

# I. Introductions

- We will cover in this presentation
  - Aircraft electrical installation
    - Materials
    - Tools
    - Techniques
    - Recommended practices

## II. Qualifier

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

# III. New AC 43.13-1B

- FAA Advisory Circular Publication documenting recommended techniques for aircraft maintenance and repair
- It is an **advisory** circular not a **rule**
- Paragraph 11 and 12 deal with Electrical and Avionics

# III. New AC 43.13 1B

## ● How to get it

- You can download it (by section) free from the FAA ([www.faa.gov](http://www.faa.gov)) use “quick find” search for “advisory circulars” then “ac 43.13 1b”
- **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.
- If you download it you will not want to print the whole document, it is in excess of 627 pages long
- Or you can buy a hard copy from most aviation book sellers or pilot shops

# IV. Wire

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

# IV. Wire

- Mil spec 5086A



- Relatively thick PVC insulation
- Finely stranded
- Found in most aircraft produced until the late 1970's
- PVC insulation produces Cyanide when it burns and will support combustion

# IV. Wire

- Mil spec.22759/ (*number*) – (*wire gauge*)



- Teflon or Tefzel insulation (In colors other than white now too!)
- Will not support combustion and does not generate poisonous fumes when exposed to flame
- Is always finely stranded
- Is always tinned with tin, nickel or silver making it highly corrosion resistant
- Table 11.11 Open Wiring in 43.13 page Par. 11-89 page 11-40

# IV. Wire

**Table 11-11 Open Wiring**

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor type
MIL-W-22759/1	600	200	Fluoropolymer insulated TFE and TFE coated glass	Silver coated copper
MIL-W-22759/2	600	260	Fluoropolymer insulated TFE and TFE coated glass	Nickel coated copper
MIL-W-22759/3	600	260	Fluoropolymer insulated TFE -glass-TFE	Nickel coated copper
MIL-W-22759/4	600	200	Fluoropolymer insulated TFE -glass-FEP	Silver coated copper
MIL-W-22759/5	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper
MIL-W-22759/6	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper
MIL-W-22759/7	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper
MIL-W-22759/8	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper
MIL-W-22759/9	1000	200	Fluoropolymer insulated extruded TFE	Silver coated copper
MIL-W-22759/10	1000	260	Fluoropolymer insulated extruded TFE	Nickel coated copper
MIL-W-22759/13	600	135	Fluoropolymer insulated FEP PVF2	Tin coated copper,
MIL-W-22759/16	600	150	Fluoropolymer insulated extruded ETFE	Tin coated copper,
MIL-W-22759/17	600	150	Fluoropolymer insulated extruded ETFE	Silver coated high strength copper alloy
MIL-W-22759/20	1000	200	Fluoropolymer insulated extruded TFE	Silver coated high strength copper alloy



