SINGLE PISTON AIRCRAFT FOR AUSTRALIAN PARACHUTING INDUSTRY

IN PARTICULAR THE

CESSNA 182

Thesis by Ray Curry

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I started Skydiving in Nelson New Zealand in 1976, learning on cheapo's and hand-deployed reserves whilst finishing my apprenticeship as an Auto Electrician. After two years in the sport and obtaining a Static line Instructor Rating, my partner and I moved to Australia. The first Drop Zone that we jumped at was Lower Light in South Australia and after a short stay we then moved north to Elderslie.

On attending our first Nationals at Corowa I participated in Australia's first eight stack and then returned to Nationals at Corowa for many years. This was a very exciting time in my life and I consider myself lucky to have been Skydiving in what was definitely the start of Australia's fun era. I don't think Mr Towers, Burns and Wilson realise, by running the DC3, how much they contributed to the advancement of Skydiving in Australia.

Over the next ten years I competed in many Nationals, finally gaining a gold medal in 4 way CRW.

During our 8 years stay at Elderslie my wife and I became heavily involved with the committee and the running of Newcastle Sport Parachute club as well as the organisation of many of the large Rutherford Boogies. It was during this time that I obtained my pilots license and in 1982 purchased my first aircraft. I then flew at Elderslie for the following 4 years before business, marriage and growing families took us both out of the sport.

The yearning for Skydiving and flying finally became too much, and in 1992 I purchased a C185 and started a Skydiving operation at Warnervale Airport NSW. During this time we constantly searched for land of our own. After 5 years of searching, in 1995 my wife and I purchased land adjacent to Cessnock Airport and moved our Skydiving operation there.

In our three years of operating at Cessnock Airport, we have established Australia's second largest 7-day/week Skydiving Centre that I now manage full-time.

I have over 1500 jumps, have obtained my instructor B with AFF rating and have flown over 3000 hours most of which have been Skydiving operations.

1. ABBREVIATIONS 4

2. DEFINITIONS 5

3. INTRODUCTION 6

4. AIRCRAFT CHOICE 7

4.1. Cherokee 6 7

4.2. Cessna 172 8

4.3. Cessna 205 8

4.4. Cessna 206 8

4.5. Cessna 207 9

4.6. Cessna 210 9

4.7. Cessna 180 9

4.8. Cessna 185 9

4.9. Cessna 182 10

5. AIRFRAME MODIFICATIONS 10

5.1. STC's. 10

5.2. Descent Enhancers: 11

5.3. Climb Enhancers 12

5.4. Comfort Enhancers 13

5.5. Safety Enhancers 13

6. ENGINE UPGRADES FOR CESSNA AIRCRAFT 14

6.1. Conversions available for Cessna 185, 206, 207 14

6.2. The Conversions available for the Cessna 182 14

6.2.1. Continental IO 470 15

6.2.2. Continental IO 550 15

6.2.3. Continental IO 520 15

6.2.4. Modified Continental Carbureted O 520 16

6.3. The turbine upgrade 17

7. RUNNING IN AN ENGINE 18

7.1. Operating to obtain the best result. 19

7.2. Suggested flight profile. 20

7.2.1. Oils 20

8. MAINTENANCE (PRIVATE CATEGORY) 21

8.1. Oil and Fuel 21

9. CRACKING CYLINDERS 22

9.1. Introduction 22

9.2. Thermal Shock. 22

9.3. Metal cracking, The cause 23

9.4. Symptoms 24

9.5. Repairs 24

10. AIRCRAFT HANDLING 25

10.1. Ground handling 25
10.1.1. Start Procedures: 25

10.2. Climb Techniques 26

10.3. Top of Climb Techniques 26

10.4. Descent Techniques 26
10.4.1. Descent during In-Flight door malfunction. 27

11. PILOTS 28

12. TROUBLESHOOTING 29

13. REFERENCES 30

14. ADDRESS'S 30

15. CONCLUSION 31

1. Abbreviations

BHP	Brake horsepower
CASA	Civil Aviation Safety Authority
CFM	Cubic Feet Per Minute
CHT	Cylinder Head Temperature
EGT	Exhaust Gas Temperature
FAA	Federal Aviation Administration
GPS	Global Positioning System
100LL	100 Octane Low Lead Fuel
MP	Manifold Pressure
O/H	Over Haul
STC	Supplementary Type Certificate
SORTIE	Time it takes for Skydive load
RPM	Revolutions per minute
PSI	Pounds per square inch
NM	Nautical miles

2. Definitions

- **BHP:** Brake Horsepower. The actually power delivered to the engine propeller shaft. It is called Brake Horsepower because it was formerly measured by applying a brake to the power shaft of an engine. The required effort to brake the engine could be converted to Horsepower - hence: "Brake horsepower"

- **Corrosion:** Deterioration of a metal surface usually caused by oxidation of the metal.

- **Manifold Pressure:** Pressure measured in the intake manifold down-stream of the air throttle. Usually measured in inches of mercury. Note : This is used as a measurement of power output of the engine ie. The higher the manifold pressure, the higher the power out-put.

- **25/25** : This is a power setting of the engine and propeller, the first 25 means ,25 inches of manifold pressure. The second 25 means 2500 RPM on the propeller.

- **Major Overhaul:** Per FAA AC43-11 consists of the complete disassembly of an engine, inspection, repaired as necessary, reassembled, tested, and approved for return to service within the limits specified by serviceable limits.

- **Mixture:** Mixture ratio. The proportion of fuel to air used for combustion.

- **CAR 35 Engineer:** Name used in the aircraft industry for an engineer who operates under Civil Aviation Regulation 35 and is allowed to issue approvals for the modification of aircraft.

- **ENGINE CODE:** Listed below are examples of what the engine numbers mean;

  O - Indicates Carburetted, horizontally opposed cylinder configuration.
  IO - Indicates Fuel Injected, horizontally opposed cylinder configuration.
  TIO - Indicated Turbo Charged.
  470 - Indicated Displacement ie. 470 Cubic Inch Total Cylinder Volume.
  M - Indicates Model on Engine.
  (1) Refers to specification number.

3. INTRODUCTION

Unlike other facets of the aircraft industry, no aircraft is specifically designed for Skydiving work. Aircraft are potentially the most dangerous and expensive component in a Skydiving operation. Unfortunately, they also tend to be the least understood.

Most Instructors have an excellent working knowledge of Sport Skydiving, the equipment, the training of students and Instructional technique. However many Skydivers lack a basic working knowledge of aircraft.

Since Tandem inception in America there have been twice as many Tandem Masters killed in aircraft accidents than actual Tandem Skydiving incidents.

The choice of aircraft, the way they are operated and their up-keep are all extremely important. The operator of a Skydiving Centre and their Instructors must have a good working knowledge of aircraft if they are to be operated safely.

Aircraft used in Skydiving are operated continually at maximum operating limitations, which adds many extra stress's to the aircraft's airframe and engine. Also, these aircraft are normally flown by inexperienced pilots. Operators and instructors need to be aware that the aircraft is an area of high risk that needs careful monitoring and constant surveillance.

It will often seem that for every opinion regarding the operating and maintaining of aircraft there is an opposing point of view.

