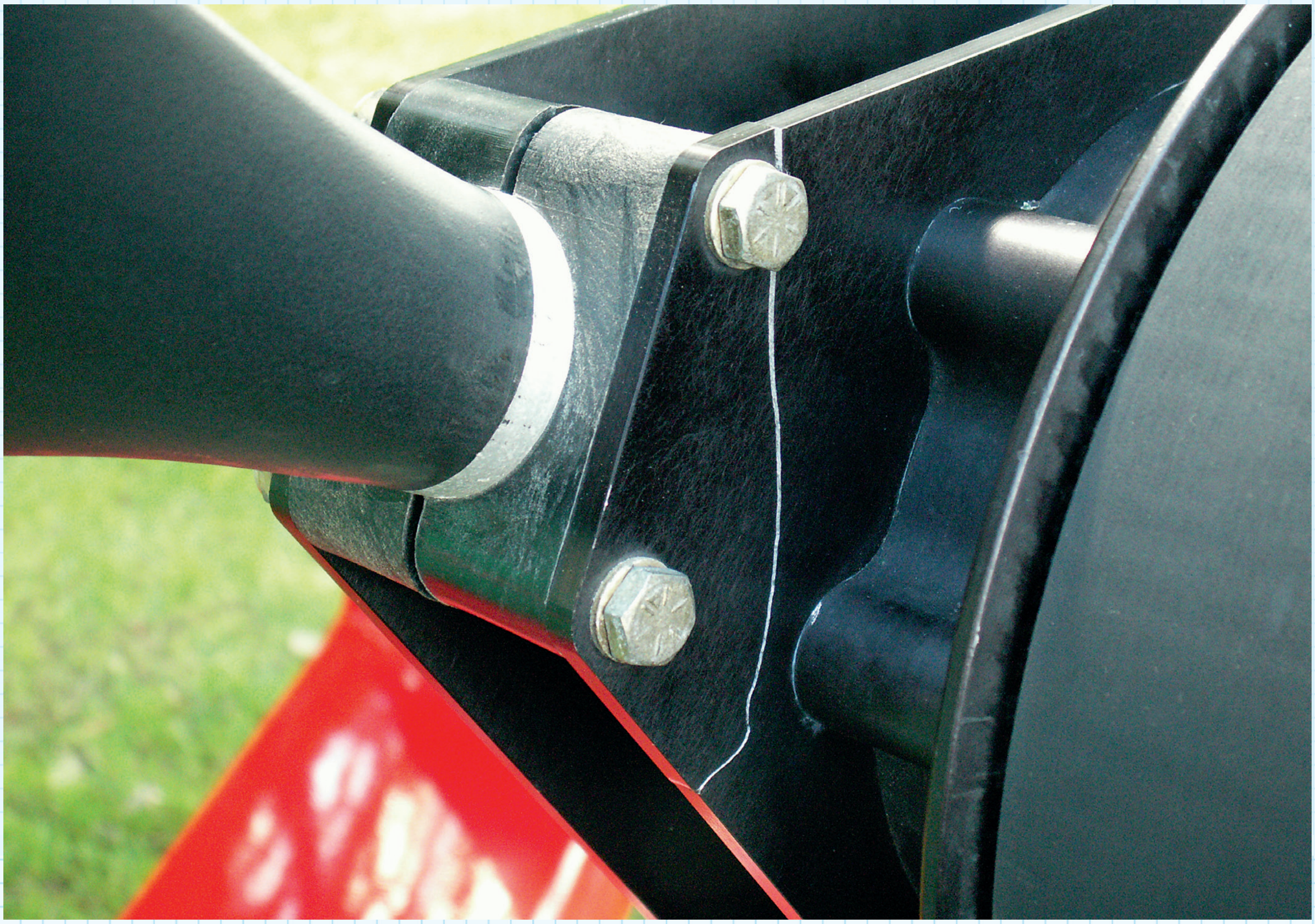
With Malcolm McBride
Airworthiness Engineer

