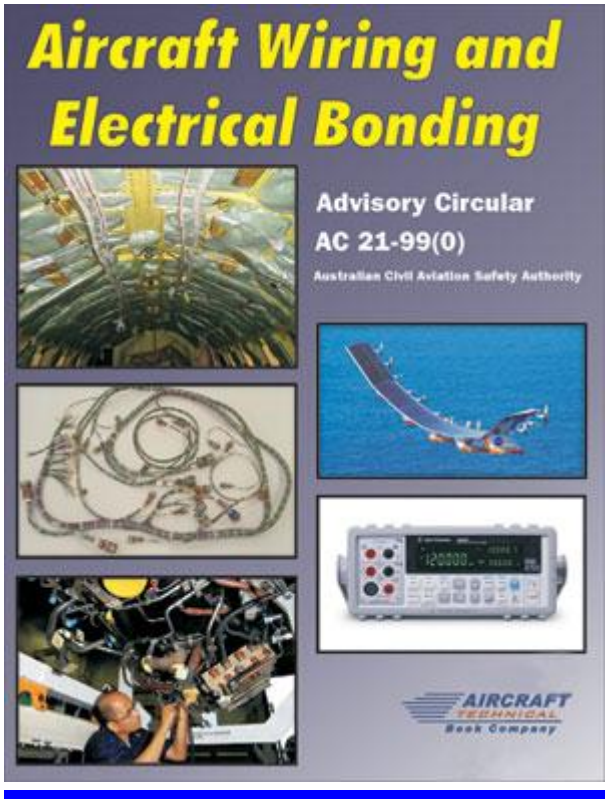
AIRCRAFT WIRING AND ELECTRICAL BONDING, ADVISORY CIRCULAR AC 21-99

Part # 13-11205



This is a highly detailed manual published by by Aircraft Technical Book Company under license by the Australian Civil Aviation Safety Authority (CASA) presenting indepth instructions for aircraft electrical work covering topics from aged wiring inspection to modern fiber optic installation, inspection and repair.

Material selection, circuit design, harness building, connectors, circuit protection, soldering, lacing, sealing, electrical bonding, grounding, repairs, and all other related skills are covered in a practical, no nonsense manner offering complete guidance to the A&P technician working with small and large aircraft electrical systems to commercial and military standards.

- **Basic Definitions**
- **Life and times of a Fault**

Reliability of the system is proportional
to the amount of maintenance received
and the knowledge of those who perform such
maintenance.
It is, therefore, important that
maintenance be accomplished using the best
techniques and practices to minimise the possibility
of failure.

Definitions

- **RELIABILITY:**

SURVIVAL PROBABILITY

• When repair is costly or function is critical

- **AVAILABILITY:**

THE FRACTION OF TIME A SYSTEM MEETS ITS SPECIFICATION

• When service can be delayed or denied

- **REDUNDANCY:**

EXTRA HARDWARE, SOFTWARE, TIME

- **FAILSAFE:**

SYSTEM FAILS TO A KNOWN SAFE STATE

• i.e. All red traffic signals

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Cause-Effect Sequence and Duration

- **FAILURE:** **component does not provide service**

- **FAULT:** **a defect within a system**

- **ERROR:** **a deviation from the required operation of the system or subsystem (manifestation of a fault)**

DURATION:

- Transient- design errors, environment
- Intermittent- repair by replacement
- Permanent- repair by replacement