Our aircraft operation changed dramatically with the introduction of AFF which required full loads to 10,000 ft where as with static line the normal operating range was 2,500ft to 8,000ft. This required a lot more aircraft time and climb capability.

My aim in this paper is to raise awareness and knowledge of aircraft used in Skydiving operations and to provide tips on good operating techniques, with the hope of improving safety and viability.

4. Aircraft Choice

This is a very important decision and one that should be studied and assessed carefully.

In evaluating any aircraft for its use in Skydiving the following points should be considered:

- Safety is the most important consideration in aircraft choice. Even though an aircraft may be legal to Skydive from, it may very unsafe for continuous operations.
- Load carried. (Number of jumpers)
- Normal turn around time. (Sortie)
- Cost of running.
- Suitability to your particular operation. ie, runway length and direction, altitude of dropzone and amount of anticipated work.
- Availability of spare parts for maintenance. Generally, the more aircraft of the type around, the more readily parts will be available.
- Ease of maintenance. The harder to maintain the more it will cost.
- Climb performance. This depends on horsepower to weight ratio ie. the more horse power for the least weight, the faster it will climb.
- Flying characteristics compatible with Skydiving requirements.
  Aircraft can be designed for climb rather than forward speed or for forward speed rather than climb. Choice of an aircraft designed to climb, is preferable to an aircraft designed for fast forward speed.
- Purchase price.

Following is a list of the usual light aircraft available for Skydiving operations in Australia and their advantages and disadvantages.

4.1. Cherokee 6

A low wing aircraft capable of carrying six Skydivers. These have a lycoming IO 540 engine which is capable of developing 300hp on take-off. Max power can only be maintained for 5 minutes in accordance with the operations manual, to avoid overheating. A reduced power setting of 25/25 is then used. These aircraft are very slow climbing and an expected sortie time is 35-40 minutes.

There is a lycoming 580 engine due for certification shortly and it is most likely the engine manufacturer will issue a STC for this engine upgrade.
This modification would increase the climb performance of these aircraft although, the amount can only be speculated on. An increase of 10% would be a realistic projection.

Advantages: They are relatively cheap to purchase, take 6 people and the lycoming engine is quite reliable.
Disadvantages: Un-even floor, hard door to exit from, the tail is a bit close and they have a very slow climb rate. For these reasons they are not a popular aircraft for skydiving. These aircraft are noisy in operation.

4.2. *Cessna 172*

A high-winged aircraft with a Lycoming O 320, 4-cylinder engine creating 150hp. They can carry 3 jumpers although these aircraft are normally too under powered for normal freefall operations. These aircraft are adequate for the one off demo with two or three people or a Static-line operation.
There is an engine up-grade, with STC for a 180hp engine. One is used successfully in NZ for single Tandem with camera operation. (Remember the cooler climate)

A Cessna 172 Hawk-SP comes out of the factory with a 6-cylinder 190hp fuel injected engine that will operate to normal free fall operation height. These have been used successfully in Australia.
Advantages : Easy to fly, allowing plentiful pilot selection. Low operating costs. These are the worlds largest produced model of aircraft, making parts easier to obtain. Suitable for in-flight door, with step below. Fuel injection. (This means no carbie ice problems)
Disadvantages : Light weight airframe not made for constant hard use. Only suitable in the Hawk XP model. only a four place aircraft. High purchase price for XP model.

4.3. *Cessna 205*

A high-winged front door aircraft that has an IO 470 engine generating 260hp maximum. Full power can not be maintained and reduced power of 25/25 is used for climb. These aircraft are very under-powered for the weight of the airframe. While they can carry 5 Skydivers, in many circumstances they would be unable to climb to 10,000ft. The front door is suitable for Inflight-door modification and the step below is suitable for Skydiving exits. These aircraft are really only suitable for Static-line operations.
Advantages : Suitable in flight door with step below. Fuel injection means no carbie ice problems.
Disadvantages : Very poor climb performance. An old aeroplane which will require high maintenance. Not being a popular aircraft makes parts hard to obtain.

4.4. *Cessna 206*

A high wing aircraft that can carry six Skydivers. This aircraft has a IO 520, 300hp Continental engine. Full power can not be maintained during the climb and a reduced power setting of 25/25 is used to avoid overheating the engine.

This is a popular aircraft for use in Skydiving operations as it will carry six Skydivers. It appears however, that only in colder climates will the aircraft climb to 10,000ft in a reasonable time.
Often in the field a reduced load is carried which makes them similar in load carrying capacity to a Cessna 182.
These aircraft have a 20% higher running cost than a Cessna 182. In addition the engines are more prone to cracking both cylinder and crankcases due to the extra stress's created from the higher horsepower.

Advantages: Can carry six skydivers. Parts and maintenance are both readily available. They have a level floor and a large cabin that makes the flight quite comfortable. Good size door, suitable for Student Skydiving, Tandem and fun jumpers. They have good handling qualities, making it easier to get pilots for them.

Disadvantage: High purchase price. Slow climb rate at maximum weight. The I.O.520 has a record for cylinder and crankcase cracking. The extra cylinder and crankcase cracking can be very expensive to repair and can result in long periods out of the air.

4.5. Cessna 207

This is a stretched version of the 206 with the same power. The same analogy applies to this aircraft as the 206 except that they are heavier. Consequently, these are not a popular aircraft for Skydiving.

4.6. Cessna 210

These aircraft have a IO 520, 300hp engine. They are designed as a fast cruising aircraft. This attribute means a relatively high stall speed and high engine temperatures on continuous climb to high altitudes. Most models have no strut and a retractable undercarriage that makes them unsuitable for Skydiving.
Advantages : Front door suitable for Inflight door.
Disadvantages : Engine installation is not designed for constant climbing. Aircraft has a high stall speed. Retractable gear is heavy and expensive to maintain. Pilot selection should be handled very carefully. High purchase price. Although the older models have a low purchase price, they have a landing gear problem and the cabin is to small because of the retractable gear.

4.7. Cessna 180

These aircraft have a O 470, 230hp engine. They are a good aircraft for Skydiving operations.
Advantages: Can carry 4-5 Skydivers, have a good climb rate and are easy to maintain and have a slow stall speed. Front door configuration suitable for In-flight door. Also has step below door.
Disadvantages: Have a small cabin size. Tail-dragger configuration thus making them very prone to ground looping even more so than the C185. This makes Pilot selection extremely critical.

4.8. Cessna 185

These aircraft have an IO 520, 300hp engine. They are a particularly good aircraft for use in Skydiving operations. These aircraft are designed and built as a working aircraft. They have the best power to weight ratio of all the Cessnas. The engine is fuel-injected and has a higher compression ratio that assists in maintaining a higher power setting at any given altitude.

Advantages : Their climb performance is quicker than other Cessna's and they are capable of carrying 5 Skydivers. They are suitable for In-Flight door installation with step below. Built as a working aircraft they handle the hard work of Skydiving operations better than most other aircraft.

