Some thoughts on

"Aircraft Wiring For Smart People"

offered by Greg Richter
at bluemountainavionics.com

Bob Nuckolls
AeroElectricConnection
15 September 2004

At 09:22 AM 9/15/2004 -0400, you wrote:

--> AeroElectric-List message posted by: Ken <klehman@albedo.net>

Well I'm not Bob but in the interests of promoting conversation:

> *I've scanned through the document . . . to conduct a thorough critique would take more time and energy than I have to donate to that cause. I'd be willing to discuss any particular topic as members of the AeroElectric-List feel useful:*

Among other things it seems to claim that teflon wire is as good or better than tefzel,

> *. . . but without foundation on simple ideas. Consider this excerpt from his text:*
>
> *--------- beginning of excerpt ---------*

"***Hookup Wire***
Everyone knows that Tefzel insulated wire is white, and you wire airplanes with it. As you might expect by now, I'm gonna disagree. Why make everything white? Can we possibly make the airplane any harder to work on? "

> *Tefzel is available in any coloration. I have a dozen colors of Tefzel wire on spools in my shop.*

"And why Tefzel? Tefzel and Teflon are chemically similar, except that Teflon handles cold better, is impervious to almost everything, doesn't burn or outgas . . "

> *Every insulation will burn or outgas at some temperature. Tefzel, PVC Teflon, rubber, you name it. Get the any insulation hot enough and it will decompose into stuff even a*

Camels smoker would find unpleasant. That's what fuses and breakers are for, the dead short on any kind of wire will make your cockpit a most unpleasant habitat.

". . . and is available in a zillion colors. Satellites are wired with Teflon. Military aircraft use Teflon."

No airplanes that I'm aware of use Teflon airframe wiring. Teflon pre-dates Tefzel about 20 years. We used limited amounts of Teflon for interior wiring of appliances and components beginning in the 70s, especially where high temperatures are involved. Electromech and Advanced Industries use real Teflon insulated wire for short pigtails that exit from high power motors that run HOT . . . Teflon was designed into these motors in the 70s when that was the best we had . . . modern designs will use Tefzel unless there's a spec requirement for higher temperature materials.

Teflon was considered for airframe wiring but found to be too soft and too expensive. Teflon extrudes at such high temperatures that tin plated wire has to be replaced with silver plated stranding . . . raises the cost considerably and the insulation was just too fragile for airframe wiring.

"Kitplanes and General Aviation aircraft are still wired with Tefzel. You know why? Because old specs never die! Better stuff came along, but no one updated the spec."

Updated what spec? There is no spec for what wire one should consider for any particular task, only specs for lots of different wires to be considered for any task. I don't understand the statement "still wired" with Tefzel. He has the order exactly backwards. Teflon came first as an update to Mil-W-16878 type E and EE wire in the 60s . . .

http://www.jaguarind.com/products/teflon/eteflon.html

http://www.jaguarind.com/products/teflon/eeteflon.html

Cessnas and Pipers were being wired with Mil-W-16878 type BN (Nylon over PVC) at the time. See:

http://www.interstatewire.com/SpecPage.asp?sCatalogPage=11b&ID=64

About 20 years later, Mil-W-22759/16 Tefzel wire is developed and offered to the industry.

See: http://www.interstatewire.com/SpecPage.asp?sCatalogPage=18c&ID=13

Although early on, it was a export controlled material because of the advantages to military programs and we had to consider non-export controlled similar products like Raychem's Spec55 wire:

http://www.raychem.com/resources/documents/datasheets/Wire_and_Cable/Spec55eng.pdf

Spec 55 was equal to Teflon in many respects (200C operating temp) but more expensive than Tefzel . . . We almost went to Spec 55 and someone got our export license cleared and 22759/16 Tefzel wire was designed onto the Gates-Piaggio GP-180 in the early 80s. I'll have to ask out at RAC to see if anyone remembers when it went into Beech aircraft.