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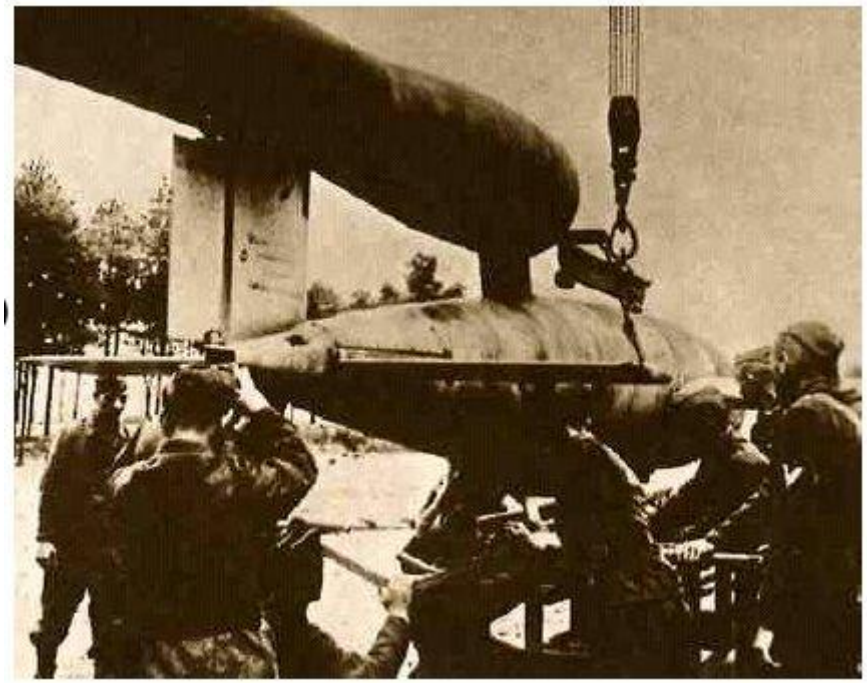
First predictive reliability models - Von Braun

Wernher Von Braun - German Rocket Engineer, WWII

- V1 was 100% Unreliable
- Fixed weakest link - still unreliable



Eric Pieruschka - German Mathematician

- 1/x^n - for identical components
- Rs=R1 x R2 x … x Rn (Lusser's law)

For example, if one were to build a serial system with 100 components each of which had a reliability of .999, the overall system reliability would be $0.999^{100} = 0.905$

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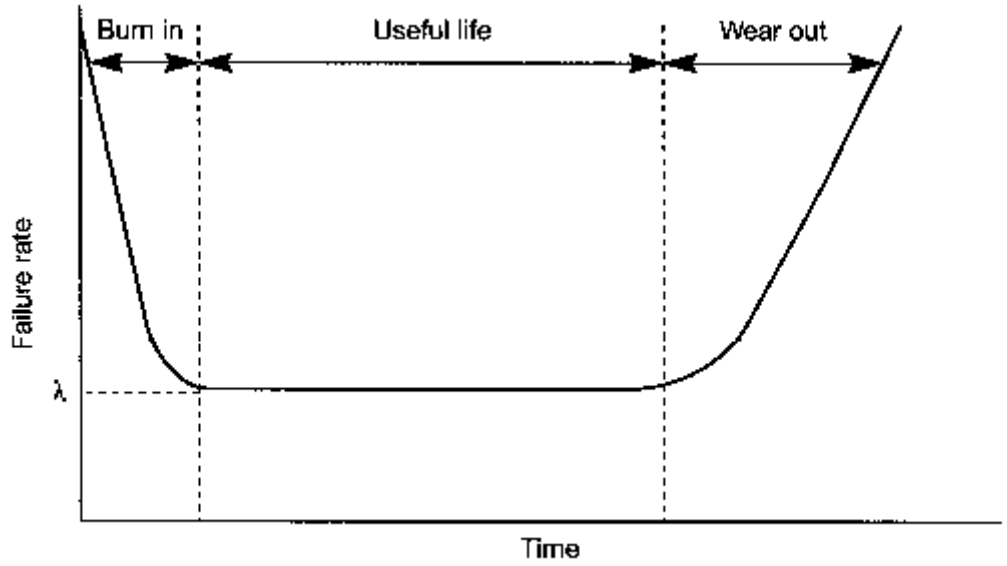
Component Reliability Model



During useful life components exhibit a constant failure rate λ.

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INSPECTION

- **Support and security of battery,** battery mount must be capable of supporting and retaining 14g load, ie 40kg! (2.65x14).
- **Improper, broken,** inadequately supported

wiring, loose connections of terminals, and loose ferrules.