# NO SPINNER HELPED THIS SPOT

## AN EXCELLENT SPOT DURING A WALKROUND PREVENTS AN IN-FLIGHT DISASTER – AND A LACK OF BASIC FITTING SKILLS IS BEHIND OTHER PROBLEMS



**This is a picture of the crack as spotted by the owner on the propeller back-plate on his RAF 2000 autogyro. A spot like this reminds us all why good daily inspections are a vital component for safe flying. Metallurgical examination showed that, in actual fact, this plate had been cracked for some time as corrosion products had formed just after the initiation point. It looks like the plate cracked during an engine run, wasn't spotted and then failed completely during the next engine run cycle. Note that the crack passes close to the top bolt/washer** *(Photo: David North)*

**I've never really given much thought to the job title 'Fitter' – I'm not sure why, but I suppose I just assumed the title belonged to somebody who, well, fitted things to, presumably, other things. As will become clear (I hope) later in this month's 'Safety Spot', I have after thinking about a couple of events featuring LAA aircraft, realised there's more to this job than first meets the eye. I punched in the title into the search engine and two options jumped out of the screen…**

The first was NATO's name for the Sukhoi Su-17… the second heading said, 'Fitter (occupation)'. 'Ah, that looks like the one…' Click. I was immediately dispatched to 'Machinist' with a warning that if you were looking for the film *The Machinist* you needed to put 'The' into the title – yet I hadn't put 'Machinist' into the thing in the first place! The best description I got was 'a person who uses machine tools to make or modify parts'. I quite like the 'making or modifying' but wasn't convinced about the 'machine tools' part of the description.

Perhaps, in this computerised age, some of the engineering skills required by a fitter have been lost, at least in job descriptions. Take, just for example, the fitting of a new set of big end shells to cure an 'orrible knock from under the bonnet. I can hear you thinking, 'Don't be stupid, nobody does that any more, it's cheaper to fit a new engine.' Well, it wasn't in the old days; I'm not that old but I can still remember helping out the old man scraping off engineers' blue from big end bearings to ensure a good fit to get a just about affordable banger back on the road. These days of course, tolerances are so tight that most of the parts that you need to fit will require no, or at least very little, tweaking. That's true of aircraft parts isn't it? Here are a couple of examples where the application of basic fitting skills may have prevented a failure.

The first is about a Warp Drive propeller failure on a RAF 2000 autogyro. Regular readers will know of the problems some members have encountered with propellers using Warp Drive blades. These stiff and light composite blades are undoubtedly good performers, but nothing comes without a price and, in this case, the energy absorption spectrum of the blades appears to be causing problems at the root end of the blade or at the attachment to the engine. Various manufacturers use the Warp Drive propeller blades in their propellers, for example Airmaster in its AP332 and NSI in its CAP 140, while Warp Drive offers its own complete unit.

Warp Drive provides a number of different hub design options and a variety of blade designs/sizes. The unit as fitted to the

RAF 2000 comprises three blades, supported between two aluminium plates, and the root of the blade is held in place between composite blocks, the clamping force being supplied by four bolts per blade. The inner two bolts act as engine attachment bolts; you will already have worked out that this makes 12 bolts in all. As this is a self-assembly propeller the unit therefore comprises (without washers and nuts) 23 separate components. Putting this lot together accurately requires a high level of fitting skill.

A couple of years ago the LAA decided that, due to reports of cracking of the attachment collar in the AP332 unit, the Warp Drive blades couldn't be approved in direct drive applications where there was no provision for damping within the power train. The currently available gearboxes all have some kind of damping devices built in, some rubber, some mechanical, but on many engines the propeller hub is directly linked to the crankshaft where each power pulse is transferred directly to the propeller. In this case the Subaru engine powers the propeller via a reduction drive belt.

I received an email from LAAer David North who was hoping to enjoy his RAF 2000 autogyro one afternoon a while back when, after a good pre-flight, he found a rather large problem with the propeller hub, which kept him on terra firma. Here's his email.

