Clo 1. Electrical cable and connectors.

NO: DATE:

Cable(wire) types:-

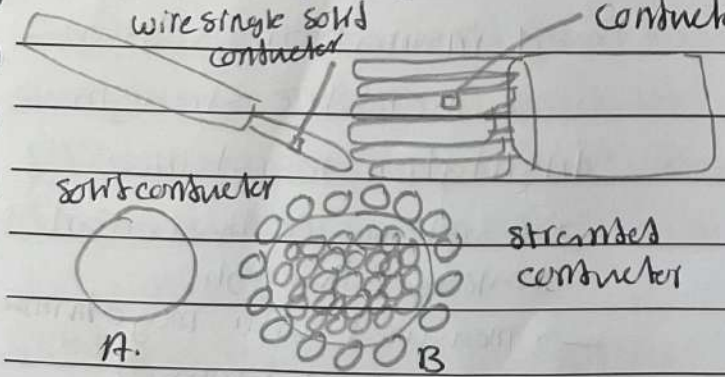
wires described as:

1. single 2. Solid conductor
3. ~~stranded~~ stranded conductor covered with insulating materials.

Because of in flight vibration and flexing, conductor round wire should be ~~stranded~~ stranded to minimize fatigue breakage.

The term cable used in aircraft electrical installation, includes:

1. two or more separately insulated conductors in the same jacket
2. two or more separately insulated conductor twisted together. (twisted pair)
3. One or more insulated conductor covered with metallic braided shield (shielded cable).
4. A single insulated center conductor with metallic braided outer conductor (radio frequency cable).



Aircraft electrical cable definitions of two wires.

Wire harness :-

Used when group of insulated conductor are bound together by

1. lacing cord
2. metal bands
3. other fitting in arrangement suitable for use only in specific equipment for which the harness was designed.
4. may include ~~terminal~~ termination.

* are extensively used in aircraft to connect all electrical components.

wires are suitable for either:

* open wiring * protected wiring application

wire temperature rating is

→ a measure of insulation
→ ability to withstand the ~~combination of ambient~~ temperature and current related conductor temperature rise

Conductors:-

two most generly used copper

Copper:-

advantages
1. higher conductivity
2. more ductile
3. high tensile strength
4. easily soldered (welding)

disadvantages
5. more expensive
6. heavier

Aluminum:

disadvantage ←
1. has only 60% conductivity of copper

2. Nonscaling effectively
3. its tightness makes possible long spans of
4. its relatively large diameter for given conductivity reduce coronas (discharge of electricity from wire when has high potential) discharge is greater when smaller diameter is used Than large diameter is used

advantage

Some bus bars are made Al than copper, where there is a greater radiating surface for same conductance.

Characteristic	Copper	Al
tensil strength (lb-in)	55,000	25 000
tensil strength for same conducting lb	55,000	40,000
weight for same conductivity lb	100	48
Cross section for same conduct	100	160
specific resistance Ohm/mil	10.6	17

rabidly with time after manufacturer.
→ it can be used up to the running temperature of 150°C.

silver coated wire:
is used where temperature do not exceed 200°C

Nickel-coated wire
→ retains its properties beyond 260°C (500°F)
→ most aircraft wire using such coated strand has insulation system that cannot exceed this T on long term exposure
→ solder termination of nickle plated conductor require: use of different solder sleeves or flux than those used with tin or silver plated conductor.

plating:-

Bare copper develops a surface oxide coating at rate dependent on temperature
oxide film is
→ poor conductor of electricity
→ inhibits determination of wire

all aircraft wiring has:
→ coating of tin
→ silver → nickel but has far slower oxidation rates.

Tin coated copper:
→ very common
→ its ability to be successfully soldered without highly active fluxes diminishes

insulation:-

two fundamental properties
1. insulation resistance
2. dielectric strength

insulation resistance:
→ resistance to the current leakage through
→ measured with megohmmeter insulation tester without damaging insulation.
→ data so obtained serves as a useful guide in determining the general condition of insulation
→ data may not give true picture of condition of insulator

what could show high value of insulation resistance but would not be suitable for use?
-> clean -> dry insulation having cracks or -> other faults.

