NEWSLETTER

Carb Heat

Hot Air and Flying Rumours

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May 1998

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Next Meeting:

Thursday May 21, 1998 8:00 PM
Aviation Museum (Bush Theatre)

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Spring Cleaning Sat. May 23

It is that time of year again, and as usual, we will try to get a crowd together on Saturday May 23rd. If the weather gods permit, we can finally finish our paint job at the rear of our hanger, and hopefully we can also finish installing the ceiling in our workshop.

Please reserve Saturday morning May 23rd 9:00 AM, and bring a paintbrush, a broom and some elbow grease along with your usual enthusiasm!

Young Eagles June 13th

With summer fast approaching expect a call from Russ Robinson our new Young Eagles coordinator. I am sure you will support Russ in continuing our fine tradition of hosting first rate Young Eagles events.

July 1st NAM

As usual, we will be supporting the National Aviation Museum's Canada Day celebrations with both a static display and a flying display. Curtis Hillier will be looking for assistance for the inside display. I will be looking for aircraft for our outdoor static and flying display. This is a first rate show, and a lot of fun, so please pitch in and help make it another resounding success. Apparently not only will we have the Snowbirds again, but also an aircraft from the Canadian Warplane Heritage.

April highlights

The April meeting featured an EAA Float Flying video which introduced our members to both the beauty of float flying and many of the special techniques needed for that special corner of aviation.

Workshop Etiquette

One of the most impressive aspects of Oshkosh is always the cleanliness of the site, a sure sign that the EAAers don't litter signs work. While we don't have such a sign in our hanger, I expect all of us to live up to the spirit of the sign. It sure would be nice if someone other than the executive members actually disposed of a full garbage bag.

If you use the lathe or mill, or any of the other machines, please clean up after yourself. If you break a tool please replace it. And please don't use improper belts on the lathe or abuse it. Dick and I had to replace a worn bearing caused by an improper belt which caused excessive side loads.

We will be installing a coin box in the machine shop to encourage donations to defray the cost of wear and tear on the machines. A dollar an hour for either the lathe or mill seems a real bargain to me.

The magnetic base and dial indicator have disappeared. If you borrowed these tools, please return them ASAP.

Joe Broeders Fatal Crash

It is with great sadness that I report the unfortunate loss of Joe Broeders due to an in-flight structural failure of his Skyhopper homebuilt aircraft at Smiths Falls on Friday May 1st.

Those who participated in our hanger 13 visit following our March meeting will recall Joe as the quiet, unassuming craftsman who was working on several projects, most notably a full scale Supermarine Spitfire.

Our condolences go to Joe's wife and family. The family have requested that any donations in remembrance be made to the Joe Broeders Memorial Award program for flight training at Smiths Falls.

May 21st Mtg. at NAM:

Our next meeting will feature an enthusiastic FSS speaker who will refresh our knowledge of weather briefings, and flight plans.

I look forward to seeing you Thursday May 21st at the National Aviation Museum, 8:00 PM start.

Fly Safely friends,

Gary

Why Vacuum Pumps Fail

by Mike Busch (

Modern dry vacuum pumps often fail prematurely--always catastrophically and without warning--usually at the worst possible time. Why do low-time pumps self-destruct, and what (if anything) can you do about it? Read on. This article originally appeared in The Aviation Consumer.

Most small aircraft depend on air-driven gyro instruments powered by vacuum produced by an engine-driven air pump. The vacuum system is a simple one, and it should be reliable and trouble-free. Too often, though, it isn't.

Here's what happens in a typical single-engine airplane vacuum system. Ambient air enters the system through a central vacuum filter, ensuring that the gyros breathe only clean air and are protected from dirt and other contaminants. The air passes through the gyro instruments (where it spins the gyros), then through a vacuum regulator, and finally to the suction inlet of an engine-driven vacuum pump. The pressure outlet of the pump usually discharges its air into the engine compartment. (Aircraft with pneumatic deicers use the discharge air to inflate the boots.)

How Much Vacuum?

Air-driven gyro instruments are designed to operate with a pressure differential of about 5 inches of mercury (about 2.5 psi). The pump is designed to produce plenty of airflow to spin the gyros even when the engine is idling on the ground. At normal flight RPMs, its capacity is much greater than necessary (as much as 20 psi). To maintain relatively constant airflow through the gyros, the regulator permits enough ambient air to leak into the system downstream from the gyros to limit the pressure differential across the gyros to about 5 in. Hg. The regulator is adjustable, and has its own foam air filter to protect the pump from contamination.

The cockpit vacuum gauge is connected to read the pressure differential across one of the gyro instruments (usually, the attitude indicator). The gauge normally has a green arc between 4.7 and 5.2 in. Hg. The vacuum regulator is adjusted so that the cockpit gauge reads about 5 in. Hg.

