Basic definitions:

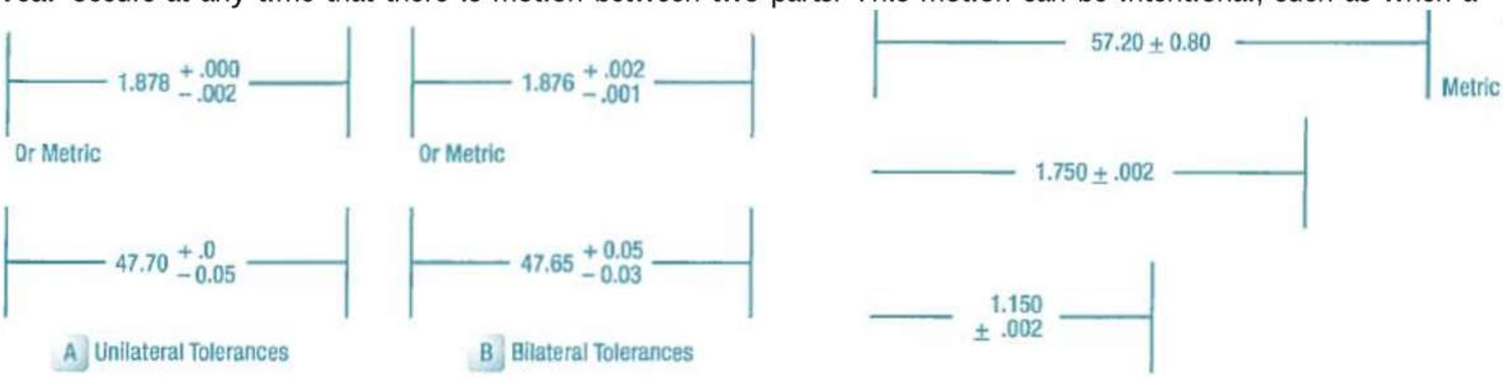
Dimension: Actual size of a part

Allowance: Difference in dimension that is necessary to give a particular 'class of fit' between two parts, for example, a shaft required to locate within a corresponding hole in a component.
To assist in the economy of manufacture, either the hole or the shaft is made as accurately as possible to the nominal size and an allowance is applied to the associated item. Note that the term 'shaft' also includes bolts andpins.

If the shaft is constant and the hole varies in size, then the system used is said to be 'shaft- based'. If the hole is constant and the shaft varies in size, then the system is 'hole based'. The hole-based system is the one in more generaluse.

Tolerance:
Tolerance is the total amount of variation in the size of a part or feature on apart.
To find the tolerance of a part or feature subtract the smallest size from the largestsize.
For example: Given a dimension of 2.5 +/- 0.05, the largest size would be 2.55, the smallest size would be 2.45. Therefore, the tolerance is 0.10 (2.55 - 2.45).
Unilateral & Bilateral tolerance:

Bilateral tolerance is when there is an amount of dimension variation above and below the design size. Unilateral tolerance is when the design size can only vary in one direction.
Schedule of fits andclearances
Wear occurs at any time that there is motion between two parts. This motion can be intentional, such as when a



shaft rotates in a plain (journal) bearing or when a roller moves

back and forth over a track. Wear can also be accidental, where two parts that should be immovable chafe together.
If the parts are intended to move together, then the maintenance documentation will have a Schedule of Fits and Clearances, based on the limit system issued for each mechanism used on theaircraft.
If the parts are not intended to move together, it will depend upon inspection procedures to discover the problem and repair schemes will be initiated in an attempt to preventrecurrence.
The Schedule of Fits and Clearances contains tables which specify;

Limits forwear
Ovality (of a hole orshaft)
Bow of ashaft
Twist of ashaft.

Limits for Wear:

The four dimensions, typically covered in wear tables are:

Dimension New

Permissible WornDimension

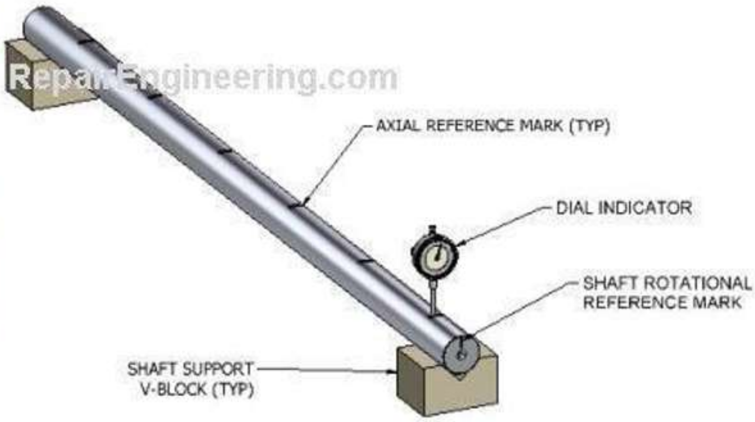
ClearanceNew

Permissible WornClearance.

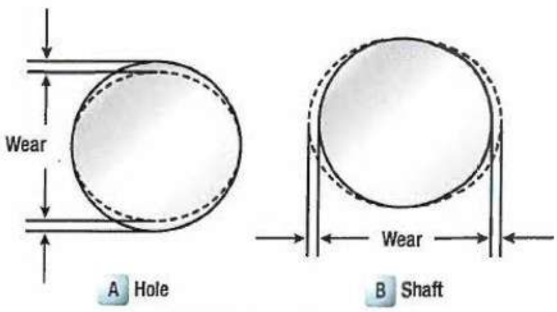
Dimension New relates to the size of the part when new, and will show the relevant tolerances.

Permissible Worn Dimension refers to the size to which a part may wear before it must be rejected as unserviceable. Parts, which are not worn beyond this size, can be used again, providing a suitable mating part is chosen to keep the clearance within the permissible figure. This will frequently involve choosing a new part to mate with the worn part.
Clearance New is the desired clearance in limit form. Interference fits are quoted as negative clearances.
Permissible Worn Clearance refers to the maximum allowable clearance when reassembling thecomponent.
Limits for ovality:

This usually occurs as a result of the surface wearing through friction or linear movement. Ovality can apply equally to holes andshafts.
Holes may be tested for ovality, using such instruments as Go/No-Go gauges, internal micrometers, orcalipers.



