Champion Fine Wire Spark Plugs: Beware
by Max Nerheim

Packed and stuffed with skis, sleds, equipment, and 6 people I did the run-up of my Cessna 421 with the GTSIO520 engines to fly back from Provo to Scottsdale just after new year. The left engine ran very rough on only one magneto. After taxiing back to the FBO and calling a mechanic, we found a Champion fine wire RHB32S that missed a piece of ceramic. We changed this plug with a new Champion fine wire plug and performed another run-up. The engine still ran (slightly) rough, so we pulled the remaining plugs, and found 3 more that were cracked. After replacing these with 3 new (er) fine wire plugs (from the mechanic’s toolbox) we could finally fly home. Once home I did some research, and found out there is quite the controversy regarding Champion Fine Wire spark plugs. I have also done my own investigation. As a summary, of the 16 Spark plugs tested, I would put only one back on the engine. I would not fly any plane with any of the other 15 plugs.... I recommend a resistive test for anyone using these plugs before taking off on any flight. I would replace any plug that read more than around 1500 ohm before flying anywhere. I would also inspect them regularly and often for cracking.

My right engine has, and has always had, Autolite massive plugs. The Fine Wire plugs were only tried on the left engine as an “experiment”, and have been installed for less than 2 years (they were used when I installed hem).

After the problems I had returning from Provo, I researched and read up on the Champion plugs. What I read made me replace them all with massive plugs of a different brand. Doing so, I found several more Champion fine wire plugs with hairline ceramic cracks! Adding up the 4 plugs that we found in Provo with ceramic cracks, now around half the plugs had some cracking of the insulators. I have an EGT sensor on each cylinder and always run them (well) below 1550 °F. (The exhaust gases continue to burn a little between the exhaust and the turbo-inlet. I keep my turbo inlet temperatures right around the green/yellow line at 1550 °F).
I decided to take the Autolite UHRB32E (same as Tempest?) spark plugs I had from before I put in the Champion Fine Wire plugs, as well all the Champion fine wire plugs and test the continuity in them using a Digital Volt Meter (DVM). The Autolite plugs read from 1115 to 1351 ohms. The Champion plugs read from 1330 ohms (the one new plug) to open/infinity. So not only did the fine wire plugs crack, they also had resistive readings that were seemingly totally random!
I suspected the open readings were due to slight corrosion buildup between the elements of the Champion spark plug: The Champion spark plug is assembled with a resistive “slug” that is held in place by a spring and a screw, which (at least in theory) can both develop some surface corrosion. I thought, if there is just some slight surface corrosion, this would be no big deal as the magneto would “burn” a path through the bad contact areas, and the resulting “high voltage impedance” should be close to nominal. To test this theory I utilized a high voltage source (a TASER X26 stun gun), an oscilloscope, a non-contact current probe, and a 25kV high voltage/high frequency probe. The oscilloscope captured the current and voltage waveforms across the plug from the spark plug wire terminal to the front round electrode (not including the spark plug gap) during the high voltage discharge. The voltage and current readings were captured after all the “bad” circuit elements had been “burned” through. By using the captured voltage and current, the plug resistance during the firing of the plug could be calculated.

Above: Champion fine wire plug with particles from inside the plug.

I tested all the plugs using this setup. The X26 is capable of generating up to around 50,000 volts, and had no problem jumping across the spark plugs (from the back spark plug wire connection to the round electrode on the front).

Using the High Voltage oscilloscope approach, all of the Autolite plugs measured within 11% of their corresponding DVM readings. Very nice. This demonstrated an acceptable consistency and also validated the approach.

The 16 Champion plugs (4 that were replaced initially, and the remaining 12) measured from 194 to 11,000 ohms using the oscilloscope method. A big surprise was that 6 Champion plugs measuring from 135 to 534 ohms. These plugs had all
measured “open” on the DVM. When discharging the TASER across these plugs I noticed there was arcing noise within each spark plug. The arcing noise is caused by the TASER having to arc across an air gap. This caught my attention – why would the TASER have to arc across INSIDE the plug (the spark plug gap was not part of the test).

