VACUUM SYSTEM SERVICE

Failure to follow the following instructions may result in death, bodily injury, or property damage.

So goes the warning from Air borne Air and Fuel Products regarding the use of their vacuum system products for flight under Instrument Flight Rules (IFR). It doesn't exactly inspire confidence in that $400 dry-air pump affixed to the back of your engine but it does describe the all-to-common result of indiscriminate failures that occur without warning and generally, without apparent cause.

With a 20% increase in the number of active instrument rated pilots over the last 20 years and considering that there are some 18 million IFR operations conducted annually across the United States, it stands to reason that some of the two thousand plus accidents occurring each year in General Aviation, are the result of a loss in aircraft control due to spatial disorientation; That condition which renders the pilot unable to recognize his position or attitude and typically, results in the immediate peril to life and limb.

Vac Sources, Wet, Dry and Static

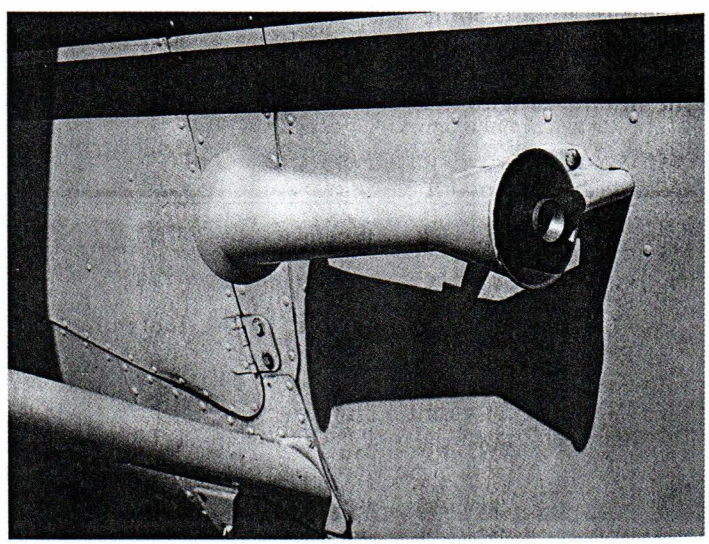
Light aircraft used in the 1940's operated basic gyro instruments with minimal control and limited capacity. Bulky, fuselage-mounted venturis were standard equipment on many single engine aircraft and vacuum performance was a direct reflection of aircraft speed. Plumbing from the vacuum air operated gyros went directly to the low pressure side of the static venturi and as the aircraft gathered speed, a low pressure drop at the venturi source would pull air through the instruments. Ground operation prior to take-off and slow climb speeds would not pull a sufficient amount of air through the heavy instruments and gyro spool-up was slow at best. While simple and trouble free, these older systems fell from grace when the engine driven vacuum pump was introduced in the late 1940's and early 1950's.

The wet pump system could provide nominal system vacuum of 4.5 inches of mercury differential at any engine speed above idle and gyro spool-up was measured in minutes rather than knots. Driven off a standard AN pad on the engine, the wet vacuum pump received a small supply of oil from a galley drilled in the pump drive boss and oil was allowed to dribble into the vane chamber. This oil was primarily used for lubrication but it also helped to form the necessary vane tip seal. An air/oil separator was needed to remove the oil vapor and mist from the vacuum pump discharge air in order to return the oil flow back to the engine. A series of low pressure hoses and fittings attached to the accessory case provided a means of return for the oil and discharge air was released below the separator canister.