Most twins and some singles (such as the Cessna P210 and the Piper Malibu) use a redundant system with two engine- driven vacuum pumps. These systems employ dual regulators and a set of check valves to ensure that instrument vacuum remains normal even if one vacuum source fails.

When the system is operating normally there is almost no pressure drop across the central vacuum filter, and only minor pressure losses in the rest of the system. The load on the vacuum pump should not exceed 6.5 in. Hg. in single-engine aircraft. (The max for twins, with their longer hose runs, is 7.0 in. Hg.)

Dry Vacuum Pumps

Since about 1970, our gyros have been powered by "dry" air pumps which use self-lubricating graphite vanes spinning inside of an eccentric aluminum cavity. (Before 1970, oil-lubricated "wet" pumps were used; see sidebar.) Because dry pumps don't use engine oil for lubrication, they don't require an oil separator, and provide oil-free discharge air for deice boots. But dry pumps have one big disadvantage, and that is their singularly unattractive failure mode: they work flawlessly for an unpredictable life span, then fail catastrophically and without warning (usually in a great puff of graphite dust).

The dominant manufacturer of dry air pumps is Airborne, a division of Parker-Hannifin Corporation located in Elyria, Ohio. Airborne manufactures a wide range of air pumps, regulators, filters, check valves, air manifolds, and also control valves for pneumatic deicing systems. Most non-deiced aircraft use Airborne 200-series dry air pumps, while booted aircraft use the larger 400-series pumps.

The small 200-series Airborne pumps list for about $400 and have a rated warranty life of 1,000 hours. But don't feel bad: the bigger 400-series pumps cost $1,200 and are warranted for a paltry 400 hours! Graphite and Plastic

All Airborne pumps are built with a slotted graphite hub and graphite vanes. The hub and vanes rotate within a polished elliptical interior cavity within the aluminum pump housing. The vanes are free to slide in and out of the hub slots as they rotate within the eccentric cavity. Centrifugal force holds the vanes against the cavity wall, providing the requisite air-tight seal.

The pump drive incorporates a frangible plastic coupling that is designed to shear instantly if the pump's rotational drag exceeds normal operating torque by any significant amount. This ensures that a pump failure cannot damage the engine's accessory drive.

Backwards is Bad

The hub slots of Airborne pumps are canted in the direction of rotation. For this reason, Airborne offers different pump models for clockwise and counterclockwise applications. The most common model numbers are 211CC and 441CC (for counterclockwise rotation) and 212CW and 442CW (for clockwise rotation). It's not difficult to break the code.

Installing a wrong-direction pump is a sure prescription for premature failure. Most Continental engines require a clockwise pump, and most Lycomings require a counterclockwise pump. But not always. In fact, twins with counter- rotating props need one of each!

Sigma-Tek vs. Airborne

For years, Airborne had the dry air pump business all to themselves. But in the mid-1980s, Sigma-Tek introduced a new air pump STC'd as a direct replacement for the popular Airborne 211CC and 212CW pumps.

The Sigma-Tek model 005 pump is identical in principle to the Airborne pumps they replace. They use similar free- sliding graphite vanes and a similar eccentric cavity. However, the Sigma-Tek pump uses an aluminum (not graphite) hub with orthogonal (not canted) slots. Consequently, the Sigma-Tek pump can be used for both clockwise and counterclockwise applications.

The Sigma-Tek 005 pump costs about the same as the Airborne 200-series units, and has a comparable warranty. Some folks are convinced that the Sigma-Tek pump lasts longer, but we've seen no hard data to support this contention. On the other hand, if you've had a bad run of luck with Airborne 200-series pumps, it couldn't hurt to give the Sigma-Tek a try.

Why Pumps Fail

Horror stories abound of dry vacuum pumps that fail before their time, sometimes just a few hours after installation. Owners who have been repeated victims of such premature failures often come to believe that obtaining rated life from a pump is a matter of luck, voodoo, or karma.

This simply isn't so. Almost every case of premature dry vacuum pump failure can be traced to one of three causes: contamination, overstress, or faulty installation.

Dry air pumps are extremely vulnerable to contamination, particularly by liquids. The graphite vanes are designed to operate absolutely dry, and the introduction of any liquid can quickly destroy a pump.

One of the most common causes of premature dry pump failure is contamination by solvents used to wash down the engine compartment after maintenance. If solvent overspray enters the pump (usually through the discharge port or the drive coupling), it will mix with the carbon dust in the pump to create a sticky residue. Even a small amount of this stuff can cause the brittle graphite pump vanes to fracture in short order. Consequently, it is absolutely essential to cover the vacuum pump and its discharge tube (usually with a plastic bag) before spraying solvent.

