

Engines

This Falco Construction Note replaces Advanced Builder Memo “Chapter 45 Engines”

Since we wrote this, High Performance Engines of Mena, Arkansas, has closed, but we are still including the information for your edification and we will re-write this when we have time.

Introduction

When it comes time to buy an engine for their Falco, builders find themselves faced with a confusing subject. Before you start looking for an engine, you need to be a knowledgeable purchaser. That’s the purpose of this chapter—to take the mystery out of buying an engine.

The 150-160-180 hp Lycoming Engines

We will confine our discussion to the 150 hp and 160 hp 320 series and the 180 hp 360 series. These engines are assembled largely from the same parts, and the differences are much more subtle than you might think. All of these engines use the same crankcase casting. The basic casting is machined for three different type of engine mounts. The conical engine mount was the first. This engine mounting system uses small rubber cones. The O-320-A and O-320-B engines use this mounting.

Next came the Dynafocal engine mount—now called the Type 1 Dynafocal mount. In this design the larger rubber isolators are positioned at an angle of 30°. The intent was to “focus” the mounts just ahead of the center of gravity of the engine/propeller combination. This mount proved to be very successful since it afforded a smoother ride. This Dynafocal mounting system is the most commonly used system.

When Piper introduced the Twin Comanche, the aircraft had long extensions to the propeller hubs. This gave an exceptionally clean cowling, but the center of gravity of the engine/propeller was moved ahead of the focal point of the Type 1 Dynafocal mounts, so the angle was changed to 18° to compensate. This is known as the Type 2 Dynafocal and is used on the IO-320-B1A engines. At the same time, larger “three inch” Lord isolators were developed.

So the crankcases are machined for one of the types of engine mounts—conical, Type 1 Dynafocal or Type 2 Dynafocal—and they cannot be converted to any other type.

The accessory case is on the aft end of the engine, and it is essentially identical on all engine of this class. Some engine have special adaptors for an oil filter, and others lack internal pieces for a propeller governor.

The cylinder heads of all of the engines are identical. The cylinder barrels of the 180 hp engine are one-half inch longer, and the crankshaft of the 180 has a longer stroke. Thus, the 180 hp engine is nothing more than a longer stroke 160. The pistons come in high compression and low compression flavors. Put the low compression pistons of a 150 hp engine on the longer stroke engine, and you have a 168 hp engine. The low compression engine only require 80 octane fuel and are thus appropriate for autogas. The higher compression engines require higher octane avgas.

The induction system of these engines is integral with the oil sump. The idea is to warm the induction air (for better fuel vaporization and thermal efficiency) by passing it through the oil—and this also helps to cool the oil. There are two types of oil sumps.

The most common type has the carburetor or injector on the bottom. Almost all engines are built this way, but the IO-320-B1A and the IO-360-B1E have a different type of sump and injection system. On these engines, the injector is mounted on the aft end of the engine. This was originally developed for the Twin Comanche. It seems like an odd place to put the injector since the air is coming from the front of the engine, but it makes for a wonderful installation. A low-drag induction can be installed on the right side of the engine, and the bottom of the cowling is not marred by the appearance of a carburetor intake. There is an additional benefit; this induction system is slightly more efficient, allowing the engine to develop slightly higher

manifold pressure.

So these engines are something of a mix-and-match combination. A carbureted engine can be converted to an injected engine by changing the right parts. A 150 hp engine can be converted to a 160 hp engine by changing the pistons. The two types of oil sumps may be changed.

There are a few conversions you cannot make. You cannot change the engine mounting on any of these engines. You cannot convert a 150 hp or 160 hp engine to a 180 hp engine. You cannot convert an engine designed for a fixed pitch propeller to one designed for a constant-speed prop. (Lycoming can do this easily, but you should forget it.) A constant-speed prop requires a “hollow” crank, a drive for the propeller governor and a delivery system for getting the controlling oil from the governor to the front end of the engine.

It is possible to convert an O-320-A or O-320-B to a sump with the injector or carburetor on the aft end of the sump, but not for a Falco! The conical engine mount has a diagonal anti-torque brace that cannot be eliminated. The anti-torque brace has been eliminated from the Dynafocal engine mounts, but these mounts have additional bracing. (We actually tested an engine mount to ultimate loads to make sure of this.)

You should also understand that the Lycoming engine numbering system can fool you into arriving at incorrect conclusions. If you have an O-320-B1A, you cannot convert it to an IO-320-B1A by simply adding an injector. The O-320-B1A engine has a conical mount, a sump for the carburetor on the bottom and 3/8” propeller mounting bolts. In fact, it is an obsolete engine no longer made or overhauled. Its replacement is the O-320-B3B which has the same 7/16” prop bolts as all of the other 150s and 160s.

You will hear a lot of misinformation and plain malarky about these engines. If you find yourself with an irresistible deal on an engine that just requires “just a few minor changes” to convert for the Falco... “do yourself a favor!” and give us a call before putting any money on the table. Over the years we’ve had Falco builders buy a lot of problem engines. Most of the deals that sound too good to be true, aren’t any good at all.

We should also tell you that there are a few odd but notable exceptions. The O-320-H engine is a completely different engine, and it was a real lemon. Don’t buy one at any price. The 180 hp O-360-E1A6D engine is the same oddball lemon.

One other point of confusion. The 200 hp IO-360 engines are completely different from the engines we are talking about here. They may have the same overall dimensions, and they do use the same conical and Dynafocal mounts, but the cylinders and exhaust system are completely different.

Which Engine?

