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Brakes

Jerry Parr talks us through the weird and wonderful world of light aircraft braking systems, offers a few handling tips and shows us what to check – and when to summon an engineer!

Very shortly after the wheel was invented, someone thought it would be a really good idea to create a means of slowing it down. Sometime later, when the aeroplane had been invented and eventually fitted with a wheeled undercarriage, it quickly became apparent that brakes would come in handy. The very first aircraft didn't have wheels at all; they were launched on ramps or rails, or were fitted with detachable bogies and they landed on skids. That made them difficult to move around on the ground, so it wasn't long until wheels were permanently fitted as a main undercarriage, with the weight of the tail being borne on a skid.

In these early days of aviation, aircraft operated from grass aerodromes, so wear on the skid was not a problem and the friction generated by the skid slowed the aircraft down after landing and during taxying. The grass fields did not have defined runways and the aircraft tended to take off and land into wind, so the landing speed of these early aircraft was relatively low.

As time marched on, the design of flying machines became more complex. To aid aircraft manoeuvrability on the ground, tail skids were replaced with tailwheels; with little drag on the ground to slow things down, wheel brakes became standard.

As with many systems and components on light aircraft, the braking system has not changed much over the years and has stayed fairly simple. There are various reasons why things do not get 'modernised' in light aircraft, the main ones being the development costs and the simple fact that the existing designs 'do the job'. Aircraft sales of a particular model are minute compared with car sales. When you factor in the cost of certification, there is simply no justification for the manufacturer to change something that works just to keep up with the modern world.

General Aviation braking systems are reasonably light and are only brought into action for a very small period of time. There is just no need to provide sophisticated anti-lock systems, electronic park brakes and the suchlike. If all goes to plan during a landing, then the brakes may not be required even on the landing roll and are almost only there for emergency use. The brake systems are also kept simple enough to not require brake servos to assist the pilot in providing extra braking force.

Without the wonders of modern science, in the form of anti-skid systems, heavy braking usually only leads to a locked wheel and the result is wear and hardship caused to many other components, whereas the landing-roll distance remains much the same! If you operate from a strip where braking is a must to stay on the designated bit of ground, you either need a longer strip or a slower aeroplane! Light aircraft brakes are not designed with repeated heavy braking in mind and if you forget that, your wallet will suffer accordingly.

(Photo: Beringer Aero)

Next time you're at a fly-in, take a little time to study the undercarriages of various flying machines – you'll quickly notice that there are many different types of brakes. There are disc brakes and drum brakes operated by cables, hydraulics and pneumatics; there are even some drum brakes activated by small, hydraulically- or pneumatically-expanding pressure tubes or bags. Brake discs may have the caliper on the outside of the disc with the disc bolted to the wheel hub, or the disc 'driven' by tenons on the inside of the wheel rim and the calliper running on the inside of the disc.

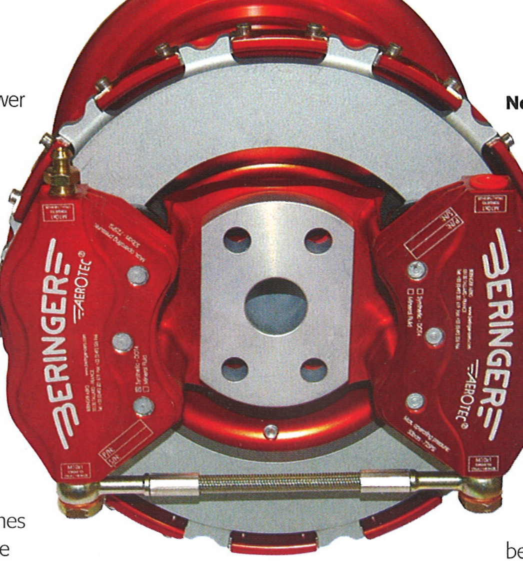
How the systems work

Most light aircraft are fitted with an independent system for each brake and brakes are only fitted to the main undercarriage, not nose or tailwheels. The pilot may operate the brakes by a variety of means and aircraft designers must have had immense fun dreaming up new ways to confuse a pilot!

The most common device is the simple toe-brake, which is usually activated by a pivoting motion of the rudder pedal. Heel brakes are found on some aircraft – usually on twitchy old taildraggers, when the last thing you want to do on landing is move your feet from the security of the rudder pedals! Heel brakes are small brake pedals mounted inboard of the rudder pedals and require the pilot to move heels to the brakes, leaving toes to dance on the rudder pedals. Heel brakes are a system independent of the rudder pedals, so that can simplify the brake system installation.

