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THE MAG CHECK

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You've been doing mag checks since your first flight lesson, but are you doing them right?

by Mike Busch

From your first days as a student pilot, you were undoubtedly taught to perform a „mag check" as part of each pre-takeoff runup. But do you know how to do it correctly, what to look for, and how to interpret the results? Surprisingly, many pilots don't.

To begin with, most Pilot Operating Handbooks (POH) tell you to note the RPM drop when you switch from both mags to just one, and give some maximum acceptable RPM drop and sometimes some maximum acceptable RPM difference between the two mags. For example, the POH for many TCM-powered airplanes specifies that an RPM drop of more than 150 RPM on either mag, or a difference of more than 50 RPM between the two mags, is unacceptable.

EGT Method

In my view, however, this archaic RPM-drop method makes little sense for aircraft that are equipped with a modern digital engine monitor (as most are these days). EGT rise is a far more reliable and revealing indicator of proper ignition performance than RPM drop. Consequently, I recommend focusing primarily on the engine monitor, not the tachometer, when performing the mag check.

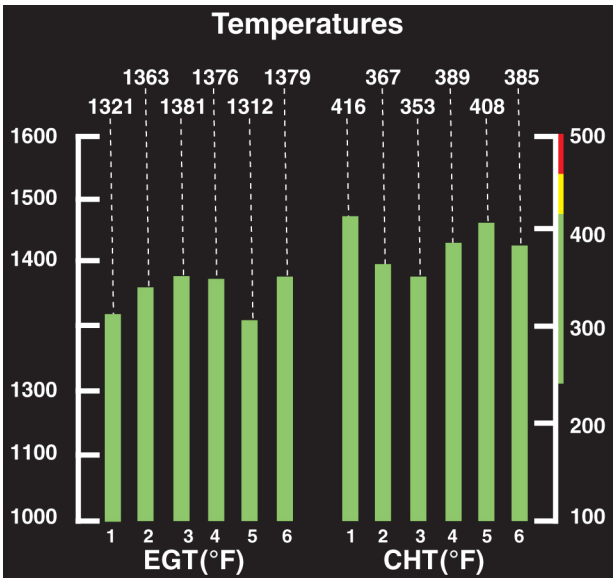

FIGURE 1: *When performing a mag check, focus primarily on your EGT bars, not your RPM.*

Look for all EGT bars rising and none falling when you switch from both mags to one mag. The EGT rise will typically be 50 degrees to 100 degrees Fahrenheit, but the exact amount of rise is not particularly critical. In fact, it's perfectly normal for the rise to be a bit different for odd-and even-numbered cylinders. Also, look for smooth engine operation and stable EGT values when operating on each magneto individually. A falling or erratic EGT bar or rough engine constitutes a "bad mag check" and warrants troubleshooting the ignition system before flying.

Most engine monitors have a "normalize mode" that levels all the EGT bars at mid-scale and increases the sensitivity of the display. It's a good idea to use this mode during mag checks because doing so will make any ignition anomalies much more obvious. Bring the engine up to the POH-specified runup RPM (commonly 1,700 RPM for direct-drive TCM engines), place the engine monitor in normalize mode, perform the mag check (BOTH-LEFT-BOTH-RIGHT-BOTH), and then return the engine monitor to its default mode (sometimes called "percentage mode").

In-flight Mag Check

The usual pre-flight mag check is a relatively undemanding, non-discriminating test that will detect only the grossest defects in the ignition system. To make sure your engine's ignition is in tip-top shape, I suggest performing an in-flight mag check at cruise power and a lean mixture - preferably a lean-of-peak (LOP) mixture.

An in-flight LOP mag check is a vastly more demanding and discriminating test of your ignition system. That's because a lean mixture is much harder to ignite than a rich one. A marginal ignition system can easily pass the normal pre-flight mag check, but it takes one in excellent shape to pass an in-flight LOP check.

FIGURE 2: *An in-flight LOP mag check is the best way to make sure your ignition system is in tip-top shape.*

The in-flight mag check is performed at normal cruise power and an aggressively lean mixture (preferably LOP). Run the engine on each individual mag for at least 15 or 20 seconds while watching the engine monitor in normalize mode. Ensure that all EGTs rise, that they are stable, and that the engine runs smoothly on each mag. Since you have a constant-speed propeller, don't expect any RPM drop. Focus primarily on the EGTs, and secondarily on any significant engine roughness when running on one mag.

Note that the engine will always run slightly rougher when LOP than when ROP, and will run slightly rougher on one mag than on two. This is normal, and due to the inevitable cycle-to-cycle combustion event variations. When I say "significant engine roughness," I mean roughness sufficient to make you (or your passengers) at least a bit uncomfortable.