- **Poor mechanical** or cold solder joints.
- **Condition of circuit breaker** and fuses.
- **Insufficient clearance** between exposed

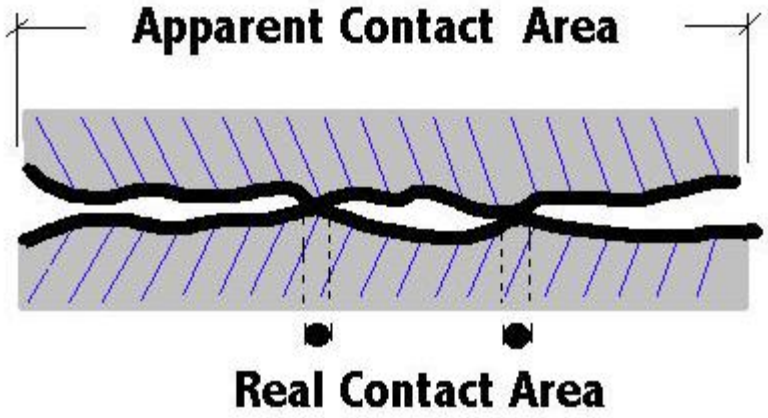
current carrying parts or poor insulation

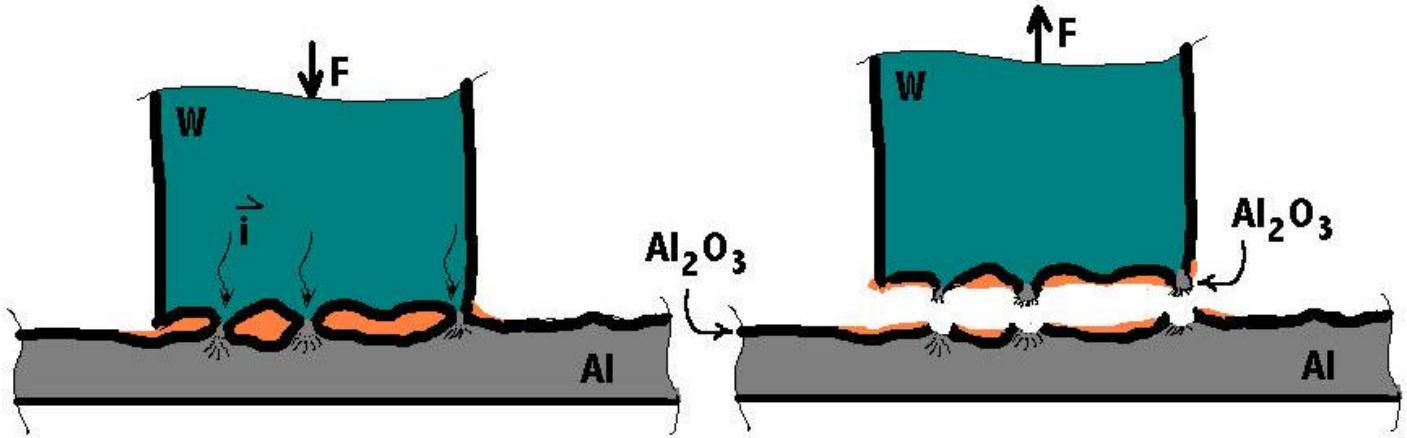
of exposed terminals.

- **Broken or missing safety wire**
- **Operational check** of electrically operated equipment. Battery load check.
- **Check service life of components.** ie battery 3-5 years, battery connectors 10 years.
  - Keep records.

CONNECTIONS

Apparent vs. Real Contact Area.





Erosion due to micro welding.

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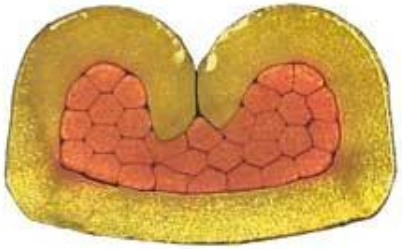
CRIMP connections


Cross section of a crimp.