*Dear Malcolm*
*Ronnie Legge suggested I drop you a note regarding a problem I discovered with my RAF2000 registration G-CDJN.*

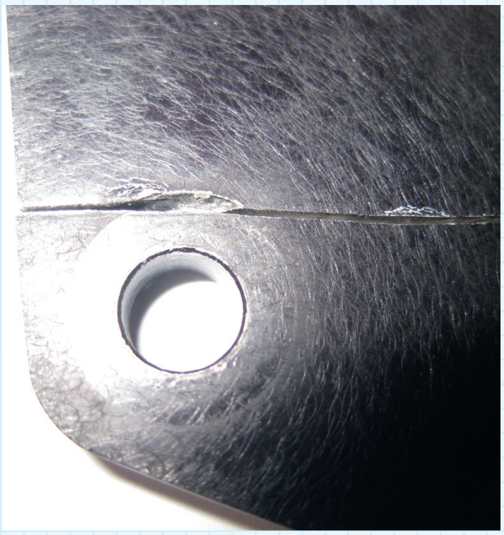
*Upon landing away from home on Saturday, I noticed a rather large crack in the propeller hub (see photo attached) and had to arrange a trailer to bring my aircraft home. I'm not really sure what would have caused this malfunction, however from speaking to Ronnie and other RAF2000 pilots, this appears to be an unusual occurrence.*

*I'm fully aware of the potential consequences this failure could have caused and feel very fortunate to have discovered the problem whilst on the ground!*

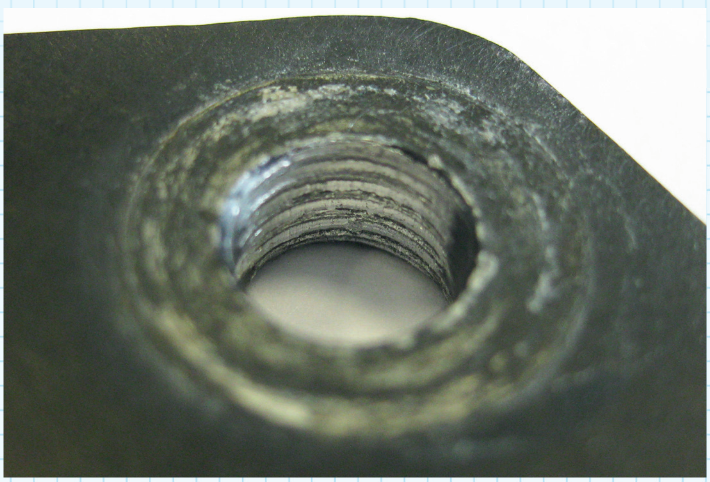
*The aircraft was purchased new in 2005 and has now completed 204 hours flying time. Although not all my landings are perfect, it has never suffered any damage or been subject to a particularly heavy landing.*

*Please let me know if you require any further information.*

**Here is a closer look at what we think is the initiation site for this crack found on the back plate of a Warp Drive propeller. What it looks like is that the plate has been subjected to bending loads and the washer has been acting as a fulcrum around which the loads have been oscillating. The gouge at the bottom of the plate matches the position of the washer.** *(Photo: Malcolm McBride)*



**Here is another picture of the failed Warp Drive back plate, this time showing where it looks like the crack started… opposite the edge of this washer. I've used a bit too much light here (on purpose) to help highlight the micro-fractures in the anodised surface; they are not visible to the naked eye. You can see that the general radius of these micro-cracks is the attachment hole; this pattern is repeated around the other outer attachment holes, which suggests that this plate is being stretched to the point where the thin anodic film is failing.** *(Photo: Malcolm McBride)*



**Another cause of cracking in highly-loaded components is stress concentrators; this is a close-up picture of the Warp Drive's front plate. This plate didn't fail but you can see the damage caused to the plate. This was either during the assembly of the propeller (the bolt wasn't correctly aligned) or during service (the plain shank of the bolt was insufficiently long and the threads were impinging into the material). Note that all the outer bolt holes were like this.** *(Photo: Malcolm McBride)*