Another common cause of pump failure is oil contamination. Oil can enter the vacuum pump in several ways. One frequently-seen culprit is a leaky pad seal gasket between the pump flange and the engine accessory case. Actually, any engine compartment oil leak that allows oil to get on the pump may find its way inside through the drive coupling. Alternatively, oil that gets on the vacuum regulator will quickly oil-soak the foam garter filter and start being sucked inside the pump itself. If even a tiny bit of oil gets inside a dry pump, it's history.

A dry pump can also be destroyed by carbon contamination. A dry pump normally fails suddenly when a graphite vane or hub fractures, generating a cloud of carbon fragments. When the failed pump stops pumping, residual vacuum upstream of the pump often cause some of these graphite chunks to be sucked out of the pump and lodge in the hoses or vacuum regulator. If the system is not meticulously cleaned of carbon before a replacement pump is installed, the new pump may ingest these fragments. This may result in failure of the new pump in just minutes or hours.

Overworked Pumps

Another cause of short pump life is overstress. This may be caused by a dirty central vacuum filter, a kinked air line, or any other obstruction or construction that causes the vacuum pump to work harder than it should. Refer to Figure 3 for an example of this situation.

Here's a typical scenario. As a result of maintenance or old age, an air hose in the vacuum system becomes constricted (due to kink or collapse). The pilot notices that the cockpit vacuum gauge reads lower than normal, and squawks this condition to his shop. The A& P readjusts the vacuum regulator to bring the vacuum gauge back to normal operating range, without troubleshooting the underlying cause.

The pilot is happy, and the mechanic is happy...but the vacuum pump is now profoundly unhappy because it now has to produce 150% of normal vacuum. A pump that is working too hard will run hot and will ultimately fail prematurely.

Installing Pumps Correctly

Installing a replacement vacuum pump is a quick and easy procedure, but there are some important rules that must be followed to ensure that the new pump can enjoy a long, healthy life.

1. Make absolutely sure that a new Airborne pump is the correct model for direction-of-rotation. A wrong-direction pump looks identical, but won't last long. (Sigma-Tek pumps don't care which way they rotate.)

2. Never clamp a new vacuum pump in a vise when installing the fittings. The soft aluminum pump housing can easily be distorted, ruining the pump. Airborne pumps come from the factory with a red-and-white "anti-vise" decal, but overhauled pumps typically don't.

3. Never use thread compound or Teflon tape when assembling threaded vacuum fittings. Any excess sealant could be ingested by the pump, causing its destruction. Airborne recommends a sparing application of silicone spray on the threads, but nothing more.

4. Make certain that the vacuum system is scrupulously clean before installing a new pump.

Always blow out the hoses with compressed air, replace the central vacuum filter and the regulator's foam garter filter with new ones, and check the regulator seat for trapped carbon fragments. Any contamination left over from the failure of the old pump can (and often does) result in premature destruction of the new pump.

Troubleshooting Tips

Troubleshooting the vacuum system is a process often misunderstood by mechanics. Most shops lack the proper test equipment, and rely on the cockpit vacuum gauge. But the cockpit gauge is a poor troubleshooting tool. It shows only the pressure differential across the gyro instruments; it does not show how hard the pump is working.

Furthermore, it's not uncommon for cockpit gauges to be way out of calibration. For example, the vacuum gauge on one single-engine aircraft was found to require 9 in. Hg. of vacuum to indicate 5.0 in. Hg. on the instrument. The vacuum pump, forced to provide 10.5 in. Hg. instead of the normal 6.5, was being replaced every 300 to 400 hours, along with frequent gyro instrument overhauls.

Proper vacuum system troubleshooting requires special test equipment. Airborne's Model 343 Pneumatic Test Kit includes everything needed to troubleshoot both vacuum and pressure systems for instruments and deice boots: a vacuum source, calibrated gauges, adjustable regulators, and various other special fittings. For small shops that cannot justify the expenditure to purchase this test kit, Airborne's technical service department has several loaner kits that they can make available on short-term loan.

Interestingly enough, one of the most helpful indicators of impending vacuum pump problems is the little red-and-white "anti-vise" sticker that comes affixed to every new Airborne dry pump. A darkening sticker is a reliable indication that the pump housing temperature is hotter than it should be. This usually means that the pump is working harder than it should, and is likely to fail prematurely. It's a good idea to check the color of the vacuum pump sticker at each oil change.

Overhaul vs. New

Sooner or later, you're going to face vacuum pump replacement. You'll have to decide whether to buy a new pump, an overhauled pump, or a do-it-yourself pump overhaul kit.