# IV. Wire

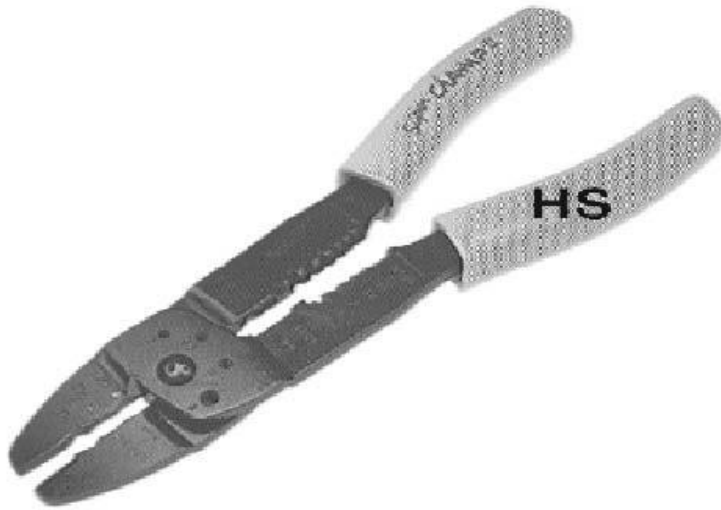
- Kapton Wire



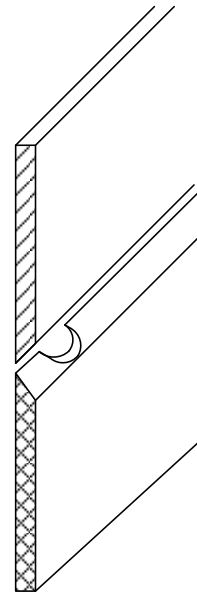
- BAD NEWS DO NOT USE!
- Plentiful and cheap on the surplus market because it is being removed from commercial and military aircraft as fast as they can economically get it out.
- Cracks rapidly with age and burns like primercord when it gets lit
- Several air carrier and military inflight fires and crashes have been traced to Kapton wire

# V. Wire Stripping Tools

- Strippers
  - Knife type
  - Make a good tack hammer



“Knife or chisel” type stripper



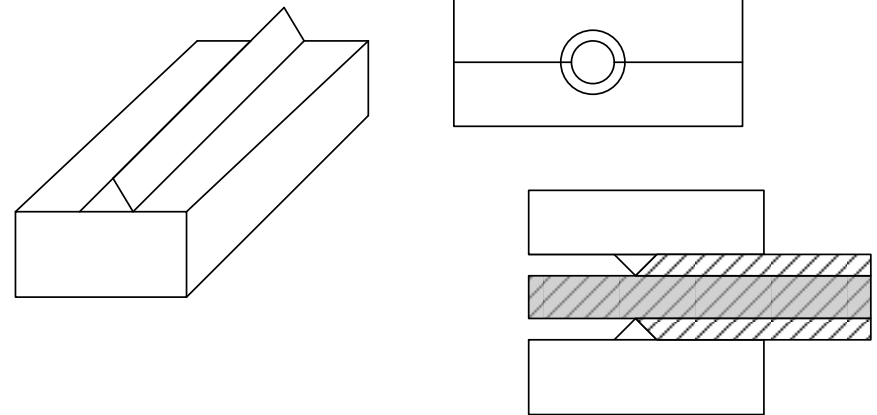
# V. Wire Stripping Tools

## ● Strippers

- “Die” or “Ring Die” type
- Ideal Tool Co. “Stripmaster” or “Custom Stripmaster”



“Ring die” type stripper



# V. Wire Stripping Tools

- Strippers

- “Ring Die” type come in several varieties
- Be careful of the surplus strippers designed for Kapton wire
- The relief for the insulation is smaller because of the thinner insulation on Kapton wire and will not work well on 22759 wire
- The dies are changeable in Stripmasters

# V. Wire Stripping Tools

- Ideal Industries 45-1987 Custom Stripmaster for MIL-W-22759/32 thru 46, 16-26 AWG wire
  - 45-1987-1 Blade Set for 45-1987
- See: **Custom Stripmaster Wire Stripper and Custom Stripmaster Lite Wire Stripper MIL-spec reference chart**
- [http://www.idealindustries.com/media/pdfs/products/charts/stripmaster\\_mil\\_spec\\_chart.pdf](http://www.idealindustries.com/media/pdfs/products/charts/stripmaster_mil_spec_chart.pdf)

# VI. Terminating and Splicing

- Crimping vs. Soldering
  - Solid wire is highly susceptible to damage from vibration
  - Houses do not vibrate (much), this is why house wiring is solid or has very large strands
  - Aircraft wire is very finely stranded to make it vibration damage resistant

# VI. Terminating and Splicing

- Crimping vs. Soldering
  - Soldering makes it a solid wire for an indeterminate distance beyond the soldered joint or terminal
  - 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

