GETTING WIRED

The Electrifying Facts of Aircraft Wiring

BY JAMES WYNBRANDT

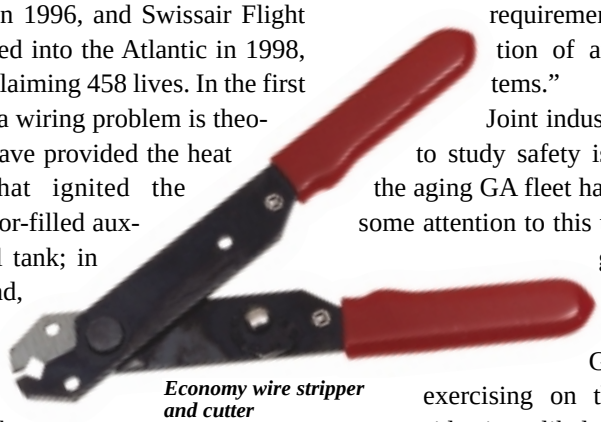
They're far from the most glamorous products avionics technicians work with. Purposely hidden from sight, they carry the load while other components reap the glory with the displays of brilliance their grunt work makes possible. And as a topic for discussion, this would seem to be anything but what it often is: a real live wire. But the fact is, avionics and aviation wiring is a critical and often ignored part of the maintenance and installation picture. And technological changes in wiring, along with increased scrutiny from aviation officials concerned about safety, make this a subject every avionics shop, repair station, technician and A&P needs to be plugged into.

EVOLVING PRODUCTS—AND CONCERNS

The wire used in aircraft applications has evolved markedly over the past two decades. The demands of large commercial customers—the Boeings and Airbuses of the world—eager to lighten aircraft, sparked a reduction program that's trimmed the size and weight of both conductors and insulation. And the new insulation materials that enabled the shrinkage offer improved protection against heat, vibration, abrasion and other assaults that wiring in aircraft is routinely subjected to. But the wiring can only be as good as its installation and maintenance.

"It's not an art, it's a science," Dick Hoffman of Tyco Electronics Inc., a wire and tool manufacturer in Harrisburg, Pa. said about aircraft wire work. "A lot of people don't pay attention. (But) if things aren't done properly, it can be catastrophic."

Wiring issues became a priority for federal aviation authorities in the last decade after TWA Flight 800 exploded in flight in 1996, and Swissair Flight 111 crashed into the Atlantic in 1998, together claiming 458 lives. In the first accident, a wiring problem is theorized to have provided the heat source that ignited the 747's vapor-filled auxiliary fuel tank; in the second, investigators pointed to faulty aftermarket wiring of an in-flight entertainment system as the likely source of the cockpit fire that preceded the crash.



Economy wire stripper and cutter

Since then the FAA has closely examined wiring practices and standards at commercial aircraft manufacturers and aftermarket facilities. The initial review found that while the OEMs were observing appropriate standards, aftermarket facilities handling maintenance exhibited poor and inadequately defined practices.

"Until several years ago, all the aftermarket process has been rather loosey-goosey," said Tom Harris, an electrical wiring and installation expert who helps oversee industry manufacturing and performance standards for aircraft wire. "A lot of activities are going on to try to place better requirements on installation of aftermarket systems."

Joint industry-FAA efforts to study safety issues involving the aging GA fleet have also brought some attention to this topic. But close government scrutiny of wiring in the GA arena, as it's exercising on the commercial side, is unlikely anytime soon. After all, there's a lot less wiring to be concerned about in GA aircraft, electrical power loads are lower, and from a risk/benefit point of view, the results of a wiring problem aboard a GA aircraft are less potentially severe. But

what would experts find if they conducted such a review? How would your shop's protocols and practices stack up?

WIRE STANDARDS

Wire inside an aircraft falls into two basic types: avionics wire and aviation wire. Avionics wire is typically found inside components or within a product's protective case. It usually has a single layer of insulation. Aviation wire is typically un-encased, connecting components to each other or to an electrical system. Aviation wire typically has at least two insulators, each a different color, making it easier to spot damage to the layers.

The specs under which aviation and avionics wiring are manufactured and installed are established by the Society of Automotive Engineers (SAE), which sets performance and safety standards for both the automotive and aerospace industries. SAE subcommittees composed of industry experts affiliated with wire and cable manufacturers and end-users oversee this portion of the standards, which are covered under (SAE) AS 50881. The standards are adapted from military specifications, which were turned over to SAE's supervision during the Clinton administration. These are the standards to which wire manufacturers usually refer customers when questions about proper techniques for working with their products arise, if the manufacturers provide any guidance at all.

