

Aviation Electrics

Chapter Three: Wires, Terminals, Tools and Other Stuff

A Practical Guide to Shipping Electrons

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Disclaimer

AC 43.13 and AC 021-99 (draft) [Australia]

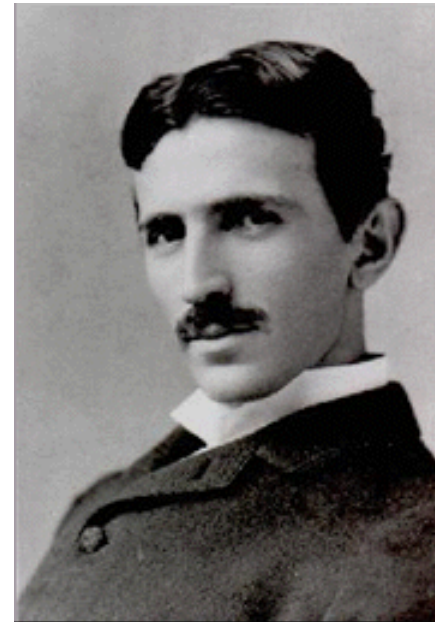
Have thorough and detailed step-by-step procedures that should be followed for aircraft wiring and maintenance.

This presentation provides only an introduction, and should not be considered complete.

If you know when to seek guidance... we have succeeded.

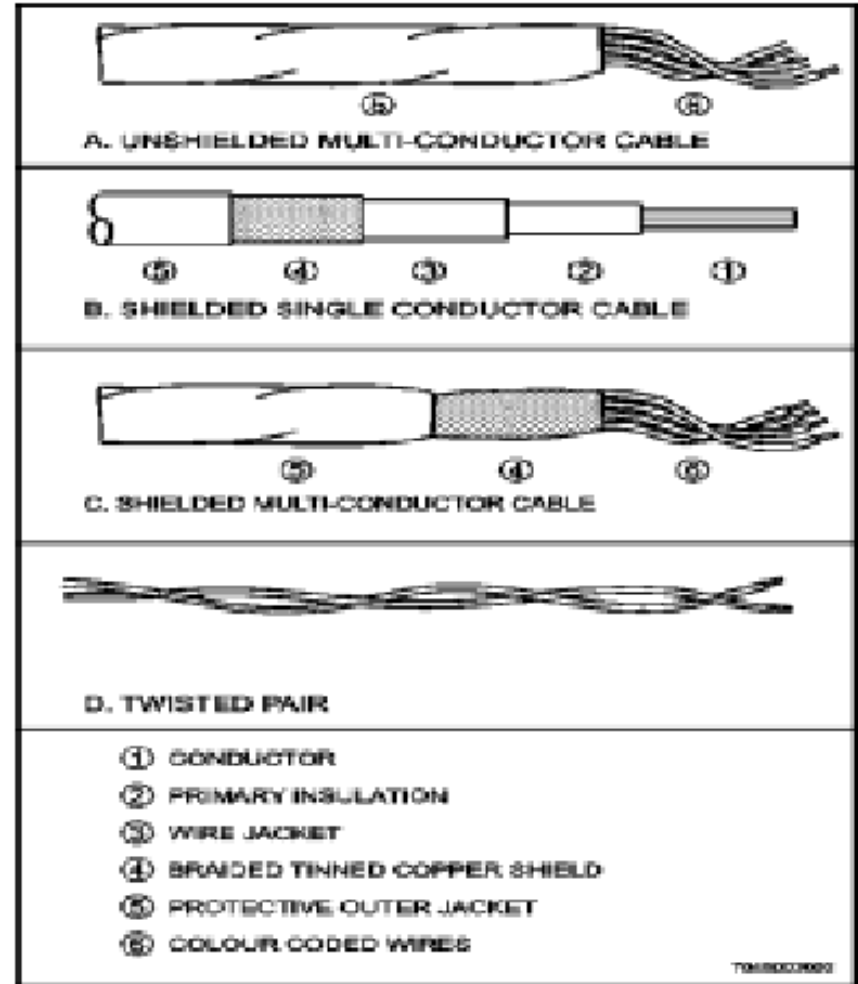
Wires, Terminals, Tools and Other Stuff

- Wires
- Coax
- Confusing Facts
- Wire properties
- Example
- Breakers and Fuses
- Switches
- Terminals
- Connectors
- Grounding
- Wire labelling
- Clamping
- Wire Bundling and Lacing
- Summary
- References
- Tools, terminals and splices (demo)
- Hands-on wiring workshop