Because of the number of Cessna Skyhawks and Piper Cherokees, there are a lot of 150 hp and 160 hp engines which can be used in a Falco but which can only use a fixed pitch propeller. A couple of problems. A fixed pitch propeller on the Falco will work, but it is not nearly so desirable as a constant-speed prop. Takeoff performance is sluggish, and you have to jockey the throttle in acrobatics to keep from overspeeding the engine. It works, but it is not a desirable combination. Secondly, the cowling that we supply as a kit will only work with the Hartzell constant-speed propeller and using the Hartzell spinner that we specify. The lines of the spinner “flow” into the cowling and this “makes” the looks of the cowling. Put another spinner on it and the cowling will not look as nice. Because the front of the cowling is slightly forward of the propeller mounting flange, a fixed pitch propeller will hit the cowling unless something is changed. If you are going to use a fixed pitch propeller, you should think about making your own cowling to match your prop/spinner combination.

If you want to use a constant-speed propeller on the Falco, your choices are very few. One option is the 150 hp O-320-A3B or the 160 hp O-320-B3B. These are the engines originally used on the Falco, and they are available in some abundance since they were used on the Piper Apache. They use the conical mount. Nothing wrong with these engines, but you will have a carburetor scoop on the bottom of the cowling and the conical mount is not nearly as smooth as the Dynafocal mounts.

The second choice is the 150 hp IO-320-A1A and the 160 hp IO-320-B1A. These engines were used on the Piper Twin Comanche and are available in much greater abundance. The 150 hp engine is rather rare and easily converted to 160 hp. There was also the IO-320-C engine used on the Turbo Twin Comanche. It was set up for a turbocharger, and you can use it on a Falco just like an IO-320-B1A (unlike many “turbo” engines, the IO-320-C does not have low compression pistons). These

engines use the Type 2 Dynafocal engine mounts.

Third choice is the 180 hp IO-360-B1E. This was used on the 180 hp version of the Piper Arrow. There aren't many of these around, but it's fairly easy for an overhauler to convert an O-360-A1A or O-360-A1D. As designed, there is a minor problem with using the IO-360-B1E in the Falco. The injector on the Twin Comanche engine is angled at 45° which is picture-perfect for the Falco. The 180 hp Arrow engine has the injector pointing straight aft, and this simply will not work (it hits the cabin heat box and interferes with the nose gear retraction). The cure is simple, you install the same 45° induction fitting from the Twin Comanche engine. Once you have done this, the IO-320-B1A and IO-360-B1E are outwardly identical except for the length of the cylinders and the Type 1 Dynafocal engine mounting.

Which engine should you use? For every car, boat, airplane or even go-kart, there is an optimum engine. Americans in particular are prone towards "big iron" and have stuffed too-large engines in every type of vehicle. One pilot installed a 340 hp engine in his SF.260—that's an increase of 80 hp—but admits that his normal cruise speed on day-to-day flying is up only 10 knots. A Falco owner told us a story about a boat he once owned. "It was the sweetest handling boat I ever owned, but I had to make it better. I put in a bigger engine, and it turned into a real dog."

So think about this before you grab for the 180 hp. Remember, the Falco first flew with a *ninety horsepower* engine, and the 135 hp Falcos were just as fast as the 150 hp ones (so what if they had wheel well doors!). In our opinion a 160 hp engine is the perfect engine for the Falco. There are a lot of extremely knowledgeable people who share the same opinion. None of us can prove it, but that is our conclusion. Remember, with a 160 hp engine, the Falco has a power-to-weight ratio that's better than most production singles. One hundred and sixty horsepower in the Falco is a lot of power.

But if you gotta go for the maximum, go ahead and get the 180 hp engine. The rate of climb will be much better. You will also get about 4% more speed. In reality, pilots usually choose a power setting that gives them the least vibration, so it's probable that most 180 hp Falcos will end up cruising at exactly the same speed as the 160 hp Falcos. With the 180 hp engine, you will use a little more fuel, you will have a restricted range on your tachometer, and you will have two blisters on the cowling to clear the engine—but in all likelihood the blisters will become a status symbol.

Where to Get It?

Once you have made your decision, the next decision is whether to buy a new engine, an overhauled engine or just a high-time engine. Each has its merits.

You can buy a new engine only through a Lycoming dealer. Because these engines are made in relatively small numbers—even in the best of times for aviation—they have always been expensive. When Lycoming's production line is running, the engines are expensive but within financial reach of many people. When the production is at a virtual state of shutdown, as it is today thanks to a lawsuit-crippled aviation industry, the price of a new engine is breath-taking. You cannot blame Lycoming for charging their costs, but you can also understand the reluctance of many buyers to pony up for the \$20,000+ list price of a 160 hp engine purchased "outright".

As of this writing (April 1987) the list prices of an IO-360-B1E is \$17,870.00 new exchange. For an IO-320-B1A, the list is \$18,825.00 new exchange. ("Exchange" means you supply Lycoming with a core. If you don't, you pay the "outright" price which is thousands more.) Expect to get about 10% off these prices.

If you buy a new engine, you can always find a dealer who will take your order for a minimum markup. It is only fair to let the dealer know how much service you expect after the sale. It's not fair to a dealer to ask him to handle an order for a minimum markup and then expect help on installing the engine.

One other problem with buying a new engine is that the entire aircraft engine business is based on selling engines on an "exchange" basis. You are expected to have an old run-out engine to turn in. If you don't have such an engine, you have to pay the "outright" price.

The run-out engine is called a "core". Most engine overhaulers don't want to sell you an engine unless you supply a core. If you don't have a core, then you must pay a "core charge" since their prices are always quoted as "exchange". In effect, you are giving them enough to go out and buy a runout engine, and then some. Overhaulers will freely tell you that it's cheaper for you to buy the core than to pay the normal core charge. Occasionally you will find an overhauler who has a few extra engines

is stock and they will lower the core charge to about what you might otherwise pay for an old engine.

