Cold Weather Operation

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■■ Cold weather is upon us again. A winter wonderland for some, but, for those who fly airplanes, it can be difficult, dangerous and downright ugly.

In addition to challenging flying weather, getting the machinery, especially the engine, to operate properly is one of winter's biggest headaches for the airplane owner. Even so, these headaches can be reduced considerably if you know what to expect, what to do and how to do it.

Once you understand how cold weather affects engine starts and operation, preparing for winter use is not all that difficult.

Fuel and oil are always adversely affected by declining temperatures. Gasoline will not burn in its liquid or visible state. It must evaporate into an invisible, dry gaseous state before it will ignite and burn properly. This evaporation process requires heat and, until the engine has started, the only available heat is ambient.

Aviation gasoline has a Ried Vapor Pressure (RVP) of 6 to 7 psi at 100° F. RVP is a means of measuring the fuel's ability to vaporize. Automotive fuels are produced with RVPs ranging from 9 to 14.5 psi. There are actually five different seasonal blends or ranges.

The petroleum industry regulates the blend or RVP to match seasonal conditions. For example, in an area that is quite warm, such as southern Arizona, one might expect to have his automobile fueled with a gasoline having a volatility range as low as 9 psi. With high ambient temperatures a low volatility fuel would be quite satisfactory and, at the same time, necessary to prevent "vapor locking" (actually vaporizing in the fuel lines to and from the fuel metering equipment).

A motorist filling up in Duluth during January, however, might receive a fuel of 14.5 psi, considerably more volatile and necessary for satisfactory operation under severe cold weather operation. Seasonal volatility changes in automobile fuel is one of the little known benefits the petroleum industry provides its customers.

Aviation gasoline, however, remains 6 to 7 psi on the same volatility range the year around, due to vapor lock requirements for the airplane to carry its fuel to altitude. Decreasing atmospheric pressure, associated with altitude increase, causes the fuel to vaporize more readily at lower ambient temperatures. Also contributing to this condition are the higher operating temperatures and close-fitting cowls of the aircraft engine.

Unlike automobiles, most general aviation aircraft can travel anywhere in the entire United States in less than one day, from an area of severe cold to one that is quite warm, without having to refuel along the way. Proper consideration of these operating factors virtually eliminates the feasibility of seasonal grades of aviation gasoline. This single volatility fuel, which is even lower than the lowest automobile fuel (6 to 7 psi vs. 9 psi), can increase the cold-weather starting difficulties as ambient temperatures decrease.

Engine oil can also make starting difficult. All oils have what is defined as a pour point. The pour point is the lowest temperature at which the oil will still behave as a liquid. Below the pour point the oil becomes semi-fluid or more like catsup, a pseudo liquid. Even at desired, normal operating temperatures (150° to 200° F) oil is viscous and offers friction or resistance to movement. This situation increases as temperature decreases until the pour point is reached.

From pour point down, the oil rapidly approaches a solid. Consequently, the colder the oil becomes, the more force it will require to move it about. The pour point for SAE 50, or Grade 100 oil, is +10° F and it only increases by 10 for SAE 30 or Grade 60 (pour point 0° F). Thus, when ambient temperatures fall to 0° F the starter not only has its usual job of cranking many moving parts to get the engine started, it must also fight the added resistance of very stiff oil. Add to this fuel that does not vaporize well and the prolonged amount of cranking necessary to get the engine started is more easily understood.

Once the ambient temperature is consistently below +40° F it is time to change to winter grade oil. Follow the engine manufacturer's recommendations. Some owners choose to run SAE 40 the year around in SAE 50/30 engines or SAE 30 all year in SAE 40/20 engines. This practice defeats the purpose of both the heavier and lighter oils. It's not only how well the engine starts, but how well the oil lubricates initially that counts. If the manufacturer found such practice satisfactory, he would not have instructed, in the operating manual, that you change grades each season.