Dielectric strength :
-> is ability of the insulator to withstands potential difference.
-> expressed in term of voltage at which insulation fails because of electrostatic stress.
-> max dielectric strength values can be measured by :
"raising voltage of test sample until the insulation breaks down".

-> The type of conductor insulation materials varies with type of installation.
-> characteristic should chosen based on environment such as :
-> abrasion resistance -> arc resistance
-> corrosion resistance -> cut through strength
-> dielectric strength
-> flame resistant -> mechanical strength
-> smoke emission
-> fluid resistance and heat distortion.

such type of material insulation PVC / nylon, Kaplon, Teflon) are no longer used for new aircraft might still installed in older.
installation material for new aircraft are Tefzel, Teflon / Kaplon / teflon and PTFE / polyimide / PTFE.

Resistance to heat is primary importance of selecting wire for aircraft use.

it is basic factor in wire selection. DATE:
wire may be required to operate at high temperature due either :
-> high ambient temperature
-> high current loading
-> or combination of both
selection should be made on basis of satisfactory performance under most severe operating conditions.

wire shielding :-
with the increase in number of highly sensitive electronic devices found on modern aircraft,
it has become very important to ensure proper shielding for many electric circuit.
Shielding is :
process of applying a metallic covering to wiring and equipment to eliminate Electromagnetic Interference (EMI).
EMI caused when :
electromagnetic field (Radio wave) induce "high frequency" (HF) voltage in a wire or component induced voltage can causes
-> system inaccuracies or
-> failure

INQS recommended to use:
Shielding with 85% coverage or greater.

→ Coaxial, triaxial, twinaxial or quadraxial cable shields be used,

→ wherever appropriate with their shield connected to ground at single point or multiple point, depending upon the purpose of shielding.

→ The "airframe grounded" structure may also be used as EMI shield.

Wire substitutions:-

when replacement of wire is required in repair and modification of existing aircraft,

→ The maintenance manual for that aircraft must first be reviewed to determine if the Original Aircraft Manufacturer (OAM) has approved any substitution.

→ if not, then manufacturer must be contacted for acceptable replacement.

Severe Wind And moisture problem (SWAMP)

SWAMP areas:

→ differ from aircraft to aircraft.

→ usually are wheel wells, near wing flaps, wing roots, pylon, other exterior areas that may have harsh environment.

wires in these area have often:

an exterior jacket to protect them from the environment.

it is important to use the wire type recommended in the aircraft manufacturer maintenance handbook insulation or jacketing varies according to environment.

wire size selection

wire is manufacture in size according to a standard American wire gauge (AWG).

→ wire diameter become smaller as gauge number become larger

→ typical wire size range from 40 to 0000.

← Gauge number:

→ are useful in comparing the diameter of wires

→ but not all type of wires or cable are measured accurately with gauge.

large wire are usually stranded to ↑ their flexibility

total area = area of strand (usually computed in circular mils when diameter or gauge number is known) X number of strand in wire or cable.

several factor must be considered in selecting the size of wire for transmitting and distributing electric power.

1. wires must have sufficient mechanical strength to allow for survive condition.
2. Allowable power loss (I_2R loss) in the line represent : electrical energy converted to heat.
   * use of large conductors reduces the resistance and I_2R loss.
   * large conductor : more expensive, heavier, need more substail support.
3. if the source maintain a constant V at input to lines, any variation in load on line cause variation in line I and consequent variation in IR drop in line.
2. wide variation in IR drop in line causes poor voltage regulation at the load.
   obvious remedy is to reduce either I or R.
3. reduction in load I : lower the amount of power being transmitted
   reduction in line R : increase the size and weight of conductor required.
   Compromise : reached whereby the voltage variation at load is within tolerable limits and the weight of line conductors is not excessive.
4. when current is drawn through conductor, heat is generated.
   2. the T of wires rises until the heat radiated or dissipated, = heat generated by passage of I through line.