To investigate I opened up the Champion spark plugs by unscrewing the screw where the spark plug wire is normally inserted. The spring and the resistive element was then removed from the plug. With good access to the element I used a DVM with sharp test clips attached to try and measure the resistance of the element. OPEN!!! Well, it must be “surface corrosion” I still thought. I then attached the TASER X26 to both sides of the resistive element, and discharged the X26, hoping to observe the current going through the resistor, so I could measure the resistance. Instead, the X26 formed an arc on the outside of the resistor: http://www.youtube.com/watch?v=DERIHonZT-k Each time the X26 discharged, a blue arc of ionized air formed across the surface of the resistor. The resistor element itself was completely OPEN. It did not conduct any electricity at all! Normally in a test setup like this, the current would flow through the body of the resistor, not arc across it. In this case, the resistor element acted as an insulator. Hence, spark plugs with “resistive” elements like this one would present the magneto with roughly a 0.5” extra spark gap in series with the approximately 0.02” spark plug gap! With this much extra gap to jump, there is not much point in arguing if a “proper” spark plug gap should be 0.02” or 0.03”!!! With my limited understanding of how a magneto works, I am also concerned regarding the possibility of the high voltage required to arc across a plug like this, could instead jump from the rotor to the next cylinder contacts (instead of to the current one). The probability of this happening would increase if the adjacent magneto contacts had normally working spark plugs. Hence, if one plug is bad and requires a much higher voltage, it is better if they are all bad!

The arcing across the resistive element also explains the very low resistive oscilloscope readings during my previous experiment: The X26 generates enough voltage to arc and ionize the air across up to around 2 inches through air or even longer across a partially contaminated surface. Once the air has been ionized the resistance of the air (gap) drops from “open” to close to zero (that is how a TASER device can across up to 2 inches of clothing.) The resistive element that was open also read “open” on the DVM TEST. I weighted the resistive element on a laboratory grade scale. It came in at 0.23 grams. The TASER X26 discharging 19 pulses per second for 5 seconds (compared to a magneto at 28 pulses per second continuously) through a working resistor made it too hot to touch. Is it a possibility that the resistor is too small to dissipate the electric energy from the magneto without degrading..? How much energy does a magneto put out? It sure seems like a good idea to have the plug resistor thermally and mechanically coupled to the spark plug body to help dissipate the electric heat (like the Autolite plugs).

Arcing Spark Plug Voltage:

I also measured the peak voltage necessary to arc across the various spark plugs. This was a slightly different test setup, as now the spark plug gap is part of the circuit. The voltage was measured from the spark plug wire attachment point to the body of the plug. In order to fire the plug, the magneto would have to put out this voltage in
addition to the extra voltage needed to jump through the compressed air mixture present in the cylinders during compression – more cylinder pressures at higher manifold pressures requires higher magneto voltages. At ambient pressures the old Autolite URHB32E plugs measured somewhat consistent (nothing in High Voltage is entirely consistent) peak voltages from 6200 to 9300 volts. With the Champion RHB32S the voltages measured from 6300 to 17000 volts. With some of these I had intermittent arcing at the back connection of the spark plug – from the screw connection, across the ceramic to the metal body. In this case there would be no arc across the spark plug gap. Operating the spark plugs in a running engine with cylinders compressing the air would require a higher break-down voltage across the spark plug gap, and thus would make this condition more likely to happen.

I was also able to talk to Kevin Gallagher, Manger of Piston and Airframe at Champion Aerospace regarding my experience. He acknowledged they are looking into the issue with the resistor increasing in value (impedance), but do not have it resolved yet. Champion is investigating the issue and might start to recommend a resistance test, and possibly accept resistance tests up to around 80,000 ohms. The acceptable resistance range is still up for discussion. I would not accept such a high value for my engines. Kevin Gallagher cautioned that the cracking of the ceramic could be an indication of pre-ignition, possibly caused by too aggressive leaning and operating the engine at or around peak EGT’s. I do not run my engines Lean of Peak (at least not knowing), and I would think that my JPI 960 multi-port EGT would indicate/alarm if a cylinder experienced pre-ignition with associated (extreme) rise in EGT’s. However, since Kevin gave me this warning, I have paid more attention to make sure every cylinder is running ROP.

Summary/discussion:

I think there are two separate problems with the Fine Wire Champions:
-Roughly half the plugs I removed had ceramic missing (1 plug) or cracked ceramic.
-Only one Champion plug read around 1300 ohms (this was the one new plug from Provo). The other 15 plugs, including 3 that were only “slightly used” (installed in Provo) displayed readings on the DVM from 4000 ohms to “open”. 9 of the plugs read “open”. I had only one plug out of 16 that read close to 1300 ohms. I would not use a plug that read higher that 1500 ohms.

I am not putting any spark plug, fine wire or massive, with the built up construction on my engines again. To my understanding the massive electrode Champions have the same construction with a spring and resistive element. These will not go on my engines either.