# VI. Terminating and Splicing

<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



# VI. Terminating and Splicing

**Plastigrip**



**PIDG**



# VI. Terminating and Splicing

## **Common PIDG Terminal Color Code and Wire Gauge**

**Clear 20-24 Gauge**

**Red 18-22 Gauge**

**Blue 14-16 Gauge**

**Yellow 10-12 Gauge**

**Red 8 Gauge**

**Blue 6 Gauge**

# VI. Terminating and Splicing

## **PIDG Faston Terminal**



# VI. Terminating and Splicing

## PIDG Butt Splice



# VI. Terminating and Splicing

## **PIDG Knife Splice or “Handshake”**



# VI. Terminating and Splicing

## Fork or Spade Terminal



**DO NOT USE IN AN AIRPLANE!**

# VII. Crimping Tools

- Crimpers

- Crimp depth is important so the wire isn't damaged in the crimping process
- The wire grip and insulation grip must both be crimped at the same time for a proper and stable termination
- "Tack hammers" do not give predictable crimp depth and crimp one grip area at a time
- 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

# VII. Crimping Tools

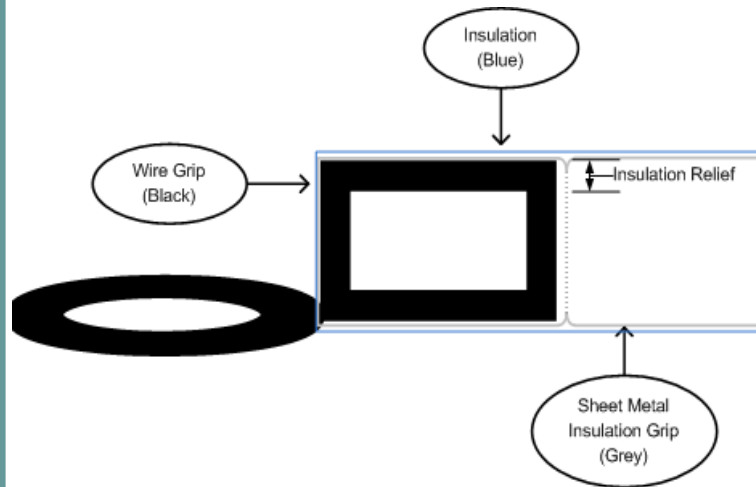
- Crimpers



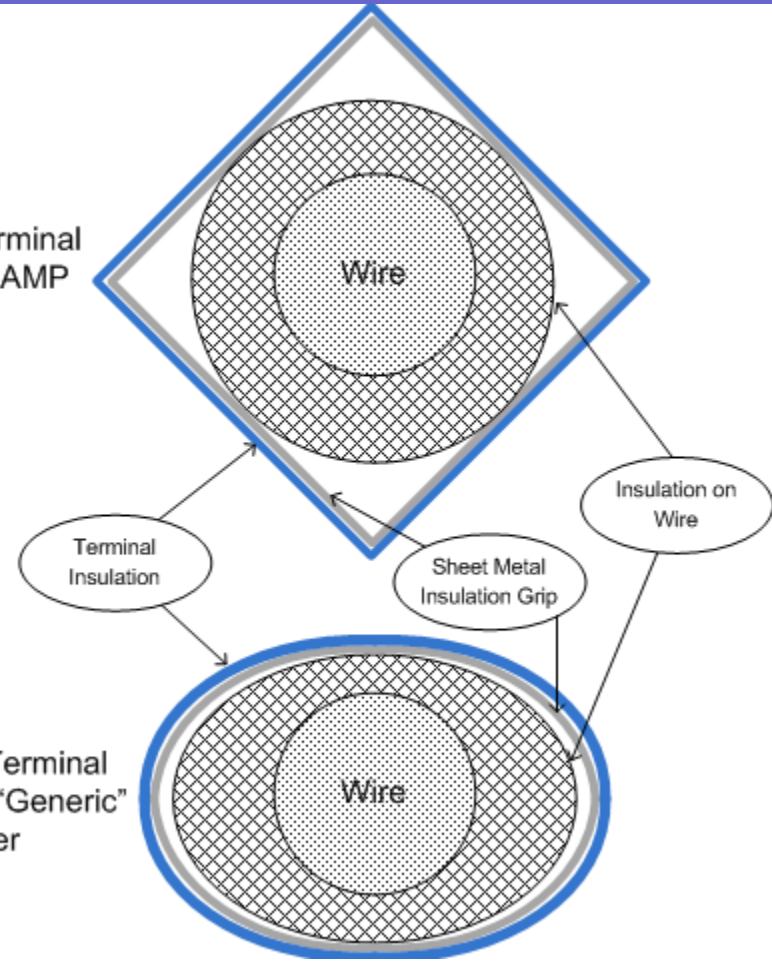


# VII. Crimping Tools

## ● Crimpers



AMP PIDG Terminal  
Crimped with AMP  
Crimper



# VIII. Coaxial Cable

- Coaxial Cable
  - Typical cable found in small aircraft VHF communication, navigation and transponder systems is RG-58



# VIII. Coaxial Cable

- Coaxial Cable

- RG-58/(letter)

- Has black PVC insulation , **stranded** inner conductor with clear nylon or polyethylene insulation