"According to my DAR, Teflon is an acceptable substitute for Tefzel in all applications since it is *better* in all respects."

Again, not so. Check out this comparison of the two at:

http://www.omega.com/techref/fluoro.html

At the bottom we find the following:

"Summary and Conclusion:The chemistry and physicochemistry inherent in the fully fluorinated polymer structures allow Teflon FEP and Teflon PFA fluorocarbon resins to provide unique resin component benefits for chemical corrosion resistance. Tefzel fluoropolymer resin comes closer to Teflon than any other partially fluorinated resin, in chemical and electrical properties, **while providing enhanced mechanical ruggedness and economical processing."**

So we'll use the good stuff, and in color Teflon wire can be had from any of the sources in the back of the book.

---------- end of excerpt ----------

I will suggest that much of what's offered as fact and rational for the selection of Teflon over Tefzel is wrong. Tefzel has been the insulation of choice in aircraft for about 25 years. The only stories I've heard on military aircraft involve horror stories about Kapton insulation failing in the salt air aboard aircraft carriers and getting new harnesses crafted of Spec55 wire.

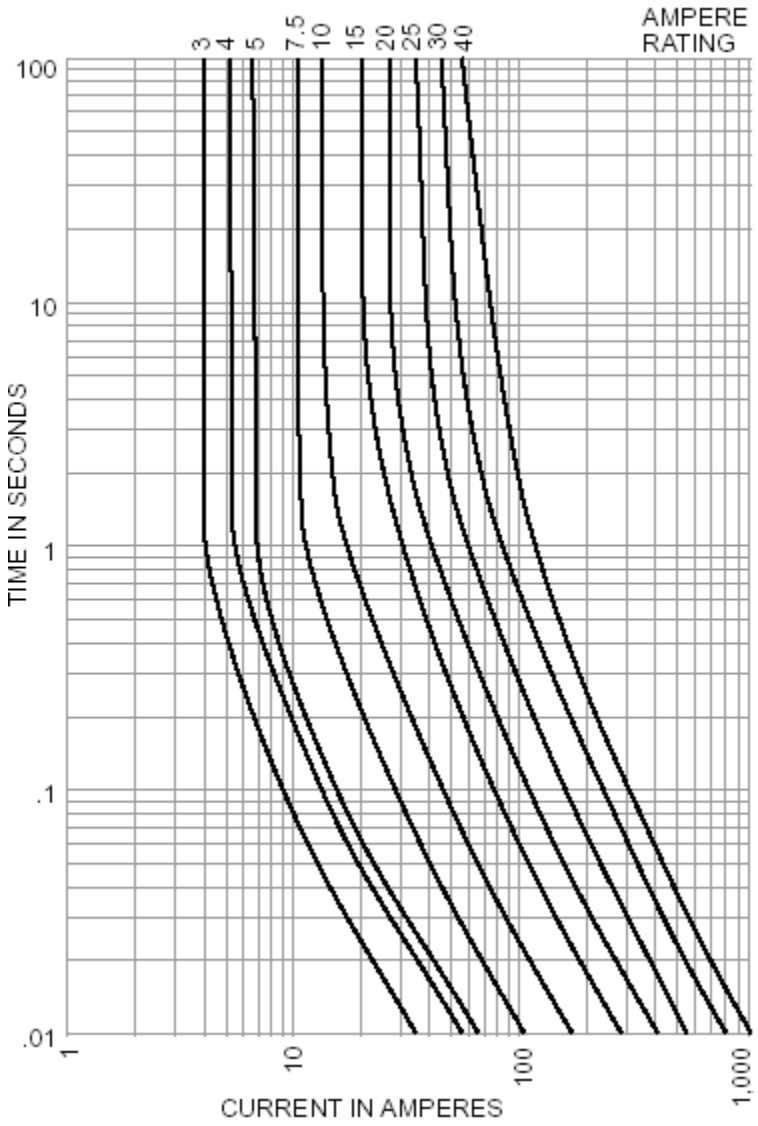
. . . that breakers and fuses will eventually pop if loaded above 80%,

