

Destructive Detonation

Know the symptoms, and act fast!

BY MIKE BUSCH

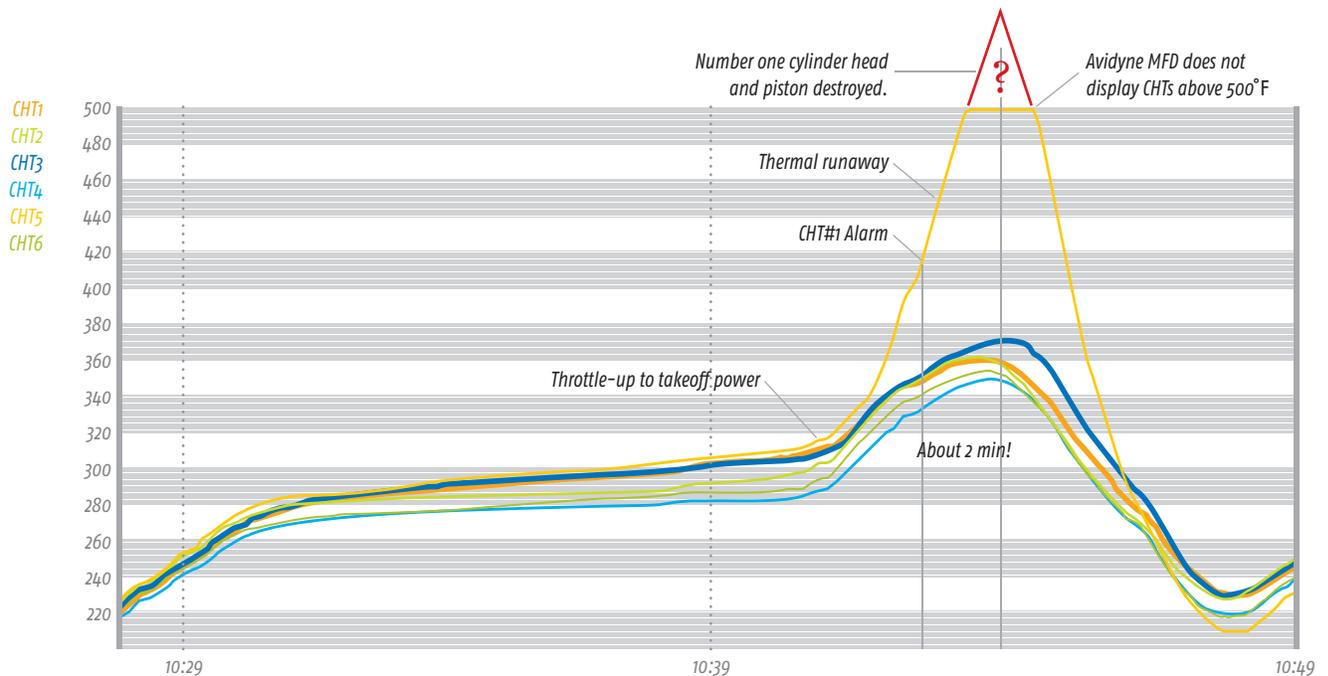
AT LEAST ONCE A year I am contacted by an aircraft owner whose piston aircraft engine was destroyed or severely damaged by a destructive detonation or pre-ignition event. Lately, the pace seems to be quickening; in a recent 12-month period, I've encountered three of them.

One incident involved a Cirrus SR20 powered by a 200-hp Teledyne Continental Motors (TCM) IO-360-ES engine. The plane was equipped with a snazzy Avidyne Entegra multi-function display (MFD) with an integrated engine monitoring system called EMax.

Everything looked fine until about two minutes after the pilot applied takeoff power, at which point the cylinder head temperature

(CHT) of the No. 1 cylinder began to climb rapidly compared to the other five cylinders. At the three-minute mark—with the aircraft at roughly 2,000 feet above ground level—No. 1's CHT rose above 400°F and set off a high-CHT alarm on the MFD.

No. 1's CHT continued its rapid rise—nearly 1°F per second—and continued unabatedly until the piston and cylinder head were destroyed approximately five minutes after takeoff power was applied and



The cylinder head temperature (CHT) data downloaded from the EMax system tells the short tale of the TCM IO-360-ES engine's demise.



Here's what the No. 1 piston looked like after the event. Note the melted corners of the piston crown, the destruction of the top compression ring lands, and the severe metal erosion above the piston pin.

only two minutes after the alarm. At that point, since the cylinder was no longer capable of combustion, No. 1's CHT started plummeting.

We can't be sure just how hot No. 1's CHT got because the Avidyne EMax system "pegs" at 500°F. A reasonable guess is that the CHT peaked somewhere between 550°F and 600°F. No cylinder or piston can tolerate such conditions for long, and this one obviously didn't.

AFTERMATH

Not long after No. 1's CHT went off-scale on the MFD, the pilot realized something was wrong and pulled the power way back. But he was a couple of minutes late, and the engine was already toast.