- Cheaper versions of this cable (CB Cable) are not “tinned” and have a bare copper outer braid and are highly susceptible to corrosion
- Is fine cable other than the “PVC burning thing” until it gets about 5 to 7 years old

# VIII. Coaxial Cable

- Coaxial Cable

- RG-58/(letter)

- Gets brittle with age and begins cracking and absorbing moisture
- 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 in the area where moisture is absorbed

# VIII. Coaxial Cable

- Coaxial Cable
  - RG 58 has been superseded by RG 400 which is a much higher performance cable



# VIII. Coaxial Cable

- Coaxial Cable

- RG 400

- Has translucent gold colored Teflon insulation, silver tinned double outer braid and stranded tinned inner conductor with Teflon insulation
- Silver tinned outer braid and inner conductor make RG 400 highly corrosion resistant
- Does not become brittle or crack with age due to Teflon insulation
- Is slightly more expensive

# VIII. Coaxial Cable

- Coaxial Cable Termination
  - All connectors made for RG 58 will fit RG 400.
  - Crimp on connectors are the preferred connectors for our applications and are easier to attach properly than clamp types that screw together
  - A good quality crimper for these connectors can be purchased for less than \$25
  - Buy some extra connectors and cable, you will need to practice

# VIII. Coaxial Cable

- Coaxial Cable Termination

- 3 blade or “3 step” clamp on strippers are a good way to go but you can use a knife as well (carefully!) with practice



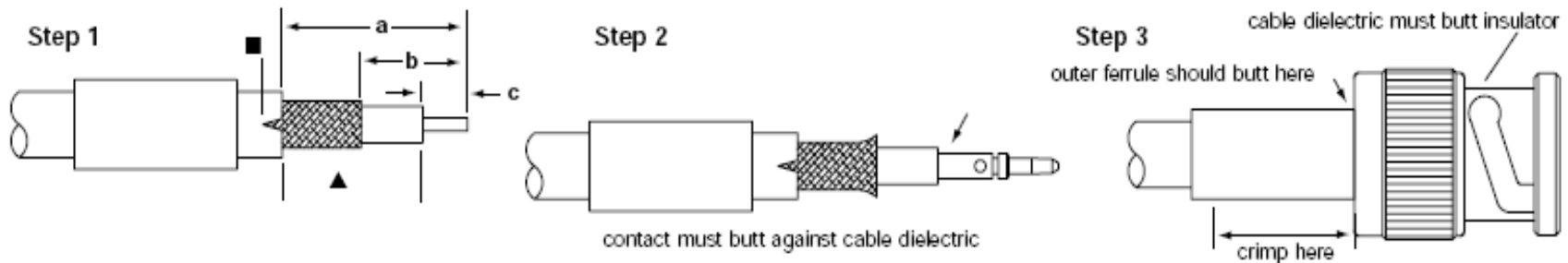
- These Come in 2 and 3 blade, you need the 3 blade
- Lowes and Radio Shack has them for about \$25