Disadvantages : Probably would be the most popular aircraft for Skydiving if it were not for the fact that they are a Tail-dragger configuration thus making them prone to ground-looping. This makes pilot selection extremely critical. They have a high purchase price. These aircraft are loud in operation. They may be fitted with a propeller of a agg aircraft which are larger and produce more lift , however they are very noisy.
NOTE: This aircraft has very good handling characteristics during the climb out and exit phase of the sortie. Would be the best aircraft for dropzones located over 1000ft above sea level

4.9. Cessna 182

The Cessna 182 is equipped with a O 470, 230hp. This is the most popular small aircraft used for Skydiving throughout the world.
There are many attributes which make this aircraft suitable for parachute operations;
Advantages :

- Approved for constant full-power operation and if correctly operated, the full power setting can be maintained throughout the climb, without damage. Unless in extremely hot conditions.
- It is an ideal sized aircraft for small dropzones.
- Because of their overall good flying and handling characteristics their choice of Pilot is less critical than other aircraft. Low stall speed with predictable handling.
- They have a lower purchase price and parts are easier to get and normally cheaper than a Cessna 206 or 185.
- The front door is suitable for the In-flight door modification.
- The wheel below the door configuration is well suited for Skydiving exits.
- There noise level is lower than aircraft of similar capabilities
- This aircraft would normally only take 4 Skydivers. However, the APF have a STC available that allows them to carry 5 Skydivers. This STC is available from the APF at minimal cost.
- **Disadvantages :** Carburettor means carbie ice problems and low power output at higher altitudes. Climb rate while acceptable, is slow at higher altitudes.

5. Airframe Modifications

5.1. STC's.

(Supplementary Type Certificate) is a certificate of approval for the modification of an aircraft to other than factory specifications A modification to an aircraft has to go through extreme testing and proving before a STC can be obtained. If the STC has been accepted by the FAA in USA then Australia has automatic acceptance of that STC.

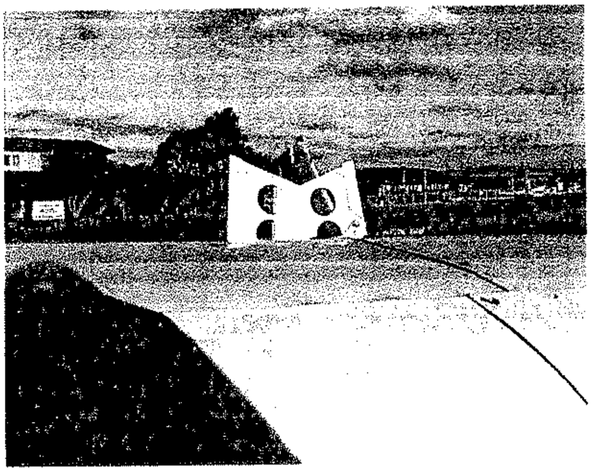
To conform with CASA requirements for continued airworthiness, a CAR 35 delegate must approve any modifications made to an aircraft.
Most capital cites have a CAR 35 Engineer qualified to do this.

In this paper we will only address aircraft modifications that have STC's.

5.2. *Descent Enhancers:*

There are two popular types of air spoiler on the market that are approved to suit Cessna aircraft.

A) SPOILER SYSTEM: (Speed Brakes).
This system protrudes out of the top of the wing and destroys the lift of part of the wing.



They are offered by Precise Flight and they will double the decent rate of the aircraft.
Speed Brakes are an excellent aid for increasing the utilisation of the aircraft in a work day.

The normal time from 10,000ft to the ground is three minutes with "speed brakes" extended (using a C182). On a busy day this means the aircraft is available for two extra loads in a day.

The use of "Speed brakes" makes flying of parachute operations easier, thus saving fatigue on the pilot. Indirectly, this is an improvement to safety when you consider that most accidents are caused through pilot error.

The writer would advise against using them when operating on a short run-way. If a pilot attempted to take off with the Speed Brakes extended and the aircraft fully loaded, by the time the pilot recognises the problem and rectifies it, the aircraft would be too fast to stop and too close to the end of the runway to fly off.

Advantages: Low maintenance. Increased aircraft utilisation. Less flight time per load. The aircraft is less likely to over speed on descent. They have an STC which makes installation easier and they are definitely fun to fly.
Disadvantages: They are on top of the wing and are not visible by the pilot. With a full load you cannot take off with them extended.

Cost is $5,000 to supply and install.

b) GAP FLAPS:
These are a drag device fitted between the flaps and the wing. When extended they destroy lift and create drag. They almost double the decent rate.

The advantages and disadvantages are the same as the Precise Flight "Speed brakes". However being mounted on the bottom of the wing they are visible to the pilot making the possibility of taking off with them extended greatly reduced.

Cost approximately $5,000.

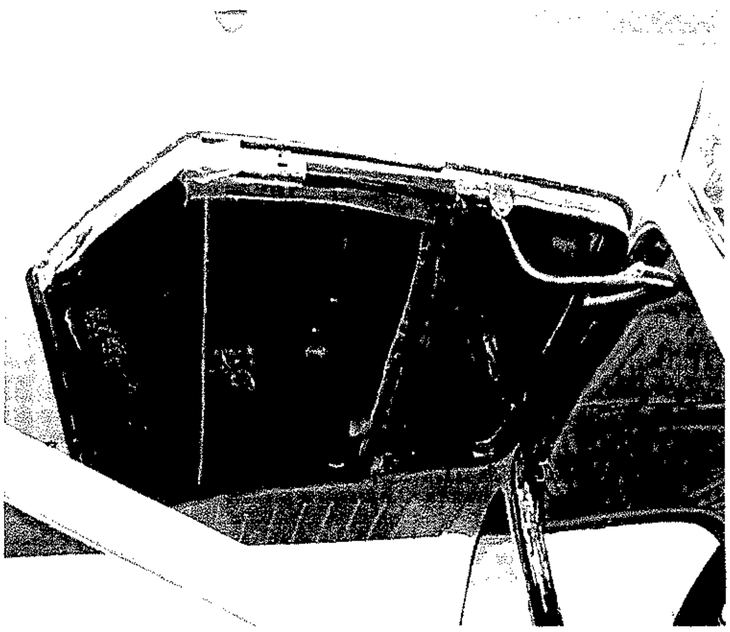
5.3. Climb Enhancers

a) Extended Wing Tips on the end of the wings are supposed to increase performance and reduce stall speed. This happens by trapping more air under the wing, although the reality of the increase in performance is very hard to prove.

b) Horton Stol-Kit will reduce the stall speed by 8-10 knots. There is no real proof of increase in climb performance. They also have extra moving parts that require extra maintenance. Their advantage is the lowering of stall speed of the aircraft. This is a important safety aid. Particularly in the event of a engine failure.

c) Sportsman Stol-Kit provides a new shape to the leading edge. This decreases the stall speed by about 8-10 knots and has no moving parts. There is a small increase in climb performance, although the main benefit is safety. In the case of an engine failure a forced landing is more survivable with a slower landing speed. A lower landing and take off speed will also mean less wear on the landing gear. This also means the aircraft is less likely to stall accidentally on a Skydiving exit. The increased safety margin is what makes this modification worth the $5,000 spent.

d) In-Flight Door will increase climb performance by about 10-15% and saves damage to the inside of the aircraft. They eliminate the possibility of accidental canopy deployment and are a major improvement in passenger and pilot comfort.



Your original door can be modified by a licensed Engineer at a cost of around $3,000. Information on the STC is available through the APF.

There is a perspex door made and approved in NZ for Cessna 172,182,180,185. This is potentially a better door and should be investigated ,if looking at doing a door modification.