Even if you have an old engine, there are core “contingencies”—not *any* engine will do. First, the core is expected to be in normal run-out condition. Second, the cylinders, crankcase and crankshaft must all be in repairable condition. They needn’t be perfect, just repairable. Third, the core is exchanged on a “like-for-like” basis only, unless it’s explicitly agreed otherwise. Thus, you can get an IO-320-B1A only if you turn in the same exact model of engine, and if it has a generator and Slick magnetos installed, that’s what you are going to get back on your overhauled engine. Any deviation from the “like-for-like” rule should be discussed and agreed upon in advance.

When you buy a used engine, you are frequently buying someone else’s problem. There is usually a reason the engine is no longer running in an airplane. There are a couple of exceptions, although both are rare. The first is when the engine comes from a “Part 135” operation. Under such charter operations, the engine must be overhauled or replaced at the recommended TBO. Because they are normally operated frequently, these are the most desirable used engines you can find. The other “good deal” is when a Twin Comanche is parted out simply because the parts are worth more than the airplane.

If you have good reason to think that your engine was running well when it was removed from the previous airplane, then it is not a bad idea to install it in your Falco without overhauling it. Many experienced homebuilders prefer to do the first flights with an engine that has not been freshly overhauled. Later after the airplane is checked out, you can do the overhaul when the engine needs it. (You are not required to overhaul an engine at TBO. Experience has shown that it’s possible to operate an engine well beyond recommended TBO, but that is a subject we won’t go in to here.)

Overhauls, New limits vs Service Limits

Things get a little confusing when you get into overhauled engines. As engines are used, the internal parts are subject to friction, and they wear. At overhaul, the engine is taken apart, and all parts are checked for wear. There are two standards by which parts are judged to determine whether they should be replaced: new limits and service limits—these are published in the Lycoming Direct Drive Overhaul Manual.

The new limits are the same limits used for the manufacture of new engines. The only difference between a new engine and an engine overhauled to new limits is that many parts of the overhauled engine are used. Service limits allow for more wear. They do not imply that an engine is less safe to operate, but a service-limits overhaul cannot be expected to last as long as a new engine or an engine overhauled to new limits.

If you shop by price alone, you will note a sizable difference in the price of an overhauled engine. It’s easy to come to the conclusion that you are being taken for a ride, but the simple fact is that with engine overhauls you get what you pay for. To overhaul an engine, the shop tears the engine down, inspects and measures all parts, replaces those parts which do not meet the limits and then puts the engine back together again. It takes essentially the same amount of labor to do a minimum service-limits overhaul as it does to do a new-limits overhaul. The difference is in the parts that you get—of the \$8,400.00 to \$8,500.00 that Mattituck charges for a new-limits overhaul, about \$2,500.00 to \$2,700.00 is for labor. Western Skyways, which specializes in larger engines, estimates that 85% of their price is for parts and 15% for labor.

When you buy an engine overhauled to service-limits, the overhauler is entirely within his legal rights to disassemble the engine—without regard to the number of hours on the engine—and put the engine back together again. If all of the parts check out to the service limits, it is an overhauled engine. In reality, there are almost always some parts which are replaced. Thus, it is important that you understand whether you are getting an engine overhauled to new limits or service limits.

Engines overhauled by Avco Lycoming to new limits are known as “factory remanufactured” engines and carry a “zero time” tag. Engines overhauled by an overhaul shop to the same new limits carry a “zero time since major overhaul”. This is the cause of much bitterness on the part of overhaul shops, and there have even been lawsuits over the right of the factory—and not an overhauler—to use the “zero time” tag.

At this writing (April 1987) the list price of a “factory reman” IO-360-B1E is \$13,665.00 exchange, and \$14,340.00 exchange for an IO-320-B1A. In all fairness, it should be said that in about 90% of the cases, Lycoming installs new cylinders on such engines. This is not the case with a new-limits overhaul from an independent shop.

The “big three” engine overhaulers are Mattituck, G & N, and Western Skyways. These companies do about 25% of the engine

overhauls in this country. Each has a reputation for doing top quality work. All of these companies are reputable, and you can be assured of getting top quality new-limits overhauls from any of them. None of them will do anything but a new-limits overhaul. As of this writing (April 1987), Mattituck's price for a rebuilt IO-360-B1E is \$8,500.00 exchange and \$8,400.00 exchange for an IO-320-B1A. These are sold only through dealers who get a 20% discount. Core charges are \$4,600.00 and are not subject to any discount, although sometimes Mattituck will drop the core charge if they have more engines in inventory than they want.

Mattituck is happy to have you call, but they only take orders through dealers. (Sequoia Aircraft qualifies as a dealer, and we can order engines from Mattituck. We really do not want to get involved in engines, but we will handle an order at a minimum charge as a service to our kit purchasers as long as we are paid in advance, and it is clearly understood that we are just handling an order.)

Another popular source of overhauled engines is Don George Aircraft Engines. If you are not familiar with the name, the company used to be known as Dick Waters, Inc., but Dick Waters retired and sold the business to Don George, his son-in-law. Dick Waters began by doing service limits overhauls, and he has been criticized from time to time as delivering poor quality engines. The same people who say this also praise the integrity of Don George. They no longer do service-limits overhauls. Instead, they do an overhaul that is very nearly a new-limits overhaul with certain reasonable exceptions, the most important of which is the lack of "yellow tag" certifications.

Don George caters to homebuilders, and he is unique in that he prefers to purchase his own cores. Because you can just call up and order an engine right off the shelf—and since you are not paying for the paperwork involved in all those yellow tags—you get a lot of engine for your money. It's not surprising that this company supplies more engines to Falco builders than all other overhaulers combined. As of this writing (April 1987), his price for an IO-360-B1E is \$8,995.00 outright, and \$7,995.00 outright for an IO-320-B1A. For the average Falco builder who wants an overhauled engine and who is "on a budget" this is the most reasonable solution.