# VIII. Coaxial Cable

## ● Coaxial Cable Termination

- Most good quality connectors (Amphenol) have a stripping dimension diagram on the package
- The hole in the center pin is NOT for soldering in a crimp type connector

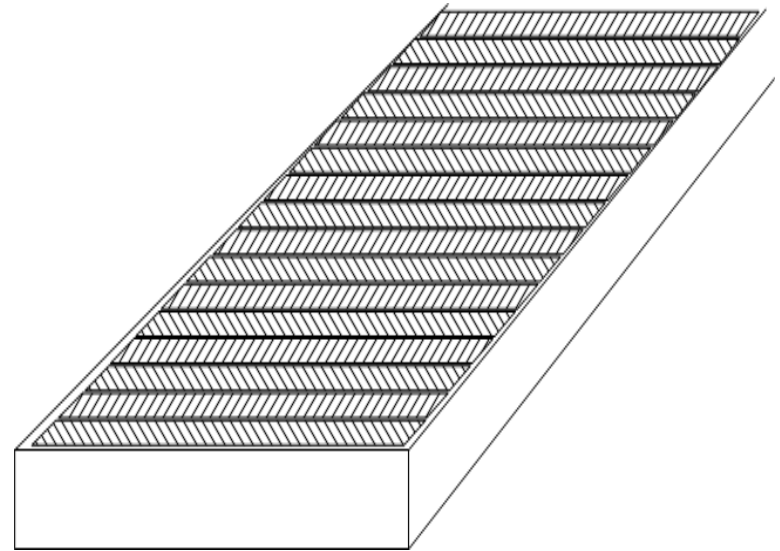
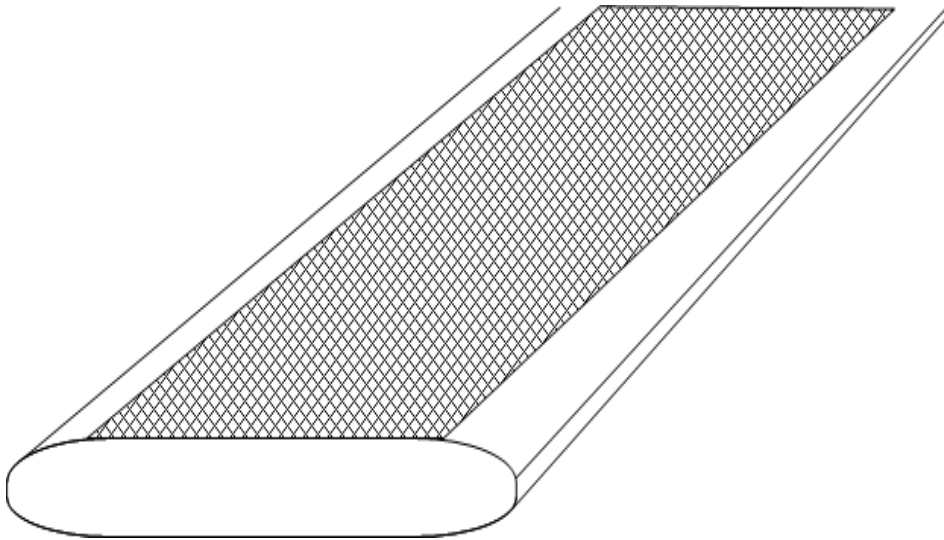


# IX. Wire Support & Securing

- Ty Wraps
  - Many varieties - some not appropriate for aircraft use
  - Typically not for high heat areas
  - Vinyl vs Nylon and telling the difference
  - Minimize blood loss, use flush cutting side cutters to cut off the tails

# IX. Wire Support & Securing

- Ty Wraps
  - Metal tab vs plastic tab



# IX. Wire Support & Securing

## ● Lacing Cord

- Better than Ty Wraps because it is easier on the wire
- Comes in several varieties, waxed, unwaxed, nomex for hot areas etc
- See the website in the next bullet for a detailed explanation of the different types of Lacing Cord
- [http://www.carwild.net/gudebrod/Braid\\_Lacing\\_Tape.htm](http://www.carwild.net/gudebrod/Braid_Lacing_Tape.htm)

