

# Aircraft Electrical Installation Hands On Workshop Sun & Fun 2012

## I. Introductions

- a. We will cover in this presentation
  - i. Aircraft electrical installation
  - ii. Materials
  - iii. Tools
  - iv. Techniques
  - v. Recommended practices

## II. Qualifier

- a. For the Lawyers among us
  - i. Information discussed here does not supersede or replace government regulations or specifications or the manufacturers' instructions

## III. AC 43.13-2B

- a. FAA Advisory Circular Publication documenting recommended techniques for aircraft maintenance and repair
  - i. It is an **advisory** circular not a **rule**
  - ii. Paragraph 11 and 12 deal with Electrical and Avionics
- b. How to get it
  - i. You can download it free from the FAA ([www.faa.gov](http://www.faa.gov)) use "quick find" search for "advisory circulars" then "AC 43.13-2B"
  - ii. **NOTE:** It is a "PDF" file so you will need Adobe Reader ([www.adobe.com/products/acrobat/readstep2.html](http://www.adobe.com/products/acrobat/readstep2.html)) if you don't already have it.
  - iii. If you download it you will not want to print the whole document, it is several hundred pages long
  - iv. Or you can buy a hard copy from most aviation book sellers or pilot shops

## IV. Wire

- a. Auto and Marine vs. Aircraft wire
  - i. Auto wire
    - 1. Is not usually "tinned" or plated with a corrosion resistant coating like tin, nickel or silver
    - 2. Wire made for automobile applications often has PVC or vinyl insulation which will burn and produce poisonous fumes
  - ii. Marine wire
    - 1. Good quality Marine wire is often tinned but often uses PVC insulation

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- iii. Mil spec 5086A Wire (See Picture #1)
  - 1. Relatively thick PVC insulation
  - 2. Finely stranded
  - 3. Found in most aircraft produced until the late 1970's
  - 4. PVC insulation produces Cyanide when it burns and will support combustion
- iv. Mil spec.22759 Wire (See Picture #2)
  - 1. Marking MIL-22759/ (*number*) – (*wire gauge*)
  - 2. Teflon or Tefzel insulation
  - 3. Will not support combustion and does not generate poisonous fumes when exposed to flame
  - 4. Is always finely stranded
  - 5. Is always tinned with tin, nickel or silver making it highly corrosion resistant
  - 6. Table 11.11 Open Wiring in 43.13 page Par. 11-89 page 11-40 (See Page 11)
- v. Kapton Wire (See Picture #3)
  - 1. BAD NEWS DO NOT USE!
  - 2. Plentiful and cheap on the surplus market because it is being removed from commercial and military aircraft as fast as they can economically get it out.
  - 3. Cracks rapidly with age and burns like primercord when it gets lit
  - 4. Several air carrier and military inflight fires and crashes have been traced to Kapton wire

### V. Wire Stripping Tools

- a. Knife or Chisel type (See Picture #4)
  - i. Make a good tack hammer
  - ii. Extremely easy to damage wire
- b. "Ring Die" type (See Picture #5)
  - i. Ideal Tool Co. "Stripmaster" or "Custom Stripmaster"
  - ii. "Ring Die" type come in several varieties
  - iii. Be careful of the surplus strippers designed for Kapton wire
  - iv. The relief for the insulation is smaller because of the thinner insulation on Kapton wire and will not work well on 22759 wire
  - v. The dies are changeable in Stripmasters

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### VI. Terminating and Splicing

- a. Crimping vs. Soldering
  - i. Solid wire is highly susceptible to damage from vibration
  - ii. Houses do not vibrate (much), this is why house wiring is solid or has very large strands
  - iii. Aircraft wire is very finely stranded to make it vibration damage resistant
  - iv. Soldering makes it a solid wire for an indeterminate distance beyond the soldered joint or terminal
  - v. A termination using the correct type of crimp terminal crimped with the correct crimper is the most reliable and longest lasting connection for a wire in an aircraft application
- b. Crimp Terminals Automotive vs. Aircraft (See Picture #6)

<u>Crimp terminals for auto use</u>	<u>Crimp terminals for aircraft use</u>
Amp calls them "Plastigrip"	Amp calls them "Pre Insulated Diamond Grip" or PIDG
Use Vinyl insulation	Always use Nylon insulation
Do not have a metal insulation grip	Have a metal sleeve for insulation grip
Do not have a brazed barrel for the wire grip	Have a brazed barrel for the wire grip

### VII. Crimping Tools (See Picture #7)

- a. Crimp depth is important so the wire isn't damaged in the crimping process
- b. "Tack hammers" do not give predictable crimp depth and crimp one grip area at a time
- c. The wire grip and insulation grip must both be crimped at the same time for a proper termination
- d. Ratcheting dual die crimpers give a predictable crimp depth and crimp both the insulation grip and the wire grip at the same time to the correct depth