The first thing you should know is that Airborne's official position is that their pumps are not to be overhauled. In fact, Airborne stamps "Do Not Overhaul" on the pump housing of each new dry air pump they make.

Nevertheless, overhauled dry air pumps are available from RAPCO, Singer, and various other sources. Typical discount-house prices for overhauled 200-series pumps range from $175 to $225 exchange, with a 400-hour warranty. Overhauled 400-series pumps for booted aircraft sell for $550 to $650 exchange. In addition, do-it-yourself pump overhaul kits (containing a new hub, vanes, drive coupling, and gasket) cost only about $70 for 200-series pumps and $135 for 400-series pumps. (These prices come from Chief and San-Val ads in Trade-A-Plane.)

Overhauled vacuum pumps have received reviews that are decidedly mixed. We believe that it is not enough simply to replace the hub, vanes, and drive coupling. If the pump cavity is not polished smooth, then the new vanes won't last long. For that reason, we don't much care for the do-it-yourself pump overhaul kits. And if you opt for an overhauled pump, be careful what overhauler you choose. Ask whether he reconditions and polishes the pump cavity on his rebuilt pumps. (On a purely anecdotal basis, we've had good luck with RAPCO rebuilts, and poor luck with Singer.)

Rebuilts Worthwhile?

Does it really make sense to buy an overhauled pump instead of a new one? For the big 400-series pumps, maybe so. A RAPCO overhaul can be purchased for $600 less than a new Airborne. The author has a 400-series RAPCO rebuilt pump on one engine of his Cessna T310 that has reached 1,000 hours and is still going strong.

For the smaller 200-series pumps, the merits of overhauled units is questionable. The same Trade-A-Plane ads that offer rebuilt pumps for $175 to $225 also offer brand new Airborne and Sigma-Tek pumps for less than $300. The new pumps come with a 1,000-hour warranty, while the rebuilts are warranted for only 400 hours. For the extra $75 to $125, we'd be inclined to go for a factory-new pump.

We'd stay away from the do-it-yourself overhaul kits in any case.

Wet Pumps

Back in the 1960s (when light plane IFR was young), piston aircraft were delivered with so-called "wet" vacuum pumps that used metal vanes and were lubricated by engine oil. The principal manufacturer of wet vacuum pumps was Garwin. These pumps were long-lasting, reliable, and usually did not fail suddenly; they wore out gradually, and eventually required overhaul.

The discharge air from a wet pump contains an oil mist, so these pumps require an oil separator in order to return most of the oil to the engine sump. Even with an oil separator, a certain amount of oil is discharged out the breather (and usually onto the belly of the aircraft).

Consequently, wet pumps aren't great for aircraft with deice boots, because the oil can cause the rubber to deteriorate. Also, pressure-type instrument systems (like the ones used in later-model Bonanzas and Barons) can't use wet pumps because the gyro instruments would become contaminated. with oil.

But if you have an older airplane that uses a wet-pump vacuum system, you might do well to hang onto your old Garwin pump and oil separator, rather than converting to the newer-style system.. In our view, a little oil on the belly is a small price to pay for a vacuum pump that doesn't fail suddenly and without warning.

Pressure Systems

Although the accompanying article talks about vacuum systems, some light airplanes (particularly later-model Beechcraft) use a pressure system to power Figure 4 illustrates the differences in hookup.

Pressure systems use precisely the same dry air pumps and gyro instruments as vacuum systems do. The filters, regulator, and cockpit gauge are different.

Pressure systems suffer from exactly the same problems as vacuum systems do. The dry pumps in pressure systems are equally vulnerable to contamination, overstress, and faulty installation. And the troubleshooting techniques and equipment are essentially the same.

Standby Systems

Because dry vacuum pumps fail suddenly, without warning, and usually at the worst possible time, backup vacuum systems have become popular add-ons for single-engine airplanes that fly serious IFR.

Some airplanes (such as the Cessna P210 and the Piper Malibu) are factory-equipped with dual engine-driven vacuum pumps, much like the system that twins use. The disadvantage of this arrangement is that both pumps are turning (and wearing out) all the time. If one pump fails, the probability of the other pump failing shortly thereafter is decidedly non- trivial.

Several manufacturers (including Airborne themselves) offer STC'd standby vacuum systems that use a dry air pump driven by an electric motor. These are excellent systems, and have the advantage that the standby air pump runs only when needed. Such systems are rather pricey, however.

Precise Flight offers a very inexpensive STC'd backup vacuum system that provides backup power to vacuum-driven gyros by using vacuum from the engine's induction manifold. This system works well, but has several limitations. It does not provide adequate vacuum at high throttle settings (such as one might use when carrying a load of ice on approach). Furthermore, the Precise Flight system should never be installed on turbocharged aircraft (although it often is, erroneously).

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