Wires

- Pipe for electrons
- The greater the flow, the bigger the wire needs to be
- Normally insulated with Tefzel insulation
- Hook-up
 - Single-conductor wire fabricated with tin or silver-plated stranded copper
- Wire size measured in AWG (American Wire Gauge)

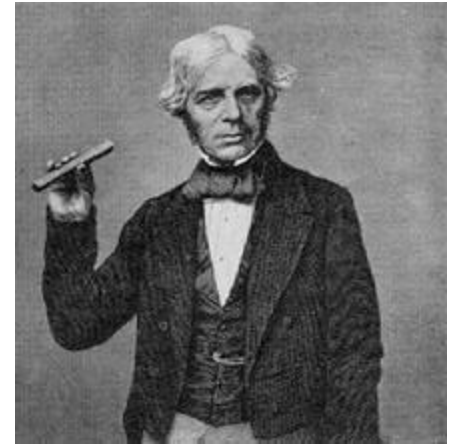


Shielded Coaxial Wiring

- Shield minimizes the effect of electrical interference
 - Does nothing for magnetic interference
- Used for antennas, audio systems and sensitive connections
- Antennas: Ground shield at both ends.
 - Failure to do this will degrade radio operation
 - Typical type is RG-400 (about \$2.50 per foot)– low loss, double shielded.
 - RG-58/U is common in older installs. This is NOT the same as RG-59/U
 - Beware: there are many types of incompatible coax.
- Audio & Other: Ground shield at one end.
 - Failure to observe this will generate audio noise in your intercom.
 - Audio coax is less stringent (cheaper)
 - Available with multiple conductors