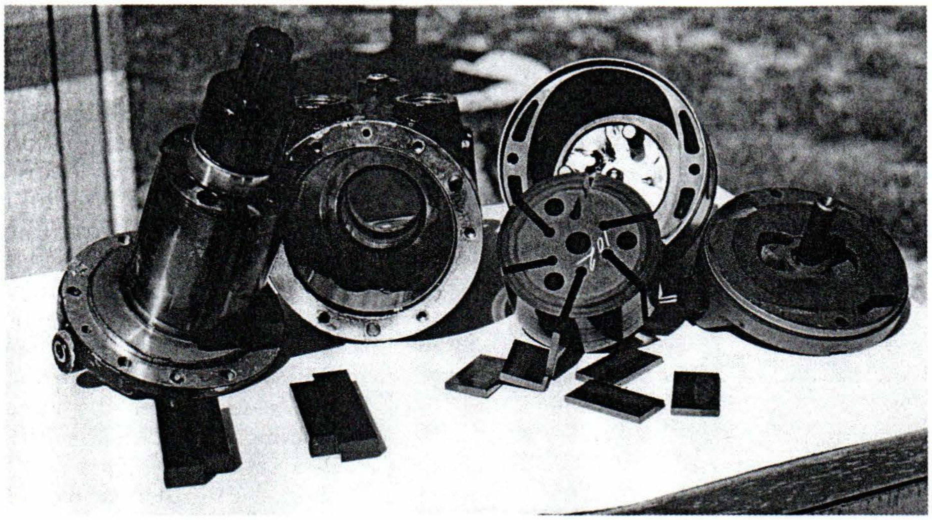
The reliability of the new wet pump system was primarily of question of external plumbing problems and oil separator maintenance. The system worked extremely well and wet style vacuum pumps became standard equipment on most all light aircraft. Their only drawback had to do with the complexity of the design, weight concerns and the mess found with the ever-leaking air/oil separator. Aside from those obstacles, the wet pumps lasted a long time and even performed well when completely worn out.

In the interest of making the wet vacuum pump system less complex and more esthetically pleasing, the wet pump was replaced by a new dry style vacuum pump introduced by the Airborne Company in 1957. This conversion, still offered today, allows for the removal of the wet pump system, along with the related hoses, separators, fittings and brackets. In its place is installed a dry type, vane style pump with only an inlet and exit fitting for plumbing. The new pump sits on the same AN pad with a gasket designed to block any oil flow through the drive area and the inlet to the new pump is connected directly to the vacuum regulator. All other system components and general vacuum system operation remain unchanged.

The dry-air pump is the standard used today for all light aircraft. Simplicity of design combined with clean operation and relatively durable performance make the dry-air pump a desirable alternative to the long lasting wet pump. For aircraft in which an air/oil separator is standard equipment, wet pumps are still used, however, many of the 300 and 400 series Cessnas, the Beechcraft twins and



Fuselage mounted venturi installed on a Cessna 140.



Wet and Dry style pumps. Note: four vanes on the wet pump, six on the dry style.

older production Pipers have been converted to the dry series pumps. All new production aircraft have replaced any wet system with a dry type pump, giving in to the lower life expectancy of the newer pump designs.

Normal Wear and Tear

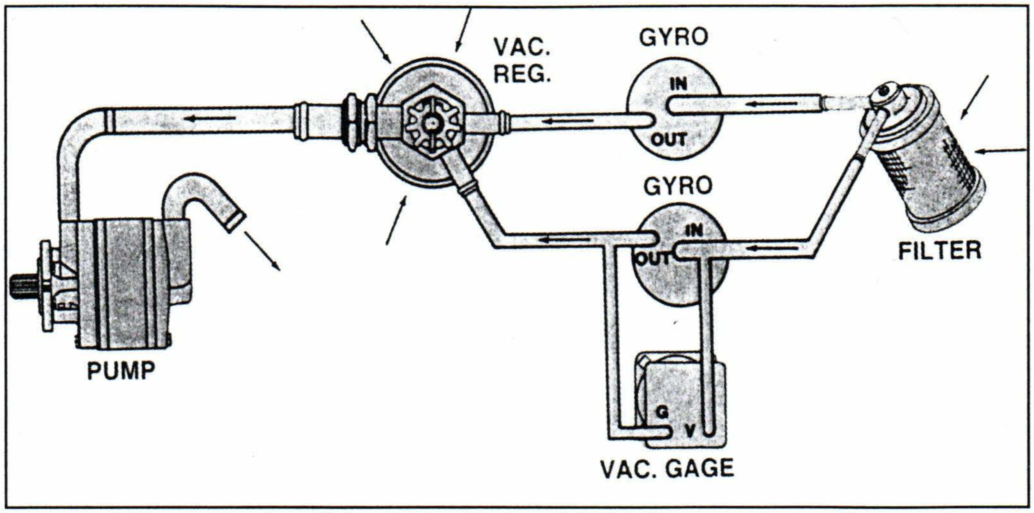
The typical dry vacuum pump is made up of nothing more than a set of six carbon vanes loosely held within a rotor which spins inside a pump housing. The vanes are rounded on the edges with a slight rake against the drive direction. Some pumps are bi-directional and are equipped with vanes that remain straight within the rotor. When the pump turns, the vanes are flung out against the housing and affect a seal against the smooth housing liner. The amount of air flow through the pump is determined by pump RPM and system regulator adjustment. The higher the speed, the higher the vacuum. Many Lycoming engines turn the vacuum pump a maximum of 3500 RPM at take-off power. Some Continental engines are spinning the pump drive at 4050 RPM. While pump wear is related to rotor speed, adverse vane wear and pump life has a direct relationship with the amount of internal heat generated by the pump and inlet air conditions. High altitude and hot pump operation will accelerate vane wear and lessen the life expectancy of any dry type vacuum pump. While pump manufacturers have changed some vane materials to offset the adverse wear characteristics, the limitations placed on the delicate design of the carbon vanes doesn't allow for any excess slop between the vane and the rotor slot. When the vane wears on the loaded face, a powder contaminant is produced. This debris by itself is not cause for immediate concern, however, the wear pattern will allow some shifting of the vane in its slot. When the vane moves too freely in the rotor, catching of the vane and chipping of vane material create large pieces of contaminant that get caught between the vanes and the housing. It is this free-floating contamination which acts to bind the vanes and seize the pump, usually resulting in the shearing of the plastic drive gear and failure of the pump.