# IX. Wire Support & Securing

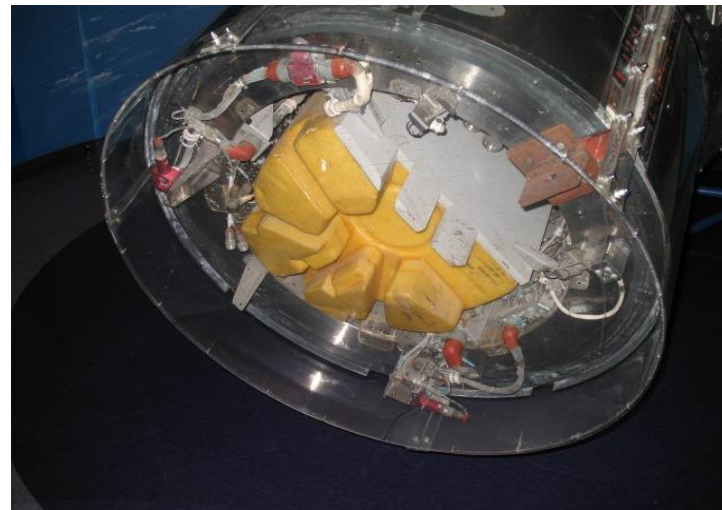
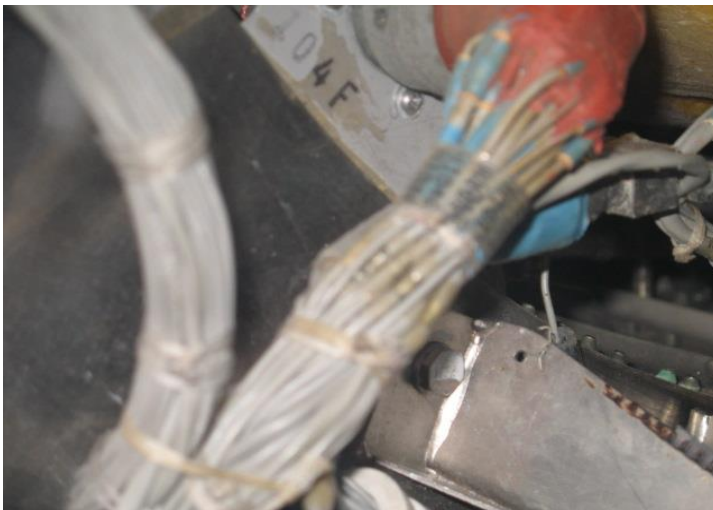
## ● Lacing Cord

- Bundle lacing shown in AC 43.13 is good but has drawbacks when maintenance or modification is required it all comes unraveled!
- The knot we are going to show you takes the place of individual Ty Wraps
- Has been used on military aircraft and spacecraft for many years