NO: DATE

insulated
if conductor is ~~bared~~, heat generated in conductor is no readily removed as it would be if conductor not insulated.
to protect the insulation from too much heat,
The I through conductor must be maintained below certain value.
when electrical conductor installed in location where the ambient temperature is relatively high, heat generated by external source constitutes appreciable part of total conductor heating.
Allowance must be made for the → influence of external heating on allowable conductor current
→ each case has its own specific limitations.
The max allowable operating T of insulated conductor varies with type of conductor insulation being used.

~~NOT desirable to use wire~~
~~smaller than #20~~,
particular attention should be
given to the mechanical
strength and insulation
handling of the wires (e.g.
vibration, flexing, termination)
wires contain < 19 strands
should not be used.
wire smaller than #20
should be provided with
additional clamp and be
grouped with at least three
other wires
they should have additional
support at termination, such
as
→ connector grommets, strain
relief clamps, shrinkable
sleeving or telescoping bushing
→ they should not be used where
there vibration, repeated bending
or frequent disconnection from
screw termination.

Current carrying capacity

1. wire may be capable of carrying
more I than is recommended for
contact of related connector.
2. it is contact rating that dictates
the max I to be carried by wire.
3. wires of large gauge may need
to be used to fit within the crimp
rang of connector contact but
adequately rated for current bay
carried

reduction
allows ← derated.

Max operating Temperature

* I that causes a temperature
steady state condition =
to the rated temperature
of wire should not be exceed
* Rated temperatur may be
based upon either:
conductor or insulation
to with stand continuous
operation without degradation
Single wire in free Air-
1. Determine ~~wire~~ system
current-carrying capacity
(WSCCC), begins with
2. determ max current
that given-sized wire
can carry without
exceeding the allowable
T difference (wire rating - ambient)
3. curves are
based upon single copper
wire in free Air.

wires in harness.
1. when wires are bundled
into harness, the current
derived for single wire should
be reduced.
2. amount I of derating
is function of number of
wires in bundle and %
of total wire bundle
capacity that is being used
harness at Altitude-
1. heat loss from the bundle
is reduced, with ↑ altitude.
2. the amount of I should be

3. altitude derating factor may be determined.

Al conductor wire

1. ~~size~~ when used, size should be selected on the basis of I rating. ,smaller than
2. use of size #8 is discouraged. two
3. Al should not be attached to engine mounted accessories or used in area having, crossive fumes, severe vibration, mechanical stresses, or where there is need for frequent disconnection.
4. use of Al wire is also discouraged for runs of $\leq$ 3 ft.
5. termination hardware should be of type specially designed for use with Al conductor wiring.

Computing current carrying capacity

Example 1.

Allowable voltage drop

The voltage drop in main power wires from generation source or battery to the bus
-> should not exceed 2% of regulated voltage, when generation is carrying 1. rated current or
2. battery is being discharged at 5 min rate.

max operating temperature

The resistance of current return path through ~~aircraft~~ structure is considered:
negligible
to determine circuit resistance,
check voltage drop across circuit.
if V_d don't exceed limit established by aircraft or product manufacturer
The resistance value for circuit may considered satisfactory.
when checked circuit input voltage should be maintained at constant value.

Calculate VD =
resistance (ft) X length X current

Electric wire chart instructions

to select correct size of electric wire, two major requirment must be met:

1. The wire size must be sufficient to prevent an excessive V_d ~~while~~ carrying required I over required distance.

2. The size should be sufficient to prevent overheating of wire carrying required I. see MOT ~~in this chap~~ to computing current carrying capacity

NO: meet by DATE requirement

For selecting correct wire, The following must be known before hand:

1. The wire length in feet
2. The number of amperes of current to be carried.
3. The allowable Vd permitted
4. The required continuous or intermittent current.
5. The estimated or measured conductor temperature.
6. is the wire to be installed in conduit or bundle?
7. is the wire to be installed as single wire in free air?