Shafts may be checked for wear by
measuring them using micrometer, however, roundness cannot be measured by taking numerous measurements of diameter at different points round the circumference.
Certain shapes appear to be round when measured in this manner although in fact they may notbe.
Testing roundness of a shaft may be achieved by placing the shaft to be tested on a block and rotating it under a scribing block or a dial indicator (this same method may be used to checking shafts forbow).
Two or more diameters of a shaft have a common axis and it is important that they shall be true with one another, they are said to beconcentric.
Concentricity may be tested by placing the shaft in Vee Blocks or between centers and rotating it under a dialindicator.
It is important to test for ovality of a shaft, before testing it for bow, as the results may be suspect if bow is donefirst.
Bow in a shaft can be determined in a workshop by utilizing V blocks, a surface gauge and a dial indicator (in conjunction with a surfacetable).
Limits for Bow:



When dealing with shafts and tubes, it is vital that not only are the ends square with each other, but that the centerline of the complete shaft or tube isstraight.
If the center line of the shaft is not straight, then the item isbowed.
When the shaft or tube is rotating, especially at a high speed in a bowed state, there is the risk of vibration which can lead to mechanical failures, loosening of fasteners and (most critical of all)fatigue.
All cylindrical items, both tubular and solid, can be given a limit to the amount of bow permitted.
For example, a drive shaft, which rotates about 1 500 rpm, may have a limit of 0.25 mm (0.01 in) bow over the length of the shaft. This ensures that, within the limits of production, the drive shafts are effectively straight, giving the least possiblevibration.
To measure the amount of bow in a structural member (for example, a strut) a straight edge and a set of feelers can be used, providing no protruding fittings prevent the straight edge being applied directly along the surface of themember.

The straight edge should be placed along the entire length of the member parallel to its axis, then by inserting feeler gauges at the point of maximum clearance the amount of bow can becalculated.

Clearance check by feeler gauges:

Over the length of a member in general a maximum bow of 1 in 600 is normally acceptable unless otherwise stated in the repairmanual.
During normal servicing or overhauling of aircraft components, dimensionalchecksmaybecarriedoutwiththeaidofvarioustypesof

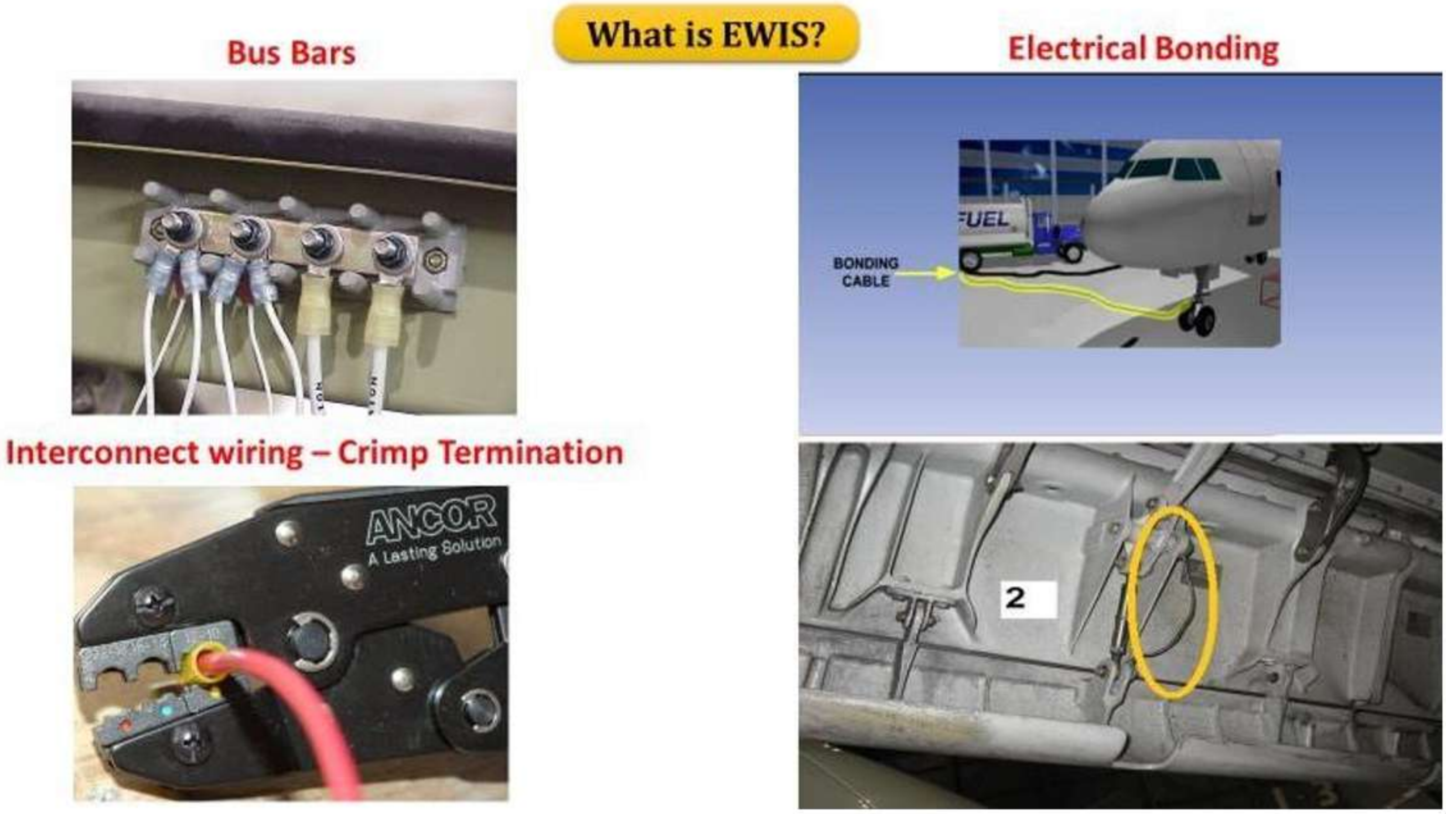
precision measuring instruments for example; micrometer, vernier caliper, and dial indicator.
Wear limits may be found in the appropriate repair or overhaulmanual.

Limits for twist:

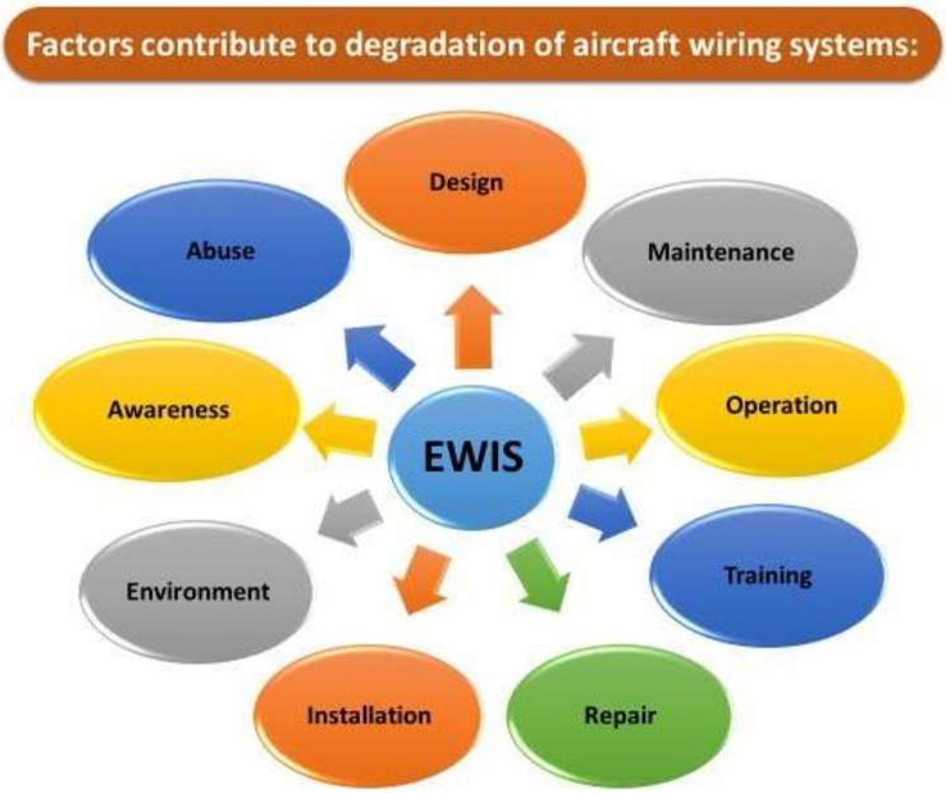
Twist is the result of applied torsion on circular or square-sectionedshafts.
If the twist disappears, as a result of removing the force, then the shaft will have been loaded below its elastic limit.
If the shaft remains twisted, after removal of the load, then it has been loaded above its elasticlimit.
The action of a shaft (of whatever section) carrying a torque load is to twist in proportion to the torqueapplied.
The result of cyclic loading of shafts is that, at certain times, the shafts have to be checked for permanenttwist.
If the shaft has a square section, it can be checked for twist on a surface table using a dial indicator mounted on a surfacegauge.
Solid or tubular shafts that have to be checked for twist will possibly have witness marks or lines engraved or etched at each end of theshaft.
The shafts can be checked, by mounting the shaft in V blocks and then locating these marks in the horizontalposition.
It is possible to measure the amount of twist, to which a shaft is subjected, whilst in operation or rotation, by the use of straingauges.
These emit varying amounts of electric current when under strain, giving an indication (on a calibrated instrument) of the load beingapplied.
The designer of the aircraft or equipment will set all limits, with regards to the distortion of parts and set them down in the relevantmanuals.
The methods used to measure the distortion will either be standard procedures, such as using a dial indicator and surface table etc., or will have a special procedure included in the manuals.
– Electrical Wiring Interconnection system(EWIS)

FAA definition of EWIS:

A EWIS is any wire, wiring device, or combination of these, including termination devices, installed in any area of the aircraft for the purpose of transmitting electrical energy between two or more intended termination points.
EWIS does not include electrical equipment or avionics qualified to acceptable environmental conditions and testing procedures, portable electrical devices not part of airplane's type design, or fiber optics.
The term originated in the aviation industry but was originally designated as Electrical Interconnection Systems. The change from EIS to EWIS was done to emphasize the focus on



the actual wires and wiring of the systems throughout aircraft.



Wire Insulation:

Insulation Resistance

Resistance to current leakage through and over the surface of insulation materials. (V/I)

Dielectric Strength

Ability of the insulator to withstand potential difference. Volts per unit time (V/t)

Insulation Material

The type of conductor insulation material varies with the type of installation.

Electricity:

Static electricity

Electrons accumulate on a surface and remain there until they build up a pressure high enough to force their way to another surface or device which has fewerelectrons.

Static electricity is uncontrollable and unpredictable; therefore, it is a nuisance, and we take steps to prevent it or to get rid ofit.

Example

When aircraft flies through air, there will be lot of skin friction as air moves around the aircraft. This friction transfers a large amount of electrons from the air to theaircraft.

If these electrons are not discharged continuously, then it will be a great problem for aircraft while it is flying and to the maintenance personal who touches it's metallicpart.

Lightning

Lightning is just a big spark. Friction of the air moving up and down inside the clouds causes the water droplets in the clouds to become charged, and when enough electrons are concentrated in a cloud, the electrical pressure they produce forces them to flow through theair.

These electrons jump between clouds having different charges or from a cloud to the ground. This is the gigantic spark calledlightning.

Current electricity

Current electricity, on the other hand, is the type we most often use. We can produce and control both direct current (DC) and alternating current (AC).

Means of discharging static charges when aircraft is flying

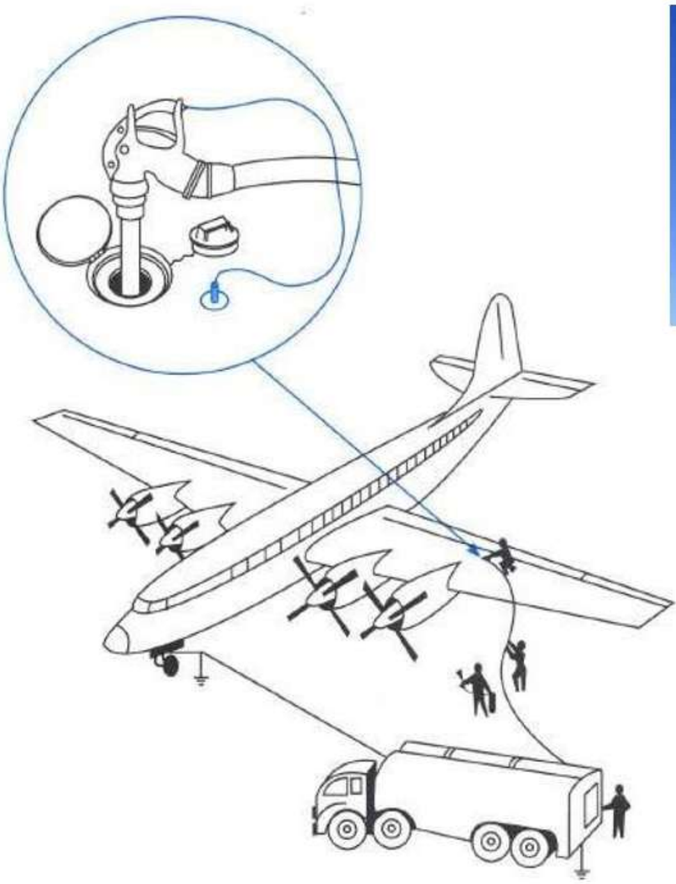
Static Wicks / Static Discharge Pins

Commonly called ESD (Electrostatic discharge device), Many airplanes have static discharge points or wicks installed on the trailing edge of the controlsurfaces.
These devices allow the static charges that build up on the control surfaces as air flows over them to discharge harmlessly into the air, thus preventing static interference in the radioequipment.