There are a few specialized shops that do "premium overhauls" in which the engine is overhauled to higher standards than a "factory equivalent" overhaul. The extra work usually comes under two categories (1) porting and (2) balancing.

Porting means that the intake passages of the engine are polished in some fashion so that the induction air will pass through more easily. Think of this as an aerodynamic drag cleanup of the inside of the engine. When an overhauler tells you he is going to polish the ports, this doesn't mean very much. It could mean that he will spend a few minutes with a piece of emery cloth. RAM has a system of porting that takes about an hour per cylinder. When it comes to porting, High Performance Engines is the best in the business and does more than any other rebuilder. First, they have a certifiable genius, Bob Bates, who specializes in the porting and polishing. Second, they flow-balance the engine so that the airflow into each cylinder is within 1-1/2 percent of every other cylinder on that engine.

It is not enough to simply polish the inside of the passages. It takes a specialist who has spent years developing this skill, and it is an art as well as a science. Secondly, the cylinders must be checked on a "flow bench" which accurately measures the flow of air.

Balancing means weighing all of the reciprocating parts and selecting matching sets. Some shops go further and balance the crankshaft and connecting rods by removing minute amounts of metal. Every rebuilder does some balancing, if only to check that the weights are within factory specifications. The tolerances vary widely, so before you pay a lot of money for balancing, you want to (a) make sure that the shop is qualified to do the work—removing metal from the crankshaft is quite safe if properly done but very dangerous if done by a novice—and (b) what the tolerances are.

For Falco builders, such extended overhauls are the exclusive domain of High Performance Engines, who rebuild engines for those who want the *crème de la crème* of aircraft engines. High Performance Engines overhauls engines to new limits and does a number of things—porting, polishing, balancing, flow balancing—to increase the performance of the engine. If you want greater power and efficiency out of your engine and are willing to pay the extra cost, this is the place to go. They have an excellent reputation, and the engines do exactly what High Performance claims. As of this writing (April 1987) the price of an overhaul is \$11,000.00 for an IO-320-B1A or IO-360-B1E. High Performance Engines expects you to bring them a core. As a service, they can locate an engine for sale, but you must buy it.

Regardless of who does your overhaul, you should make sure that you understand exactly what you are getting for your money. All of these companies are prepared to explain their overhauls. When everyone understands what is being done, it is a happier experience for all.

First, determine if the overhaul is to new limits or service limits. If there are exceptions to the new limits (as in the case with Don George Aircraft Engines) you should have these explained. Ask for a list of mandatory replacement parts. These are the parts that a company guarantees to replace without regard to the condition of the part. As a rule, most overhaulers do about the same things, but there are subtle differences. Determine if the engine is run-in in a test cell after the overhaul—this is particularly important if you have not yet flight-tested your Falco. Finally, ask about the warranty.

Please find descriptions of overhauled engines from Mattituck Air Base, Don George Aircraft Engines and High Performance Engines at the end of this chapter.

Wide Deck vs. Narrow Deck

The engine you buy will be one of two different styles. Engines built by Lycoming prior to about 1965 are called “narrow deck.” At that time Lycoming adopted a new design for their engines that is now called the “wide deck” engine. The base of a cylinder has a flange, and there are eight bolts that hold the “jug” in place. On a wide deck engine, the flanges are a little wider and the bolts are a little different.

Because the wide deck engines are the later design, the natural inclination is to choose the more “modern” design. It is difficult to get an engine overhauler to tell you that one should be avoided; in fact, many prefer the narrow deck engines. The wide deck engines are prone to small cracks in the crankcase between the cylinders. This is not dangerous, but it creates a small oil leak and the crankcase must be repaired at overhaul.

Our conclusion is that there is not much difference in the design. If the sound of “wide deck” appeals to your ear, get that type. One real advantage of the narrow deck engines is that they sell for less because many people feel there must be something inferior about them.

Alternator Mounting Pad

Early model engines had generators installed with brackets mounted on the crankcase through-bolts. At some point in the mid-60's Lycoming redesigned the crankcase with a mounting pad for an alternator or generator fitting. If your engine does not have this mounting pad, your engine will require an alternator installation kit. Your engine rebuilder should get this for you and install it, but you can expect some extra cost.

The alternator mounting bracket is available from Lycoming for about \$570.00 (1987 price). You can buy the same bracket used from El Reno Aviation for a lot less. If you would like to make your own bracket, write us for a drawing.

Fuel Injectors for the 180 hp IO-360-B1E

The fuel injector for the 180 hp IO-360-B1E engines is very similar in appearance to the injector used on the 160 hp IO-320-B1A however there are important internal and external differences. Because of the increased horsepower, you cannot use the 160 hp injector on a 180 hp engine.

The engine installation on the Falco has all of the engine controls and fuel lines set up for the IO-320-B1A, and there are two significant problems with the 180 hp injector in this installation. First, the throttle arm linkage is “closed” when in the forward position (toward the engine.) To use in a Falco, this must be reversed. Any injector overhaul shop can do this work. To reverse the action of the throttle arm, a throttle arm of the 160 hp injector must be installed and the idle stop moved 90° to the other hole provided. A homebuilder should not attempt to do this work.

Second, the bent mixture control arm should be replaced with a straight arm and the ball end fitting does not need to be installed. The fuel inlet should be installed on the mixture arm side using the normal straight fitting and the fuel outlet should be installed on the “name plate” side of the injector using the normal 90° fitting. The injector should be installed so that the throttle arm is on the starboard side of the engine and the mixture control arm is toward the center of the airplane. Thus, the fuel inlet is on the inboard side of the injector and the fuel outlet is on the top of the injector. All these details are as shown on Drawing No. 131. For specific details, see “Engine Specification: 180 hp IO-360-B1E” below.

