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Switch Ratings, What's it all Mean?

Just catching up on piles of snail-mail and e-mail that tends to build up while we are flitting from fly-in to seminar. Picked up a copy of the Oct 97 issue of Van's Air Force and read an article on switch selection that makes some good points but arrives at the wrong conclusion. The author was privileged to observe some work done at UL Laboratories on switches and expressed some concern for builder naivety with respect to AC versus DC ratings.

He correctly cites an increased difficulty for breaking a DC circuit versus an AC circuit . . . particularly when inductive loads are involved. Quoting from the article:

"Typical of this is the roller and bar micro switches made by MICRO(switch) Corporation. Rated at 10 amps for 125/250 volt AC, the same switch can only carry 0.15 amps at 250 volts DC! The voltage stayed the same!"

The statement is true but not relevant to our task. We're not building 250-volt airplanes, we build 14 and a few 28-volt airplanes. Check out this data table plagiarized from the same Microswitch catalog . As one picks from the various switch products in the catalog, an "electrical code rating" is quoted for each device . . . the chart above states the ratings for each code. When one buys a toggle switch from Microswitch . . . the choices above are all inclusive.

The charge cites a variety of conditions for applying switches. Various combinations of AC or DC voltage along with loads can have a profound effect on switch life. Inductive loads do call for some derating . . about 25%. However, look at the column for lamp loads . . . it calls for the greatest derating . . . on the order of 75%!

I'll call your attention to the 250 VDC column for ALL switches. Note that none are rated at more than 0.5 amps in spite of the fact that the same switches are good for 6 amps at 250 VAC and MANY more amps at lower voltages. Quoting again from the article:

"Those of you who can still remember the old Kettering coil ignition systems will recall that when the condenser in the distributor went bad, the points generally turned blue and melted down in a few minutes. . . . "

The cited capacitor was to slow down a the rate-of-rise for voltage across relatively slow moving, cam driven switch contacts. If an arc were allowed to form between the opening points, energy intended to spark combustible mixtures in a cylinder would be used up at the points instead . . . the most notable result of bad "condenser" was the car ran very badly if at all . . . the points were indeed subject to more electrical stress but seldom for very long . . . this situation demanded timely repairs. Switches of choice for airplane panels are not cam driven. Toggles use spring loaded, over-center mechanisms that provide higher contact spreading velocities. Going on with the article . . .

"Cockpit switches don't have benefit of the condensers to absorb the electrical inertia present in a DC circuit and as a result, the gap temperatures get hot enough to weld contacts. That includes AC rated switches, even those made with exotic high temperature alloys."

The Kettering ignition example is an excellent way to illustrate"inductive" circuits. However, there are few such circuits in an airplane. Most notable of these are battery and starter contactor coils. We don't put "condensers" on these systems but we do install "catch diodes" or MOVs (metal oxide varistor) to protect switch contacts. This has been standard practice in airplanes for 30+ years (just worked on my kid's '72 Chevy truck today and saw a 1N4001 diode crimped into the connector for the air-conditioning compressor clutch). The article also overlooks the differences in physics between burning contacts and welding them.

Toggle Switch Ratings Table from Microswitch Catalog									
Elect Code Rating	28 VDC			115 VDC	250 VDC	115 VAC			230 VAC
	IND	RES	LAMP	RES	RES	IND	RES	LAMP	RES
1	15	20	5	.75	.5	10	15	3	6
2	10	15	4	.75	.5	7	15	2	6
3	15	20	7	.75	.5	15	15	4	6
4	10	18	5	.75	.5	8	11	2	6
5	12	20	5	.75	.5	15	15	4	6
6	10	18	4	.75	.5	8	11	2	6

Most damage to switches is done during the breaking of a circuit where an arc forms in the widening gap. Depending on contact spreading velocity -AND- thermal mass of the contacts, this can be the most stressful task for switching. However, this is when the contacts are getting farther apart . . an improbable scenario for welding.

The physics for closing a circuit are different. Here, potentially high inrush currents are impressed across contacts that may have small hills and valleys eroded in them from previous switch openings. These little hills become potential welding material when the large inrush current is forced to flow through a small cross section of material. This can happen to any switch with either DC or AC.

By-in-large, switched circuits in airplanes are resistive but let's look again at the purloined data from Microswitch. In nearly all cases (except Code 5) DC ratings at 28 VDC for the switches cited are better than the ratings for 115 VAC! (????) As a general rule of thumb, I've told builders that the 115 VAC rating is directly translatable to 14 VDC applications. I'll offer the chart above in support of this advice. The article continues . . .

"What often happened during UL testing was that the points welded shut, making it impossible to open the circuit."

Sure, let me pick the test parameters and I can probably weld about any switch shut. Keep in mind that UL has to test for EVERY possible safety contingency in product design and utilization. We design and build failure tolerant designs and select electrical devices that perform in narrowly defined settings. In years of fiddling with airplanes, I've never seen a manual switch weld shut. I've seen them corrode open, I've seen over-center springs rust out, I've see wires break off the back, etc. But never a welding. Now, contactors weld . . . with some frequency . . . but that's another topic. Electrical stresses that weld switch contacts in the lab simply don't exist in airplanes. Most switch failures I've observed show up when the switch fails to make good contact . . . mostly from die-use and corrosion as opposed to electrical abuse.

The heaviest currents handled by panel switches are landing/taxi lights (which have their own special inrush values -see "lamp" ratings in table above), and pitot heat. For most 14-volt airplanes this is about 8 amps. Everything else drops rapidly from there. I can also tell you that switching an 8-amp landing light with a 4-amp "lamp" rated switch is not an automatic formula for welding. The 200% "overload" will indeed reduce the life of the switch. However, let us suppose the switch was originally rated for 10,000 cycles (a low estimate) and the reduction was to 10% of rated life(also very low) . . . How long will it take you to put 1000 cycles on your landing light switch? Further, while one applies MOV or catch diodes for controlling inductive circuits, inrush limiters in high-current lamp circuits may be used to insure that stresses on the switch are only slightly more than purely resistive loading.

In a nutshell, 125 VAC ratings equate favorably and conservatively to 14 VDC ratings - as long as the switch has a healthy "snap" action . . . all toggle switches and most rocker switches do. Just because the numbers stamped on the side of the switch don't mention a DC capability doesn't mean that the switch doesn't have one. Manufacturers are unable to put ALL of the information from the chart onto the side of every product, the lettering would be too small to read!

The article also alluded to a 3X increase in the price of switches to get "DC rated" devices and postulated that delta-dollars for 10 switches would be $35. Hmmmmmm . . . this means that the original switches being compared cost about $1.75 each! I can't think of any $1.75 switch I would consider for use on an airplane and it has nothing to do with AC/DC ratings! The switches we stock sell for $5.00 in a single-pole device and carry no markings for DC ratings. They are rated at 7 amps or better at 115 AC and will work just fine in virtually every slot on an airplane panel. No matter where you choose to purchase switches, know that concerns raised by the original article are unsupported either by experience or failure mode physics.

Happy switching.