Means of discharging static charges when aircraft is in ground

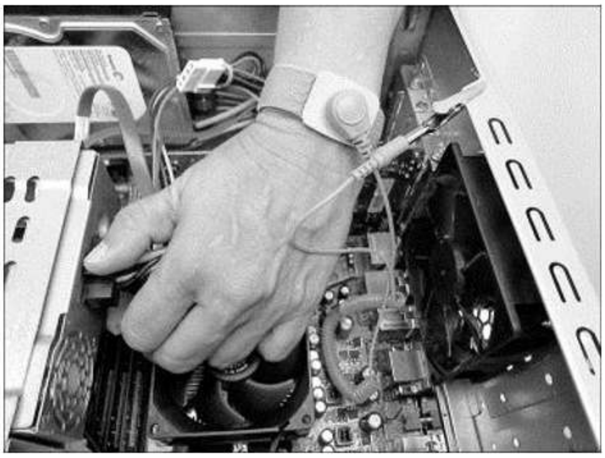
Earthing point

During any maintenance in aircraft in hanger, the aircraft should be grounded to the earthing point in the hanger, so all static charges will be discharged and the maintenance personnel can worksafely.
Static electricity causes a serious fire hazard when aircraft are being fueled ordefueled.
The flow of gasoline or turbine fuel in the hose produces enough static electricity to cause a spark to jump and ignite explosivefumes.



Anti-static wrist wrap

In addition to giving us a mild shock when we touch the metal part of aircraft, static electricity can cause radio interference and can damage sensitive electronic components.
It is possible, on a dry day, that just taking a few steps on a nylon carpet can build up more than 10,000 volts of static electricity on ourbody.
This much charge can destroy delicate electronic circuit devices, and technicians should wear a grounded wrist strap to bleed off any static charge from their bodies before handling this type ofequipment.



If a particular area gets excess charge due to static charges, then how those excess charges travels to static wicks to get discharged to atmosphere?

All metallic components of aircraft are bonded together, so when a particular area gets excess electrons due to static charges, the bonding cable will discharge the excess electrons into the next metallic area, which then discharge it's excess electrons into the next and this connection goes on till the static wicks, and the static wicks discharge those excess electrons into the atmosphere and so all metallic components of aircraft will be at samepotential.

Static dischargers will not function if they are not properly bonded to theaircraft.

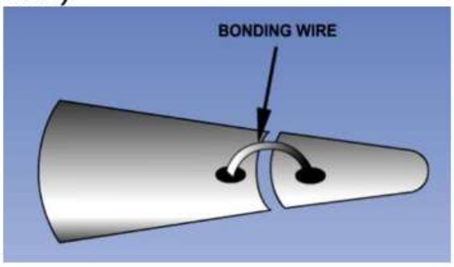
There must be a conductive path from all parts of the airplane to the dischargers, otherwise they will beuseless.

Access panels, doors, cowls, navigation lights, antenna mounting hardware, control surfaces, etc., can create static noise if they cannot discharge through the staticwick.

Quiz: Static charges are dissipated to ground through tyres after landing. How?

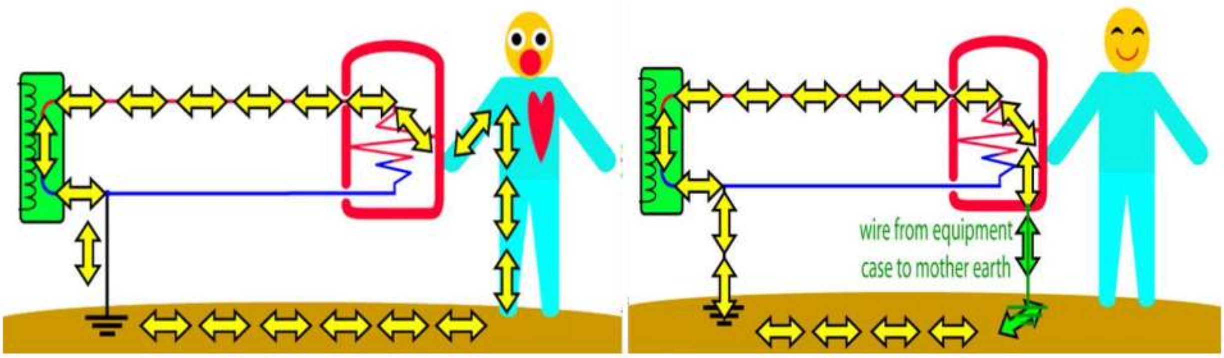
Means of discharging static charges Bonding

Bonding is the electrical connecting of two or more conducting objects not otherwise connected adequately (not supposed to carry current all the time).



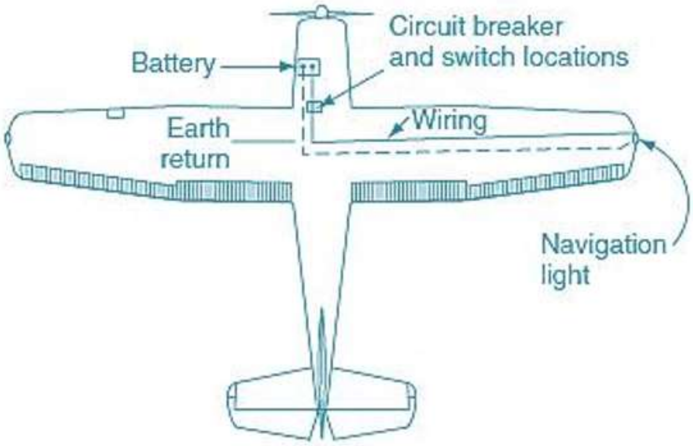
Grounding / Earth

Grounding can be defined as the technique of electrically connecting components to either a conductive structure or another return path for the purpose of completing a circuit.



Means of discharging return current Earth returns

Aircraft with metallic structure use the airframe as the means of completing the electrical circuit, thereby reducing the cost, weight and installation time of installing a return wire.



Example: The positive side of the battery power supply is connected to the navigation light via the circuit protection and control switch.

The earth (or ground) return is connected to the negative side of the power supply via the aircraft structure. In some installations, grounding of the load, e.g. the navigation light is via the body of the component's housing . In other installations, all the negative connections are collected at earth stations.

The location of the earth stations depends on a number of factors including the:

mechanical strength of thestructure
current through theconnections
corrosive effects (dissimilar materials)
ease of accessing/making theconnections.

Return paths

It is essential that the ground (or earth points) are not mixed between different types of circuit e.g. AC and digital signals. Using a common return path can lead to corrupted signals.