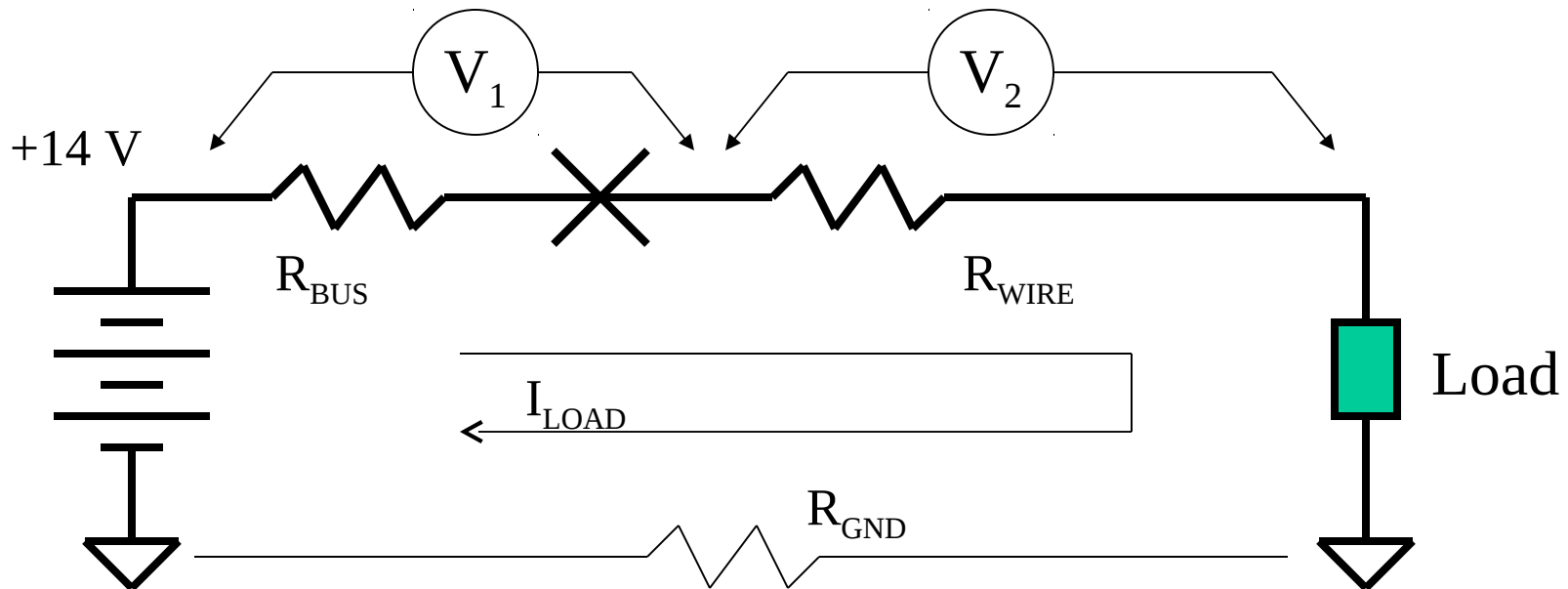


Confusing Facts



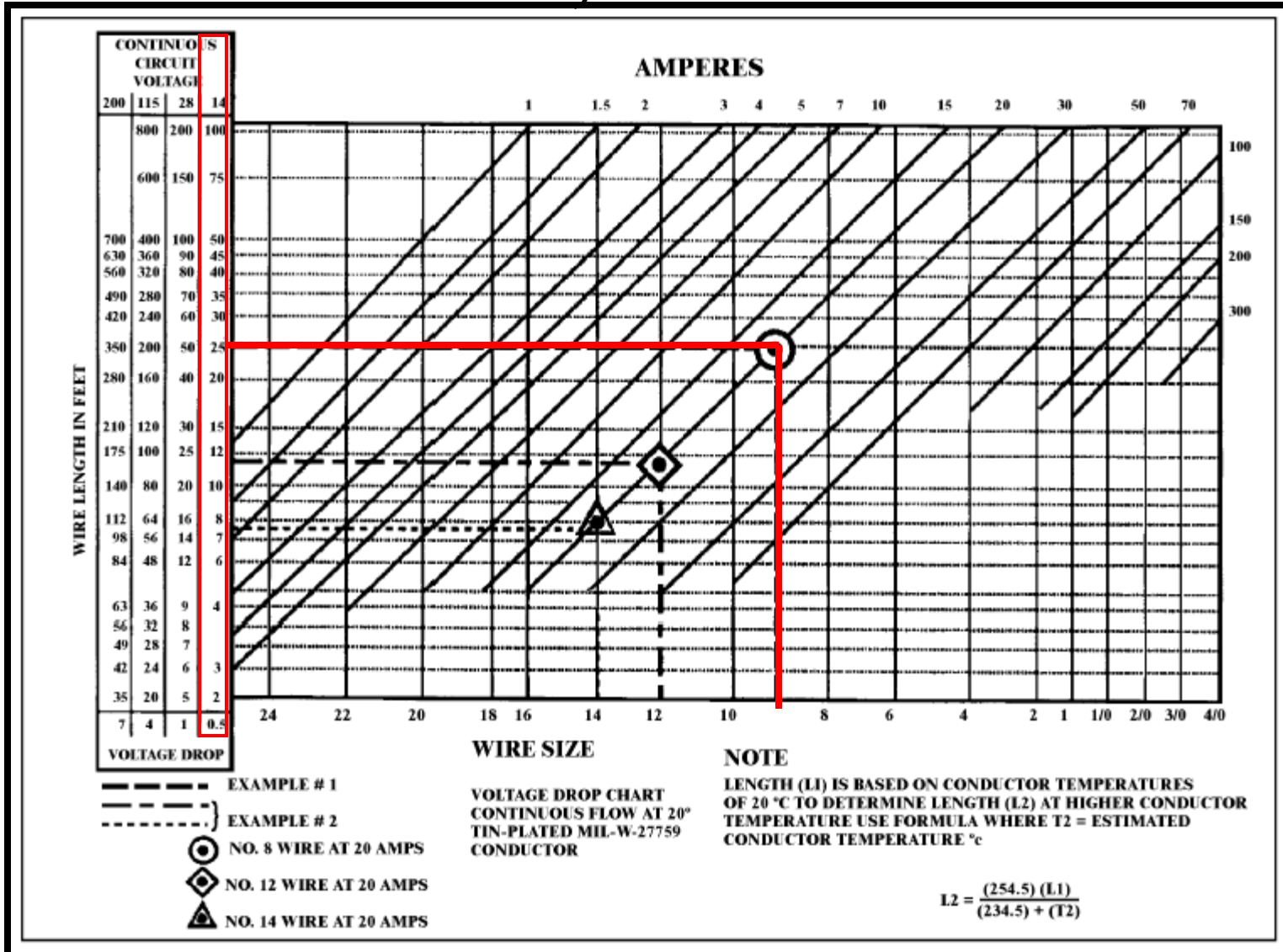
- Remember Ohm's Law
 - $V = I * R$
 - $P = V * I = I^2 * R$
 - Big currents need big wires
- Power (to load) = $V_{load} * I_{load}$
- Power (lost in wire) = $I_{load}^2 * R_{wire}$
 - Power dissipation (in a wire, circuit breaker) is proportional to current squared.