If pump life is related to extremes in operating temperatures and high, dry-air environments, then it stands to reason that some pumps installed in turbocharged aircraft would fail more often than their low powered, normally aspirated counterparts. Generally speaking, they do. The Cessna P210 will destroy a new vacuum pump in as little as 400 hours when a Cherokee 180 might get 1000 hours or more on a single 200 series pump. Aircraft equipped with de-ice boots and dual flight panels place additional stress on the vacuum pumps and these systems usually require pumps of larger capacities. Regardless of the installation and the size of the pump, heat generated within the housing, pump speed and very dry air conditions all combine to determine the life of your vacuum pump. Unfortunately, your usually the last to recognize the wear and the first to find the failure.

System Description

The typical vacuum pump system is made up of a central air filter, a vacuum regulating valve, a vacuum pump or source and the necessary lines, fittings and clamps. Other, more sophisticated systems, use in-line filters, de-ice boot valves, sonic venturis, check valves and a variety of isolating devices to keep two or more intermixed systems separate from each other. Regardless of the installation, the principles of operation are basically the same for all.

The engine driven vacuum pump is located at the end of the system and functions to pull air through the vacuum operated flight instruments. Cabin air is pulled through the central gyro filter (the beginning of the system), through all lines and instruments, past the vacuum regulator and finally exits the output side of the vacuum pump. In a pressure system, the vacuum pump becomes a pressure pump and instrument air is pushed through the panel rather than pulled. The principle of operation is the same, however, the order is reversed. In a vacuum system, the central filter cleans the air introduced to the instruments and vacuum pump. The vacuum regulator is equipped with an adjustable bleed valve which can be reset to obtain correct vacuum pressure. This calibrated bleed will control the amount of vacuum applied to the system by allowing air to be sucked into the system from outside the instrument loop. It is usually located underneath the instrument panel (as is the central filter) and is generally located very close to the vacuum pump source. It too, is supplied with a foam filter which cleans the relief air pulled into the system. The central filter should be changed every 500 hours and the vacuum regulator filter should be replaced each 100 hours. Airborne recommends they both be changed at every annual. How often the filters are changed should be based on your environment, both in and out of the cabin. Dusty conditions and smoke particulate clog these filters very quickly and a dry-air pump is very sensitive to any contamination at all. Of course, no filter change is going to mean a thing if the system has developed leaks at lines or fittings. If the



Typical single engine vacuum system.