Crimp is gas tight and mechanically ridged. Ie. Oxygen excluded = no oxide layer.
Wire size and terminal size must match.
Correct tools must be used.

- If in doubt use uninsulated terminals, crimp and solder.
- Always use ring type terminals under screw connections.

Definition of a reliable connection is that it is **gas tight.**

Wire termination

DO NOT tin wires for screw terminal connections - DO NOT!!!
Best practice is to use Boot Lace Ferrules for any screw termination

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Protection

Fuses do not protect equipment, they prevent fires!

Fuses vs Circuit breakers.

Fuse

Pro

Cheap

Low voltage drop (100-250mV)

Con

Can't be reset.

Low pressure contact on tubular types, use automotive blade types.

Circuit Breaker

Pro

Easy to reset and identify.

Can function as a switch.

Con

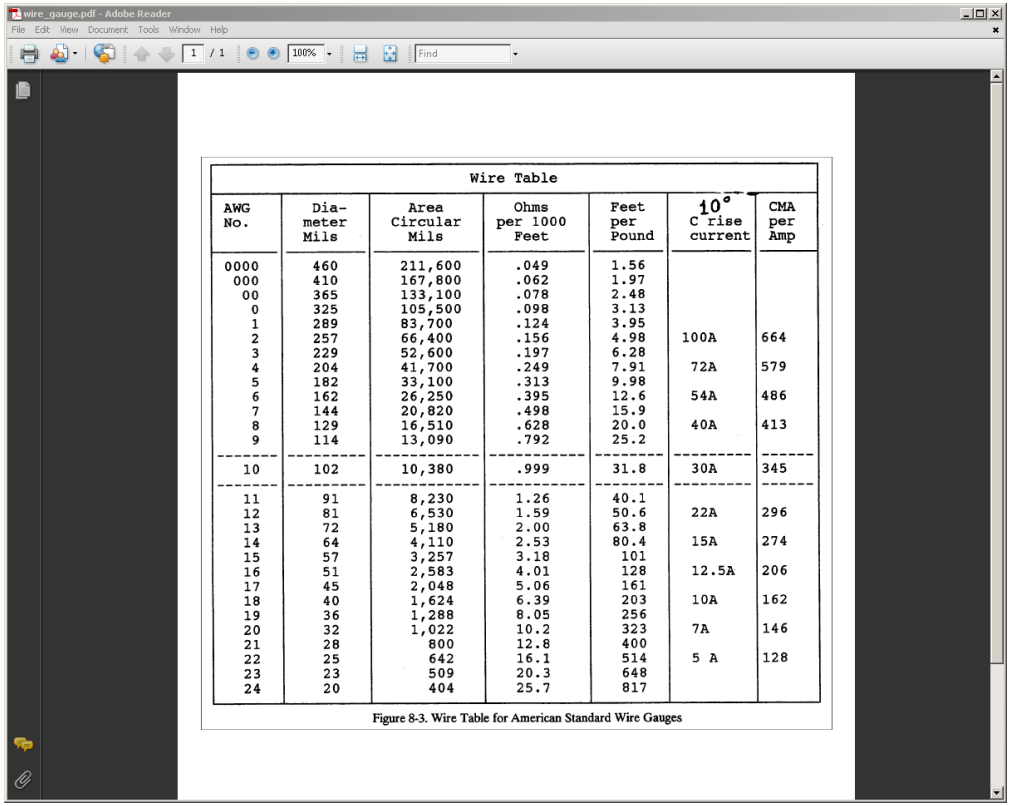
Expensive

Voltage drop (0.5-1.0volt)

Cable/Wiring

For many years the standard hookup wire in light aircraft has been MIL-W-5086A, which calls for use of tin-coated copper conductor rated at 600 volts and temperatures of 105°C. This basic wire is then coated with various insulating coatings including PVC. There has been much