Note the melted corners of the piston crown, the destruction of the top compression ring lands, and the severe metal erosion above the piston pin (much of this molten metal wound up inside the crankcase and contaminated the bearings and oil passages). Also note the severely hammered and gouged appearance of the piston crown, undoubtedly caused by loose chunks of metal flying around inside the combustion chamber.

The cylinder head was found to have a big chunk of metal missing from it, and both spark plugs were destroyed.



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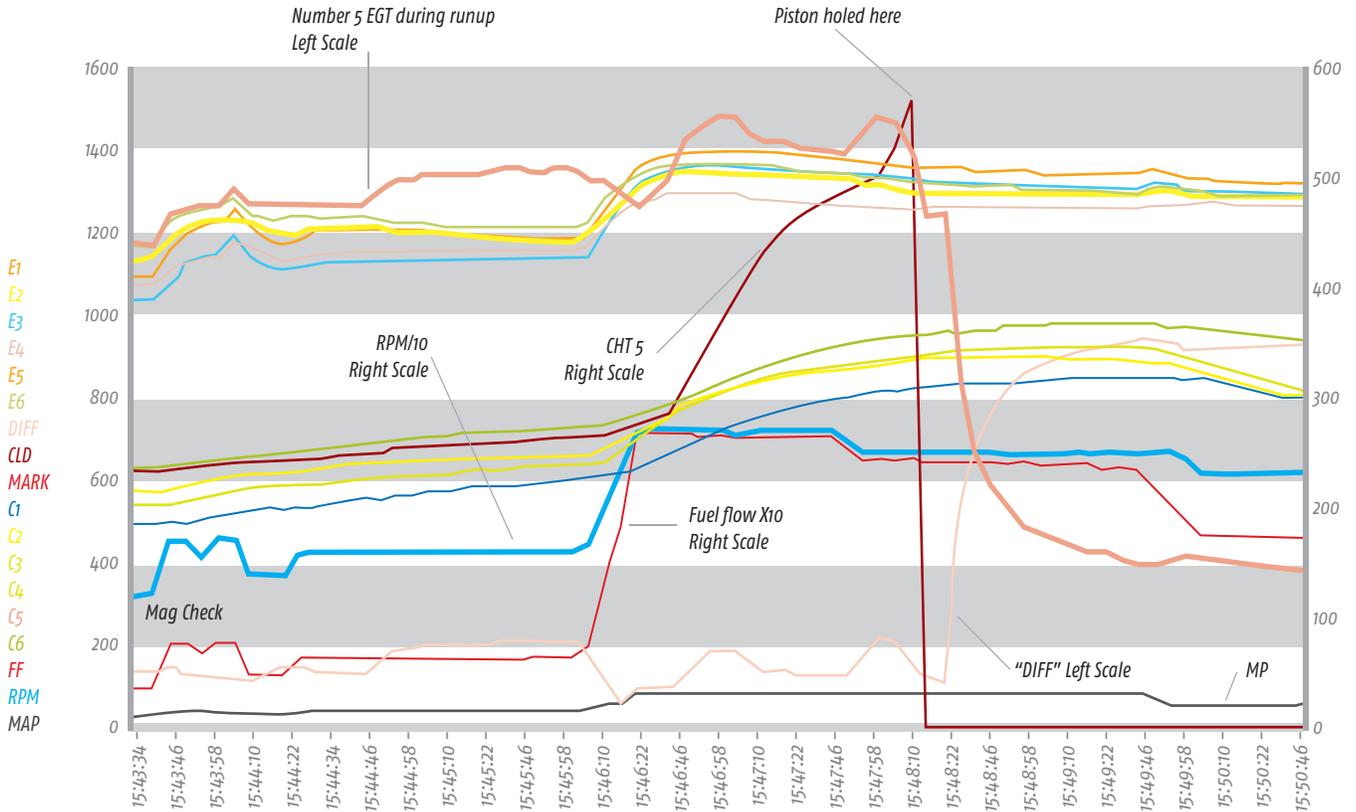


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This engine was a low-time factory-new engine, so the owner figured that the severe engine damage would be covered under TCM's warranty. I advised him not to bother filing a warranty claim, because I've never known TCM to give warranty consideration for a destructive detonation or pre-ignition event. TCM considers this to be operational abuse, not a defect in materials or workmanship, and therefore not covered by warranty. (For what it's worth, I agree with TCM on this.)

The owner didn't believe me and filed a warranty claim anyway. TCM promptly and unequivocally denied the claim.

A similar case occurred to another TCM-powered airplane shortly after takeoff. The annotated J. P. Instruments (JPI) data for this event is courtesy of General Aviation Modifications Inc.

This time, it was the No. 5 cylinder that experienced thermal runaway and pre-ignition. It was an even more severe event

Within minutes, the airplane was back on the ground, engine destroyed. A forensic post-flight evaluation revealed that the magnetos had been timed approximately 10 degrees advanced from the proper timing...

than the one suffered by the Cirrus, and it took only two minutes from the application of takeoff power to the complete destruction of the No. 5 piston, which wound up with a large hole melted through the piston crown.