# IX. Wire Support & Securing

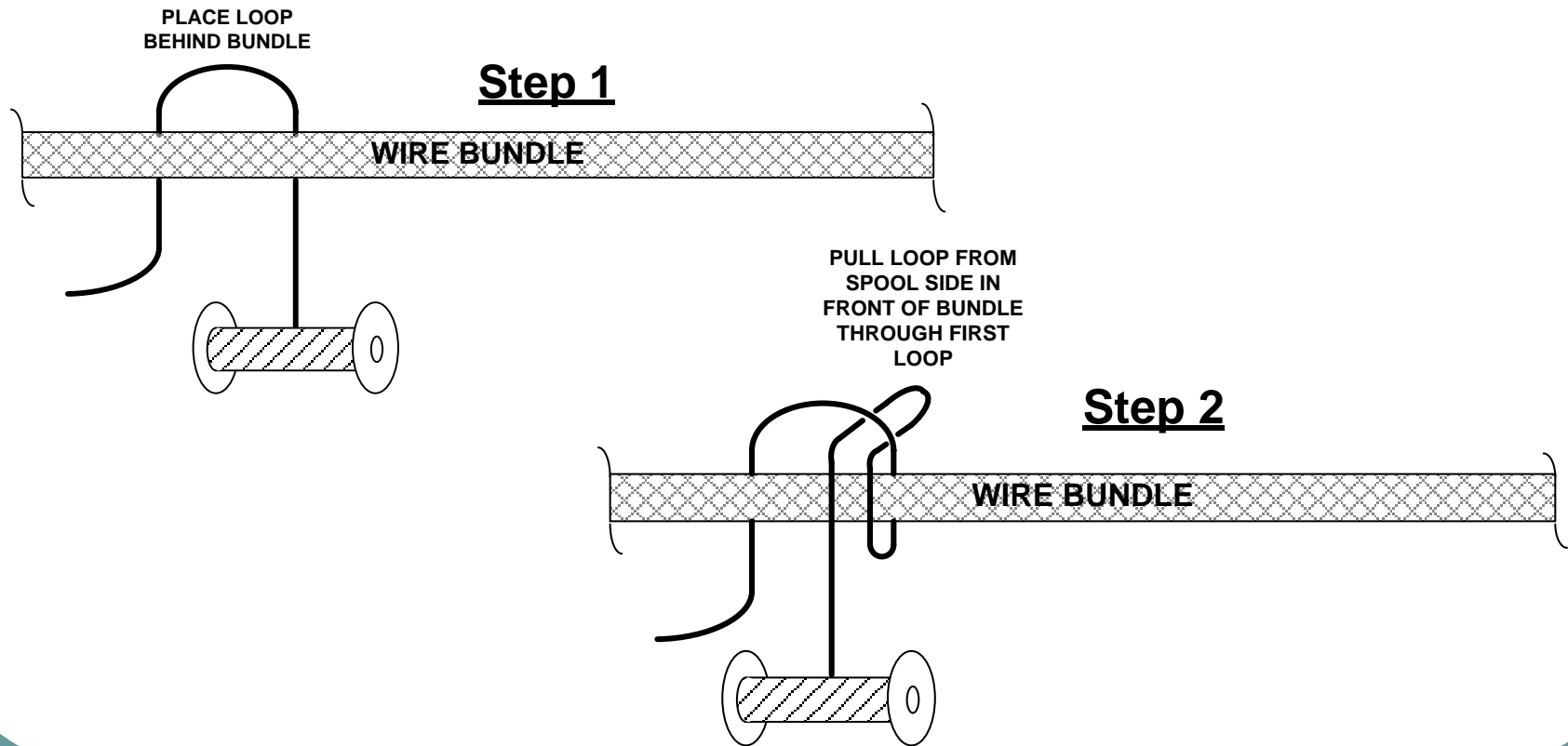
- Lacing Cord

- Here is our knot on the wiring harness on a Gemini space capsule
- The entire wiring harness on the capsule is tied up with this knot