I am mystified by this statement. Can't find a thing in the Bussman or Littlefuse catalog that tells me to de-rate their

fuses by 20% to make sure that they stay put. Check out the ATC Fuse specs at:

http://www.bussmann.com/shared/library/catalogs/BUSS_Auto-OEM_Cat.pdf

On page 7 we find the following graph:



Note that the blowing time for a 3-amp ATC fuse goes asymptotic (parallel) to infinite blowing time at 4-amps. This tells me that the manufacturer of the device is guaranteeing me that his 3-amp fuse will be just fine running at 100% of it's rated value and that he has ALREADY de-rated it about 25% to insure predictable performance.

. . . . that there are 50 lb of wire in small airplanes and a 28volt system will save 10 lb of wire,

Okay, let's crank the numbers for this. Assume a Long-Ez with 30 feet of 2AWG at 4 oz per foot gives us 120 oz or 7.5 pounds of fat-wire. Let's assume 20' round trip for both wing tip landing/taxi lights -AND- pitot heater for a total of 60' at 0.035 lb/ft for 2.1 more pounds. Let's call out 40' of 20AWG for nav lights at .0053 lb/ft for 0.21 pounds. This comes to 9.8 pounds of wire for all the big-fuse items. Let's see . . . 50 minus 10 pounds leaves us 40# worth of 22AWG wire for the rest of the airplane which works out to about 10,800 feet of wire. Yup, that ought to be enough to wire up the rest of my "small airplane".

Now, let's assume that the 28-volt system lets us downsize the fat-wires by half their cross-section for about half the weight. So the fat-wire list drops from 10 pounds to 5 pounds. My 50 pound wire budget for a 14-volt "small airplane" drops to 45 pounds by going to 28 volts.

Hmmm . . . We know that the 50 pound number is bogus. The typical RV with firewall mounted battery is carrying closer to 2 pounds of 4AWG wire. The fat-wire budget is a lot smaller than for our all-plastic canard pusher extreme. Further, 10,800 feet of instrumentation and avionics wire seems a bit excessive for even the most gizmo-crazed builder. 200 feet of wire is closer to reality for a TOTAL wire-budget well under 10 pounds of which only 2 pounds MIGHT benefit from downsizing by going to 28 volts.

I've done this exercise dozens of times for the OBAM aircraft community over the last 15 years. I'm sorry, the results are always the same . . . weight savings for 28 volts is small assuming that all other accessories are a wash. Yes, one CAN get a lot more POWER from the same weight of alternator . . . but our need for power should be going DOWN not up. I'm working a program at RAC right now where an upgrade of systems and avionics promises to allow installation of SMALLER batteries and leave us much cooler running generators.

. . . he doesn't like two alternators, and 10 awg wire is fine for up to 100 amps of alternator output, and he markets a fancy electronic distribution center... He does give reasons for much of what he says - but I do like to stir the pot and he definitely diverges from the common list wisdom here!

He's very much entitled to his opinions . . . but if he aspires to the role of teacher and/or engineer, he should be prepared to support opinions with simple-ideas in physics, historical facts, and lucid analysis of the data. I am

disappointed that he would spend so much time creating a document that was so full of anecdotal and off-hand statements (Be cautious of DARs who tout Teflon over Tefzel as an airframe wire). I scanned the book and easily detected many similarly weak and/or erroneous arguments.

It's even more disconcerting to read this kind of dissertation from one who aspires to a position of stature in the instrumentation and navigation display marketplace. I'm astounded that in the design and fabrication of his products he appears to be unaware of the Tefzel/Teflon story and oblivious to manufacturer's data on ordinary products like fuses. This has not been a good day.

Bob . . .