Moss Smith in New Zealand do make a perspex door for a C182 which requires no modification to the airframe so would be ideal for a hired aircraft.
An engineering certificate would have to be obtained.

e) Gap Seals between the aileron and wing and the flap body and wing will enhance the efficiency of a wing. This in some way will improve climb performance. There is no factual substantiated flight data as to the amount of improvement.

5.4. *Comfort Enhancers*

- The In-Flight door is by far the best step forward in Skydiver comfort.
- Stereo installation, ideal for relaxing nervous students.
- A rubber mattress covered by carpet on the aircraft floor makes the ride to height, and kneeling a lot less painful.
- Improving the ventilation will improve comfort particularly in warmer climates.
- Handles at the top of the rear section of the door on a Cessna where the seat belt used to be mounted will not only make it easier for people to get up, but will save the interior linings from damage.
- Shade on the back window is very good when operating in warmer climates.

5.5. *Safety Enhancers*

- The in flight door is also a great step forward in safety. It is impossible to have an accidental opening of a parachute when the door is closed.

- A permanent step on Cessna 182 is absolutely essential and will save the pilot having to remember to put the brakes on, on exit.

  Note: The original step should be removed as this is the cause of jumpsuit booties being caught on exit.

  An engineering Certificate is required from a CAR 35 engineer for the step.

- The GPS is a tool which when used correctly will greatly increase the accuracy and consistency of spotting. With today's high performance canopies, the risk of injury increases dramatically with Off Drop Zone landings.

6. ENGINE UPGRADES FOR CESSNA AIRCRAFT

The most practical and successful way to increase the climb performance of the Cessna aircraft is the installation of an engine with more horsepower.
The upgrade of the Cessna with a bigger engine of the same type with a STC is the most viable option that is currently available.
Practically and financially the best time to upgrade is when the engine is due for overhaul.
Following is an appraisal of upgrades available.

6.1. Conversions available for Cessna 185, 206, 207

The Continental 550 is an engine upgrade from the original engine manufacturer. These engines will bolt straight into the aircraft with no modifications required. These engines are sold as a replacement for the existing IO 520.

This engine upgrade comes with a STC and will increase the climb performance by 10%-20%. The engine can be run constantly at a higher power setting and thus give an increased climb rate, although a higher fuel consumption will result.

Cost of engine and propeller is about $55,000.

Conversion is usually carried out when the engine and propeller are due for o/h then the cost is off-set by the overhaul cost of existing components. This could be anticipated to be around $35,000, making the cost of the upgrade about $20,000. You will then gain a more efficient engine and propeller.

These motors can be run at 300 hp constantly. They are the newest designed aircraft engine on the market today and should be less prone to cracking. This writer believes that over-heating could be an area of concern and would recommend careful investigation before carrying out this modification.

Often modifications can reduce the re-sale value of an aircraft. However the installation of a Continental IO 550 does appear to increase the value of the aircraft .

6.2. The Conversions available for the Cessna 182

A larger engine in the Cessna 182 is the most practical way to increase the climb rate.
The most viable option is the upgrade with a larger Continental engine. These are used in Cessna 185's and 206's and are the same configuration as the original O 470, therefore they require minimum modifications to the aircraft.
There is a STC for these conversions.

Note: All upgrades require a new propeller to suit the larger engines.
Note: For the installation of a fuel injected engine, the fuel system and fire-wall requires modification, the supplier of the STC estimates approximately 200 hrs labour for these modifications.

I have looked into these engine upgrades for the C182 and my assessment is as follows:

6.2.1. Continental IO 470

There is the option of upgrading to a fuel injected high compression Continental IO 470 engine. This will give you a slight increase in power for the same upgrade cost as the 520. In this writer opinion, the IO 520 conversion that would cost the same would be more beneficial.

6.2.2. Continental IO 550

The continental IO 550 conversion is the highest horsepower motor conversion available in the piston engine category.

This is by far the most horse power available to be installed in a C182, and would make a very fast climbing Cessna 182.

This engine can be purchased through the Australian dealer Rossair. A new engine and propeller installed ready to go will cost about $60,000 which is the most expensive upgrade of them all.

Advantages: This is the latest designed aircraft engine on the market. The manufacturer claims to have addressed the problem areas of crankcase cracking and crankshaft failure.

Disadvantages: It is expensive. The extra horsepower will generate extra heat and you could expect overheating problems.

6.2.3. Continental IO 520

This engine has high compression and fuel injection which is a configuration which gives the most amount of power for a given engine size.

This installation requires the airframe and fuel system to be modified.

Purchasing a new engine is expensive. Used engines are hard to find, and are also normally expensive

The end result is that this upgrade would cost about $20,000-$25,000 more than a normal engine and propeller overhaul.

Advantages . This engine will perform better at higher altitudes than the low compression engines.
Disadvantage . Capital outlay and the modifications required to the airframe and fuel system.

6.2.4. Modified Continental Carbureted O 520

I have gone into detail with this particular upgrade because after much research I feel this is the most viable & practical upgrade.

A company called P. Ponk Aviation in Seattle USA hold the STC for this upgrade.
The engine is a 520 cubic inch capacity with low compression and a carburettor.

This configuration can be achieved in two ways;

a : The fitting of 520 piston and cylinders to a existing 0470.
b : The down grading of a original 520 to low compression, removal of injection system and replacing with a carburettor

This modified engine has less power than the original 520 engine because of lower compression (7.5 to 1 instead of 8.5 to 1) and a carburettor is less efficient than fuel injection.

On the original IO 520, power must be reduced to 25/25 on climb to reduce over-heating.
On the P.Ponk O 520 full power can be used constantly throughout the climb.

What this means in Skydiving operations is that both 520 engines can be operated at about the same power output to approximately 6,000ft, but above this altitude, the higher compression and fuel injection of the original IO 520 means that this engine would perform better.

The STC and the engine can be purchased from Rudy's Aero Engines in Melbourne (phone 03 51492300). They are the only company licensed to build the engines here in Australia.

6.2.4.1. Engine and Propeller Costs:

Although the engine will cost no more than a normal engine O/H. You will have to purchase a new propeller.

There are five different McCauley propellers approved with the STC.
The propeller I recommend is a McCauley 401 which is a three bladed type.

These propeller's are;

- Quieter because the blade tips are cutting through the air at a slower speed.
- Smoother. The propeller is the fly wheel of the aircraft engine and the three bladed propeller has a lot more even weight distribution.
- Ground clearance. The 2 bladed propeller has longer blades than a 3 blade propeller, making the blades very close to the ground. All your damage comes from stones off the ground. The more clearance, the less damage to the blades.
- The new propeller to suit the bigger engine will cost $11,000
  You can expect a resale value of the old propeller of around $3,000. Deduct the $3,000 you would have spent on overhauling the old propeller. This makes the extra cost of the new propeller upgrade about $5,000.

6.2.4.2. Installation

The engine bolts straight in with no modification in the engine bay, although on some model182's, the fibreglass flaring on the engine cowls located behind the propeller had to be removed to fit the new propeller.
This is because the original spinner back plate is angled forward at 30 degrees and the replacement propeller back-plate is straight. Sheet aluminium is fitted in place of the fibreglass to suit the new back-plate. This took 4 hours work with no problems.
This was the **only** modification that has to be done.