Early Piper PA-28s had a single, hand-operated lever mounted under the instrument panel, almost out of reach, giving a simple 'both brakes on and off together system', whilst other aircraft use bicycle-type handles on the control column to achieve the same result. On some aircraft, like Jodels, the brakes might only be applied on full rudder travel, whereas the Chipmunk uses a hand-operated lever to pre-set the braking force on both main wheels, with a bias to a particular wheel with rudder pedal movement. In dual-control aeroplanes, brake operation may be by the 'P1' position only, or duplicated for the 'P2' position. Some dual-control aircraft have an individual master cylinder on each rudder pedal (later Piper PA-28) whilst some use mechanical linkages to operate the pilot's rudder-pedal-mounted master cylinders from the co-pilot's pedals (Cessna152/172).

As mentioned earlier, by whatever means the pilot activates the brakes, the actual means of carrying out the pilot's desire to slow down may be accomplished by a number of methods, be it cable, hydraulic or pneumatic. The cable system is pretty much self-explanatory – a flexible Bowden cable (as found on a bicycle) is operated by the pilot using a mechanical lever and the other end of the cable transmits the force to another mechanical lever to move the brake pad against the brake disc or drum.



Need more stopping power? Some systems use dual calipers

The components found in the air and fluid systems are broadly similar. The main components are a reservoir, a master cylinder that is mechanically linked to the brake-operating mechanism and then pipework to the wheel brake cylinder. When the pilot brakes, a mechanical force is applied to the master cylinder piston, forcing fluid/air through pipelines to the wheel cylinder; the resulting braking force is directly related to the amount of force applied by the pilot. The wheel cylinder piston forces a brake lining against the brake disc and, with every force having an equal and opposite reaction, a lining mounted on the other side of the calliper is effectively pulled against the disc. When the operating control is released, a return spring in the master cylinder returns the piston to its original position and system pressure is released. Most light aircraft utilise hydraulic systems but some such as Yaks use pneumatics from an engine-driven air compressor.

Types of brakes

Drum brakes are still found on many older aircraft types, although, as in cars, they have largely been superseded by the disc brake. Many older types can be modified with disc brake kits, parts for the older systems becoming harder to source.

A back plate is attached to a flange on the wheel axle and mounted on it are the brake linings, the slave cylinder (or rubber expander tube) and the appropriate cable, hydraulic or pneumatic connections. A drum is attached to the wheel and fits over the back plate.

When the pilot's control is operated, hydraulic or pneumatic pressure is applied to the slave cylinder pistons or expander tube, which in turn forces the brake linings or 'shoes' against the brake drum. When the system pressure is released, return springs pull the linings away from the drum. With the cable-operated system, the initial force is applied mechanically to the brake linings.

Disc brakes are more common on 'modern' light aircraft. A torque plate is attached to a wheel ▸

axle flange, on which is mounted a calliper with a piston inside and a pair of friction pads. The calliper slides in and out on torque pins through holes in the axle flange as the piston reacts against the brake linings. A steel disc is attached to the wheel and rotates between the friction pads. On some designs, the calliper is fixed and the brake disc 'floats' inside the wheel driven by tenons.

When the brakes are operated, fluid pressure is applied to the calliper piston, forcing it towards the disc, squeezing the disc between the two friction pads. One of the pads is able to slide on the torque pins as pressure is exerted on it from the piston, the other pad is fixed to the calliper. When the brakes are released, the hydraulic pressure dissipates and the wheel is free to rotate.

Larger aircraft may have more than one calliper fitted and the callipers may contain more than one piston.

Parking brakes deserve a special mention. These come in a variety of designs, operating the wheel brakes by slightly different means.

Some aircraft, like the Piper PA-28, use a hand-operated parking brake, which is another master cylinder which applies hydraulic force to both brake units. For some reason, pilots often seem to apply excessive force when setting the park brake on the PA-28s; extra force is then required to release it, which tends to break the ratchet mechanism.

Alternatively, a mechanical control may be used to trap pressure in the system by operating a valve by a selector knob in the cockpit, or the normal brake-operating control can be mechanically locked in the 'brakes on' position. Release may be via a catch or further normal brake application. The Cessna 150/152 uses this method of locking the master cylinder pistons, requiring further foot pressure to release them. If they are applied with great gusto and are suffering from worn piston shafts they can be a nightmare to release. This is why 152s can be seen trying to pirouette in their parking slot at high rpm with the rudder thrashing from side to side; people seem to think high rpm will help release the brake – it doesn't! The best way to get out of this situation intact is to stop the engine, get out and release the park brake by applying hand-power on the rudder pedal, before getting back in and starting up again having reset the park brake at a sensible pressure!