Wire Properties

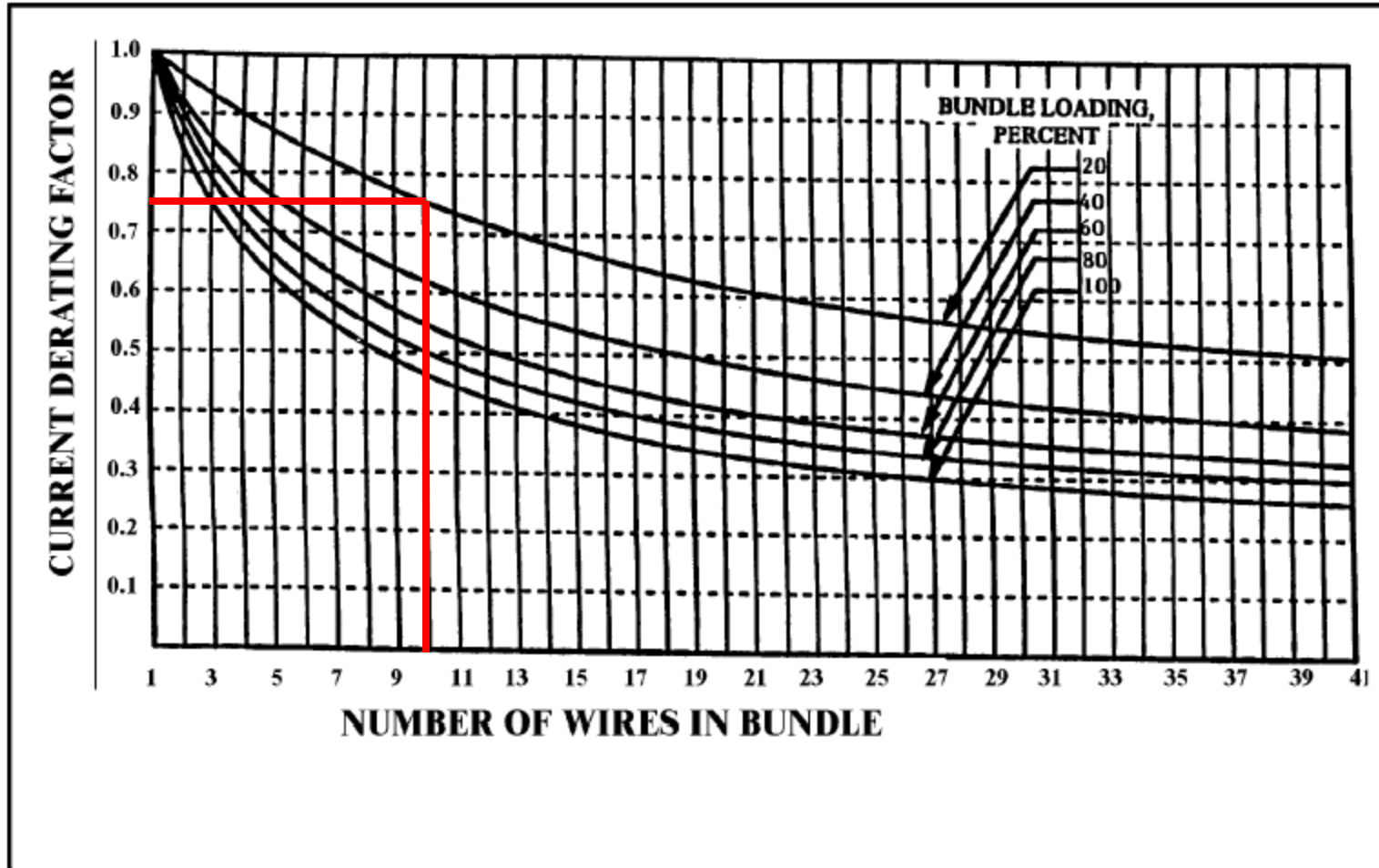


- V_1 is limited to 2% (0.28 V). Determined by resistance of fat battery wires and contactor
- V_2 is limited to 0.5 V (1.0 V) in 14 V systems
- R_{GND} is assumed to be zero (or lumped into bus resistance)