Wire identification

The proper identification of electrical wire important:

For 1. Safty of operation
2. Safty to maintenance personnel
3. ease of maintenence.

identifying wire manufacturer

→ All wire must have identification imprinted every length

→ follow parts number ~~with~~ with 5 digit/letter commercial and government Entity (CAGE). (IM)

Placement of identification markings

1. should be placed at each end of wire, at is then max intervals along the length of wire
2. wires < 3" (8cm) in length need not be identified
3. wires 3 to 7" (8-18cm) in length should be identified approx at center
4. Added identification marker sleeves should be located so that ties, clamps or supporting devices need to be removed to read identification

code

5. The wire ID must be printed to read horizontally (L to R) or vertically (T to B)

two method of marking wire or cable are as follow:

1. Direct marking is accomplished by printing the cable outer covering.
2. Indirect marking is accomplished by printing heat shrinkable sleeve and installing the the printed sleeve on wire or cable outer covering

→ should be identifying with printed sleeve at each end and at interval not longer than 6 feet.

→ individual wire inside cable should be identified within 3" of their termination

NO: DATE:

Type of wire markings

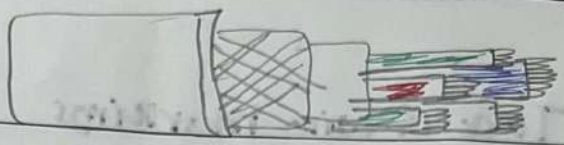
The preferred method is to.
→ to mark directly on wire without causing insulation degradation
what kinds of wires require several sleeves to carry identification marks
→ Teflon coated wires
→ Shielded wiring
→ multi conductor cable
→ thermocouple wires.
The marking should be
→ legible
→ the color should contrast with wire insulation or sleeve
Several different method can be used to mark directly on wire:
→ hot stamp marking
→ ink jet printers
→ laser jet printers

hot stamp method can damage the insulation of newer type of wire but use min insulation.
→ The fracture of insulation of wall and penetration to conductor of these material by stamping die have occurred.
When this opening have been wetted by various fluids or moisture serious arcing and surface tracking have damaged wire bundles.

identification sleeve can be used if
direct marking on wire is not possible
Flexible sleeving either clear or opaque, is satisfactory for general use.
When color code or shapes component wire is used as part of cable,
IS specify which color is associated with ~~with~~ each wire I.C.
identification sleeve are normally used for identifying
The type of wire or cable:
1. unjacketed shielded wire
2. thermocouple wire
3. Coaxial cable
4. multiconductor cable
5. high temperature wire
Identification tap can be used in place of sleeving.

for sleeving exposed to high T (over 400°F) material such as silicone fiberglass should be used.
Polyolefin sleeving should be used in areas where
→ resistance to solvent
→ synthetic hydraulic fluid is necessary.
sleeves may be secured in place with cable ties or by heat shrinking.

High tension and coaxial cables



High tension cables :-

These cables are used for transmission high voltage in both piston engin and turbine engine ignition system.

→ are of singk core stranded type suitably insulated

→ screened by metal braided sheathing to prevent interference.

The number of cables required for system corresponds to that of

→ sparking plugs

→ igniter plugs

made up into a complete ignition cable harness.

Depending on type of engine installation, the cables may be

→ encloses in metal conduit, which also form part of harness.

→ or may be routed openly.

Cable are connected to relevant system components by

→ special end fitting comprising either 1. small spring or
2. contact caps

secured to the
1. cable conductor
2. insulation
3. threaded coupling assembly.

Coaxial Cables :

Contains two or more separate conductors.

The innermost conducter may be

→ solid or stranded copper wire

→ plain, tinned, silver plated or

→ even gold plated in some application

depending on degree of conductivity required.

The remaining conducter are in the form of tubes, fine wire braid.

insulation is usually poly thylene or Teflon

outer covering or jackets serve to

→ weatherproof The cable

→ protect them from fluid or

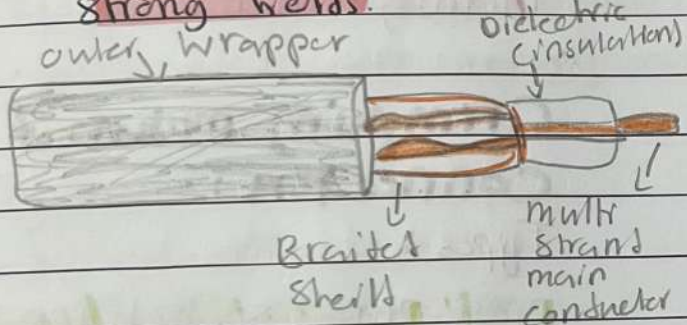
→ mechanical and electrical damage

The material used for covering are manufacture to suit operation under varying environmental conditions.