Engine Run-in

After an engine is overhauled, it should be “broken in” in a test cell. This procedure is described in the Lycoming Direct Drive Overhaul Manual. All quality overhaulers do this. It is very important that this is done. For one thing, the engine will give you better performance if it is properly broken in. Secondly, the proper break-in procedure is completely incompatible with the flight-testing procedure. The break-in procedure calls for high power operation. That is *not* how you test a new airplane.

Insist on having the engine run-in. See the Falco Flight Test Guide and Lycoming’s Overhaul Manual for additional information.

What an Engine Includes

Finally, you must make sure you are getting all of the parts for the engine that you need.

A Lycoming aircraft engine does not include the vacuum pump, propeller governor, propeller, propeller spinner or engine baffling (except for the intercylinder baffling). Related engine accessories such as gascolator and electric fuel pump are not part of the engine and are purchased from other sources. Oil pressure senders, cylinder heat temperature senders, oil temperature senders, exhaust gas temperature senders, fuel pressure senders, fuel flow transducers, tachometer cables and other senders for instrumentation are not supplied with the engine. This applies to all Lycoming engines, whether new, remanufactured, overhauled or used. The earliest O-320 engines had 7/16” valves. These were a problem and all engines should have been converted to 1/2” valves. The IO-320-B1A and IO-360-B1E should come only with a geared starter.

A new IO-320-B1A or IO-360-B1E engine from Lycoming will include the following:

- Alternator (or generator) with mounting brackets, hardware and belt
- A geared Prestolite starter
- Two magnetos
- Mechanical fuel pump
- Fuel line, fuel pump to injector throttle body
- Fuel line, injector throttle body to spider
- Oil filter

A typical rebuilt engine does not include the following:

- Alternator (or generator) and the required mounting bracket, hardware and belt
- Starter ring gear assembly

The reason is that the alternator/generator installed in the airplane requires a matching starter ring support. This has a “V” for the belt. Because there are so many variations, most overhaulers do not supply these things. You do want these things, and you should make sure they are supplied with the engine.

The IO-320-B1A engine requires 4 Lycoming P/N 74465 spacers. While they are technically part of the engine, no one seems to supply them or consider them part of the engine. You should specify that these be included with the engine, or you can make your own if you have a lathe.

The list of parts for an engine is included in the Lycoming parts manual. By FAA regulation, Lycoming may not deviate from that list. Thus, the IO-320-B1A engine includes short governor studs. Lycoming can supply you with the long governor studs you need for the Woodward governor. You can install these yourself, but Lycoming cannot install these studs in the engine for you. Any changes to the basic engine must be done by you.

The Vacuum Pump

The vacuum pump is not supplied with the engine. A number of pumps can be installed on the engine, but not all will clear the engine mount. We know, for example, that the Sigma-Tek pump cannot be installed in a Falco because it will hit the engine mount. As shown on Drawing No. 158, the vacuum pump you want is the Airborne 211CC.

Engine Specification: 160 hp IO-320-B1A Engine

This is the engine that is most commonly installed in the Falco. It uses a Type 2 Dynafocal engine mount, and the injector is mounted on the aft end of the oil sump. To avoid any misunderstanding, use the specification below to order the engine for your Falco.

Lycoming IO-320-B1A engine with

Alternator:	70 amp 14 volt Prestolite alternator (or 60 amp 14 volt Prestolite alternator)
Starter:	Geared Prestolite starter
Include:	Fuel line, fuel pump to injector throttle body Fuel line, injector throttle body to spider 45° fittings at inlet to fuel pump Long governor studs (for Woodward governor) Starter ring gear support assembly Standard alternator supports (i.e. not air-conditioning idler-pulley type) Oil Filter
Accessories:	Alternator, starter, magnetos (2), mechanical fuel pump. Note: the vacuum pump and propeller governor are <i>not</i> part of the engine.
Features:	1/2" valves Wide Deck or Narrow Deck as specified by purchaser.
Break-in:	Engine run-in according to Overhaul Manual.
Preservation:	Engine preserved for 60 days short term storage with preservative oil.
Other:	Supply 4 Lycoming P/N 74465 spacers for engine mount. If engine ported and dyno tested, please supply data for engine sea level power chart. If in doubt, please call Sequoia Aircraft at (804) 353-1713

Engine Specification: 180 hp IO-360-B1E Engine

This is the 180 hp engine that is most commonly installed on the Falco. It uses a Type 1 Dynafocal engine mount, and the injector is mounted on the aft end of the oil sump. To avoid any misunderstanding, use the specification below to order the engine for your Falco.

Lycoming IO-360-B1E engine with

Alternator:	70 amp 14 volt Prestolite alternator (or 60 amp 14 volt Prestolite alternator)
Starter:	Geared Prestolite starter
Include:	Fuel line, fuel pump to injector throttle body Fuel line, injector throttle body to spider 45° fittings at inlet to fuel pump Long governor studs (for Woodward governor) Starter ring gear support assembly Standard alternator supports (i.e. not air-conditioning idler-pulley type) Oil Filter P/N 74207 elbow. (45° elbow for the injector).
Fuel injector:	Change the standard Bendix P/N 2524054-10 (P/N 2524297-10?) injector so that the injector will be externally identical to the Bendix P/N 2524145 for the IO-320-B1A,
specifically:	<ol style="list-style-type: none"> (1) Install a throttle shaft of a P/N 2524145 so that the throttle arm is in the "open" position when the arm is toward the front of the engine. (2) Replace the bent mixture control arm with P/N 2522004 straight arm. (3) No ball end fitting installed in mixture control arm. (4) Install fuel inlet on mixture arm side. Use normal straight fitting. (5) Install fuel outlet on name plate side of injector. Use normal 90° fitting. (6) Install the fuel injector on the engine with the throttle arm on the starboard side and with the mixture control arm toward the center of the airplane. <p>These details are shown in Sequoia Aircraft Drawing No. 131, available to</p>

	engine overhaulers on request.
Accessories:	Alternator, starter, magnetos (2), mechanical fuel pump. Note: the vacuum pump and propeller governor are <i>not</i> part of the engine.
Features:	1/2" valves Wide Deck or Narrow Deck as specified by purchaser.
Break-in:	Engine run-in according to Overhaul Manual.
Preservation:	Engine preserved for 60 days short term storage with preservative oil.
Other:	If engine ported and dyno tested, please supply data for engine sea level power chart. If in doubt, please call Sequoia Aircraft at (804) 353-1713