There is yet another cold-weather problem—the battery. At 32° F a standard lead-acid battery is reduced to one-half of its normal capacity. That means

Prudent pilots prepare for winter flying weather

that the battery can be counted on for approximately half the cranking time it could deliver at 70° F. Unfortunately, just when you need the most from your battery, you get the least.

Most piston-engine aircraft are equipped with the lead-acid, storage-type battery. I am not exactly certain what the term storage was intended to imply, but I am certain that such a battery does not store electricity. A fully charged battery does not mean that it is fully charged with electrical energy. What full charge does mean is simply that the battery's chemical process has been restored to its full potential. This statement is true only when the battery is brand new.

For example, a 24-ampere hour battery, when new, can deliver 24 amps continuously for one hour before becoming exhausted. If you doubled the 24-amp draw to 48 amps, then the delivery period would be reduced to one-half or 30 minutes. A typical, warm-weather start on a 12-volt system such as a Cessna Skylane may required up to 350 amps initially, then taper off to 150 amps during the remainder of the cranking process. Under zero-degree starting conditions, that initial draw could reach, or even exceed, 700 amps with a considerably higher continuous draw.

In warm weather, a 24-ampere hour battery could sustain a 700-amp load for approximately two minutes before exhaustion—in zero-degree conditions, less than one minute. Even with a reduction to 200 amps continuously, after the initial engagement, you would have maybe three to four minutes, at best, and that's with a new battery.

The battery's total capacity is relative to the amount of plate material it has. Each time a battery is discharged, even a little, and then recharged, some of the plate material deteriorates and falls into the sediment chambers below. Now there is slightly less capacity than before. This process continues with normal use until, eventually, there isn't enough active plate material for even one start.

Although you cannot prevent this normal "wear out" process, you can prolong it by prudent use of your battery. Keeping your engine in top operating condition will go a long way towards prolonging the life of your battery. Keep in mind that allowing a battery to get so low on water that the plates become exposed will also reduce its capacity. The more the battery has to crank the engine to get it started, the sooner it will have to be replaced. As cold weather approaches, consider the age of your battery. It may be starting the engine now, but will it when the going gets tough in cold temperatures?

Poor fuel vaporization, increased lubricating oil resistance and less cranking power from the battery aren't the only adversaries to winter aircraft operation. An extremely dirty and/or excessively oily induction air filter can also add to cold weather starting problems. Although it may seem illogical at first, an air filter heavily impinged with dirt can reduce normal air flow, even during cranking, to the point of causing overly rich mixtures.

Under such circumstances, the engine quickly goes from too lean at the initial starting attempt to too rich to support combustion. Once it has been determined that the mixture is too rich, more cranking with the throttle full open to clear the combustion chambers of excess fuel is necessary.

Under extremely cold conditions, the battery is unable to support that kind of nonsense which usually results in a dead battery before you get a second chance. Be certain that the induction air filter is clean when you face those cold weather starts.

The ignition system may become another wintertime bugaboo. Fouled, oily, worn-out spark plugs may get you by when all else is working well, but weak mixtures, from poor fuel vaporization, coupled with poor compression, from reduced cranking speed, will nearly always drag the battery down before weak or misfiring spark plugs can adequately "light off."

Under average conditions, the massive electrode spark plug will be efficient for approximately 30 hours, after which it will begin to deteriorate. Because they deteriorate quite gradually, you are seldom, if ever, aware of the loss until they begin to misfire. However, one zero-degree morning can quickly make you aware of poor spark plugs. Needless to say, it will be less painful to have your plugs checked and cleaned before the freezing weather sets in.