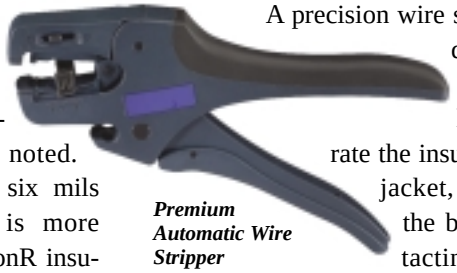
"Rather than limit our customers to what we see as recommended equipment and applications, it's just as simple to remind people they have an industrial standard," said Bill Brown, product manager for aerospace and military wiring at Judd Wire, a major manufacturer of aviation wire.

Bruce Pike, an engineering manager for Nexans in Elm City, N.C., another major manufacturer of aircraft wire, said "We tend to leave that to end users" when asked what advice the company could provide on tips and techniques for working with its wire.

TODAY'S WIRE: BENEFITS & CHALLENGES

The changes in aviation wire have brought both benefits and challenges. New insulation materials now coat the wire, like FEP (Fluorinated Ethylene Propylene) and ETFE (Ethylene Tetrofluoroethylene). These new materials are not only lighter in weight, but perform better than their predecessors, as previously noted. Insulation that is five and six mils (millimeters) thick today is more robust than the 20 mil KaptonR insulation typical of aviation wiring of two decades ago. The new materials also enable manufacturers to create wire that meets specific and more extreme application requirements, and to allow smaller gauge wire to be used for a given application; the conductor will become hotter with the greater load, but improved insulation can withstand more heat than their predecessors. But the lighter insulation comes at a price.

"It's more difficult to strip," said James Ide, chairman of the ASE's aerospace subcommittee on wire and cable, and VP of technology at Thermax CDT. "Proper stripping is more critical."



Premium Automatic Wire Stripper

Wire manufacturers and standard-setters say that makes the wire stripper—an aviation-grade wire stripper—a key shop tool. If the insulation isn't properly removed, or the conductor beneath is nicked or scored, the operation of the equipment the wire is powering or feeding data to, and ultimately the safety of the aircraft, can be compromised.

"You really need precision tools [for wire stripping]," Ide said.

A precision wire stripper is designed to cleanly separate the insulation, or jacket, without the blade contacting the conductor.

"It's very critical that you remove edges, collars or straggly tails," advised Jack Zinkann of Ideal Industries, a manufacturer of precision tools in Sycamore, Ill. "It's critical to get a nice, clean cut every time."

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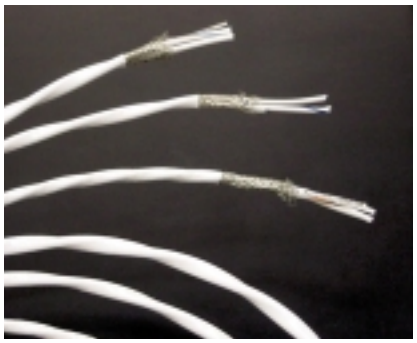
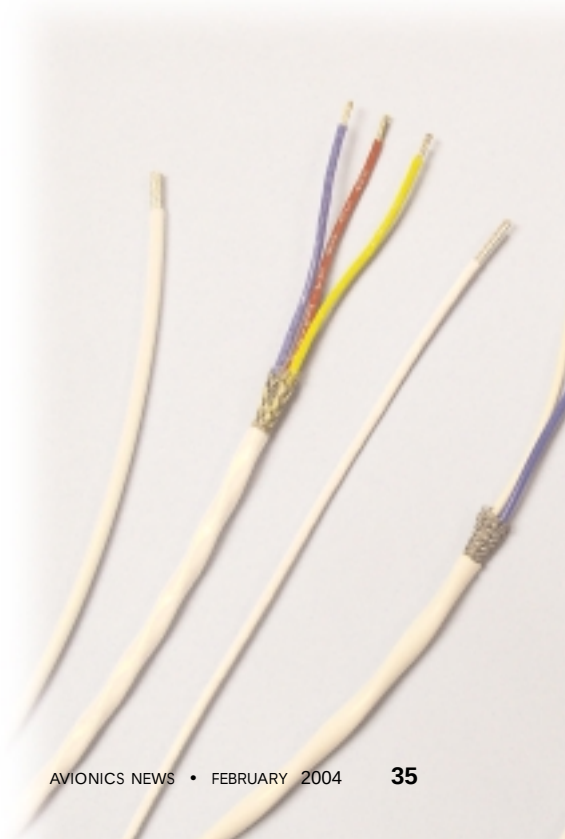


These are pictures of typical cable constructions with ETFE insulation for the primary wires and and cable jackets.