See casa: AC 21-99 Aircraft Wiring and Bonding -



Wire Table

AWG No.	Dia-meter Mils	Area Circular Mils	Ohms per 1000 Feet	Feet per Pound	10° C rise current	CMA per Amp
0000	460	211,600	.049	1.56		
000	410	167,800	.062	1.97		
00	365	133,100	.078	2.48		
0	325	105,500	.098	3.13		
1	289	83,700	.124	3.95		
2	257	66,400	.156	4.98	100A	664
3	229	52,600	.197	6.28		
4	204	41,700	.249	7.91	72A	579
5	182	33,100	.313	9.98		
6	162	26,250	.395	12.6	54A	486
7	144	20,820	.498	15.9		
8	129	16,510	.628	20.0	40A	413
9	114	13,090	.792	25.2		
10	102	10,380	.999	31.8	30A	345
11	91	8,230	1.26	40.1		
12	81	6,530	1.59	50.6	22A	296
13	72	5,180	2.00	63.8		
14	64	4,110	2.53	80.4	15A	274
15	57	3,257	3.18	101		
16	51	2,583	4.01	128	12.5A	206
17	45	2,048	5.06	161		
18	40	1,624	6.39	203	10A	162
19	36	1,288	8.05	256		
20	32	1,022	10.2	323	7A	146
21	28	800	12.8	400		
22	25	642	16.1	514	5 A	128
23	23	509	20.3	648		
24	20	404	25.7	817		

Figure 8-3. Wire Table for American Standard Wire Gauges

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Airframe Parts
Avionics
Books
Composites
Covering Matl
Electrical
Engine Parts
Hardware
Instruments
Landing Gear
Metals
Pilot Shop
Tools
Wood
Kits & Plans
Catalog

STORES
West Coast
East Coast
Avionics

WORKSHOPS
Dates/Locations

NEWS
2006 Air Shows
Cozy Mark IV
Custom Metal Parts
Sponsorships
SpaceShipOne
ACS Award
Norwalk High President's Message

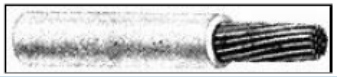
LINKS
ACS Specials/New Products
ACS Gift Cards
Shopping Lists
Order Form
E-Mail List
EAA Chapter Listing
Long-Eze-Vari-Eze Metal Parts
Sport Aviation Manufacturers
Nelson Aviation
Overstock

INTERNATIONAL
Representatives

Unshielded Wire MIL-W-22759/16

For many years the standard hookup wire in light aircraft has been MIL-W-5086A, which calls for use of tin-coated copper conductor rated at 600 volts and temperatures of 105°C. This basic wire is then coated with various insulating coatings including PVC. There has been much discussion during the past few years about the use of wire with PVC in aircraft. The Air Force does not permit such wire to be used in military aircraft due to the toxic fumes generated in the event of a fire which can disable the crew. Although there is no formal restriction on the use of MIL-W-5086A wire as of early 1991, as our supplies of MIL-W-5086A wire are depleted we will now be supplying MIL-W-22759/16 wire which complies with current military and anticipated future FAA requirements.