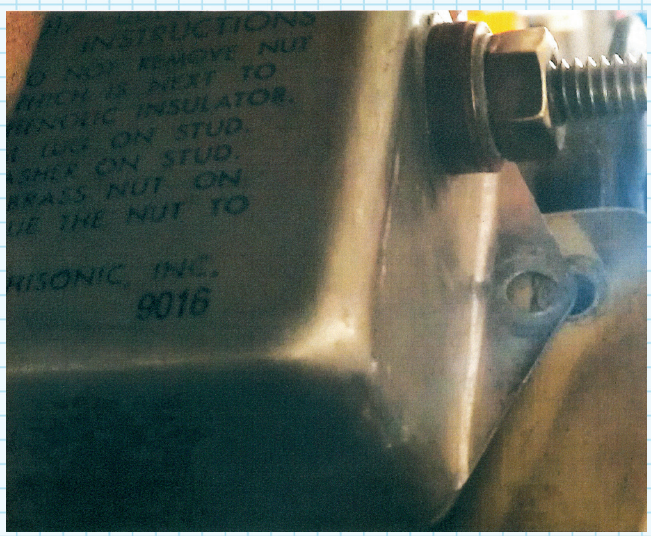
**Whilst looking at the micro-structure of the fracture face on the back plate of the Warp Drive propeller featured in the text, I came across this small ferrous inclusion and thought that you would like to see it. Even in the best quality materials there can be hidden defects. Who can guess where this tiny piece of iron originated?** *(Photo: Malcolm McBride)*

# SAFETYSPOT

*"It can be that poor fitting/assembly practices will thwart even the best design intentions!"*

**The failed casing of the output filter that caused the alternator failure on the FLS Sprint** *(Photo: John Webb)*


**The very photogenic Sprint and, personally, I think that this is a smashing looking aircraft. The design originated as the Trago-Mills SAH 1 and there are four examples still flying in the UK. This is the only LAA example, the FLS Sprint 160.** *(Photo: Chris Burleigh)*




**And here's why the case failed! When the new filter was offered up it was almost a complete hole out (3/16 of an inch); that's enough tension in a piece of material to cause a premature failure, which is exactly what has happened... This 'overstretched' case failed at about 100 hours flight time.** *(Photo: John Webb)*

David kindly sent the propeller hub to us here at engineering HQ for examination and, as you can see, I took a few pictures that may be relevant to this failure. I do think that Ronnie and David are correct that this appears to be an unusual occurrence; this is the first time we've seen this type of problem with the Warp Drive unit as fitted to the RAF 2000 autogyro. Certainly a good thing about this design is that it is easily 'inspectable' and David's diligent pre-flight may have prevented an in-flight disaster. Perhaps this is especially true where there is a significant risk of a propeller blade detaching and impacting a rotor blade.

It might be worth pointing out that covering up a propeller hub with a spinner will undoubtedly improve the looks and may even improve the performance of the propeller a little, but it does come with a cost, as it will reduce the inspectability of this assembly. In the light of this failure, albeit on the drive side of the propeller hub, you might consider looking at your maintenance schedule to see how frequently your propeller hub is removed. Bearing in mind the fact that this failure appeared to be unusual, I felt sure that I had seen a similar thing before and, after a bit of digging, I found a similar report concerning the failure of the hub on a microlight aircraft powered by a Rotax 582 back in 1995. This failure led to the issuance of a Mandatory Permit Directive by the CAA, MPD 1995, 103 requiring checks and modifications.

The reason for the 1995 failure was that the failed hub came from an earlier design of hub and, after some initial failures, the design was improved by upping the material spec (and thickness) and, on some installations, incorporating a steel load-spreader plate on the engine side of the hub. This action appeared to solve the problem of hub cracking in the early units and since then the design has evolved still further.

You will see in the photographs that there is a high probability that this crack emanated in the opposite face to the edge of an outer attachment bolt's washer; I've discussed the crack morphology in the text below the photographs. In my view there are a number of possible reasons for this fatigue failure and it is worth exploring these possibilities, in general terms, here. I say 'in general terms' because this sort of failure can (and does) happen anywhere on the airframe/engine; designers try to reduce the stress concentration points that can lead to failures and, where possible, eliminate the cyclical loading of a component so that the average stress in any part of the component is low when related to the ultimate materials strength. However, it can be that poor fitting/assembly practices will thwart even the best design intentions!