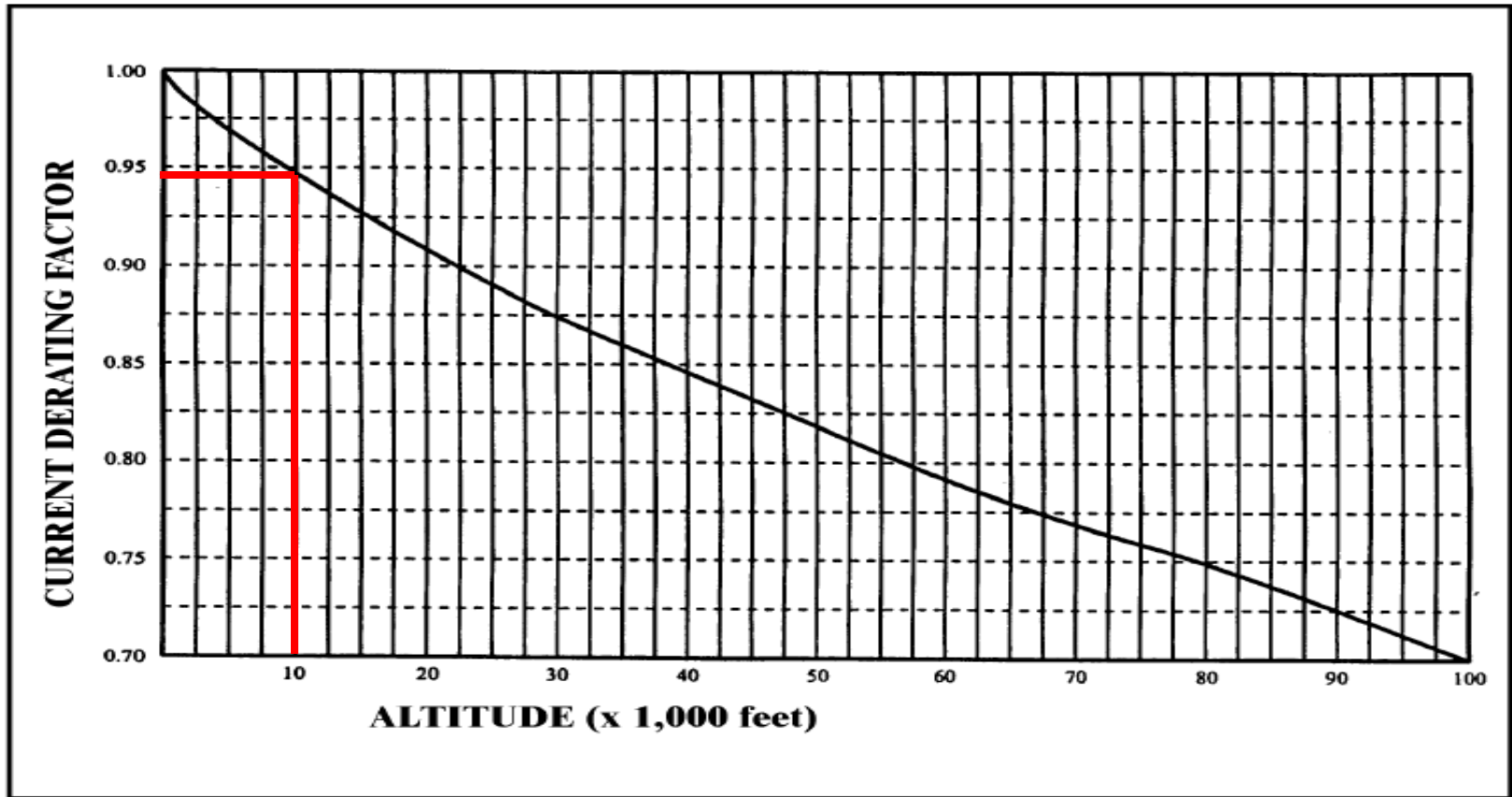
Wire Selection, Continuous Flow



Bundle Derating



Altitude Derating



Circuit Breakers/Fuse Selection

- Breakers and fuses protect the wire...
- Not the load



TABLE 11-3. DC wire and circuit protector chart.

Wire AN gauge copper	Circuit breaker amp.	Fuse amp.
22	5	5
20	7.5	5
18	10	10
16	15	10
14	20	15
12	30	20
10	40	30
8	50	50
6	80	70
4	100	70
2	125	100
1		150
0		150

Basis of chart

- (1) Wire bundles in 135 °F. ambient and altitudes up to 30,000 feet.
- (2) Wire bundles of 15 or more wires, with wires carrying no more than 20 percent of the total current carrying capacity of the bundle as given in Specification MIL-W-5088 (ASG).
- (3) Protectors in 75 to 85 °F. ambient.
- (4) Copper wire Specification MIL-W-5088.
- (5) Circuit breakers to Specification MIL-C-5809 or equivalent.
- (6) Fuses to Specification MIL-F-15160 or equivalent.