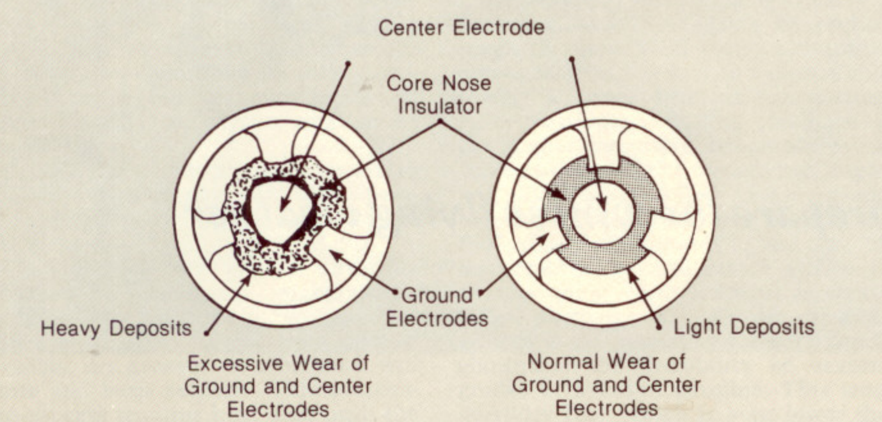
If you wish to check the plugs yourself, look for the conditions illustrated in Figure 1. A good spark plug will have a round, center electrode and the ground electrodes will have a near-matching radius. Excessively worn spark plugs will be quite evident. The center electrode will be worn out of round with the ground electrode having an opposite radius. Also, the core nose insulator should be reasonably free of deposit build-ups. Most service facilities have a spark plug tester and this is the only certain way to be sure of a plug, especially one having had several hundred hours of operation.

Magnetos should also be checked. Improper timing, malfunctioning impulse couplings and/or retarded spark systems can make for hard cold-weather starting. Dirty, oily breaker points from leaking magneto oil seals is yet another contributor to cold starting problems. A deteriorated ignition harness is another source of trouble and such a harness nearly always leaks. You can be certain it will manifest its condition during cold-weather starting.

Aircraft equipped with carburetor-type engines usually employ a separate priming system for cold starting assist. The most common of such systems is a manually operated, plunger-type pump. A ball check valve is provided to admit fuel to the plunger chamber when the plunger is withdrawn. A similar type ball check valve is also provided to exhaust fuel to the primer discharge line, when the plunger is pushed in.

While this device is quite reliable, it can cause fits. Should the inlet check valve leak, the plunger will force a portion of its charge back to where it came from. This behavior isn't readily recognized during operation of the primer and, therefore, may go unnoticed. However, it will definitely increase cold starting difficulties by reducing the amount of fuel delivered to the engine

Figure 1



during the priming operation.

This device has another nasty little surprise if the inlet check valve is leaking and the plunger is not returned to its locked position after use. In the unlocked position, the leaking inlet valve can continue to pass fuel through the primer and into the engine, causing rough idling and excessive fuel consumption. It isn't difficult to check the primer for proper operation and this should be accomplished once each year prior to cold-weather operation.

The electric starter motor, like any other mechanical device, is subject to normal wear and will eventually need servicing. With normal, proper use, the starter motor should perform satisfactorily to engine TBO. Unfortunately, this isn't always the case and the primary reason for premature repairs is due to abuse. By nature of the task it must perform, the starter motor is not a continuous-duty-type motor. Continuous cranking beyond the recommended intervals will cause severe overheating and subsequent damage.

A starter motor should never be operated continuously for more than 90 seconds on an initial starting attempt. If still more cranking is necessary, a full, 60-second wait period should be observed to allow sufficient cool-down of the starter motor. Thereafter, cranking periods should not exceed 30 seconds of continuous operation and should include a 60-second cooling off period between each succeeding attempt. Failure to observe this recommendation even one time can lead to starter motor failure from overheat damage.

If your engine is getting near to TBO and/or you know that your starter motor has been subjected to such over cranking abuse, it may be well worthwhile to have your A & P mechanic inspect your starter motor and its brushes before the cold weather is upon you. Be aware that some starter motors have provisions for periodic oiling of the rear end plate bearing, an often-neglected service item. You might check for this feature on your airplane. If it does, a few drops of SAE 30 engine oil at each oil change will satisfy its needs.