Separate return paths should be considered on all new system designs; this separation must be maintained whenever specified in the aircraftmanuals

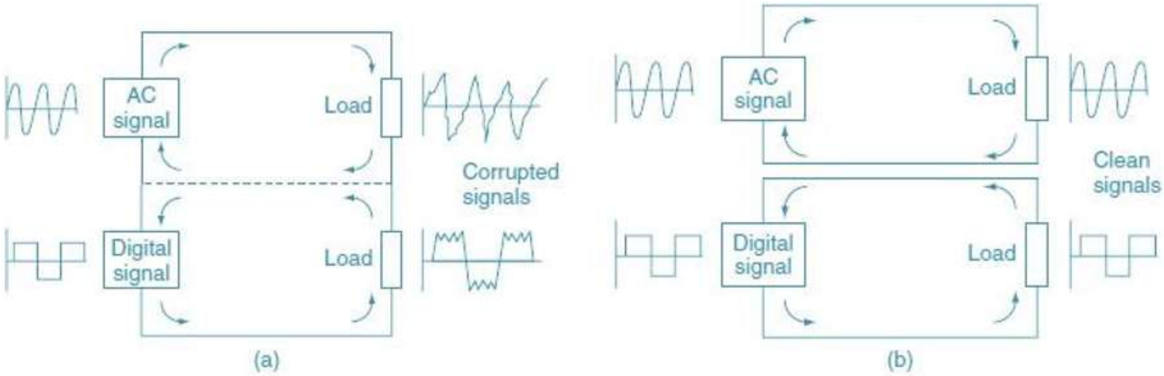
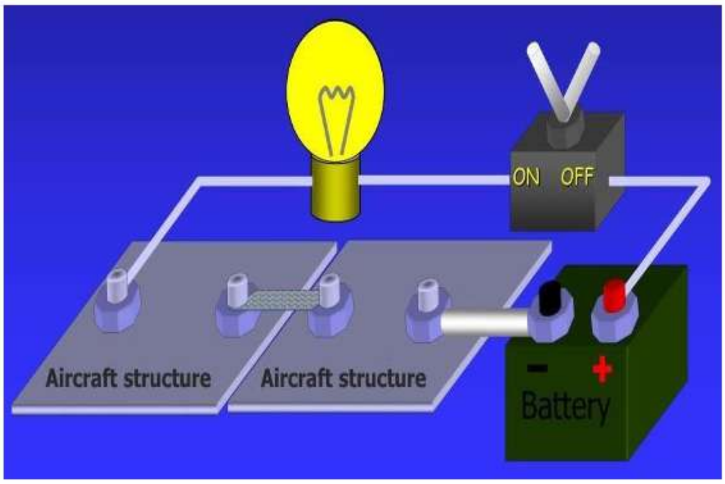


Figure 20.15 Earth/ground loops: (a) common return paths, (b) separate return paths



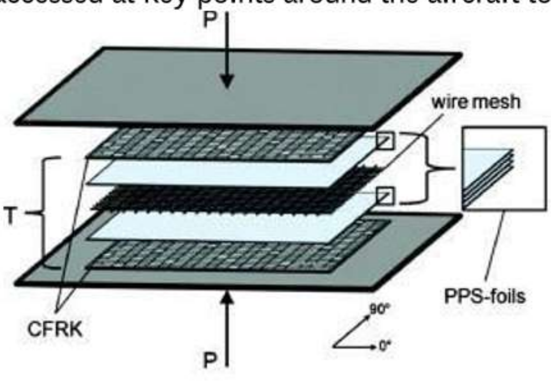
Return paths in composites

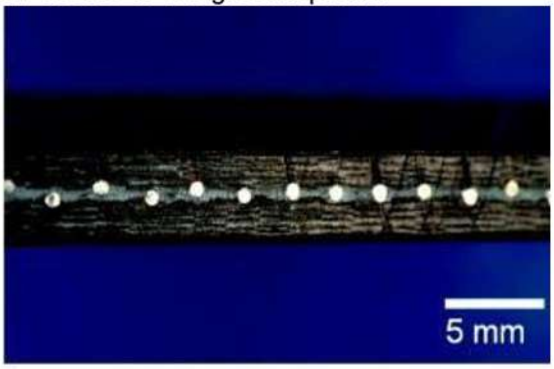
There is an increasing use of composite materials being used in the construction of aircraft because of their good strength-to-weight ratio (compared withaluminium).

Composite material has a high electrical resistance and is intrinsically unsuitable for bonding, earth returns and lightning strikedissipation.

A ground plane has to be integrated into the airframe; this is normally achieved by bonding an aluminium wire mesh into the composite structure duringmanufacture.

This mesh is accessed at key points around the aircraft to gain access to the ground plane.





Direct bonding is achieved by exposing the mesh (ground plane) and mountingthe equipment directly onto the conductivepath.

Indirect bonding is achieved by exposing the mesh and installing a bonding wireand connector.

The mesh must always be coated after making a connection since the aluminium will oxidize when exposed to air, leading to high resistance and unreliablejoints.

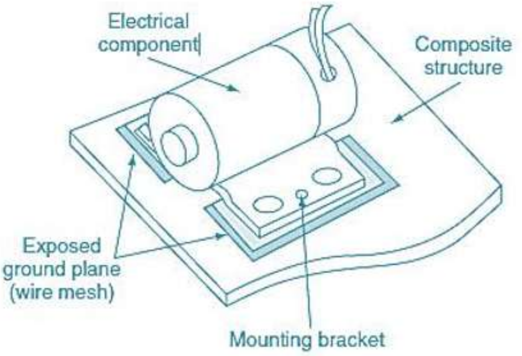


Figure 20.11 Direct bonding on composite structure

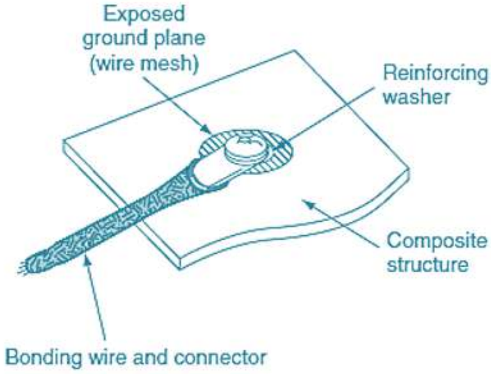


Figure 20.12 Indirect bonding on composite structure

Bonding

It is a mandatory requirement that aircraft structure and equipment are electrically bonded. Specific bonding and grounding connections are made in an aircraft to accomplish the following:

dissipate energy from a high intensity radiated fields (HIRF) and lightningstrikes.
dissipate static electricity.
limit the potential difference betweenequipment.
provide a low resistance path for earth returnsystems.

Bonding is categorized as either primary or secondary; this is determined by the magnitude of current being conducted.

Primary bonding is designed for carrying lightning discharges and to provide electrical returnpaths.
Secondary bonding is used to dissipate static electricity and keep all structure at the same potential.
Bonding straps (or leads) are pre-fabricated from braided copper or aluminium terminated with crimps.
The following general procedures and precautions apply when making bonding or grounding connections:
Grounding and bonding resistances of less than 0.001 ohms to 0.003 ohms are usually required
bond or ground parts to the primary aircraft structure wherepossible.
make bonding or grounding connections so that no part of the aircraft structure is weakened.
bond parts individually iffeasible.
install bonding or grounding connections against smooth, cleansurfaces.
install bonding or grounding connections so that vibration, expansion or contraction, or relative movement in normal service, will not break or loosen theconnection.
check the integrity and effectiveness of a bonded or grounded connection using an approved bondingtester.