Switches

- Not all switches are created equal.
- AC switch ratings are not applicable to DC loads.
- Buy from aircraft parts suppliers to be sure
 - (B&C Specialties, Aircraft Spruce)
- There are even Mil Spec switches!
 - Aircraft Spruce sells them ~ \$12.00



Terminals

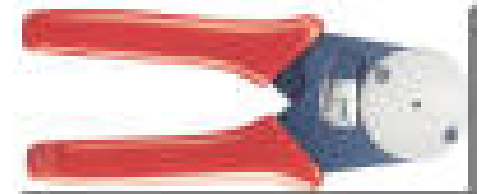
- Crimp terminals
 - Fast-on, bullet, ring, splice
 - ‘Avikrimp’ brand, with metal strain-relief
 - Not hardware store types
- BNC terminals (Amp, Amphenol)
 - 50 Ohm type, NOT 75 ohm
 - Easy to confuse
 - Ask an expert to be sure
- Purchase only from trusted (aviation) sources
 - From clearly marked bags





Connectors

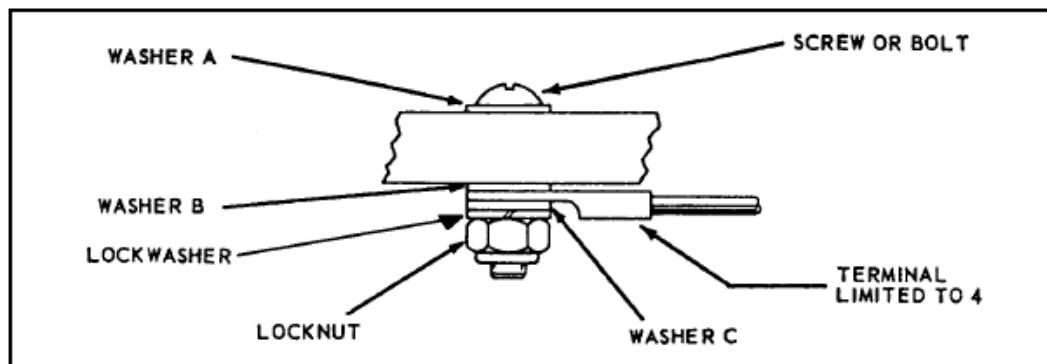
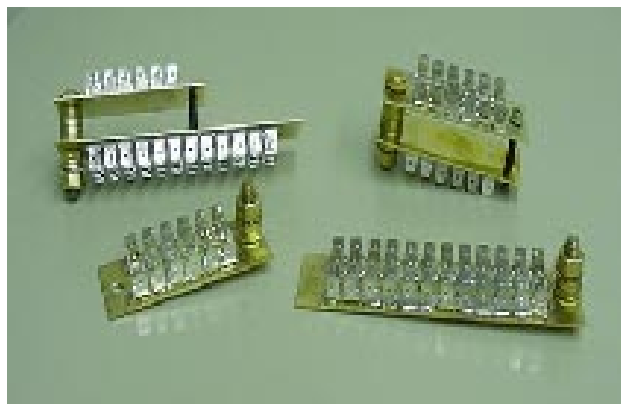
- Box connectors, (Amp, Molex)
- D-Subminiature connectors (Amp, Norcomp)
- Mil-Spec circular



Grounding

TABLE 11-16. Bolt and nut bonding or grounding to flat surface.

- AC 43.13 has several charts
- Hole and face must be clean and free of paint, oxide or anodization
- Ground bus blocks for fast-on connectors
 - B&C



Aluminum Terminal and Jumper					
Structure	Screw or bolt and nut plate	Lock-nut	Washer A	Washer B	Washer C
Aluminum Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminum	None	Cadmium Plated Steel or Aluminum
Magnesium Alloys	Cadmium Plated Steel	Cadmium Plated Steel	Magnesium Alloy	None or Magnesium alloy	Cadmium Plated Steel or Aluminum
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminum
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cadmium Plated Steel	Cadmium Plated Steel	Corrosion Resisting Steel	Cadmium Plated Steel	Cadmium Plated Steel or Aluminum
Tinned Copper Terminal and Jumper					
Structure	Screw or bolt and nut plate	Lock-nut	Washer A	Washer B	Washer C
Aluminum Alloy	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	Aluminum ² Alloy	Cadmium Plated Steel
Magnesium Alloy ¹	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	None	Cadmium Plated Steel
Steel, Cadmium Plated	Cadmium Plated Steel	Cadmium Plated Steel	Cadmium Plated Steel	None	Cadmium Plated Steel
Steel, Corrosion Resisting	Corrosion Resisting Steel or Cadmium Plated Steel	Cadmium Plated Steel	Corrosion Resisting Steel	None	Cadmium Plated Steel

¹Avoid connecting copper to magnesium.