In addition to the starter motor, there is also the starter adapter. This is the drive clutch unit located between the engine and starter motor. Usually these units begin slipping just before they fail. If your engine appears to crank unevenly, or even stops, and then starts cranking again, you could have a slipping starter drive. It should be checked prior to cold weather because, if it's slipping when the temperature is normal, it's a cinch that it won't turn an engine stiff from cold. Incidentally, there are agencies around the country that rebuild these units for considerably less than what a new one costs.

With ambient temperatures down to +20° F, most opposed-type aircraft engines, in proper operating condition, will usually start without too much difficulty. However, here are some steps that will help.

Where a manual primer is employed, unlock the primer and pull it slowly to the extent of its travel. A slow outward movement usually results in better filling of the plunger chamber. Now push the plunger in as hard and rapidly as you can. A hard, fast push on the primer produces higher pressure on the fuel being discharged from the primer nozzles. The ensuing result is better atomization of the discharged fuel, and remember, with the low volatility of avgas every effort counts.

Make at least two strokes of the primer prior to cranking the engine. This helps to accumulate sufficient fuel vapor to alleviate the lean conditions so prevalent with cold starts. Make certain that the primer is full and ready before engaging the starter. Once the engine fires, the primer can be used to enrich the mixture sufficiently to keep it from quitting. Once the engine has started, full carburetor heat for a few minutes will help provide better fuel vaporization.

Carburetor heat is usually provided by an exhaust gas heat exchanger so it will be only seconds until you begin to get some heat from this source and, again, every little bit helps. Since most carburetor heat systems use unfiltered air, avoid such operation if the immediate vicinity is dusty. When carburetor heat is used as a vaporization assist, discontinue its use as soon as the engine operates smoothly without it.

Once the engine has started, attempt to keep the speed below 1,000 crankshaft rpm for a few minutes, until adequate lubrication gets established. Do not attempt to expedite your warm-up by operating with the cowl flaps closed. Such practice can cause hot spots and possibly could overheat accessories. Avoid revving the engine for taxi or runup, until oil pressure settles down and does not exceed the high end red line, unless your operator's manual states otherwise.

The same precaution should be observed with runup. The engine should be ready for takeoff if it will accept takeoff power smoothly and without hesitation. Oil temperature should be off the peg and headed towards the green on non-oil radiator engines and at least in the bottom of the green for oil radiator-equipped engines.

Always observe oil pressure during the takeoff run and immediate climbout. A fluctuating oil pressure needle could be an indication of oil pump cavitation, caused by congealed lubrication oil in the supply sump. A continued takeoff with such indications could prove disastrous.

Ambient temperatures below +20° F may require preheating. If the engine just barely turns over during the initial starting attempts and refuses to light off, you can be reasonably certain that any further attempts will result in nothing more than an exhausted battery.

Continuing to crank an engine under such circumstances can sometimes result in "frosted" spark plugs. Cylinder mixtures, too weak to develop the power to get going, can cause moisture condensation on the spark plugs which then freezes across the gaps during the next inlet charge and the plugs cease firing.

Preheating can be accomplished by a variety of devices and methods. Whatever the method used, the ultimate goal should be to heat the engine oil to a temperature that will permit easy cranking and satisfactory lubrication upon start-up. Thus, the best type of preheat is the method that applies heat directly to the oil sump. Once the oil is heated nothing else matters because, if you get the oil warm enough, you will, in the process, accomplish the other necessary requirements.

It is possible to preheat an engine until the cylinder head temperature gauges are indicating near red-line temperatures and still have congealed oil in the crankcase. Such conditions can and actually have resulted in engine failures during takeoff because the engine started easily, appeared ready for takeoff and then failed from oil starvation, due to congealed oil in the crankcase. Just getting the cylinders hot isn't enough if the method employed does not adequately heat the oil in the sump.

Remember, you put the odds in your favor when you're ready for the cold weather before it gets cold. □