Airworthiness Requirements for bonding paths are as follows: For Primary conductors:
The cross-sectional area of Primary Conductors made from copper strands shall be not less than 0.0045 sq.in, i.e. 0.25-in by 26 s.w.g (0.018-in), except that, where a single conductor is likely to carry the whole discharge from an isolated section, the cross- sectional area shall be not less than 0.009 sq.in, i.e. 0·5-in by 26s.w.g.
Where additional conductors are required to provide or supplement the inherent primary bonding paths provided by the structure or equipment, then the cross-sectional areaofsuchprimaryconductorsmadefromcopperstrandsshouldnotbelessthan3
except that, where a single conductor is likely to carry the whole discharge from an isolated section, the cross-sectional area would be not less than 6.

For Secondary conductors:

The cross-sectional area of secondary conductors made from copper must not be less than 0.001 sq.in which corresponds to 44 strands of 39 s.w.g for braided conductors. Where a single wire is used its size must be not less than 18s.w.g.
Where additional conductors are required to provide or supplement the inherent secondary bonding paths provided by the structure or equipment, the cross-sectional area of such secondary conductors made from copper should be not less than 1.
Where a single wire is used its size should be not less than 1-2 mmdia.
Bonding conductor:

The manufacturers of solid bonding strip and braided bonding cord usually quote the cross-sectional area on the relevant datasheet.

However, in the case of renewal or repair, if the original conductor cannot be matched exactly, a replacement manufactured of the same type of material, but of greater cross-sectional area, should be selected.
Primary flexible conductors are often made of 600 strands of copper wire, 0·0048 inch in diameter, and formed in a flat braid approximately 0·625 inch wide.
The number and location of bonding connections to the various components is important and this should be checked and verified by reference to the relevantdrawing,
e.g. where an engine is not in direct electrical contact with its mounting it should be bonded with at least two primary conductors, one on each side of theengine.

Bonding Jumper:

Braided copper or aluminium cords fitted at each end with connecting tags or lugs (usually referred to as 'bonding jumpers'), should be used for bonding connections between moving parts or parts subjected to vibration, and these are suitable both as primary and secondaryconductors.

Bonding jumpers should be made as short as practicable, and installed in such a manner that the resistance of each connection does not exceed .003 ohm.
The jumper should not interfere with the operation of movable aircraft elements, such as surface controls, nor should normal movement of these elements result in damage to the bondingjumper.
The tags or lugs on bonding jumpers are generally fitted by the 'crimping method', and only the correct form of crimp and crimping tools should be used for the particular connection.
During assembly of the connections to aluminium cords, anti-oxidant (crimping) compound consisting of 50% by weight of zinc oxide in white petroleum jelly, and complying with DTD 5503, should be applied to theconnections.
Note: In electrical engineering, petroleum jelly is often smeared on terminals to avoid contacting with air as a measure to prevent corrosion, especially battery terminals and aluminium bonded joints as aluminium in contact with oxygen creates corrosion in the form of aluminium oxide (a white powdery layer), which depletes conduction properties.
The use of solder to attach bonding jumpers should beavoided.
Tubular members should be bonded by means of clamps to which the jumper is attached. Proper choice of clamp material should minimize the probability ofcorrosion.

The following bonding requirements must be considered:

Bonding connections: To ensure a low-resistance connection, nonconducting finishes, such as paint and anodizing films, should be removed from the attachment surface to be contacted by the bonding terminal.
Electrical wiring should not be grounded directly to magnesiumparts.
Corrosion protection: One of the more frequent causes of failures in electrical system bonding and grounding is corrosion. Corrosion tends to form at a bonding or earth connection and is often the cause of excessive resistance.
The areas around completed connections should be post-finished quickly with a suitable finish coating.
Corrosion prevention: Electrolytic action may rapidly corrode a bonding connection if suitable precautions are not taken.
Aluminum alloy jumpers are recommended for most cases; however, copper jumpers should be used to bond together parts made of stainless steel, cadmium plated steel, copper, brass, or bronze.
Where contact between dissimilar metals cannot be avoided, the choice of jumper and hardware should be such that corrosion is minimized; the part likely to corrode should be the jumper or associated hardware.
Equipment bonding: Low-impedance paths to aircraft structure are normally required for electronic equipment to provide radio frequency return circuits and for most electrical equipment to facilitate

reduction in EMI.
The cases of components that produce electromagnetic energy should be grounded to structure.
Metallic surface bonding: All conducting objects on the exterior of the airframe must be electrically connected to the airframe through mechanical joints, conductive hinges, or bond straps capable of conducting static charges and lightning strikes.
Exceptions may be necessary for some objects, such as antenna elements, whose function requires them to be electrically isolated from the airframe. Such items should be provided with an alternative means to conduct static charges and/or lightning currents, as appropriate.
Static bonds: All isolated conducting parts inside and outside the aircraft, having an area greater than 3 square inches and a linear dimension over 3 inches, that are subjected to appreciable electrostatic charging due to precipitation, fluid, or air in motion, should have a mechanically secure electrical connection to the aircraft structure of sufficient conductivity to dissipate possible staticcharges.
A resistance of less than 1 ohm when clean and dry generally ensures such dissipation on larger objects. Higher resistances are permissible in connecting smaller objects to airframe structure.

Bonding of metallic and non-metallic aircrafts:

The skin of an all-metal aircraft is considered adequate to ensure protection against lightning discharge provided that the method of construction is such that it produces satisfactory electrical contact at the joints. An electrical contact with a resistance less than 0·05 ohm is consideredsatisfactory.
With regard to aircraft of non-metallic or composite construction, a cage consisting of metallic conductors having a surge carrying capacity at least equal to that required for primary conductors and to which metal parts are bonded, forms part of the configuration of the structure.
The earth system, which in the case of aircraft of metallic construction is normally the aircraft structure and for aircraft of non-metallic construction is the complete bonding system, which must be automatically connected to the ground onlanding.
This is normally achieved through the nose or tail wheel tyre, which is impregnated with anelectrically conducting compound (Carbon black), to provide a low resistance path [Answer toprevious quiz]
NOTE: On some aircraft, a static discharge wick or similar device trailed from a landing gear assembly is used to provide ground contact on landing.
The reduction or removal of electrostatic charges which build up on such surfaces as glass fibre reinforced plastic, can be achieved by the application of apaint,
e.g. PR 934, which produces a conductive surface.

Bond tester:

A meter widely used, consists of an ohmmeter operating on the current ratio principle, and a single 1-2-volt nickel alkaline cell housed in a wooden carrying case. Modern testers are of advanceddesign.
The associated cables are 60 feet and 6 feet in length, and are fitted with a single-spike probe and a double-spike proberespectively.
Plug and socket connectors provide for quick-action connection of the cables to the instrument.