Description: Mattituck New-Limits Overhaul

Engine overhauled to new limits as specified in Avco Lycoming Direct Drive Overhaul Manual. Starter, alternator (or generator) and magnetos overhauled.

Mandatory replacement parts include the following:

- Connecting rod bearings and main bearings
- Pistons, piston rings and piston pin plugs
- Connecting rod bolts and nuts
- Camshafts and tappets (These may be replaced with re-ground ones.)
- All valves, valve guides and seats
- All gaskets and seals
- Sparkplugs and ignition harness
- Oil pump gears
- Mechanical fuel pump

Engine run-in for 35-45 minutes in a test cell.

Warranty. Full warranty on engine and accessories for 6 months and unlimited time. After six months the engine is covered by a pro-rated on 40 hours per month or actual time (whichever is highest) to the TBO of the engine. No warranty on accessories after six months.

Mattituck Air Base, Airway Dr., Mattituck, N.Y. 11952. Telephone: (516) 298-8330. Fax: (516) 298-8412.

Description: Don George Aircraft Engines Overhaul

Don George Aircraft Engines has been operated for years at Dick Waters, Inc. Don George carries on the business he bought from his father-in-law. This company specializes in supplying engines to homebuilders. In the past, Dick Waters specialized in service-limits overhauls and gained a reputation as a supplier of engines with a sometimes uneven reputation. Don George is now doing a better job and the engines are overhauled to new limits with a few exceptions, listed below. Don George prefers to sell you an engine outright. They already have a ready supply of engines.

As a homebuilder, you are not required to have the engine certified, and the paperwork involved in "yellow tagging" everything can be substantial. Engines sold by Don George as "Experimental" are not certified. If you want to buy a certified engine, Don George can accommodate you, but at higher cost. Mandatory replacement parts are:

- Connecting rod bearings and main bearings
- Pistons, piston rings, piston pins and piston pin plugs
- Connecting rod bolts and nuts
- Exhaust valves, valve guides and seats
- All gaskets and seals
- Sparkplugs and harness
- Oil pump
- Mechanical fuel pump

Don George's engines are overhauled to new limits with the following exceptions:

1. The intake valves, guides and seats are not automatically replaced.
2. Accessory case gears are not automatically replaced.
3. Engines sold as “Experimental” engines are not certified.

Engine run-in for 35-45 minutes in a test cell.

Warranty for homebuilders is a 90-day unconditional warranty from the date of starting the engine. The Electrosystems harness is warranted to the TBO of the engine. There is also a one year/480 hour warranty, but this was unclear—something about “if our fault, we’ll fix it.”

Don George supplies the IO-320-B1A for \$7,995.00 outright. This includes the starter ring assembly but not the alternator or the engine mount spacers. The IO-360-B1E sells for \$8,995.00 outright. This includes the 45° induction adapter and the starter ring assembly, but not the alternator.

Don George Aircraft Engines, Inc., 1325 Washington St., Bldg. B-8, Orlando, Florida 32805. Telephone: (407) 422-0188.

Description: High Performance Engines Overhaul

High Performance Engines overhauls engines to new limits and does additional work to the engines to gain additional performance. If you want a standard plain vanilla overhaul to factory new specs, this is not the place to go. High Performance takes a Lycoming to new levels of performance. First a few words about their overhauls. Mandatory replacement parts are:

- Connecting rod bearings and main bearings
- Pistons, piston rings, piston pins and piston pin plugs
- Connecting rod bolts and nuts
- Camshafts and tappets
- All valves, valve guides and seats
- All gaskets and seals
- Sparkplugs, fine wire iridium or platinum plugs only
- Bendix or Slick ignition harness
- Oil pump body and gears
- Mechanical fuel pump

In addition to the overhaul of the engine, High Performance does a number of things to the engine to improve the performance and reduce the vibration. The cylinders are “ported”, which means that the intake ports are polished and ground so that the air will flow in more easily. This will increase the power output of the engine, or—if you operate at reduced power settings—will increase the efficiency of the engine. All cylinders are checked on a flow bench to insure that the flow to each cylinder is very nearly the same. This insures that each cylinder will get the same amount of air, and it contributes to a smoother running engine.

The cylinders and other reciprocating parts are carefully weighed and a matched set is installed in the engine. This does nothing for engine power, but it does mean the engine will have less vibration. If you wish, high compression pistons can be installed to increase the power of the engine. High Performance says that about 80 percent of engine smoothness comes from balancing the flow of air to the cylinders and that the other 20 percent comes from mass balancing the components.

High Performance does a number of things to the engine to improve the operation and quality of the engine. Many of these things are very small refinements. For example, on the 150-180 hp Lycomings, they install piston cooling nozzles in the case. These squirt oil on the pistons and transfers some of the heat to the oil. This is what Lycoming does on the 200 hp engines anyway. Like all of the “modifications” to the engines, the things that High Performance does are very small refinements. High Performance’s literature details the many other refinements to the engines.

