Order.
CFRP	Carbon Fibre Reinforced Plastic
Chord	The distance between the leading and trailing edges of a flying surface such as a wing or tailplane etc
C of A	Certificate of Airworthiness.
Control circuit friction	The friction present in a control circuit resulting from the cumulative friction of all the components in the circuit.
Control circuit stiffness	The stiffness of a control circuit resulting from components deforming or stretching under load. Higher stiffness = less deflection/deformation/stretching = less flexibility.
CG	The point on the aircraft through which the total weight acts with the line of action at right angles to the earth's surface.
CP	Centre of Pressure - the position on the wing where all of the aerodynamic pressure field may be represented by a single force vector with no moment.
CRP	Carbon Reinforced Plastic.
CTOA	Chief Technical Officer Airworthiness. The officer appointed by the GFA to supervise the airworthiness functions of the GFA and who holds delegated authority from CASA.
DI	Daily Inspection.
DIN	Deutsche Industrie-Norm. A set of standards originating in Germany.
D-nose	For earlier sailplanes with little or not much structure aft of the main spar, the D shaped front section of a wing, forward of the main spar and consisting of a load-bearing skin and numerous internal ribs. Resists the torsional or twisting loads exerted on a wing
DoITRD	Department of Infrastructure, Transport, Regional Development & Local Government
EASA	European Aviation Safety Agency - implements Europe wide aviation regulation.

EC	Experimental Certificate
FAA	Federal Aviation Authority
Form 2	The GFA form used during an Annual Inspection as a checklist and record
Freeplay	Slack in the control systems. eg the amount of movement required of the control stick before the elevator moves
FRP	Fibre Reinforced Plastic - a generic term for all forms of fibre reinforced plastic structures.
g	The acceleration due to gravity, equal to 9.81 m/s^2
Gelcoat	The smooth, hard polyester resin surface coating of a fibreglass structure
GFA	Gliding Federation of Australia.
GFA Ops Regs	The GFA Operational Regulations
GRP	Glass Reinforced Plastic.
“I" spar	A spar constructed of two booms (top and bottom) joined together by a single shear web usually equidistant between the front and rear of the booms
JARs	Joint Airworthiness Requirements - a European standard - Section 22 re sailplanes and powered sailplanes now superseded by CS-22 issued by EASA.
KRP	Kevlar Reinforced Plastic
LAME	Licensed Aircraft Maintenance Engineer
LE	Leading Edge
LSA	Light Sport Aircraft
MAC	Mean Aerodynamic Chord - the average chord of a flying surface taking into account geometric taper and other characteristics of the wing profile and geometry.
Major Defect	A significant defect, recorded in the Maintenance Release, which renders the sailplane un-airworthy until it is cleared by an appropriately authorised person.
MAR	Mandatory Airworthiness Requirements. A set of GFA requirements for new sailplane types.
Minor Defect	A defect, recorded in the Maintenance Release, which does not render the sailplane un-airworthy but needs to be monitored at subsequent DIs (in case it hasgot worse) and pilots should be aware of. It may be cleared by an appropriately authorised person.
MOSP	The GFA Manual of Standard Procedures.
MR	Maintenance Release. The document providing the legal records of the maintenance status of the sailplane and informing of the actions required of a Daily Inspector seeking to release the sailplane for flight operations on a particular day. Must be kept with the aircraft at all times.
N	Newtons – The unit measure for Force.
NDI	Non Destructive Inspection
NDT	Non Destructive Testing
ONL	A standard for bolt specification originating from Czech Republic
OSTIV	An acronym in French which translates as "International Scientific and Technical Organisation for Gliding". A body of people interested in these aspects of gliding.
OSTIVAS	Airworthiness standards according to OSTIV
PSI	Pounds Square Inch – A unit of pressure
PTT	Press To Talk – button the pilot presses to transmit on the radio
RF	Radio Frequency
RTOA	Regional Technical Officer Airworthiness
SDS	Safety Data Sheet – information provided by the manufacturers of materials and chemicals
Shear	A load tending to deform a structure by sliding one section against or over another.
Shear web	The vertical facing used to join together the top and bottom booms of a sailplane spar and carrying shear loads when the spar is deflected up and down.
STOA	Senior Technical Officer Airworthiness – a GFA appointed role
TBO	Time Between Overhauls

TC	Type Certificate
Torque tube	A metal tube which transmits control forces to a control surface (e.g. flaps) by means of torque/twist/torsion applied to the tube.
Torsion box	Structure designed to resist torsional (twisting) loads.
TOST	A manufacturer of launch cable releases and undercarriage components
TTIS	Total Time In Service
UV	Ultra Violet – a form of light
V_A	Maximum manoeuvring speed (the speed beyond which full deflection of the controls may create forces that could cause structural damage)
V_B	Design speed for maximum gust intensity
V_D	Design diving speed, the highest speed planned to be achieved in testing
V_{NE}	Never Exceed airspeed
W&B	Weight & Balance