UNSHIELDED WIRE MIL-W-22759/16

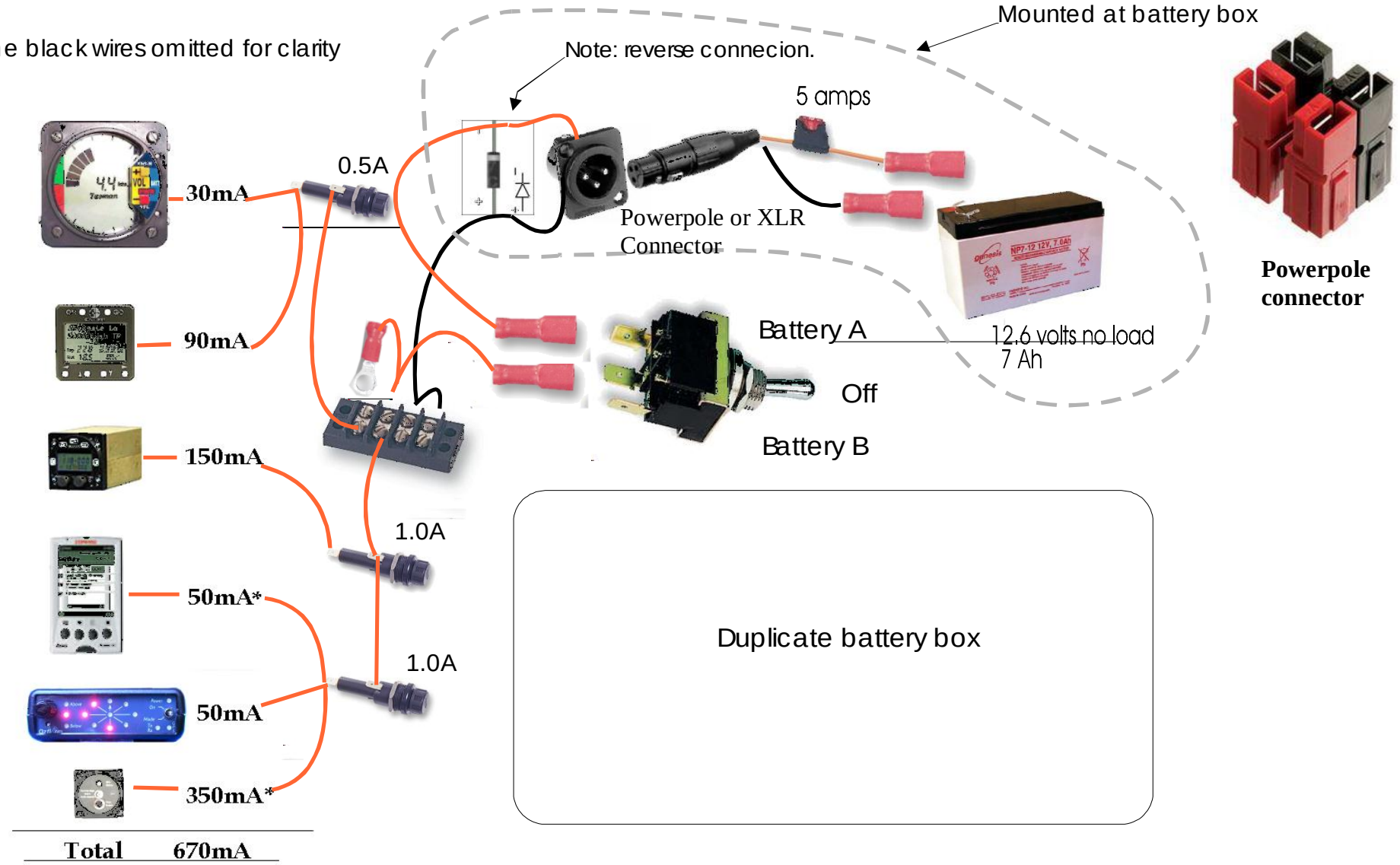


This top quality aircraft unshielded wire is manufactured to Specification MIL-W-22759/16. It features standard tin-plated copper conductor and is insulated with extruded Tefzel (ethylene/tetrafluorbethylene) which has a maximum temperature rating of 150°C. This wire is rated for 600 volts. Color: white. 22 thru 10 gauge sold in 10 ft. increments only. Sold in 10 ft. increments only

Wire Gauge	Wt./1000 Ft. Lbs.	Part No.	Price per Ft.	Buy
22	4.2	11-14522	$0.17	ORDER
20	6.0	11-14520	$0.22	ORDER
18*	8.6	11-14518	$0.26	ORDER
16*	10.7	11-14516	$0.28	ORDER
14	16.7	11-14514	$0.36	ORDER
12	25.0	11-14512	$0.68	ORDER
10	40.1	11-14510	$0.81	ORDER
8	66.6	11-14508	$1.73	ORDER
6	104.6	11-14506	$2.80	ORDER
4	160.1	11-14504	$3.75	ORDER
2	244.1	11-14502	$3.65	ORDER
0	381.3	11-14501	$7.30	ORDER
00	485.8	11-14500	$11.40	ORDER

*STRIPED WIRE	P/N	Price per ft.	Buy (per ft.)
18 GA white with black stripe	11-15601	$0.38	ORDER
18 GA white with red stripe	11-15607	$0.38	ORDER
16 GA white with black stripe	11-15501	$0.47	ORDER
16 GA white with red stripe	11-15507	$0.39	ORDER

Note: some black wires omitted for clarity



Powerpole connector

*

110 mA

With a 303 connected -- 130ma

With a Pocket PC and 303 connected — 230ma to 450+ ma. 350 typical

General Sailplane wiring scheme.