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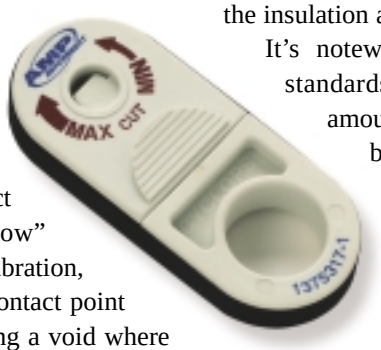


Cyclops cable stripper

Insulation left on the wire at its contact point will "cold flow" under pressure and vibration, and back out of the contact point or crimp barrel, leaving a void where metal-to-metal contact is supposed to be. This gap will increase resistance at remaining contact points, increasing resistance and creating a hot spot that can cause a fire. Such an improperly prepared wire can also work completely loose, and the circuit fail all together.

The relative thinness of aviation wire and its individual strands gives it great flexibility for being worked into cramped spaces. But as with insulation, benefits of thin, flexible conductors can be an Achilles heel. Any scoring can lead to failure of the wire, resulting in possible short circuiting or fire.

"The number of strands is critical to carry the proper load," said Dick Hoffman of Tyco Electronics Inc., "They figure 'I've got wire with these 48 strands, if I lose a couple it's OK,'" he said, but it's important to maintain the integrity of all the strands of a braided wire.

Rotary cable stripping tool

In a standard aviation wire configuration of 19 strands (12 on the outside over six strands within wrapped around one strand at the core) a strip that only slightly scores the conductor can be enough to make all 12 outer strands fail. Though the seven remaining can carry the current, line resistance will increase, creating a "hot spot" capable of burning through the insulation and causing a fire.

It's noteworthy that while ASE standards allow a prescribed amount of damage and number of cut strands a wire can exhibit and still be legally usable, as a matter of course OEMs reject wiring with any signs of such damage.

Attention must also be paid to any drilling activity in the vicinity of wiring due to the potential effects of metal shavings. If the insulation has been damaged or has a manufacturing imperfection, metal filings can cause current to pass through the insulation at such weakened points, creating a localized area that can "spark out," again possibly resulting in a fire.

CHOOSING THE RIGHT TOOL

Given the variety of insulation materials and thicknesses, and the variations in conductor gauges, dozens of different blade combinations are needed to cover all the possibilities. Ideal Industries, for example, makes about 25 blade sets for 16 gauge wire to accommodate all the differences in conductor and insulation thickness and type.

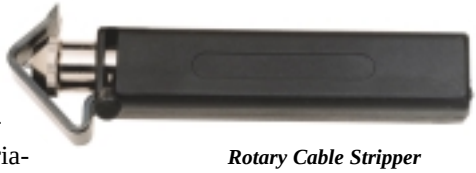
"We have customers all the time who say, 'We want one blade that does it all,'" said Zinkann, "but there is no such thing."

Many OEMs have made extensive tables specifying which wire stripper by part number should be used on which wires. But there's an evolving school of thought at the OEM level that can make sense in the GA marketplace:

"Instead of a proliferation of table after table of all these combinations, the (standards) should specify not what to use, but a visual requirement, under a 3x or 5x spec, make sure you haven't nicked or scraped, not scraping of plating over the conductor," said wire expert Tom Harris. Harris is chairman of the ASE's aerospace subcommittee on wiring and installation, and an electrical standards engineer with the Long Beach division of Boeing. But Harris notes adopting a visual standard requires more oversight than simply prescribing what tool to use.

"The catch is, if you're going to rely on (visual inspection) as the only means of verifying good quality stripping, you better have a good quality assurance program and trained and certified employees."

The quality of the blade must also be maintained. Wire stripper blades may last a lifetime, but can wear out if used heavily. In the wiring operations at some OEMs, strippers may be recalled every three or six months to check for excessive wear. Avionics shops and repair stations should periodically check their stripper blades, as well.



Rotary Cable Stripper

CONCLUSION

The safety and integrity of aircraft wiring is critically important, and is in the hands of those in the aftermarket involved in its installation and care. A study found that 98 percent of all the wire mishaps documented by the Air Force were the result of actions that occurred during maintenance. As James Ide notes, "Wiring as installed is fairly benign. Left untouched it can survive a lifetime." But expose wire to improper aftermarket care and the picture changes. "That's where you usually end up with problems." ❑