²Use washers having a conductive finished treated to prevent corrosion, suggest AN960JD10L

Labeling

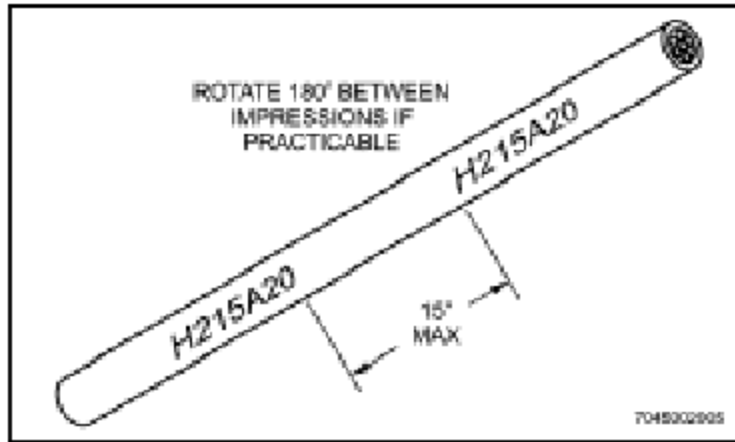


Figure 2-2 Spacing of Identification Marking on Wire and Cable

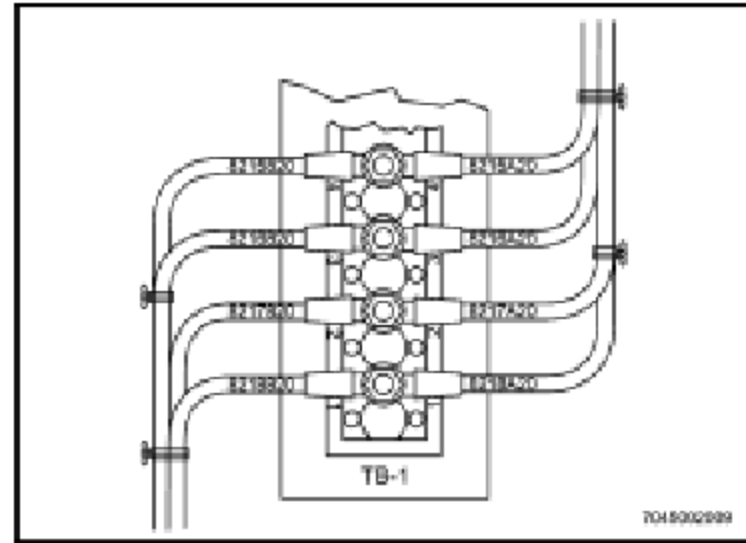


Figure 2-6 Wire Identification at Terminal Board

- AC 021-99 (draft) is quite thorough in how to designate wires and labelling procedures
 - Most amateur-built aircraft use somewhat more primitive schemes
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Clamping

- AC 43.13 has a section dedicated to Clamping
- Use to prevent abrasion and interference with mechanical systems