6.2.4.3. Paper Work.

This can always be the biggest problem with any new modification but as there is already two modified C182's with 520 carburetted engines flying in Australia, things should be a lot easier. The STC will cost $1,250 US.
It then costs about $250 for a CAR 35 engineer to have the paper work approved in Australia and the flight manual supplement issued. This will normally take one week. In total the engine up-grade will cost $2,000 more than a normal engine o/h and the propeller upgrade will cost about $5,000 extra.

6.2.4.4. Flight Test

The engine runs **very** smooth and the 3 bladed propeller combined with good engine balancing makes for less vibration in the engine. After 500 hours of flying I believe this balancing is very important for smooth running and longer engine life. Also vibration can be the cause of many premature failures of the engines accessories.
There is a 10 knot increase in the aircraft's speed, at the same power setting. We noted that it was quieter in the cabin than it used to be however, outside noise is increased. A point to watch if you operate in a noise sensitive area.
Climb performance is improved at all altitudes. Flight tests show that it took 5 minutes less per 4 or 5 person load of Skydivers to 10,000ft.
This modification, in the writer's opinion is the best value upgrade for the 182. While not delivering the most power increase, it is the least expensive upgrade and still provides a reasonable increase in performance.

6.3. The turbine upgrade

The turbine conversion is available for the Cessna 185, 206, 207 and 210 by the Solely Company. The most popular aircraft for conversion is the 206 and the conversion is a 420hp Alison Turbine engine and propeller installation. It is the most horse power increase available in the conversions on the market today. The engine is also smaller and lighter than the existing engine.

Climb performance should be increased a lot compared to the standard aircraft. This conversion makes quick turn around times available, however it is still only a six place aeroplane.
The cost of this up-grade is very expensive. At around $400,000.

There is a problem with the propeller being too close to the ground meaning that improper handling can cause the propeller to strike the ground.

The writer would advise very strongly that a thorough investigation of the aircraft be carried out prior to investing in this conversion. It is noted that two clubs in Germany have gone broke after upgrading their 206 to a turbine.

7. Running in an engine

The requirement of running in a new or overhauled piston aircraft engine is extremely important and extra care must be taken. Unlike the modern car engine, an aircraft engine requires special handling during the run in period for at least the first 10 hours.

The bedding-in of bearings can be accomplished regardless of the type of flying carried out. The requirement to fly an aircraft on a set procedure after a top O/H (New rings) or complete O/H is due to the requirement that the rings need to be bedded into the cylinder walls. This will facilitate maximum sealing of the compression chamber giving maximum power output from the engine.

Cylinder walls of a new engine are not mirror smooth as one might imagine. A special hone is used to put a diamond like pattern of "scratches" over the entire area of the cylinder wall.

A film of lubrication oil holds the piston ring away from the cylinder wall. Proper break-in of piston ring to cylinder wall requires that the ring rupture this oil film and make contact with the cylinder wall.

During such "metal-to-metal" contact, the little peaks on the ring face and cylinder wall become white hot and rub off. This condition will continue to occur until the ring face and cylinder wall have established a smooth compatible surface between each other.
At this point, break-in is said to be relatively complete and very little metal-to-metal contact occurs there after. In fact, as the break-in process progresses, the degree of metal-to-metal contact will regress.

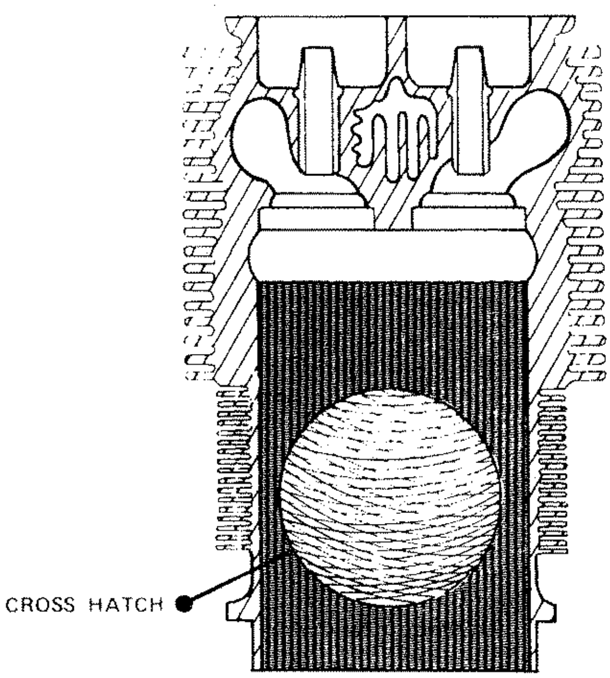


Figure 1 shows a magnified view of these "scratches". The cross hatch treatment of the cylinder walls plays an important role in proper break-in of piston rings to cylinder walls.

Lubricating oil is there to prevent metal-to-metal contact however in the break-in process that is exactly what we want it to do, therefore rupture of the oil film is necessary. Two factors under the pilot's control can retard this necessary rupture; low power and improper lubricating oils during the break-in period.

Figure 1:
Above is a highly magnified view of the cross hatch pattern honed into the cylinder's surface.

Figure 2 illustrates a cut-away of piston, ring and cylinder wall as these components would actually appear during normal operation in a new engine of very little time.

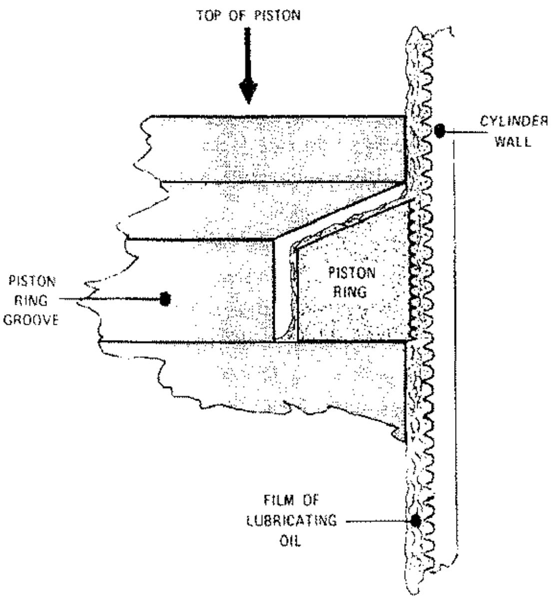


Figure 2:
Notice the "Saw Teeth" like surface of the cylinder wall and piston ring face. The piston ring is being held away from the cylinder wall by a film of lubrication oil.

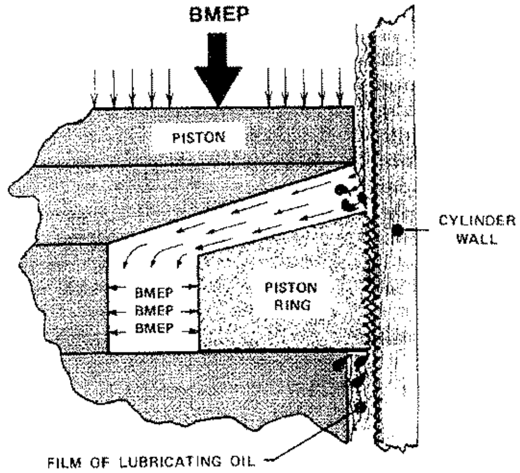


Figure 3;
Exaggerated illustration of oil film rupture and ring to cylinder wall contact. Notice the compression arrows pushing the ring down on its ring land and pushing between ring groove wall and the back of the piston.