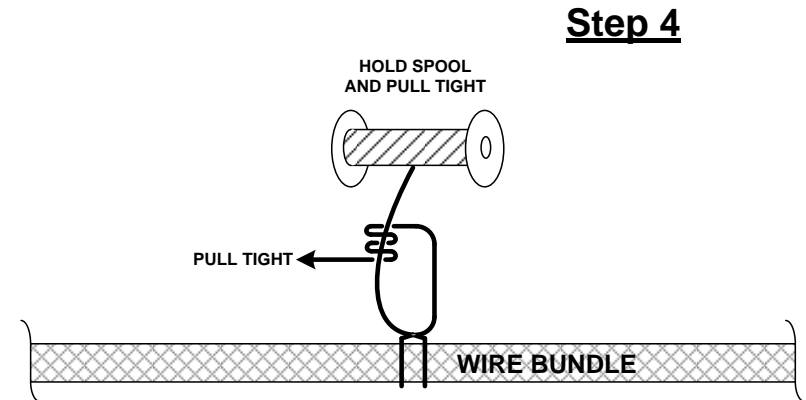
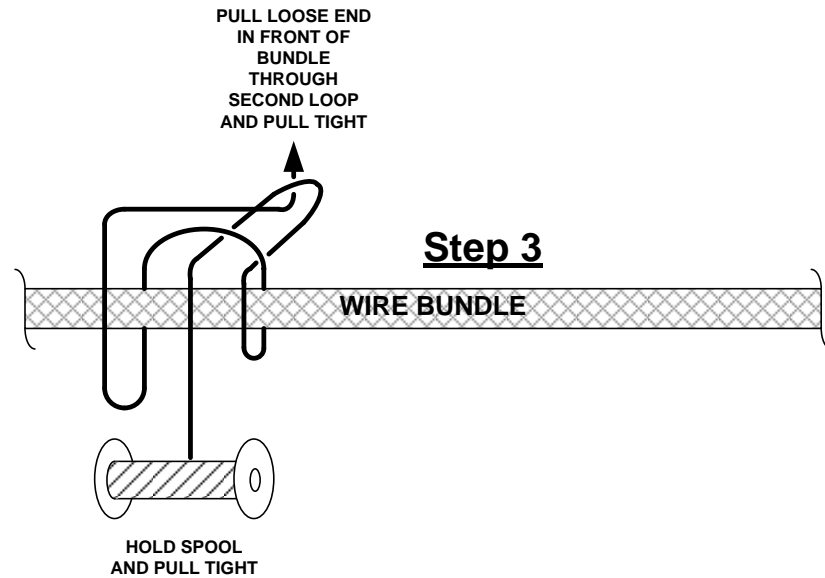
# IX. Wire Support & Securing

## Wire Tying Knot (Way better than a Ty-Wrap!)



# IX. Wire Support & Securing

## Wire Tying Knot (Way better than a Ty-Wrap!)





# IX. Wire Support & Securing

- Clamps
  - Adel Clamps MS 2919-XX-X
  - <http://www.aeroelectric.com/articles/adel.html> (In Handout)
  - Color code: generally black color is for cool areas and red or orange is for hot areas
  - Nylon Clamps not for hot areas
  - Same caution applies as for nylon and vinyl Ty Wraps
  - Spacing

# X. Wire Bundle Routing

- Separate Noisy Bundles from Quiet ones
  - Route high current (flap and landing gear motors, landing lights, starters etc.) or noise producing (strokes) circuits as far as possible away from instrumentation, audio and data circuits
  - Six inches is good but farther is better

# X. Wire Bundle Routing

- Crossing Angle
  - If you have to cross an audio, instrumentation or data cable with a high current or noisy circuit do it at 90 degrees
  - This minimizes the electrical coupling between the two

# X. Wire Bundle Routing

- Pay attention to where wiring is in relation to liquid lines (especially fuel)
  - Route wiring ABOVE fuel or other liquid lines so if the lines leak they will not leak on the wires
  - Do not secure wiring to liquid lines

# XI. Wire Protection

- Strain relief and environmental protection
  - Heat shrink tubing is great but has some limitations
  - Regular heat shrink can actually trap moisture under it
  - Special types of heat shrink are available with heat setting gel inside to make it waterproof
  - Most inexpensive heat shrink is PVC which can burn and make cyanide gas
  - Heat shrink for aircraft use is made from Polyolefin
  - Protect sharp edges with chafe protection
  - Give yourself service loops at the ends of wires

# XII. Wire Marking

- Mark everything so you can find it later
- 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
- White heat shrink with lettering by ball point pen or fine point sharpie works great
- Clear heat shrink with paper underneath for marking is also slick way to do this

# XII. Wire Marking

- Dymo, Brother and Brady make inexpensive (<\$75) label makers that work great for this
- Oil and moisture resistant label tape is available for these
- These are commonly used for data network cable labeling
- Get one that can print in “wrap” format so it can be wrapped around the wire

**THE END**

That's all Folks!

Come on up and try what I  
just showed you