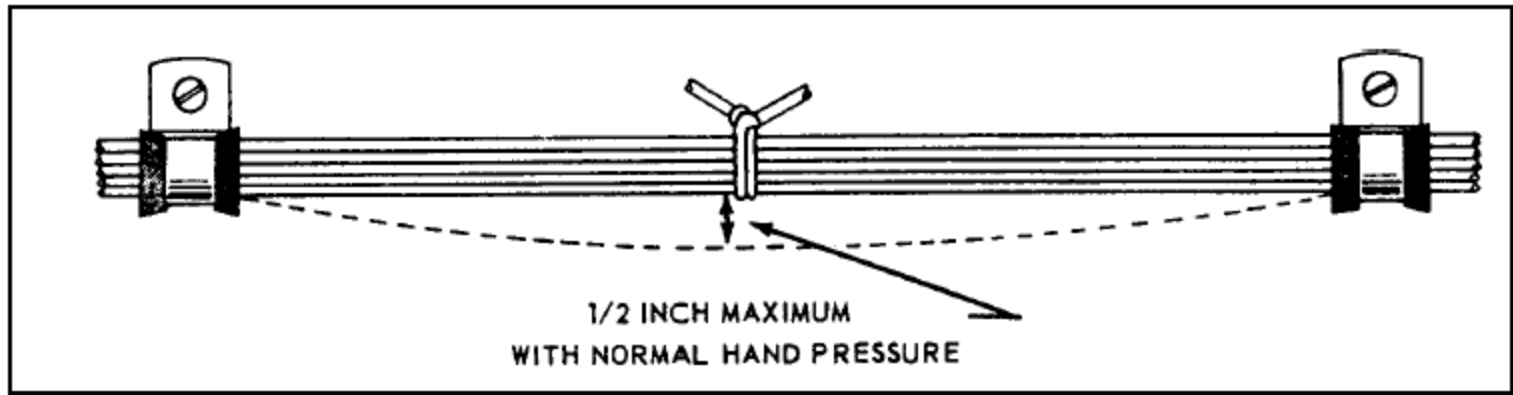
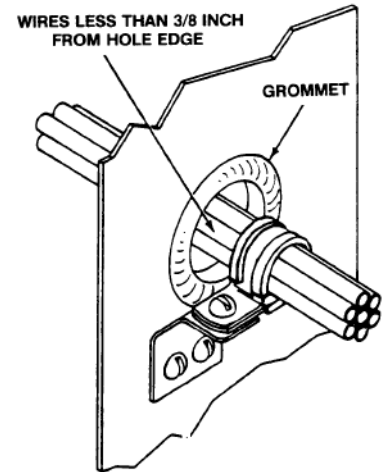


FIGURE 11-9a. Slack between supports

Wire Bundling and Lacing

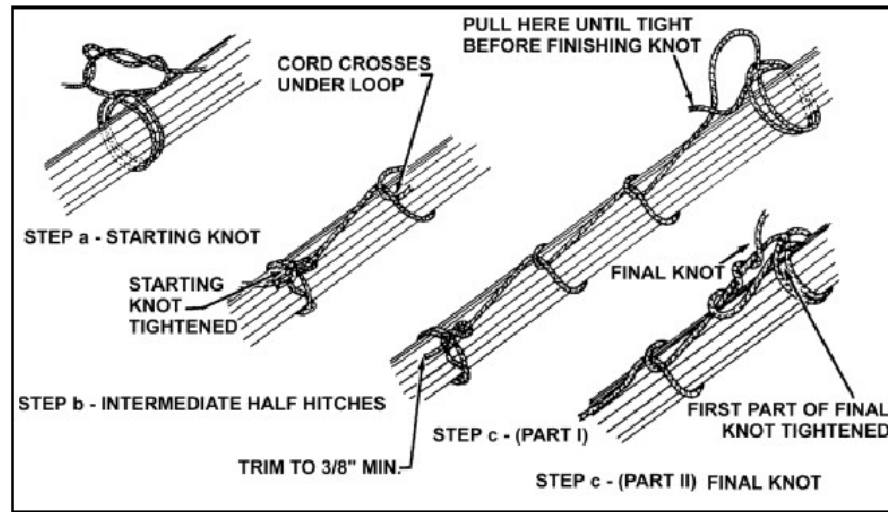


FIGURE 11-15. Single cord lacing.

- A dying art. Replaced in general by nylon tie-wraps.
- Often used by pros to make amateurs feel inadequate. Peter claims to be a pro!

Summary

- The key references AC 43.13 and AC 021-99 contain everything you need to know.
- Select wire sizes and breaker sizes from the charts provided in the references.
- Use only Tefzel insulated (aircraft) wire.
- Use crimp terminals and connectors from trusted aviation sources.
- Route wires and harnesses properly, and prevent interference or abrasion.
- Use the proper tools
- Take up knitting or use tie-wraps for lacing



References

- **AC 43.13-1b: Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair**
 - Flight Standards AC. Chapter 11- Aircraft Electrical Systems
- **AC 021-99(draft)**
 - Australian bible on electrical aircraft wiring. Complete book of recipes and techniques, highly recommended
- **The Aeroelectric Connection**
 - Home builder's bible. www.aeroelectric.com
- Wiring supplies and tool sources
 - www.steinair.com
 - <http://www.bandc.biz>
 - <http://www.aircraftspruce.com>
 - <http://www.affordablepanels.com/>
 - www.digikey.ca
- Complete RV electrical system design available at
 - www3.telus.net/aviation/vx.html

Tools, Terminals and Splicing

Demo and Workshop

Peter Klein