The increase in engine power is the result of a greater fuel/air mixture entering the cylinder and being burned—and not from any reduction in friction. This is the same as the increase in power from any other conventional means such as ram air induction, supercharging or turbocharging—the engine is doing more work! With low-compression pistons, a “180 hp” Lycoming will produce 168 hp, while the same engine will put out more than 200 hp with the full treatment from High Performance Engines.

There is a direct relationship between power output and engine wear and reliability. Grace Hopper says of warships, "A ship in harbor is safe, but that is not what ships are for." The same is true of engines. The performance increases come from more fuel burned and greater torque at a given manifold pressure and rpm. There will be some additional wear on the main bearings, but this is probably not significant.

The balancing of the reciprocating parts and the flow-balancing of the induction system will help with reliability. With all other things being equal, a smoother engine will be more reliable and will cause less vibration to the cowling, baffling and airframe.

It is impossible for anyone to say with any certainty if these offset each other. Our guess is that the difference in reliability is too close to be noticeable. Remember too that you do not have to operate these engines at the same power settings as other engines. If you throttle back so that your 65% power setting is the same as another's 75% power setting, you will have the same strain and wear on the engine.

High Performance can install higher compression pistons for even more horsepower. In this case the choice is a simple trade-off of power vs reliability. Our advice is to stay away from the 9 and 10-1 compression pistons since there is not enough statistical evidence of the reliability of the engines. But if you've got to have the most power possible, the high compression pistons will give you more power.

In our opinion, an engine overhauled by High Performance Engines is the ultimate engine you can install in your Falco. If you want the absolute best, this is it. The engine will be smooth and powerful, and you can operate it at reduced power settings for more efficient operation or you can pour on the coals and run circles around all your friends. High Performance charges \$11,000 to overhaul an IO-320-B1A or IO-360-B1E.

If you have an engine overhauled by High Performance Engines, request that they get enough data points on the dynamometer to construct a sea level performance chart. You will need three dynamometer runs:

- (1) Full throttle run. Their normal dynamometer run at full power.
- (2) Medium power run. At 25" MAP, run the engine at 2700 rpm and back the dyno down to 2000 rpm.
- (3) Low power run. At a low MAP (about 18" MAP or as low as possible and still be able to maintain 2700 rpm) run the engine at 2700 rpm and then back the dyno down to 2000 rpm.

This engine data is needed to for performance flight testing. We are working on a flight test guide which will allow you to test your Falco and produce performance charts for the speed, range, fuel consumption, etc., and accurate engine power data is essential.

Recently an article appeared in *The Aviation Consumer* regarding some problems that were reported to the magazine. The controversy centers around John Youngquist, owner of Graphics Engines Monitors. Mr. Youngquist took delivery of six cylinders for the Continental IO-470 engine in his Bonanza. After 22 hours, all six cylinders were burned up. Associates of Mr. Youngquist now admit that Mr. Youngquist was engaged in a race with another aircraft (he lost) and ran the engine as hard as he could. Continental engines are rated for full power for only five minutes. Mr. Youngquist demanded new cylinders. High Performance agreed to replace the cylinders if Mr. Youngquist would return the damaged cylinders, since they wanted to know what had gone wrong. Mr. Youngquist refused to return the cylinders and High Performance reports that he said "If you don't do exactly what I want you to do, no matter who's at fault, then I will use *Aviation Consumer* to ruin you."

We have talked to the reporter at *Aviation Consumer* regarding this. His conclusion is that over a three-month period in 1986—when Terry Capehart had just sold the business to John Watkins, while they were short of help, and while the new owner's wife was dying of cancer—High Performance Engines let their quality control slip and shipped a few bad engines and had the distinct misfortune to ship a few marginal cylinders to the hard-charging, abrasive Mr. Youngquist, who was already angry with High Performance over the late delivery of the cylinders. The reporter also feels that in porting the cylinders High Performance may have exceeded its legal limit to modify the engine without obtaining an STC. He reported that the cylinders were examined by George Altgelt (Altgelt invented the process of chrome overhauls and is the acknowledged expert on

aircraft cylinder design) who reported that at least one of the cylinders had not been honed and thought that too much metal had been removed from around the intake valve on the one cylinder he cut in two. He also said that *The Aviation Consumer* has received a few letters from owners of Continental engines who reported some problems with their cylinders ported by High Performance.

The reporter had talked to many people who have bought engines from High Performance and noted that most report a high degree of satisfaction. One Mooney speed merchant has bought 25 engines from High Performance and was happy with the engines with the exception of some chrome cylinders, all of which were “furious oil burners”. They report that High Performance very willingly replaced the cylinders and were much easier to deal with in this regard than the Lycoming factory. The *Aviation Consumer* reporter also mentioned that he had not heard of any similar problems with Lycoming engines overhauled by High Performance.

In ordinary circumstances, an engine that has been ported will run about 10°F cooler due to the higher flow of air, better exhaust scavenging. Our take on the Youngquist brouhaha is that High Performance may have been a little too aggressive on porting and thinned down the cylinder head, but that this had nothing to do with six equally overheated cylinders. Okay, so maybe some of the cylinders were not honed but this would not have caused all six cylinders to have burned up.

It sounds to us like Mr. Youngquist overheated his engine and wants to blame someone else. Remember, Mr. Youngquist is the proud designer of an engine monitor that is supposed to warn against overheated cylinders. It couldn't *possibly* be his fault—not if he wants to continue to sell the monitors! And when you consider that High Performance consistently gets praise from its customers for fixing problems and replacing parts, Mr. Youngquist comes across as having been unreasonable.

Continental has always gotten a little more power out of their engines than Lycoming, and as a result they have been a little less tolerant of abuse. High Performance is in the process of getting an STC for the porting and as part of this has developed a method of checking the thickness of the metal. They have found a surprising variation in the thickness of the metal on the cylinders they receive. High Performance has overhauled more than 2,000 cylinders and a few problems with Continental cylinders is not surprising.