Of course, this failure may have occurred for other reasons, while aircraft materials are made to the highest possible standards there may still be problems; note the picture of the ferrous inclusion in the plate... perhaps a particle of steel from a failing bearing in the rolling machine, maybe a spark from a welding machine nearby carried on a long-passed gust of wind, we'll never know, but it may have been one of the many factors involved in an aircraft accident perhaps many years later.

Another factor may be that the damping offered by the belt drive is only minimal and this 200-hour example may be the fatigue limit in this particular plate. I took a look through our fleet records of the RAF 2000 and, for the 24 autogyros counted, the average flight hours for the type was just

**(Above) Good fitting practice is not just about making sure that holes are lined up. The undercarriage on this Rans S6 was damaged during a forced landing caused because the engine failed shortly after take-off. The cause of the engine failure is thought to have been a fuel restriction caused by a kinked pipe this, in turn, was caused by the pipe being fitted through too tight a turn radius**
*(Photo: Steve Clarehugh)*


**Here is a picture of what happens to a flexible pipe that is forced around too tight a bend… it morphs into quite an effective OFF valve.** *(Photo: Malcolm McBride)*

over 300 hours. In actual fact, looking at these numbers more closely, I noticed that one airframe had completed nearly 1,500 hours (probably an old training machine) so, removing this one from the list, the average drops to about 250 flight hours, worryingly close to the failure case. We'll discuss this failure event during the next Airworthiness group meeting and it might be that we'll issue a bulletin requiring checks.

Well done to the pilot, David North, for spotting this crack during the pre-flight walkround; this 'spot' very likely prevented a nasty incident.

## FLS SPRINT 106: ALTERNATOR FAILURE

I received an email from LAAer John Webb reminding me we'd, some time in the past, had a dog conversation while he was doing an engineering inspection on one of the C of A types in the hangar here at Turweston. He'd got an old German pointer who was quite determined to make friends with me. Naturally my old Collie, Jed, knew immediately on my return home that I'd been flirting; there's not much you can keep from a dog! Anyway, John works at Stockton Airstrip and found an interesting spot on the Sprint aircraft he was doing the annual inspection work on. Here's his email.

*Dear Malcolm,*
*G-OAGI is the prototype Loveaux Sprint and was ferried into Colson Aero at Stockton by its owner for a Permit renewal inspection. He did not report any faults with the aircraft. During the ground run prior to compression test and oil change the low volts warning light came on and alternator field circuit breaker popped.*

*One reset produced an immediate re-trip. Subsequent electrical fault finding revealed nothing and the circuit breaker did not trip. Alternator field current was normal. During the general inspection of the engine bay I noticed that the alternator output filter was slightly loose at one end. Upon removal it became clear that the case of the filter, complete with one mounting lug, had* *fractured and there was evidence of burning where the case had been shorting the alternator output lug to ground.*

*When I went to fit a replacement filter it became clear why the original had failed. The spacing of the mounting holes in the two brackets fitted to the alternator attachments were incorrect, being more than half-a-hole out. It was possible to fit the two AN3 bolts at an angle so, when they were tightened, a lot of stress was imparted to the filter case which failed after a little over 100 hours in service. A trawl of the NTSB data base revealed the loss of a Cessna P210 where the same type of filter had shorted causing an in-flight electrical fire.*

*Later, during the airframe inspection, I found a 10p piece lodged in the tailplane adjacent to the elevator. The aircraft is cleared for aerobatics!*

*Three spots all together?*

Well John, I only counted two spots… but I don't blame you for trying to squeeze another one!

Take a look at the photos and you can see the problem; initially the box didn't quite fit so it was, well, graunched is a reasonable word for this kind of fitting practice. In this case, the material in the filter box itself was pre-loaded, probably fairly close to the material failure point because the mounting holes didn't quite line up during assembly.