Coaxial cables have two main advantages :

NO: DATE:

First,
→ they are shielded against electrostatic and magnetic fields
→ electrostatic doesn't extend beyond outer conductor and fields due to current flow in inner and outer conductor cancel each other.
Second
→ Coaxial cable do not radiate energy.
→ They will not pick up any energy, or
→ be influenced by other strong fields.



open wiring :-

interconnecting wire is used in point to point open harnesses, normally in the interior or pressurized fuselage.
Electrical wire is often installed in aircraft without special enclosing means.

Bonding and grounding

what is the one of the more important factor in the design are maintance of aircraft proper bonding and grounding

inadequate bonding or grounding lead to:
1. unreliable operation system
2. electromagnetic ~~interference~~ electrostatic
damage to sensitive electronics
3. personal sheock hezard
4. damage from lightening strike.
5. electromagnetic interference (EMI)

Grounding :-

→ is the process of electrically connecting conductive object to either conductive structure or some other ~~conductive~~ conductive return path for the propose of safely completing either normal or fault circuit.
if wires carrying return current from different type of sources, such as signal. Ac and DC generator are connected to the same ground point or have connection in return path, interaction of the currents occures.
Mixing return current from various sources should be avoided because noise coupled from one source to another and can be a major problem for digital system.

NO: DATE:

To minimize interaction between various return current Different type of grounds should be identified and used. As a minimum, the design should use three ground types:

→ AC returns
→ DC returns
→ All others

Conditions from Coaxial Cable

1. All wiring needs to be protected from damage.
2. Coaxial and triaxial cables are particularly vulnerable to certain types of damage.

Where the coaxial damage can occur???

1. Clamped too tightly
2. Bent sharply (normal at or near connectors)
3. Unrelated maintenance actions around coaxial cable.
4. Can be severely damaged on inside without any evidence of damage on outside.
5. Solid center contactors should not be used.

Standard center coaxial cable can be used as direct replacement for solid center coaxial.

Coaxial Cable precautions includes:

1. Never kink coaxial cable.
2. Never drop anything on coaxial cable
3. Never step on coaxial cable.
4. Never bend coaxial cable sharply.
5. Never loop coaxial cable tighter than the allowable bend radius.
6. Never pull coaxial cable for handle, lean on it or hang things on it (including other wires)

Crimping methods & Connectors:

Types:

pins, plugs, socket, insulator, current, V rating, coupling and identification codes

AN and MS connector:-

Connectors (plugs and receptacles) facilitate maintenance when frequent disconnection is required.

Connectors are also used to 1. electric 2. electronic assemblies 3. line replaceable units. (LRUs)

such as: Voltage regulators, flight computer, inverters, radio equipment

when it is necessary to replace such assembly,
→ The connector make it possible to disconnect until quickly → to reconnect the new unit with no danger of connecting any of the leads incorrectly.
Connector must be kept:
→ minimum, selected and installed to provide the max degree of safty and reliability to the aircraft.
For installation of any particular connector assembly,
The specification of manufacture or appropriate goverment agency must be followed.

Types of Connectors

→ The connector type that use crimped contacts are generally used on aircraft.
→ some common type are
→ round common type
→ rectangular
→ modular blocks
Environmentally resistant connectors should be used in application subject to
→ fluids → vibration
→ heat → mechanical shock
→ corrosive elements

When HIRF/lightning protection is required,

NO: DATE:

special attention should be given to termination of individual or overall shields.
The number and complexity of wiring system have resulted in an increased use of electrical connectors.

* Firewall class connectors → incorporating these same feature should, in addition
1. be able to prevent penetration of fire through the aircraft firewall connector opening.
2. continue to function without failure for specific period of time when exposed to fire.

Hermetic connector provide pressure seal for maintain pressurized areas.
When EMI/RFI protection is required,

* Backshell adapters designed for shield termination, connectors with conductive finishes, and EMI grounding fingers are available for this purpose.