The important thing to remember about aircraft parking brakes is not to trust them. It is far safer to carry some chocks in the aircraft and to use them if parking somewhere for any length of time. Historically, most car handbrakes use cables to operate the system, unlike light aircraft systems, i.e. they do not rely on hydraulic pressure to keep the brakes set. Not only is it possible that system pressure will drop and therefore release the brakes, but it is not particularly good for the system to remain under pressure for a protracted period. If the brakes are hot after landing and taxying, there is a very real chance that the various components will contract as they cool down and all of a sudden there will be no parking brake. If the engine is running, be extremely careful should you decide to rely on the parking brake. How effective would your car handbrake be, if the car was in gear and drive was applied?

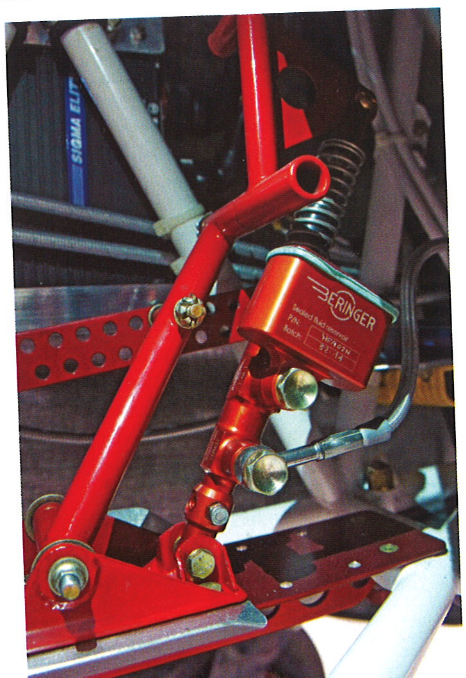
Using the correct fluid is paramount to protect items like O-rings in the system

Tips to stop brakes breaking

The braking system found on most light aircraft is relatively simple and reliable. On an hydraulic system, little maintenance is required other than keeping the fluid level topped up with the specified fluid and checking the brake linings and discs for wear.

Some aircraft brake systems, like the PA-28, utilise a single, remote reservoir to feed the entire system. Other master cylinders (such as those often found on Cessnas) have the reservoir mounted as an integral component, which keeps each wheel brake system completely independent. Some reservoirs are readily accessible during Check A inspections, others are hidden under cowlings. Cessna systems require great cunning to access and are effectively impossible to check for correct fluid level on a pre-flight check, relying more on topping up regularly by an engineer.

Do you know what your brake master cylinder looks like, and where it's located?



It is paramount that the correct type of fluid is used. If it isn't, it could cause rapid failure of the O-rings, seals and hoses in the system. Check with the service manual or pilot's operating handbook for your aircraft. Most aircraft use a red, mineral-based brake fluid, not like the paint-stripping stuff found in cars. One UK-based, French-built aircraft suffered a brake failure whilst over in France. The helpful French engineer topped up the system with the normal aircraft mineral brake fluid but the brakes failed again on its return to the UK. The reason was that the brakes were of Renault car origin and actually required a car-type fluid – you just can't win! As the saying goes: "Don't assume – check!"

The brake linings, drums and discs will obviously wear faster the more they are used and this is potentially true of an aircraft which has a castoring nosewheel (like the Cirrus, Diamond DA40 or many of the LSA-type aircraft) and taildraggers. This is because steering with these aircraft is by primarily using the rudder but backed up by differential braking. That said, some people taxi their aircraft around using power against brakes and forget about the rudder. With the toe-pedal-operated brake systems it is extremely easy to ride the brakes without realising it (until you come to take-off) and this will obviously greatly increase the wear on the linings and discs or drums.

Some disc brake linings, such as those manufactured by Rapco, have an indent on the edge of the lining to indicate when it has reached its wear limit. Drum brakes may have a sighting hole in the back plate, so the lining thickness can be determined.

The linings on either disc or drum systems do not tend to wear evenly, normally due to wear in the calliper torque plate and torque pins; do not assume that because one lining (or even one end of a lining) is of an acceptable thickness, that brake is serviceable. Check as much of each lining as is physically possible. Owners of aircraft fitted with wheel spats are now cursing their smart-looking fairings. Ensure the linings are replaced as soon as any part of them is down to minimum thickness – the linings are cheaper to replace than the disc or drum.

Brake linings are normally riveted to their attachment plates – a simple process to change the linings but it is another process that takes a bit longer than the equivalent job on a car for the engineer to complete.

After a lining has been replaced, make sure the manufacturer's bedding-in procedure is followed. The type of bedding-in procedure required will depend on the type of lining fitted. Brake linings are either of a non-asbestos organic composition or an iron-based metallic composition. It is worth pointing out here that as general rule, chrome discs must not be used in conjunction with metallic linings. By properly conditioning (glazing) the linings before use, they will then provide optimum service life. The service manual for the aircraft or information provided by the brake manufacturer should explain the exact procedure for glazing the linings prior to use. Some bedding-in procedures call for a high-speed taxi of up to 35kt. If this is necessary, then a