Figure 3 is an exaggerated illustration of oil film rupture. Note that the points or ridges of the honed-in scratches have partially worn away. During the actual oil film rupture, only the ridges on the piston rings and cylinder walls contact each other. The little "valleys" between the ridges retain a film of oil and thereby prevent a total dry condition between piston ring and cylinder wall. Note also that the combustion pressure forces the ring against the cylinder wall.
This is the "key" to the break-in process. You can see then that low power won't provide the same results and the break-in process will require a longer period of time, however time in this instance will have a detrimental effect on you engine because any prolonged, low power break-in procedure usually leads to "glazed" cylinder walls.

7.1. Operating to obtain the best result.

During each power stroke, the cylinder walls are subjected to very high temperatures. This period is very brief but nevertheless long enough to cause oxidation of minute quantities of some of the lubricating oil on the cylinder walls. Some of this oxidation will settle into the "Valleys" of the honed cylinder wall "scratches."

Eventually this situation will fill the "valleys" of the cylinder walls creating a smooth, flat surface. This is also a normal situation, although the ring break-in process practically ceases when these valley's become filled or "glazed" over. If this "glazed" over process occurs before break-in is complete, you will experience operation difficulties with the engine.

Excessive oil consumption resulting from incomplete ring seating will present itself and the only certain remedy is re-honing the cylinder walls which is both expensive and unnecessary

7.2. *Suggested flight profile.*

After take-off, reduce power to 25 inches MP and 2500 RPM, cruise climb to 3000-4000ft maintaining 25 inches manifold pressure. Leave cowl flaps open to assist cooling.
Cylinder Head Temperature should be below 400°F at this configuration. 5 -10 hours flying in this configuration is required to bed-in the rings.
A cruise altitude low enough to maintain 25 inches of manifold pressure should be used.
If high manifold pressure is not maintained there is not enough pressure to force the rings against the cylinder bore.
Parachute operations should not be carried out during the running in period because above 4000ft the manifold pressure drops off which means that the rings are not being forced against the bore at enough pressure.

On a normal parachute sortie three quarters of the flying is in conditions that are not favourable to running-in of the engine.
Improper running in of an engine may result in glazing of the bore which will cause high oil consumption, loss of engine power and short engine life.

Avoid long power-off let downs especially during break-in period and carry enough power during let down to keep cylinder head temperatures at least in the bottom of the green.
Avoid long ground running times and be especially generous with mixture controls and cooling air during break-in.

Pick a good quality, non-compounded aircraft engine lubricating oil and stay with it throughout the break-in period. Duration of the break-in period is usually defined as the first 50 hours or until oil consumption stabilises.

Follow these simple recommendations during break-in and your engine will reward you with a healthy service life.

Above all: Don't use low power on your engine during its "break-in" period.

7.2.1. Oils

Engine lubricating oils can be divided into two basic categories, compounded (detergent and ashless dispersant) and non-compounded. The compounded oils are superior lubricants with a greater film strength than non-compounded oils. Consequently, only non-compounded oils should be used during the break-in period. (ie petroleum mineral oil)

Some owners insist on using additives or super lubricants along with the regular engine life during the break-in period. They believe that such practice will aid the engine during its breaking in. This practice is wrong and actually causes harm.

8. Maintenance (Private Category)

There is no such thing as cheap maintenance. A properly maintained aeroplane is safer and more reliable. In the long run this is less expensive.

Two methods of maintenance are currently available:

a)- 100 hourly Inspections: Advantages are that problems can be detected early and rectified, often with less cost.

b)- Annual Inspections: Advantages are that there are lower costs as you are not paying for repetitive inspections. Only recommended for the owner operator who has a good working knowledge of their aircraft as this ensures any problems are detected early.

8.1. Oil and Fuel

- ***Oil***: Oil and filters should be changed at 50 hour intervals.
  You should drain and replace engine oil as often as recommended and if operating conditions are unusually dusty or dirty, more frequent changes may be necessary.

- ***Fuel*** MoGas was approved in the 80's for use in some aircraft. The properties of fuel that effect engine performance are the volatility and the manner in which the fuel burns during combustion. This also determines the engine power out-put.

  Automotive fuel does not have as good a quality in these areas as aviation fuel hence the loss of power, particularly above 5000ft.

  According to engine over-haul facilities, valve and valve guides are wearing out prematurely when MoGas is used . Extra corrosive properties of MoGas can be the cause of premature wear in carburettors.
  The use of MoGas also increases the likelihood of carburettor icing.

  The main reason for not using MoGas is the lower "quality control" standards of the fuel, both in manufacture and storage.
  There are many operators who swear by the use of MoGas.
  I would strongly recommend that if using this a cost reduction measure extreme care be taken with handling and storage.

9. Cracking Cylinders

9.1. Introduction

Aircraft engines were never designed to carry out Skydiving operations. The extra loads and stresses that this type of work places on the aircraft will appear in many forms, in both the airframe and engine.

A common problem with the piston engine aircraft is the cracking of cylinders. This is a major concern, not only financially but also from a safety point of view.

This problem can be adequately addressed by firstly understanding the cause of cracked cylinders. Then secondly applying flying procedures with an emphasis on engine handling, that will minimise the potential of cracking cylinders.

Components of the aircraft engine are designed to maintain their structural integrity during normal temperature changes for the serviceable life of the components, however should the engine be exposed to rapid temperature changes then damage, in the form of cracking will occur.

9.2. Thermal Shock.

The cause of cracking cylinders is thermal shock.
Thermal shock is the rapid change in temperature of a metal component.

Metal is stressed unduly when it is repeatedly heated and cooled . This process will crystallise the metal and cause the metal to have little bonding strength. The particles are therefore more likely to part company and the stressed area is seen in the form of a crack.

The most common area to crack is between the spark plug and exhaust valve. This is the area that has the least amount of metal and is exposed to the extreme heat caused by combustion.

The two contributing factors that cause "Thermal Shock" in an air-cooled engine are the amount of heat produced by combustion in the engine. (This is directly proportional to the amount of power produced) and the amount of cooling applied to the engine.

Cooling of an aircraft engine is via 3 main methods;

1. Air forced into the engine compartment passing over the cylinders and back out of the engine compartment absorbs some of the heat from the cylinders
2. The oil cooling system. The oil is passed through the oil cooler which cools the oil.
3. The fuel. In fact fuel amounts to about 60% of the cooling component of the aircraft engine.

The amount of cooling applied to the engine via fuel is preset by the fuel system.
The amount of cooling by the oil cooler is pre-set by the size of the cooler.

The two variables we can use to reduce the effect of thermal shock are

a : power (heat generation)
b : air speed (cooling)

The amount of air passing through the oil cooler and cylinders can be changed by the air speed of the aircraft. The higher the air-speed the faster the engine will cool.
Power is used to generate heat to reduce the rate of cylinder cooling.

Prevention is always better than the cure.

This section is specific to cylinder cracking. The <u>Aircraft handling section</u> covers what we can do practically, to reduce the risk of cracking cylinders.

