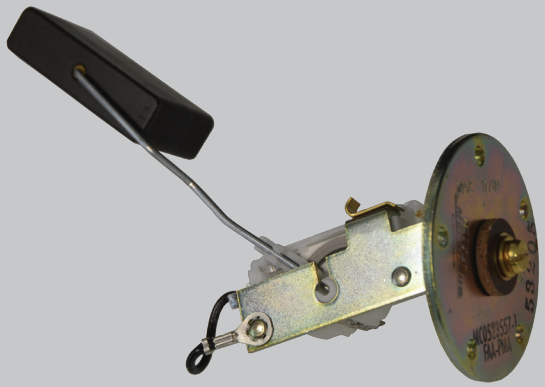
Electricity in the Fuel Tank

Is it Safe?

By Dave McFarlane



Have you ever thought about those fuel quantity transmitters in your fuel tank? Just how much electricity go through them anyway? Is there any chance of a spark? Could they touch off an explosion? Could they be improved? How do they fail? These are some of the questions we had when we started to develop new FAA- PMA replacement fuel transmitters for the Cessna single engine airplanes. What we found out was quite shocking.

The first things we did were to review the aircraft electrical schematics for the fuel quantity system and dissect several fuel gages. A fuel indicating circuit was analyzed while it was working. Then we collected a lot of transmitters that were removed from service and a few new ones. Some of them still worked and some were obviously bad. After disassembly, the transmitter failure modes and defects were noted with the most common electrical defect being actual wear failure of the stainless-steel wire that is wound around a phenolic (laminated plastic) insulator board making up the variable resistor.

One particular defective transmitter caught our attention. The phenolic board was charred and discolored. This clearly indicated the stainless-steel resistor wires had been HOT! How did it get hot? There were no signs of external heat in the transmitter

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housing or flange that would indicate external heat or fire.

Looking at and smelling this transmitter took me back twenty five years to when I ran a repair shop in Iowa. A customer brought in an almost new Cessna Agwagon that had an alternator run away due to a shorted field wire near the alternator. Before the pilot could shut down the master switch, the 28-volt system fried all the electrical components that were turned on at the time and the electrical instruments were brown and filled with smoke. I remember that the over-voltage had also damaged the fuel transmitters. An over-voltage might explain our one hot transmitter, but Fred McClenahan, our design engineer, and I were not convinced that was the only possibility.

In the normal operating mode, there are only a few milliamps of current flowing through the fuel transmitter to ground. Buss (battery or alternator) voltage is put into the fuel quantity indicator where the fine wire instrument coils reduce the voltage going to the transmitter. The voltage and related amp flow is very small as it goes through the transmitter to the grounded fuel tank. The chance of a spark at the point of contact of the transmitter's resistor wiper arm on the stainless-steel wire is very remote. The amp flow through the stainless steel resistive wire is so small it does not generate heat. But what happens when a malfunction occurs that would put full buss voltage directly to the transmitter? We were about to find out. Not having enough available amp power with our lab power supply, we took a good transmitter outside and lifted the hood on the company truck where we had the brute strength of a seven hundred amp Sears Die Hard®. We held the transmitter flange on the negative battery post and put a jumper wire from the positive post to the transmitter wire terminal. What I saw sent a cold chill down my spine. After a few seconds, the transmitter started to emit smoke and the stainless-steel resistor wire began to glow red hot!

Our certification tests proved that it will take the vibration and other abuses of the aircraft environment. Analyzing what this means, we determined if you had a short in the transmitter wire as it goes up the aircraft door post and this wire was shorted to another buss voltage wire, let's say the navigation light wire, you would have the same situation as we had under the Ford hood. The only difference would be that the smoke and red hot wire would be in your gas tank just before dark and maybe at six thousand feet. Another possibility for this type of failure would be if the wire going to the fuel quantity indicator was to touch the wire leaving the fuel quantity indicator, shorting buss voltage to the normally low voltage transmitter wire. If a mechanic was to accidentally short the transmitter wire to buss voltage, he better yell "IGNITION" and clear the hangar because he just switched on the fuel tank glow plug!

Why haven't we seen a lot of single engine airplanes with fuel

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tank fires or blown off wings? I guess it says a lot for the wiring reliability designed into our light aircraft. Another factor might be that the fuel air mixture must be correct for a gasoline explosion. If the tank was near full there is very little oxygen in the tank.

Our next question was "what can we do to eliminate this risk?" The choices were to either keep the electricity out of the tank or find a resistor that would be safe at any voltage. Keeping the electricity out of the fuel tank

"What can we do to eliminate this risk?"

would be very difficult without developing a totally different fuel quantity system with heavy modifications to the fuel system itself.

Other styles of fuel tank senders were looked at and we finally discovered the new Stewart Warner® "Thick Film Ceramic" transducer technology. This resistor is built by coating a ceramic base with a hard semiconductor film. This film is then laser cut to the exact resistance needed. The beauty of this beast is that being a semi-conductor it is "current limiting". In other words, applying more voltage has less effect on the number of amps that will flow through it. With limited amp flow, there is a corresponding limit to the heat that can be generated. The real test was to see how it reacted to the Sears Die-Hard®. When we duplicated our previous test at full voltage there was no heat generated at the higher resistance and about 350° F at the low resistance and the transmitter worked fine after the test.

One of the other advantages of this technology is the hard smooth and flat surface of the semi-conductor. The follower arm does not have to jump over wires. Stewart Warner®'s tests show this resistor will out wear their wire wound type many times. The accuracy of the resistance inputs is improved by the laser precision and increased number of resistance divisions built into the resistor. Our certification tests proved that it will take the vibration and other abuses of the aircraft environment.

McFarlane Aviation Products has FAA-PMA transmitters for most single engine Cessna and Piper airplanes at substantial savings over the old wire wound replacements and we are developing them for other aircraft.

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