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### VIII. Coaxial Cable

- a. RG-58/(letter) (See Picture #8)
  - i. Has black PVC insulation , **stranded** inner conductor with clear nylon or polyethylene insulation
  - ii. Cheaper versions of this cable (CB Cable) are not “tinned” and have a bare copper outer braid and are highly susceptible to corrosion
  - iii. Is fine cable other than the “PVC burning thing” until it gets about 5 to 7 years old
  - iv. Gets brittle with age and begins cracking and absorbing moisture
  - v. Coaxial cable is used in systems where constant impedance for the length of the cable is vital. When it absorbs moisture it changes the impedance of the cable
- b. RG-400 cable (See Picture #9)
  - i. RG 58 has been superseded by RG 400 which is a much higher performance cable
  - ii. Has translucent gold colored Teflon insulation, silver tinned double outer braid and stranded tinned inner conductor with Teflon insulation
  - iii. Silver tinned outer braid and inner conductor make RG 400 highly corrosion resistant
  - iv. Does not become brittle or crack with age due to Teflon insulation
  - v. Is slightly more expensive but very much worth it for airborne applications
- c. Coaxial Cable Termination
  - i. All connectors made for RG 58 will fit RG 400.
  - ii. Crimp connectors are the preferred connectors for our aircraft applications
  - iii. Crimps are easier to attach properly and are more vibration resistant than “clamp type”
  - iv. A good quality crimper for these connectors can be purchased for less than \$25
  - v. Buy some extra connectors and cable, you will need to practice
  - vi. Most good quality connectors (Amphenol) have a stripping dimension diagram on the package (See Picture #10)
  - vii. The hole in the center pin is NOT for soldering in a crimp type connector it is a view hole to verify that the center conductor is bottomed in the pin

### IX. Wire Support & Securing

- a. Ty Wraps
  - i. Come in many varieties not all of which are appropriate for aircraft use
  - ii. Vinyl vs Nylon and telling the difference
  - iii. Metal tab vs plastic tab
  - iv. Limitations in high heat areas
  - v. Minimize blood loss, use flush cutting side cutters to cut off the tails
- b. Lacing Cord
  - i. Better than Ty Wraps because it is easier on the wire.
  - ii. Comes in several varieties, waxed, unwaxed, nomex for hot areas etc
  - iii. Bundle lacing shown in AC 43.13 is good but has drawbacks when maintenance or modification is required it all comes unraveled!
  - iv. The skilled technicians at NASA have a better way this knot as been used on military aircraft and spacecraft for many years
  - v. (See Picture # 11) Here is the knot on the wiring bundles on a Gemini space capsule, the entire wiring harness on the capsule is tied up with this knot

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- vi. The knot I am going to show you takes the place of individual Ty Wraps (See Picture #12)
- c. Clamps
  - i. Adel Clamps MS 2919-XX-X
  - ii. <http://www.aeroelectric.com/articles/adel.html> (See Page 12 of 13)
  - iii. General Color code: black or darker color is for cool and/or less chemically threatening areas and red, orange or yellow is for hot and/or more chemically threatening areas
  - iv. Nylon Clamps not for hot areas
  - v. Same caution applies as for nylon and vinyl Ty Wraps
  - vi. Spacing

### X. Wire Bundle Routing

- a. Separate Noisy Bundles from Quiet ones
  - i. Route high current (flap and landing gear motors, landing lights, starters etc.) or noise producing (strobes) circuits as far as possible away from instrumentation, audio and data circuits
  - ii. Six inches is good but farther is better
- b. Crossing Angle
  - i. If you have to cross an audio, instrumentation or data cable with a high current or noisy circuit do it at 90 degrees
  - ii. This minimizes the electrical coupling between the two circuits

### XI. Wire Protection

- a. Strain relief and environmental protection
  - i. Heat shrink tubing is great but has some limitations
  - ii. Regular heat shrink can actually trap moisture under it
  - iii. Special types of heat shrink are available with gel inside to make it waterproof
  - iv. Most inexpensive heat shrink is PVC which can burn and make cyanide gas
  - v. Heat shrink specifically for aircraft use is made from Polyolefin
  - vi. Protect sharp edges with chafe protection (See Picture #13)
  - vii. Give yourself service loops at the ends of wires

### XII. Wire Marking

- a. Do yourself a favor, mark everything so you can find it later
- b. Mark both ends of a circuit and if it is a long one every 3 or so feet along the way if it is accessible
- c. White heat shrink with lettering by ball point pen or fine point sharpie works great
- d. Clear heat shrink with paper underneath for marking is also slick way to do this

### XIII. THE END

- a. That's all Folks!  
Come on up and try what I just showed you