Points to consider

- The most critical time for thermal shock related problems are at the "top of decent".
- Cylinders do not crack from a one off sudden temperature change. It is repeated shock cooling of the cylinder that will cause cracking.
- The higher the temperature the quicker and easier the damage occurs. For example a CHT drop from 400°F to 380°F in one minute, will be more likely to cause cracking than a temperature change from 350°F to 330°F in the same time.
- The higher the rate of temperature change, the higher the risk of cracking. For example a change in CHT of 50°F in one minute will cause more cracking than a change of 50°F in two minutes.
- Never operate with Cylinder Head Temperature constantly over 400°F.

9.3. Metal cracking, The cause

It should be noted that cracked cylinders are the first sign of thermal shock. The crankcase is also affected by the detrimental affect of thermal shock. The cracking of the crankcase takes longer with more exposure to thermal shock than the cylinders to have cracking problems appear.

A crack in a crankcase normally appears initially where the cylinder is bolted to the crankcase. This is the area of the crankcase most affected by heat generated as a by product of combustion. Also this area is stressed by the load caused by combustion in the cylinder.

9.4. Symptoms

The following symptoms may be noticed:

- If a gauge indicating the temperature of individual cylinders is fitted then a cylinder indicating a higher than normal temperature may be a cracked cylinder.

- A slight chuffing noise may indicate a cracked cylinder. (the sound of compressed air escaping through a very small hole)

- Reduction in climb performance or normal cruise speed indicates the possibility of a cracked cylinder.

- Rough or uneven running.

If any of the above symptoms are present, The possibility of a cracked cylinder must be considered and the engine should have a cylinder leak down test immediately which will confirm the condition of the cylinders.

9.5. Repairs

The decision to repair or replace is made with consideration to several key points;

- Hours to run on the engine.
- Will new cylinders be fitted on the next o/h?
- The amount of work the aircraft is required to carry out.

a) The crack in the cylinder can be repaired by grinding a cut along the crack and welding the area, then grinding the weld back to the original shape.
Normally, valve seats have to be removed and replaced in this procedure. Do not forget that if you are carrying out the repairing option, the rest of the cylinder and head portion have also been stressed.

b) Replacing with a new cylinder is always the best option.

A very important point to consider is the replacement of cylinders at engine o/h time. The cylinders were never designed to last forever . The manufacture of most aircraft engines recommends replacement of cylinders at each o/h.

Experienced operators in fields where the engines work hard and require a high degree of reliability use a cycle of replacing the cylinders at every second overhaul. This combined with correct engine handling will make it extremely unlikely that you will have cylinder cracking problems during the working life of an engine.

10. AIRCRAFT HANDLING

The correct handling of the aircraft is necessary for the reliability and safety of the aircraft. A "Pilots Operation Manual" should be implemented to ensure that all pilots know the correct method of operation. This also ensures continuity of operation between pilots.

Following is a suggestion for the basis of a manual for operating a Cessna 182.

10.1. Ground handling

- Areas of the field that are OK for taxiing and no-go areas should be indicated via a map.
- Aircraft should be tied down every night and/or approaching in-clement weather.
- Control locks in place during night storage. (Do not leave Park Break on as the system is not designed for long term pressurisation)
- Re-fuelling to assigned level via dip-stick and fuel drain procedure.
- Radio's are turned off prior to shut-down. Cowl-flaps opened and aircraft trimmed for take-off so that the aircraft is ready for the next flight.

10.1.1. Start Procedures:

Cold Start:;

- Prime with primer three times, place key on dashboard and pull propeller through (always treat propeller as live).
- 2ml throttle then start engine.
- Warm engine up for 5 minutes at 1000 RPM or until the CHT is above 200°F (the warming of an engine before maximum power take-off is extremely important to ensure the long service life of the engine).
- Complete magneto check and cycle propeller twice prior to take off for the first load of the day.

Hot Start

- 2 ml of throttle, wind over and engine should start.

WARNING: Do not pump the throttle whilst engine is not turning over.
By pumping the throttle fuel is put directly into the carburettor and not the Intake manifold. As the carburettor is upside down there is a possibility that extra fuel will fall into the air duct where there is a high possibility of it catching alight caused by a back-fire.

This can result in the complete loss of the aircraft due to fire.

Note: This is a common cause of aircraft destruction.

10.2. Climb Techniques

- Once airborne, establish climb speed of 85kts with cowl flaps open and flaps raised.

- Mixture left full rich to assist in cooling. Approximately 4000ft reduce speed to 80kts, approximately 7000ft reduce speed to 75kts.

- Some operators reduce power to 25MP and 25RPM, however full throttle and full RPM settings are approved for the O 470 engine and most operators leave the engine at full-power for climb.

- During climb CHT should not be allowed to climb above 400°F.

- Carry out wind speed assessments on GPS. Note these are more accurate if done flying into wind.

10.3. Top of Climb Techniques

- Approaching top of climb engine handling is carried out with the assistance of a GPS.
- At 0.3nm before exit point, reduce RPM to 2100, close cowl flaps, lean mixture slightly, maintain 75 kts. At exit point, open door and reduce manifold pressure to 12-15 inches (Note: for AFF Stage 1, reduce power to 10 inches) These procedures must be carried out in this sequence to minimise "Thermal Shock."
- Keep aircraft on heading using aileron and rudder during the climb out.

10.4. Descent Techniques

- Close door, without letting airspeed build up. An aggressive side-slip will assist closing. Increase manifold pressure to 20 inches (winter) 18 inches (summer) before airspeed is built up to 140 kts. It is absolutely imperative that the manifold pressure is increased before the airspeed is built up. ***It is emphasised very strongly that this is the time period that cylinder cracking will occur if not handled correctly.***

- Do not descend over Skydivers in case of premature opening.

- Reduce manifold pressure 1 inch per 1000ft until 15 inches.

- Joining the circuit with minimum level flight is where the most amount of time can be saved on a normal sortie. Ensure speed is washed off prior to power reduction.

- Some operators prefer to land flap-less saving wear on flaps.

- We note that Full-flap landings on empty aircraft are very nose high hence the tendency to drop rapidly at the end to the round-out flare. The pilot should use the method they are most comfortable with to obtain the best landing.

- Upon landing re-set trim and cowl-flaps for next flight.

10.4.1. Descent during In-Flight door malfunction.

- Do not carry out descent unless positive closure of in-flight door is carried out. If In-flight door should accidentally open during high-speed descent severe damage will result.

- The door open descent technique is full flap, 15 inches, 80° bank turn which will result in approximately 2g's in a spiral descent.

Note: that landing with door open is no problem.

POINTS:

- Avoid noise sensitive areas as much as practical.

- Familiarise yourself with local radio procedures.

- ***Important***: We are a high profile airspace user, show utmost courtesy and assistance to other airspace user's at all times.

- Parachute operations are extremely hard on aircraft. Good airmanship and careful handling of the aircraft are important to it's reliability and safety.

- Always be vigilant of people approaching the aircraft with the propeller turning.

- Fuel management is critical. Always check the fuel and carry more than enough for each flight. A common operating procedure is, half hour reserve plus 2 loads of fuel. Remember the loadings are on the maximum in all up weight and very near the maximum aft C of G. Five large people in a Cessna 182 would need to be assessed very carefully

11. Pilots

Here lies the single most important contributing factor to the safe operation of any aircraft. The normal Cessna Skydiving operation will have pilots knocking on their doors constantly looking for a chance to build up hours flying Skydivers.