This might seem like a small thing. OK, what's the big deal? So you loose an alternator? Well, there's a lot of energy in the output from a generator, especially if the field current for some reason switches to maximum, perhaps because of a spurious feedback from a leaky alternator output filter. Remember, and I quote John, 'This is a 24 volt system.' Incidentally, an output filter, sometimes called a smoothing filter, in the alternator output line acts in a similar way to the rubber or mechanical dampers in the engine/propeller drive path, an inductance coil and a capacitor takes the place of the rubber. Thanks John for taking the time to let us know about these spots.

**RANS S6-ES COYOTE II: EFATO**

I shall start this story with the synopsis from the Air Accidents Investigation Branch's report: 'The aircraft engine stopped at low height, shortly after take-off. The pilot turned back to the airfield and attempted a landing on a secondary runway, but the aircraft landed heavily, causing damage to the landing gear and forward fuselage. Neither occupant was injured.'

At the time the report was published, the actual cause of the incident had not been established; an engine failure, in itself, is not normally a reportable incident under the rules of the ANO but, in this instance, there was damage to the airframe on landing, so the incident had to be reported to the authorities by the pilot. Cause aside, just for the moment, the AAIB report stressed the dangers of turning back when an engine quits on climbout, Here's what they had to say: 'The engine failure occurred at a critical stage of flight. The success of the manoeuvre was probably due to the pilot's experience and familiarity with the aircraft and airfield, together with relatively benign weather conditions and favourable airfield layout.'

> “Previous experience has shown that a number of turn-backs have resulted in loss of control…with sometimes fatal outcomes.”

I think that when the author used the term 'success' he was alluding to the fact that the pilot survived the experience; clearly, as you can see yourself from the picture of the damaged machine, the landing wasn't textbook! Anyway, machines can be repaired/replaced, people can't. The best advice to follow with regard to engine failures after take-off is the oldest advice in the book. 'Never turn back.' In this instance, even though everything was on the pilot's side, the aircraft was still badly damaged. The AAIB report continued '…the aircraft sustained significant damage and was probably close to the stall when the pilot attempted to flare. Previous experience has shown that a number of attempted turn-backs have resulted in loss of control, normally due to decayed airspeed, with sometimes fatal outcomes.'

Actually, I knew about this incident a little before the AAIB… even though I didn't know it. Let me explain. I received in the post one morning what Maxine Oades, our Engineering Administrator, calls "Another strange package". As you will imagine, I get quite a few interesting (to me anyway) broken components sent by owners. This one was just a bit of fuel pipe which, unusually, looked in good order.

I opened the accompanying letter which I noted came from LAA Inspector Steve Clarehugh, the boss of Northumbrian Microlights. Here's what it said.

*Dear Malcolm,*
*Thought you might like this piece of fuel hose taken from a Rans S6 which had an engine failure on take-off. If you bend the end of the tube down the line of the letter E you will feel the pipe kink very easily. This was, we believe, the cause of the power loss (as it was fitted to the fuel selector valve at a very sharp angle).*

*The fuel lines have been replaced using conventional tube.*

*I had a bit of a play with the fuel pipe and could see exactly what Steve was talking about. You can see from the accompanying photographs that it is very important to ensure that fuel pipes are routed carefully to avoid kinks like this. I expect that this pipe would have looked fine when it was first fitted but, perhaps through ageing, or even a change in ambient conditions, the properties of the pipe's sidewall changed and a kink appeared, shutting off the fuel supply to the engine.*

*Incidentally, it's definitely worth pointing out that a small kink in a fuel pipe can be a dangerous thing, and not just because of the obvious reduction in fuel flow. A kink can initiate a tiny change in pressure and this may be enough to cause a bubble to form in the fuel. This is especially true in unpressurised fuel systems where the vapour pressure of the fuel is close to the ambient local pressure.*

*Thanks for your report, Steve.*

**GLASAIR IIS RG: FUEL PIPE FAILURE**

LAA Inspector and Glasair owner Ken Bowen sent me a package with, what I later learnt to be, the remains of a fuel transfer pipe normally buried deep within the wingtip of his aircraft. With the pipe was a letter explaining all.