Rectangular DATE: Connecter are typically used in apprcation where a very large number of circuits are accommodated in single mated pair.
They are available with a great variety of contacts, which can include a mix of standard, Coaxial, and large power type.
Coupling is accomplished by various means.
Smaller types are secured with screw which hold their flanges together.

larger ones has integral guide pin that ensure correct alignment of jack screw that both align and lock the connecter.
Rack and panel connecters use integral or rack mounted pins for alignment and box mounting hardware for couplings.

* module blocks are types of junction that accepte crimped contacts similar to those on connectors.
Some use integral busing to provide a variety of circuit arrangements
They are useful where number of wires are connected for power or signal distribution.
When used as grommet modules,
They save and reduce hardware installation on the aircraft.
* Standardized modules are available with
→ wire and grommet seals for environmental application.
→ are track mounted
* Function module block are used to provide easily wired package for environment resistant mounting of small resister, diods, filters and suppression networks.
connecter must be identified by
* original identification number derived from MIL, specification (MS) or OEM.

in line junction
→ used in lieu of connecter when only a few wires are terminated

NO: DATE:

-> Where the ability to disconnect the wires is desired.
-> is environmental resistant
-> terminal junction splice is is small and may be tied to the surface of wire bundle when approved by OEM.

pins and socket:
-> identified by number or letters it is usual in many type of connector to signify this sequencing by spiraling guideline embossed on the faces of the inserts

The size of connector is indicated next with the higher number, the larger the connector.
The contact arrangement identifies The number and size of contacts and their physical arrangement
-> use chart to identify each arrangement by code number
The contact style may either S or P to indicate a socket or pin.
Final letter indicates the rotation of insert in the connector.

connector identification code

MS number is the basic configuration of the connector.
MS 3100 - wall receptacle
MS 3101 - cable receptacle
MS 3101 - Box receptacles
MS 3106 - straight plug
MS 3107 - Quick-Disconnect plug
MS 3108 - Angle plug.

letter following configuration tells the class of connector
A general purpose, solid Al alloy shell
B general purpose, split Al alloy shell
C pressurized, solid Al alloy shell
D Environmental resistant, solid All shell
E Fire and flame-proof, solid steel shell

if component has two or more connectors of same type, it is possible to connect the wrong plug to receptacle to prevent this, insert may be rotated in their relationship to index slot so that only the correct plug may be inserted into receptacle.

current and voltage Rating

selected connectors must be rated for continuous operation under max combination of
-> ambient temperature
-> circuit current load

DATE:

Hermetic connectors and connectors used in circuit application involving high inrush current should be derated

it is good engineering practice to conduct preliminary testing in any situation where connector is to operate with most or all its contacts at max rated current load.

when wiring is operating with high conductor T near its rated T,

connector contact sizes should be suitably rated for the circuit load.

=> this may require ↑ in wire sizes.

Voltage derating is required when connectors are used at high altitude in non pressurized areas.

Spare contact for future wiring

for future wiring:

spare contact is provided locating unwired contact along outer part of connector ~~access~~.

facilitates future access.

provide 2 spare: 25 or fewer contacts

4 spare: 26 to 100 contacts

6 spares: > 100 contact

unwired contact should be provided with plastic grommet sealing plug.

Questions:

1. A wires. described as single solid conductor, or as stranded conductor covered with insulating material.

2. Name ~~four~~ 4 factor to be considered in selecting the size of wire for transmitting and distributing electrical power.
   1. sufficient mechanical strength
   2. allowable power loss
   3. voltage variation
   4. wire temperature.

3. The current must cause the rated max operating T of wire to be reached should not be exceeded

NO: DATE:

The voltage drop in main power wires from generator source or battery to bus should not exceed 2% of regulated voltage when generator is carrying rated I or battery is being discharged at 5 min rate

what is mean by spiral line drawn on inside of connecting socket?
to illustrate the sequence of pin numbers within socket

If connectors designed with additional fire protection abilities, how is this identified?
By operating class rating: in ~~class~~, in case it would have E rating

what is typical usage of high tension cable?
used to carry high voltage such as engine ignition system.

primary advantage of coaxial cable?
1. prevent leakage of electromagnetic energy, both going in to wire or emanating from wire.