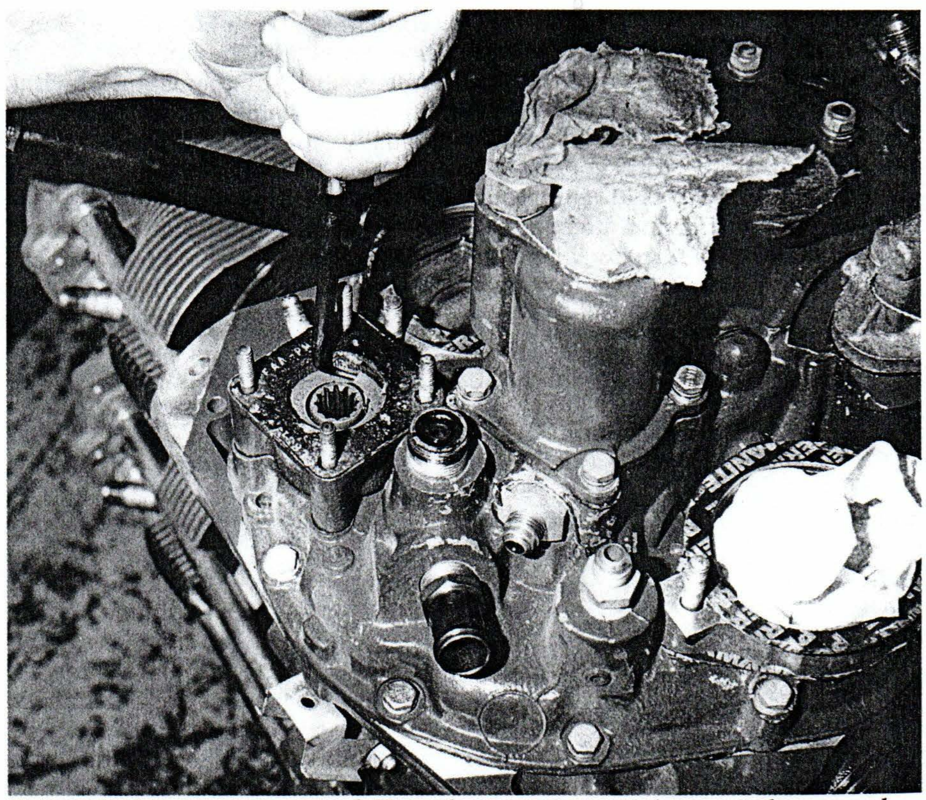
though, expect a failure at some point in life. When it happens, some precautions should be made to eliminate the potential contamination of the new pump by debris from the failure. Flush all lines going to and from the pump with dry, compressed air. Inspect or replace filters and clean the vacuum regulator. Make sure all fittings are clean and not trapping any residue from the vane disintegration. Most often, true vacuum systems don't distribute much in the way of debris through the failed system. However, a pressure system, one that pushes air through the instruments, can blow carbon dust and chips past the in-line filter and clog the small screens installed in the inlet to the instruments. On twin engine aircraft, some of the contamination from the failed pump can make its way to the manifold check valve thereby providing the good pump with the same contamination that destroyed the failed pump. In all cases, regardless of the system

vacuum gauge indicates a lower than normal reading, check the system for leaks before adjusting the vacuum regulator. Compensating for a leak by jacking up the regulator will allow unfiltered air to contaminate the pump and, ultimately, lead to complete pump failure. Loose clamps, cracked lines or damaged fitting threads all lead to system leakage and should be repaired when found. Also note that all fittings are to be installed dry (or sprayed with silicone and allowed to dry) and torqued only enough to be secure. Don't use any form of thread seal and keep the breaker bar in the tool box. One to one and a half turns on the fitting are enough to keep the fitting secure.

Check closely for signs of vacuum pump drive seal leakage. The drive end of the pump must be clean and free from oil or grease. Any oil leakage from the pad drive seal is reason enough for seal replacement. These Garlock seals can wear the vacuum pump drive gear resulting in a groove cut around the gear circumference and, typically, end up generating oil seepage from the pad. The seal can be replaced by drilling or punching a small hole in the metal part of the seal and gently prying the old seal out of its boss. Be careful not to damage the soft aluminum pad area. After the seal area is completely cleaned of any grease, oil or old sealant material, install the new seal with a small amount of Locktite around the outside of the seal cage (not on the rubber part of the seal) and gently tap in place. A large, twelve point socket will work well to seat the seal and still allow room for the gear to fit inside the socket diameter.

All This and it Blows Up Anyway

Don't be discouraged. Vacuum pumps are very sensitive components and the only sure way to keep one from shearing the drive or otherwise self destructing is to leave it in the box. For those who wish to use their pumps



Removing the vacuum pump seal. Note: the vacuum pump adaptor can be removed from the engine in this picture which means that prying the seal out is unnecessary.

design, flush the lines and change the filters as a minimum.