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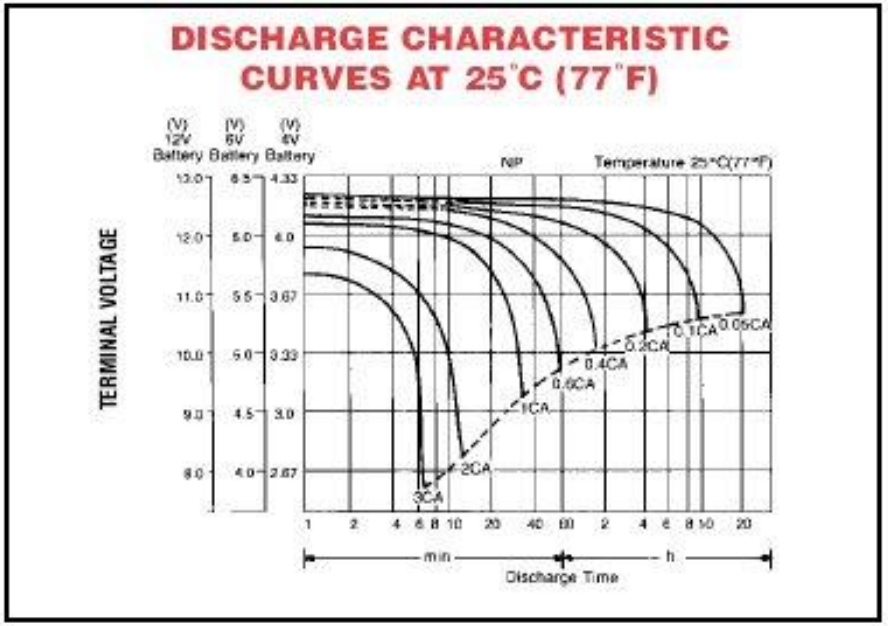
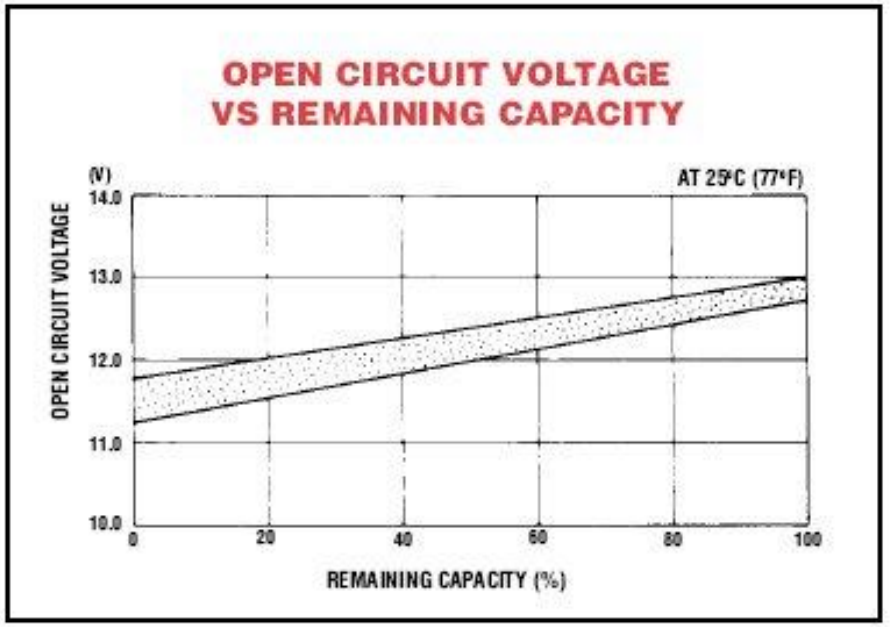
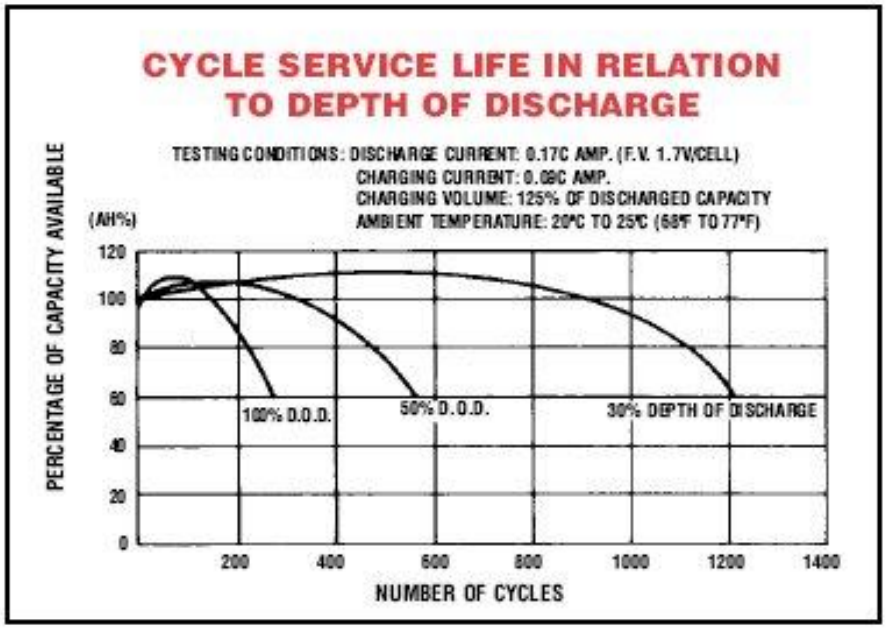
MalC 2013