*Dear Malcolm,*
*Please find enclosed the remains of the fuel transfer pipe from the extended wingtip tanks of my Glasair. Each year I religiously check the plane out for its Permit as well as any ongoing maintenance; however, the wing-tanks are held in place by some 30 or so countersunk screws 'loctited' in place. Early attempts to check inside the wingtip to wing joint resulted in destroying the screws. Reading the build manual gave the impression that it was a 'for life' assembly. So I left well alone.*

*A fuel leak appeared, so off came the wing tank (30 odd screws scrapped), inside, the horror before you.*

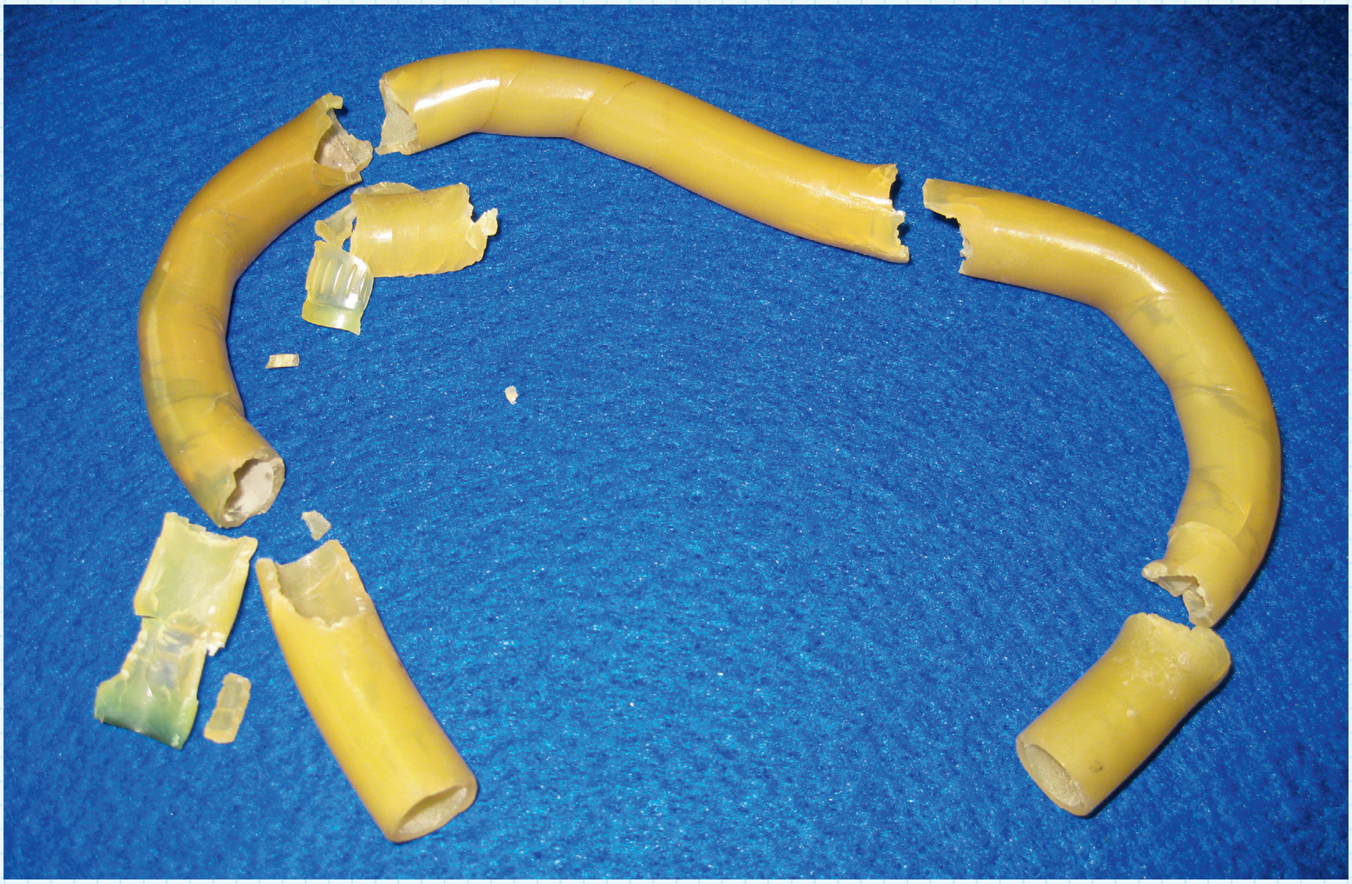
*I believe that there are several Glasairs on the register with tip-tanks. Please let the owners know of this potential fire/accident hazard. The tanks do come off without too much hassle; new screws will be required as well as some proper fuel pipe.*