In yet another case (for which I unfortunately have no photos), a drop-dead gorgeous Lancair IV-P kit plane powered by a fire-breathing 350-hp TCM TSIO-550 engine went up for its first test flight after 10 years of laborious building time by the owner. Within minutes, the airplane was back on the ground, engine destroyed. A forensic post-flight evaluation revealed that the magnetos had been timed approximately 10 degrees advanced from the proper timing, which turned out to be a \$50,000 mistake.



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The Lancair's instrument panel was wall-to-wall glass, including an ultra-sophisticated digital engine monitoring system. The engine monitor was literally crying out for attention throughout the short test flight, but the test pilot never noticed its warnings until the engine cratered.

CAUSES

A number of things can cause or contribute to destructive events like these. I've already mentioned one: advanced ignition timing. I'm astonished at how often we see engines with the magneto timing advanced several degrees from specifications. (For example, 25 degrees before top dead center (BTDC) when the engine data plate calls for 22 degrees BTDC). Even a couple of degrees are enough to significantly reduce the detonation margin of the engine. Add a hot day and perhaps a cooling baffle that isn't quite up to snuff, and *boom!*

Owners should be particularly alert for mistimed magnetos whenever maintenance is done that involves magneto removal or adjusting magneto timing (more often than not, these occur during the annual inspection). If mag timing is advanced, you'll notice that your exhaust gas temperatures (EGTs) are lower and your CHTs are higher than what you were seeing prior to maintenance. Retarded timing results in the opposite: higher EGTs and lower CHTs. If you notice this after the airplane comes out of maintenance, take it back to the shop and have the mag timing rechecked. It's a quick check and could save your engine. Magnetos are required to be timed within 1 degree of the timing specified on the engine's data plate, and any error should be in the retarded direction.

Another common culprit is inadequate fuel flow on takeoff. When taking off from a near-sea-level airport—or from any elevation if you're flying a turbocharged airplane—you need to see fuel flow that's right up against the redline on the gauge (or the maximum fuel flow shown in the pilot's operating handbook). Unlike most other gauges on your panel, hitting redline on the

Now that's ugly! The result of thermal runaway and pre-ignition.

fuel-flow gauge, or even going a smidgen over, is a good thing. Takeoff fuel flow is a lot like tire pressure: a bit too much is a whole lot better than a bit too little. Anything less than redline fuel flow on takeoff reduces the engine's detonation margin, and significantly less can reduce it enough to cause a catastrophic event.

Not long ago, a client of my maintenance-management firm had a prop-strike incident that required a teardown inspection of the engine. When the inspection was complete and the engine was reinstalled in the airplane, the owner picked up the airplane from the engine shop and flew it back to his home base airport. Upon arriving there, he informed us that the fuel flow was 3 gph below redline on takeoff and asked that we schedule a service appointment to have the fuel flow adjusted.

I was flabbergasted. What was this owner thinking? Why didn't he abort the takeoff immediately when he noticed that the fuel flow was 3 gph short and ask the engine shop to adjust it? Why would he fly the airplane home in that condition? What part of "detonation" didn't he understand?

Yet another cause is a partially clogged fuel injector nozzle. This can occur anytime, but most frequently it occurs shortly after the aircraft comes out of maintenance,

If your airplane isn't equipped with a digital engine monitor with CHT alarm capability, do yourself a favor and install one.

because that's the most likely time for foreign material to get into the fuel system. I've had two serious clogged-nozzle episodes in my airplane over the past 23 years, and both occurred shortly after an annual inspection.

SOLUTIONS

Regardless of the cause, the solution is not rocket science. There are two simple rules that will almost always prevent these sorts of destructive events from occurring.

First, check your fuel flow gauge early on every takeoff roll. If the fuel flow is not at redline or very close to it, abort the takeoff and sort things out on the ground. The exception is takeoffs at high-density altitudes in normally aspirated airplanes, and detonation is quite unlikely under those conditions.

Second, set your engine monitor CHT alarm to 400°F or less (I have mine set to 390°F). When the alarm goes off, immediately do whatever it takes to bring the CHT back down below 400°F. Verify that the mixture is full rich, and turn on the boost pump if it isn't already on. Open the cowl flaps if you have them. If CHT climbs above 420°F, throttle back aggressively. Don't be shy about doing these things immediately, because you may have only a minute or two to act before your engine craters.

If your airplane isn't equipped with a digital engine monitor with CHT alarm capability, do yourself a favor and install one. Trust me, it'll pay for itself quickly.

When you get on the ground, put the airplane in the shop and have the spark plugs removed and inspected for damage, the cylinders borescoped, and the magneto timing checked. If takeoff fuel flow was short of redline, have it adjusted before further flight. *EAA*

Mike Busch, 2008 National Aviation Maintenance Technician of the Year, has been a pilot for 44 years, logging more than 7,000 hours. He's a certificated flight instructor and an airframe and powerplant mechanic with inspection authorization. E-mail questions to Mike at mike.busch@savvyaviator.com. Mike also hosts free maintenance webinars on the first Wednesday of each month at 8 p.m. (central). To sign up or access the archives visit www.Savvyymx.com/webinar.

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500 1500

400 1400

300 1300

200 1200

GAL USED 8.2 11.6 7.5

CHT 1171 1211 1202 1172

EGT 10.5 28 176 78 13.4 10

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