If you see a falling or unstable EGT, write down which cylinder and which mag, so you or your mechanic will know which plug is the culprit. If you don't write it down, I guarantee you'll forget the details by the time you get back on the ground. (Don't ask me how I know this.)

Bad Mag Checks

When you perform a mag check, ground or flight, and don't like what you see or feel, then what? How can you tell what's wrong, and what should you do to correct it?

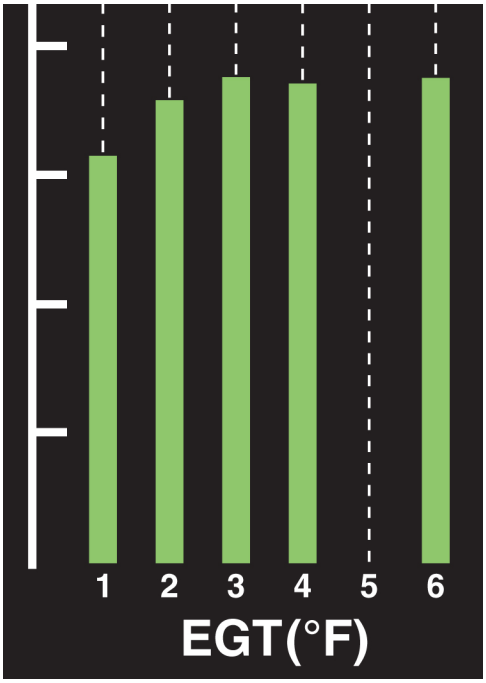

FIGURE 3: *A non-firing spark plug affects only one cylinder, while a faulty mag affects all cylinders.*

To begin with, the phrase "mag check" is a bit misleading. The vast majority of "bad mag checks" are caused by spark plug issues, not magneto issues. We really should call it an "ignition system check." Using the EGT method, it's usually easy to tell whether a bad mag check is due to a spark plug problem or a magneto problem: A faulty spark plug affects only one cylinder (i.e., one EGT bar on your engine monitor), while a faulty magneto affects all cylinders, and all EGT bars.

If you detect a non-firing spark plug during your pre-takeoff runup, the most common cause is oil fouling. You can try to clear an oil-fouled spark plug by running the engine for 30 seconds or so with the mixture leaned out to about peak EGT. If that doesn't cure the problem, then the plug may be lead-fouled or damaged, and you'll want to have it inspected and cleaned or replaced before fight.

On the other hand, if you observe a non-firing plug during an in-flight mag check, there's no need to panic because the cylinder will not be damaged by running on only one plug. If the engine runs smoothly on both mags (probably with an elevated EGT on the cylinder that has the non-firing plug), simply proceed to your destination and deal with the problem when you get there.

Mag Timing Issues

During a pre-takeoff mag check, if you get an excessive RPM drop when you switch to one mag but all EGTs rise and the engine runs smooth, chances are that it's not a bad magneto but rather retarded ignition timing. This is sometimes caused by a mechanic's error in timing the mags during maintenance, especially annual inspections, but it can also be caused by excessive magneto cam follower wear, possibly due to inadequate cam lubrication, or some other internal mag problem. Retarded ignition timing also results in higher-than-usual EGT indications. Mildly retarded timing is not a serious problem, but it does cause some loss of performance so it should be addressed.

Conversely, advanced ignition timing results in lower-than-usual EGT indications, and also higher-than-usual CHT indications. Advanced timing is a much more dangerous condition because it can lead to detonation, pre-ignition and serious engine damage. If you observe low EGTs and high CHTs after your aircraft comes out of maintenance, do not fly until you've had the ignition timing re-checked.

FIGURE 4: *If you notice lower-than-usual EGTs and higher-than-usual CHTs after the airplane comes out of maintenance, have the ignition timing re-checked before further flight.*

High-altitude Misfire

We've already seen that it's more difficult to ignite a lean mixture than a rich one. In turbocharged/turbonormalized airplanes, there's also another factor to consider: altitude. The higher a turbocharged airplane flies, the more difficult it is for the spark to jump the gap between the spark plug electrodes, and the more likely that the spark will instead "arc-over" inside the magneto itself.

A "high-altitude misfire" is bad for two reasons. First, it can cause the engine to run rough - sometimes frighteningly, "change-of-underwear" rough. Second, it can damage the magneto internally, and in extreme cases cause the magneto to fail mechanically - not good.

There are two fundamental strategies for preventing high-altitude misfire: make it easier for the spark to occur at the spark plug gap (where it belongs), or make it harder for it to arc-over inside the mag (where it doesn't).