I took a look at the history of Ken's aircraft and noted that the build was first registered with us in 1991. After a bit more digging I found the build records which dated the fitment of the wingtip tanks to 1995; not long after this the aircraft flew for the first time. That's 17 years ago and, in this time, the aircraft has accumulated 652 flying hours.

I shall be writing to the Glasair owners directly letting them know about this incident of course, but this story has wider implications, which is why I share it with you here.

The reason for the flexible fuel pipe in this application is that the wingtip tanks on this design were a bit of an afterthought. The flexible pipe in question joined the tip-tank to the main wings fuel system and, because there are no access panels, the connection needed to be made before the wingtip was actually attached. To achieve this, a loop of fuel pipe was connected at each end and the tip put in place; to prevent the pipe from kinking a 'U' tube, made from aluminium fuel pipe, was inserted into the flexible pipe.

Regardless of the various rules about the life of flexible pipes, here is a case where an aircraft hasn't been completely inspected for some considerable time, if it



**This sad-looking section of flexible fuel hose shouldn't really have been anywhere near an aircraft as it's about 17 years old. The reason it was overlooked (and therefore not replaced) is that nobody was aware that the pipe was in the aircraft. It was fitted between a (what was thought to be) permanently installed tip-tank and the wing of a Glasair IIS RG. Luckily, apart from loosing all the fuel over the hangar floor, no harm was done.** *(Photo: Malcolm McBride)*

had been the wingtips would have come off. To try to avoid this happening with aircraft operating on an LAA Permit to Fly, where specific major inspections are rarely actually specified, we like to see a complete inspection each three years. By complete, we mean every part of the airframe.

Where lifed items are involved, say an inspection or replacement every five years, these should be listed in (and built into) the aircraft's maintenance schedule so that they are not overlooked. Normally, aircraft-quality flexible pipe is required to be inspected and pressure tested every six years but it should be noted that CAA MPD 1998-019 RI requires all light aircraft (below 2,730kg) operating on a Permit to Fly to have their fuel pipes inspected 'prior to the issue or renewal of the Permit to Fly'; that effectively means that aircraft operating on a Permit must have all their fuel pipes inspected annually.

OK, that's it for August, I've got to write to the RAF 2000 owners and, as you have just learnt, LAA members lucky enough to be able to fly a Glasair; I had better get on with it.

Fair winds! ■

## LAA ENGINEERING SCALE OF CHARGES

| | |
|---|---|
| **LAA Project Registration** | |
| Kit Built Aircraft | £300 |
| Plans Built Aircraft | £50 |
| **Issue of a Permit to Test Fly** | |
| Non-LAA approved design only | £40 |
| **Initial Permit issue** | |
| Up to 390kg | £320 |
| 391 - 499kg | £425 |
| 500kg and above | £565 |
| Three seats and above | £630 |
| **Permit renewal** | |
| Up to 390kg | £105 |
| 391 - 499kg | £140 |
| 500kg and above | £190 |
| Three seats and above | £210 |
| **Modification application** | |
| Prototype modification | £45 |
| Repeat modification | £22.50 |
| **Transfer** | |
| (from CofA to Permit or CAA Permit to LAA Permit) | |
| Up to 499kg | £135 |
| 500 kg and above | £250 |
| Three seats and above | £350 |
| **Four-seat aircraft** | |
| Manufacturer's/agent's type acceptance fee | £2,000 |
| Project registration royalty | £50 |
| **Category change** | |
| Group A to microlight | £135 |
| Microlight to Group A | £135 |
| **Change of G-Registration fee** | |
| Issue of Permit Documents following G-Reg change | £45 |
| **Replacement Documents** | |
| Lost, stolen etc (fee is per document) | £20 |
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