Sad as it is true, not everybody is cut out to be a pilot just like all of us are not world champion Tennis players. Flying schools are operating in an ever decreasing market, and are under extreme financial pressure for every prospective student to continue to learn to fly regardless of their ability. Couple this with the fact that so many people dream of the high paid glamorous position of flying the Jumbos of our International airlines.

This means that many people who do not have the ability to operate an aircraft safely will appear before a Skydiving operation fully qualified to fly your aircraft, but severely lacking the skills to do so. A retired ag pilot with 10,000 hours will not need any consideration. However, in reality most new pilots will be inexperienced pilots looking for hours.

Following is a recommended procedure to follow:

- Inspect log book and confirm experience and qualifications meet CASA and insurance requirements.

- Note operations that have hired them aircraft and talk to them about the pilot's skill.

- Assess their attitude towards being told what to do. This is extremely important. They will have to be taught how to operate the aircraft which is sometimes in complete contradiction to what they have been taught in the past. Their inability to accept new knowledge can be an insurmountable hurdle to over come.

- Make them stay on the DZ for a day. Take note if they are comfortable "hanging around". Remember they are going to do a lot of it, if they start flying for you. This will also give them an insight as to how you operate and what is expected of them.

- The Banks loaning criteria has "character" at the top of the list. This writer would suggest you follow the lead of some very experienced operators in the field of trusting other people with their assets, by making the person's character the top priority in your assessment list.

- Flying skills. Get to know a local flying school with an Instructor you can trust. Have them check out your perspective pilot with a aggressive type flying test.

- Have your existing pilots take them for a check flight.

- Having passed all the tests. Invest heavily in the future safety of your operation and train the person to do the job. Don't just throw them in the deep end. You may pay very dearly for this short cut.

The full training of a new pilot will take an investment of 20-40 hours of your time and hundreds of dollars in aircraft time. As with all personnel, good performance will only come with correct training.

12. TROUBLESHOOTING

PROBLEM	CAUSE	SOLUTION
Excessive oil consumption	Glazing of cylinder walls during break-in. Oil leak. Worn rings.	Re-hone the cylinder walls and break-in correctly. Repair oil leak. Replace rings.
Over-heating during climb	Poor rubber: Cowl / engine seal. Timing too advanced.	Replace sealing rubber, seal all holes. Be really fanatical about this Adjust to correct setting.
High Oil Temperature	Low oil supply Cooler air passages clogged Cooler core plugged Thermostat faulty. Oil viscosity too high Prolonged ground operation Malfunctioning gauges Worn engine. Worn or faulty baffling	Replenish Clean thoroughly Remove cooler and flush Replace and reface valve seat Drain and refill with correct oil Limit ground operation Check and Replace malfunctioning parts Overhaul engine. Replace.
Low Oil Pressure	Low oil supply or Oil viscosity too low Foam in oil due to presence of alkaline solids in system. Malfunctioning pressure pump. Malfunctioning pressure gauges. Weak or broken oil pressure relief value spring. Clogged filter or strainer. Worn engine.	Replenish. Drain and refill with correct seasonal weight. Drain and refill with fresh oil. Replace Pump Check gages, Clean plumbing Replace if necessary Replace spring. Adjust pressure to 30-60 PSI by adjusting screw. Clean strainer or replace oil filter. Overhaul engine.

Low climb performance.
This can be caused by anything from worn spark plugs to a sad and tired airframe.
The most common cause is low engine power. Check the engine for compression. Make sure compression is good, to very good. Low compression may be within limits but will cause slow climb performance. Worn spark plugs should always be replaced. Make sure the carbie ice flapper valve is not worn as this will let hot air in that will reduce power. Also make sure the engine is at the correct angle so that the propeller is pushing at the correct angle.

Propeller. The blades of the propeller create all the thrust of the aircraft. The blades may be within legal limits but if they are well down on size, this will reduce the performance of the aircraft. Replace blades if they are worn.

Airframe. Have the aircraft trimmed. ie. The flaps set right up so they do not cause drag,. The ailerons set correctly and the angle of the wings should be set for best climb.

13. REFERENCES

"Tips on Engine Care" Teledyne Continental Motors Aircraft Products Division
Form X30548

"Cessna Service Manual Model 182 and Skylane 1977 through 1980

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"Model 200 Series Piston Single Engine Aircraft Continued Airworthiness Program"
Manual D5121-13, Dated 1 July 1992 and revision 1
Cessna Aircraft Company, Wichita. Kansas USA.

"Pilot Safety and Warning Supplements"
Cessna Aircraft Company Wichita, Kansas USA 2nd October 1985

"0-470-SERIES Continental Aircraft Engine Operator's Manual"
Teledyne Continental Motors Aircraft Products Division
FORM NO. X30097 FAA Approved April 1985

14. ADDRESS'S

NAME	FOR	ADDRESS	WORK PHONE	FAX
Australian Parachute Federation	STC's for 6 place in C182 In-flight door	PO Box 144 Deakin West ACT 2600	02 62 81-6830	02 62 85-3989
P. Ponk Aviation	STC for engine upgrade of O470 to O520		0011 1 360 629 4812	0015 1 360 629 4811
Rudy's Aero Engines	Only operator in Australia licensed by P. Ponk to do 520 conversion		03 5149 2300	03 5149 2305
Precise Flight	Speed Breaks		0011 1 541 382 8684	0015 1 541 388 1105
Moss Smith	In-Flight Door		0011 64 8681086	

15. Conclusion

Aircraft education and training will undoubtedly improve our awareness of safety related issues and help maintain and improve our safety record.

As a sporting organisation within the aviation industry we need to continually improve our image and professionalism in the eyes of the Aviation Governing Body and the general public.

We currently have a better safety record than many other Skydiving nations, however the potential for accidents is demonstrated by our insurance excesses and that we are still referred to as a 'HIGH RISK' sport.

As a sport/industry we need to be more aware of the enormous workload that we place on our aircraft and pilots. A clear example of this is the number of take-off and landings that are made in skydiving operations compared to hours flown.

An Integrated pilot selection and training programme would be a big step forward and would improve the safety of our operations.
I'm sure we will all agree the day of the *'cowboy'* pilot has passed.

Improved Skydiver awareness and training in relation to aircraft will assist in the maintenance and improvement of the safety of Skydiving operations.

The advent of the Tandem Skydive has raised the public awareness of Skydiving and helped dispel the 'daredevil' image of the past. Modern society no longer will accept unsafe activities. The professional image that we are striving to develop and portray to survive in the public eye is critically dependent upon acceptable and proven safety standards. An integral part of our safety standard is aircraft operations.

The media story of a horror aircraft accident involving Skydivers definitely has the potential to cause irreparable damage to our industry. A classic example of this is the balloon industry has yet to recover from the terrible crash at Alice Springs in 1988.

The continued sharing of knowledge and training methods which have benefited our sport has been very successfully demonstrated by our governing body in the APF which is recognised worldwide for achievements in this field. If we can extend this methodology to aircraft operations we will undoubtedly improve the safety and enjoyment of our sport.