Prior to carrying out a bonding test, a check should be made on the state of the nickel-alkaline cell of the tester by observing;

that a full-scale deflection of the meter is obtained when the two spikes of the 6-foot cable probe are shorted by a suitable conductor;and

that the meter reads zero when the two spikes of the 6-foot probe are shorted by the single spike of the 60-footprobe.

➤ Bond Tester

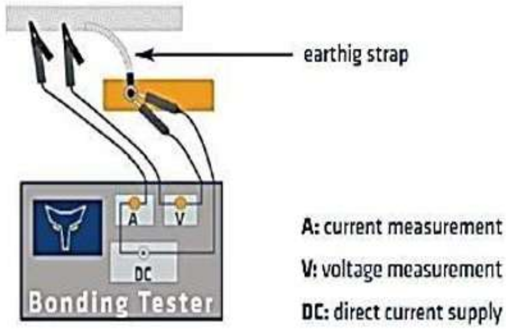


Figure 6. Point to structure measurement [2]

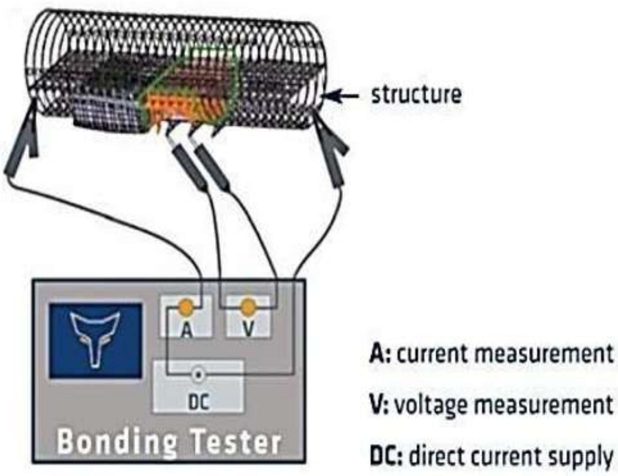


Figure 7. Return current measurement [2]

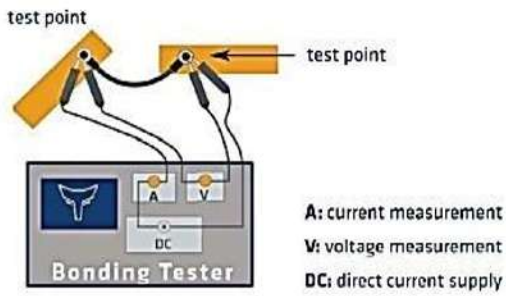
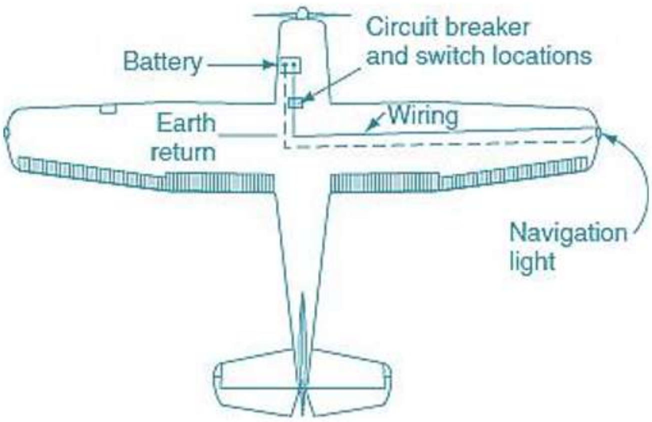


Figure 5. Point to point measurement [2]

footlead

The 60-foot lead of the test equipment should be connected to the main earth (also known as the bond datum point) at the terminal points which are usually shown diagrammatically in the relevant Aircraft MaintenanceManual.

Since the length of a standard bonding tester lead is 60 feet, the measurement between the extremities of the larger types of aircraft may have to be done by selecting one or more main earth points successively, in which event the resistance value between the main earth points chosen should be checked before proceeding to check the remote point.



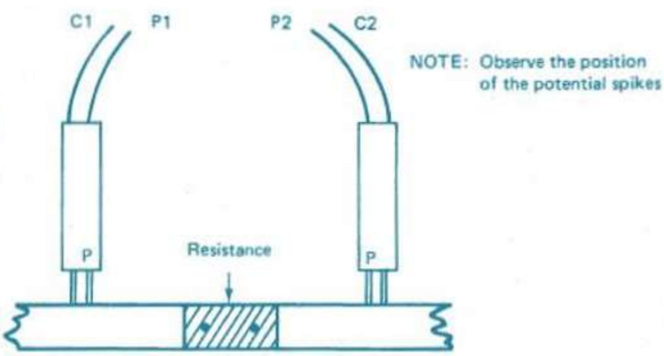
footlead

The 6-foot test lead should be used to check the resistance between selected points; these are usually specified in the bonding test schedule or the Maintenance Manual for the aircraftconcerned.
When the two spikes of the test lead probe are brought into contact with the aircraft part, the test-meter will indicate, in ohms, the resistance of thebond.

Milliohm meter (four terminal method)

The instruments utilize the four-terminal, Kelvin technique to eliminate errors caused by the resistance of theleads.

With this type of instrument, a test current (approximately 2 amps) is supplied bythe internal batteries and passed through the resistance via cables CI andC2.
The voltage drop across the resistance is measured (PI and P2) and compared withthe currentflowing.
The resultant value is then displayed (normally digitally) on themeter.
The test leads may be in the form of duplex spikes or when used in association with crocodile type test leads, singlespikes.



To ensure good electrical contact at the probe spikes, it may be necessary to penetrate or remove a small area of a non-conducting protective coating. Therefore, after test, any damage to the protective coating must be restored.

Continuity testing

A concealed break in a cable core or at a connection may be found by using a continuity tester which normally

consists of a low voltage battery (2,5 volts is satisfactory) and a test lamp or low readingVoltmeter.
Before testing, the main electrical supply should be switched off or disconnected. A check should be made that all fuses are intact and that the circuit to be tested is not disconnected at any intermediatepoint.
All switches and circuit breakers, as appropriate, should be closed to completed the circuit.
When carrying out a low voltage continuity check, it is essential to work progressively through the circuit, commencing from the relevant fuse or circuit breaker and terminating at theequipment.

Millivolt drop test

Excessive resistance in high-current carrying circuits can be caused by loose terminal connections, poorly swaged lead ends,etc.
Faults of this kind are indicated by low terminal voltage at the connections to theservice load and by heating at a conductorjoint.
For continuously-rated circuits, the test should, whenever possible, be made with the normal operating current flowing, the power being derived from an externalsource.
For short-rated circuits, a suitable resistance or other dummy load should be used in lieu of the normal load and the current should be scaled down to avoidoverheating.
The millivolt-meter should be connected to each side of the suspected joint and a note made of the volt dropindicated.
The indicated reading should be compared with the figures quoted in the relevant publication (an approximate guide is 5 mV / 10 ampsflowing).