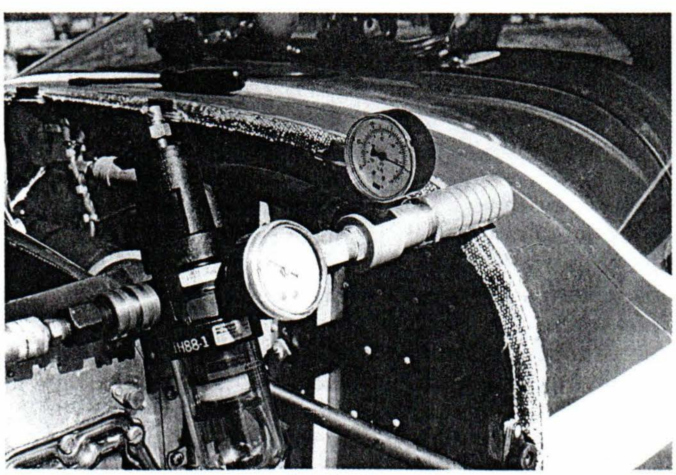
New, Used and Rebuilt

There are several sources for new vacuum pumps and a couple of outfits that supply rebuild kits. Parker Hannifin, parent company to the Airborne Division, Air & Fuel Products, 17325 Euclid Ave, Cleveland, OH 44112-1290, phone: 216-531-3000 and Sigma-Tek (formally Edo-Aire), 1001 Industrial Rd, Augusta, KS 67010, phone: 316-775-6373 are the major suppliers of factory new pumps. Rapco, Inc. 445 Cardinal lane, Hartland, WI 53029, phone: 414-367-2292, supply rebuild kits and overhauled vacuum/pressure pumps for all light aircraft at about half the normal cost for a new Airborne or Sigma-Tek pump. While Airborne does not recognize or authorize the rebuild of any of their pumps and Sigma-Tek maintains that their pumps can't be overhauled, the rebuild process continues to flourish. Unlike the Piper Seneca owner who acquired a Rapco kit and rebuilt his Airborne pump on his living room table, some rebuilt units go beyond the 16 minutes of operation found with the Seneca effort. To say the rebuild is a delicate matter is an understatement. If your flying is strictly VFR and your vacuum operated flight instruments are basically filling the holes in the panel, then acquiring a Rapco kit or similar FAA/PMA replacement can be had for around $115. For the not-so-daring, a rebuilt vacuum pump can be purchased for just under $195. Aircraft frequently operating in IMC conditions will probably insist on going with a factory new pump with all the normal precautions during installation. Pricing for new Airborne pumps run in the $400 to $500 range with Sigma-Tek selling slightly lower in price. Regardless of the pump option you buy, a cooling kit can extend the life of your pump well beyond normal expectations. Rapco provides cooling kits for most models of pumps for under $60 and while installation can take longer than the directions lead you to believe, the work involved will pay dividends down the road.

Loaner Airborne Test Kit 343 .

System Adjustment and Testing

The set-up and adjustment of the typical single-engine vacuum system consists of insuring that the pneumatic loop is clean and secure and setting the vacuum regulator to the prescribed system pressure. The vacuum regulator is adjusted with a jack screw held in place by two bend tabs. Move the tabs away from the screw handle and turn the adjusting screw in to increase the vacuum and out to decrease the pressure. The vacuum regulator is usually mounted underneath the instrument panel, close to the firewall or it may be installed in the engine compartment. Where appropriate, the regulator can be adjusted with the engine operating in a cruise configuration, however, some installations make this a hazardous practice. When in doubt, adjust the valve with the engine off and then check your setting at cruise RPM.



Regulator P/N 1H88-1 is plumbed to the system replacing the vacuum pump source allowing for system troubleshooting.

Airborne test kit #343 provides an easy means to replace your engine operated vacuum pump with a box designed to supply system vacuum and pressure on demand. This kit will easily check the setting and operation of the vacuum regulator as well as identify restricted filters and fittings. While it won't clean the system or tighten loose instrument connections, it will locate sources of trouble and allow for quicker troubleshooting of the system. These test boxes can be purchased from Airborne for around $600 but a call to the Airborne Technical Service Hotline (1-800-382-8422) will get you a loaner test kit and instruction manual for use on your troublesome vacuum system. In addition to finding the source for plumbing leaks or restrictions, setting the system with this kit will allow you to verify the strength of your vacuum pump, which is something you can't do without the box.

While safety warnings and liability waivers will remain intact for aircraft operating in IMC conditions, especially those without a back-up vacuum system, in-flight pump failure can be avoided and system performance can be enhanced by visiting annually with the various components of your vacuum system. It's not a guarantee, but piece of mind comes at a price for all and the simple vacuum system demands its share.