Inverted Oil System

If you plan to install a Christen Inverted Oil System on your Falco equipped with an IO-320-B1A or IO-360-B1E, you will need Christen Kit No. 801-4 Basic System Kit, 811-A Angle Fitting, 812-2 Weld Boss Kit. The optional hose kits (you only need one of these) are 807-4 Deluxe Hose & Fitting Kit and 808-4 Basic Fittings Kit.

For other model engines, please refer to “Inverted Oil Systems”, available from Christen Industries.



Figure 1. This shows the installation of the sump fittings on an IO-360-B1E (Dan Dorr photo)



Figure 2. Another photo of the sump. (Dan Dorr photo)

From Dan Dorr: As I recall, I used the hole for the drain plug for one fitting (attaching a “T” fitting to retain the drain function). The other fitting required drilling a hole in the sump and welding in a threaded boss which was supplied with the inverted oil kit from Aviat (formerly Christen). I took my IO-360-B1E to an engine shop to have the the sump modified, and these photos show the installed results.

Engine Overhauleders

AAR Western Skyways, Inc., Portland-Troutdale Airport, Troutdale, OR 97060. Telephone: (503) 665-1181. A quality overhauler, specializing in larger engines.

Air-Tec, 1339 West Washington St. Orlando, FL 32805. Telephone: (800) 366-4746, fax: (407) 648-4617. Dick Waters is the owner of this business.

Aviall G & N Aircraft, 1701 E. Main St., Griffith, IN 46319. Telephone: (800) 348-9220 or (219) 924-8330. A quality overhauler working on all engines.

Barrett Performance Aircraft Inc, 2870B North Sheridan Road, Tulsa, OK 74115. Telephone: (918) 835-1089. A small, high-quality shop specializing in experimental and modified aircraft engines. Work includes polishing, porting, flow balancing, static balancing and dyno testing of every engine.

Piedmont Aviation, Inc., P.O. Box 2720, Smith-Reynolds Airport, Winston-Salem, NC 27102. Telephone: (919) 767-5476.

Don George Aircraft Engines, Inc., 1325 Washington St., Bldg. B-8, Orlando, Florida 32805. Telephone: (407) 422-0188. Fax: (407) 422-0836.

Firewall Forward, 140 N. Racquette Dr., Ft. Collins, CO 80524. Telephone: (303) 669-6185. Fax: (303) 669-1044. A quality overhauler which specializes in high performance work similar to that performed by High Performance Engines. Contact Dick Demars.

Lake Aero Styling and Repair, 4725 Highland Springs Road, Lakeport, CA 95453. Telephone: (707) 263-0412. Fax: (707) 263-0420. Mooney service center that frequently has engines for sale either as overhauled or cores. Does some overhaul work. Contact Paul Loewen.

Mattituck Air Base, Airway Drive, Mattituck, NY 11952. Telephone: (516) 298-8330. Fax: (516) 298-8412. A quality overhauler working on all engines. Contact Mahlon Russell.

Nick Carter Aviation Supply, 2116 West G St., Elizabethton, TN 37643. Telephone: (800) 251-7050 or (615) 542-2032. Fax: (615) 542-2633. Lycoming distributor and overhauler of engines. Contact Bob Carter.

RAM, Waco, Texas. A quality overhauler specializing in “premium rebuilds”.

Schneck Aviation, Inc., Stinson Municipal Airport, San Antonio, TX 78214. Telephone: (512) 924-9261.

T.W. Smith Engine Co., Hangar No. 1, Lunken Airport, Cincinnati, OH 45226. Telephone: (513) 871-3500. Fax: (513) 533-2444.

Victor Aviation Service, Palo Alto, California. A quality overhauler specializing in “premium rebuilds”.

Other Sources

Aircraft Accessories of Oklahoma, 2740 No. Sheridan, Tulsa, OK 74115. Telephone: (918) 835-9924. Overhauler of Bendix fuel injectors. We thank Pete Popplewell for explaining the difference between the injectors for 160 hp and 180 hp engines.

Av-Pac, P.O. Box 81539, Lincoln, NB 68501. Telephone: (800) 228-1836 or (402) 475-4125. Full line parts outlet for engine parts, new, used and overhauled.

El Reno Aviation, Inc., Box 760, El Reno, OK 73036. Telephone: (405) 262-2387. A good source for odd engine parts such as alternator brackets. This company parts out lots of engines.

Engine Components, Inc., 9503 Middlex, San Antonio, TX 78217. Telephone: (512) 828-3131, (800) 531-7398 Telex 767311, EasyLink 62942770. Engine Components does not do overhauls of complete engines, but they do overhaul the various parts—cylinders, crankcase, cam shaft and lifters—and they magnaflux connecting rods. They are the largest in this business and have an excellent reputation.

Global Aircraft Part, 5412 N. Rockwell, Bethany, OK 73008. Telephone: (405) 495-8000. One of the two largest light aircraft dismantlers in the U.S. They have a good stock of common engine parts.

McElroy Aircraft Salvage, Box 221, Shelbyville, IL 62565. Telephone: (217) 774-3968. One of the two largest light aircraft dismantlers in the U.S. They have a good stock of common engine parts.

Norm Bender, Inc., P.O. Box 30343, Memphis International Airport, Memphis, TN 38130. Telephone: Norm Bender is a well-known discounteer of Lycoming engines. He is not a Lycoming dealer, but he is always able to get a new engine at a low price. He freely admits that his “game” is that he sells the cores to homebuilders for more than Lycoming pays, thus he can sell a new engine below dealer cost and still make money by selling the core. The run-out engines are sold by a related company: Memphis Power...???

Trade-A-Plane, P.O. Box 929, Crossville, TN 38555. Telephone: (615) 484-5137. Best place to find an engine.