The easiest way to make it easier for the spark to occur at the spark plug gap is to tighten up the gap. Most aviation plugs have specs calling for a gap of between.016 and.019 inch. Keeping the gap at the tight end of the range (.016) provides increased resistance to high-altitude misfire. Of course, the gap increases as the plug wears, so it's important to re-gap the plugs on a regular basis, typically every 100 hours or less for a turbocharged engine.

FIGURE 5: *To prevent high-altitude misfire, keep plugs gapped at the tight end of the allowable range.*

There are two ways to make it harder for arc-over to occur inside the magneto during high-altitude fight. One is to use a magneto that is physically large, which greatly reduces the likelihood of internal arc-over between widely-spaced components. For example, the huge TCM/Bendix S-1200 mags that I use on my Cessna T310R have distributor block electrodes spaced 1.2 inches apart, nearly twice as far as smaller mags like the TCM/ Bendix S-20s and Slick 6300s used on Cirrus SR22s and SR20s. However, the S-1200s are a good deal heavier and more expensive than their smaller brethren, and are simply too large to fit in the crossfow-induction engines used in the SR22. (The induction plumbing gets in the way.) That's a shame, because the S-1200s are by far the best magnetos for high-altitude operation.

The other way to inhibit arc-over at high altitudes -and the one used in Cirrus turbos - is to pressurize the mags with upper-deck air. This solves the misfire problem, but it's something of a mixed blessing. Pressurized mags tend to be less reliable and need more maintenance than unpressurized mags, because the pressuriza-tion pumps moist air through the magnetos (particularly when flying through clouds and precipitation), and often causes corrosion and contamination issues.

Preventive Maintenance

Regular preventive maintenance is the key to good ignition performance. Every 100 hours, the plugs should be removed, cleaned, gapped, rotated and reinstalled, and the ignition timing should be checked and adjusted if necessary. When the plugs become excessively worn, they should be replaced with new ones.

Conventional massive-electrode spark plugs typically last 400 to 500 hours; fine-wire (iridium) plugs can go nearly three times as many hours, but cost more than three times as much. I am not a fan of fine-wire plugs, especially in view of the epidemic of cracked insulators we've been seeing in the Champion RHB32S fine-wire plugs. I use conventional massive-electrode plugs in my airplane.

Every 500 hours without fail, the magnetos should come off the engine and go through a complete disassembly inspection, lubrication, adjustment and reassembly process generally referred to as a "500-hour IRAN" (inspect and repair as necessary). Although many shops and mechanics do this magneto IRAN in-house, I prefer to send mags out to a magneto specialist like Aircraft Magneto Service in Seattle, Wash. (www.aircraftmagnetoservice.net), The Magneto Shop in Olivehurst, Calif. (www.themagnetoshop.com), or G&N Aircraft in Griffith, Ind. (www.gnaircraft.com). Figure on spending $300 to $400 per mag on the IRAN -occasionally more if a lot of parts need to be replaced -plus a couple of hours of shop labor to remove, reinstall, and time them.

The ignition harness sometimes gives problems as well. If your harness has more than 1,000 hours in service or if it's starting to look a bit ratty, you might want to consider replacing it. The harness isn't terribly expensive (around $500), but it takes a couple of hours of labor to install.

In addition, I recommend giving the ignition system a "stress test" every few flights by performing an in-flight LOP mag check, and taking prompt corrective maintenance action if less-than-optimal ignition performance is observed. It's a far better test than anything you or your mechanic can do on the ground. My habit is to perform an LOP mag check at the end of the cruise phase, just before I start my descent. If the results are at all questionable, I dump my engine monitor data onto a thumb drive when I get on the ground and analyze it carefully when I get home. COPA

About the Author

Mike Busch - honored as "National Aviation Maintenance Technician of the Year" for 2008 - has been a pilot for more than 44 years and 7,000 hours, and an aircraft owner and CFI for more than 40 years. He became increasingly interested in the maintenance aspects of aircraft ownership about 20 years ago, and ultimately earned his A&P/IA. Mike is also a prolific aviation writer, with hundreds of technical articles published in *American Bonanza Society Magazine, Aviation Safety, AVweb, Cessna Pilots Association Magazine, IFR, Light Plane Maintenance,* and *The Aviation Consumer*. He co-founded AVweb in 1995 and served as its editor-in-chief for more than seven years. Mike conducts weekend "Savvy Owner Seminars" at which aircraft owners learn how to obtain better aircraft maintenance while spending a lot less money (www.savvyaviator.com). He is founder and CEO of Savvy Aircraft Maintenance Management (www.savvymx.com) that professionally manages the maintenance of owner-flown aircraft including Cirrus SR20s and SR22s. Questions for Mike Busch may be emailed to mike.busch@savvyaviator.com.