Material bill for glider wiring scheme					
Description					
Qty		Cat no. Farnell	Price/per	Cat no RS.	other
1	Battery 12v 7AH	151 308	52.49		
2	Insulated crimp female spade 4.8mm	997 1874	33.14/100		
3	Insulated crimp female spade 6.3mm	997 1882	34.57/100		
1	Diode 1N5404	956 5086	0.33		
1	XLR chassis plug 3 pin	149 324	2.86		
1	XLR free socket 3 pin	149 323	6.96		
4	Series:PP15/45 Powerpole	156 6444	1.20		Alternative to XLR
1	Fuse holder auto blade	994 3110	4.61		
1	Fuse blade 5amps	994 3404	3.34/10		
Duplicate the above for dual battery		Total	138.30		
	Wire 18awg **MIL-W-22759/16**		35.20/100ft		Aviall 16-18wire100ft
	Wire 22awg **MIL-W-22759/16**		26.4/100ft		Aviall 16-16wire100ft
4	Insulated crimp female ring 3.7mm	997 1556	17.20/100		
1	SPDT switch	767 4279	10.16		
1	Barrier strip 4 way	105 365	4.04		
3	Fuse holder M205	319 315	3.19		
2	1 amp M205 fuse	992 2245	3.65/10		
1	0.5 amp M205 fuse	992 2237	3.44/10		
		Total	41.68*		* add wire cost







CHARGING METHODS (At 20ºC) Cycle use: Maximum charging current 1.75A
Charging voltage 14.4 to 15.0V
Standby use: Float charging voltage 13.50 to 13.80V
CAUTION •Avoid short circuit
•Do not charge in a sealed container.

SLA battery charging

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NP7-12

6.5Ah 10 hour discharge when new.
1.75 Amp charge current limit.
4.75mm terminals.
3-5 years life.
~$50.00

REC10-12

10Ah
6.35mm (1/4”) tabs
Same size.
Deep discharge.
7 year life.
~$60