Wires andCables

Wires are formed from a single solid conductor or stranded conductors, contained within insulation and protective sheath materials.
Cables can be defined as:

two or more separate wires within the same insulation and protectivesheath.
two or more wires twistedtogether.
any number of wires covered by a metallic braid, orsheath.
a single insulated conductor covered by a metallic outer conductor (co-axialcable).

Types of Wires and cables

There is a vast range of wires and cable types used in an aircraft; these can be categorized with their specific uses and applications:
Airframe wires andcables

Equipment wires andcables
Ignition systemcables
Thermocouple cables
Data buscables
Radio-frequency (RF)cables.

Wiresorcablesdesignedforsmallsignals,e.g.databuscablescarryingdigitaldata,are screened to prevent their signals from being affected by electromagnet interference.
Wires and cables that carry high power and/or high frequencies are also shielded to prevent them being the cause of electromagneticinterference.

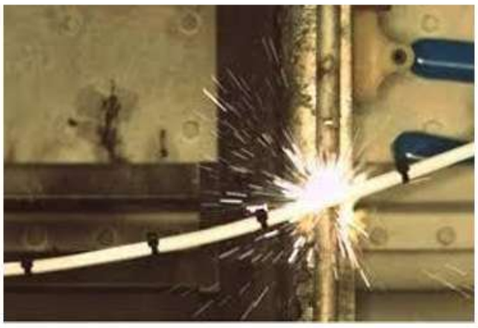
Operating environment:

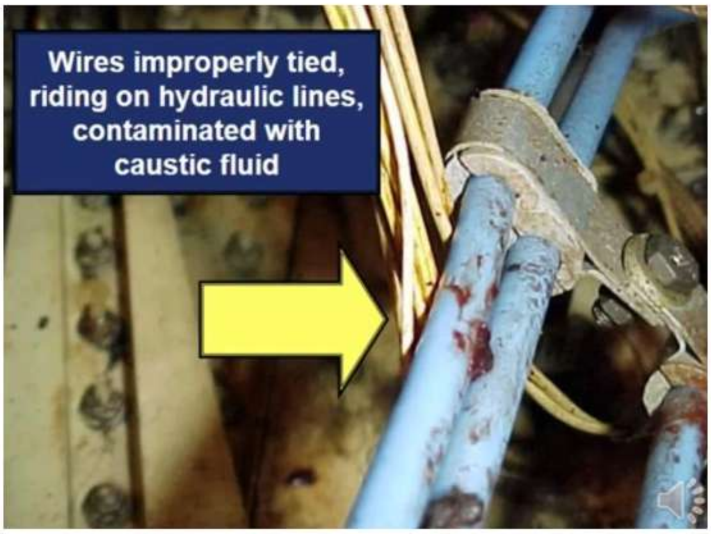
Wiring installed in aircraft has to operate in a harsher environment than that found in cars, buildings or industrial applications. In addition to conducting current (often at high voltages), aircraft wiring will be exposed to a variety of environmental and in-service conditions including contaminants, for example:
hydraulicfluid
fuel and/oroil
temperatureextremes
abrasion
vibration

Construction & Materials – Why copper is more suitable than Aluminium?

The insulating material has to be able to withstand the applied voltage; the sheath material needs to be able to withstand the specifiedcontaminants.
Aluminium conductors are sometimes used in aircraft; however, the majority of installations arecopper.
The choice of conductor material is a trade-off; the first consideration is the **material's resistance over a given** length, called resistivity (symbol ρ , measured in ohm-metres, abbreviated Ωm).
Annealed copper at 20°C has a resistivity of $1.725 \times 10^{-8}\ \Omega$ m; copper is more ductile than aluminium, and can be easilysoldered.
Aluminium has a resistivity value of $2.8 \times 10^{-8}\ \Omega$ m, it is 60% lighter than copper but it is moreexpensive.
A major consideration for using aluminium is that it is self-oxidizing ; this reduces manufacturing costs (no plating required) but extra precautions are necessary for terminating the conductors due to the increased terminationresistance.
Individual strands of copper need to be coated to prevent oxidation. The choice of coating for the strands depends on the operating temperature of the wire. In general terms, three types of coating are used: tin, silver or nickel, giving temperature ratings of 135°C, 200°C and 260°Crespectively.
Wet arc tracking:

The combined effects of insulation damage and fluid contamination gives rise to wet arc tracking .
This phenomenon can occur when insulating surfaces are contaminated with any material containing free ions; the surface then behaves as an electrically conductive medium (an electrolyte).
Leakage currents are sufficiently high to vaporize the contamination and in turn emit flashes of light at the insulation surface, and produce localized temperatures in the order of1000ºC.
These high temperatures cause degradation of the insulationmaterial.





Preventing Wet arc tracking:

The ability of aircraft wiring to resist wet arc tracking is highly dependent on thewire insulationmaterial.
Higher power supply voltages are potentially lethal and the insulation provides a level of protection againstthis.
Theinsulationmaterialanditsthicknessdependmainlyontheoperatingtemperatureand system voltage; examples of insulating and sheath materialsinclude:
ethylene tetrafluoroethylene (ETFE): this is a fluorocarbon-based polymer (fluoropolymer) in the form of plasticmaterial
polytetrafluoroethylene (PTFE), a syntheticfluoropolymer.
fluorinated ethylene-propylene (FEP): this retains the properties of PTFE, but is easier to form
polyvinylidene fluoride (PVF 2 or PVFD) has good abrasion and chemicalresistance, and (like most fluoropolymers) is inherentlyflame-retardant.

Wire specifications

Typical specifications used for wires and cables are contained in the US military specification MIL-W-M22759E .
This specification covers fluoropolymer-insulated single conductor electrical wires manufactured with copper or copper alloy conductors coated with either tin, silver or nickel.
The fluoropolymer insulation of these wires can either be PTFE, PVF 2 , FEP or ETFE. Wires manufactured to this specification are given a part number using the following format:M22759/x-xx-x.
M22759/x - xx - x determines the specific wire type (Insulation, sheath and wire coating) from a table in thespecification
M22759/x - xx - x determines the wire size from a table in thespecification
M22759/x - xx - x determines the insulation colour from another specification(MIL-STD-681).
For example, a wire printed with number M22759/34-22-948 would designate a wire constructed in accordance with MIL-W-22759/34, wire size 22, white insulation (9), first stripe yellow (4), and a second stripe of grey (8).
Wire Identification:

The proper identification of electrical wires and cables with their circuits and voltages is necessary to provide safety of operation, safety to maintenance personnel, and ease of maintenance.
All wire used on aircraft must have its type identification imprinted along itslength.
It is common practice to follow this part number with the five digit/letter Commercial and Government Entity (CAGE) code identifying the wiremanufacturer.

You can identify the performance capabilities of existing installed wire you need to replace, and avoid the inadvertent use of a lower performance and unsuitable replacementwire.

Placement of Identification markings:

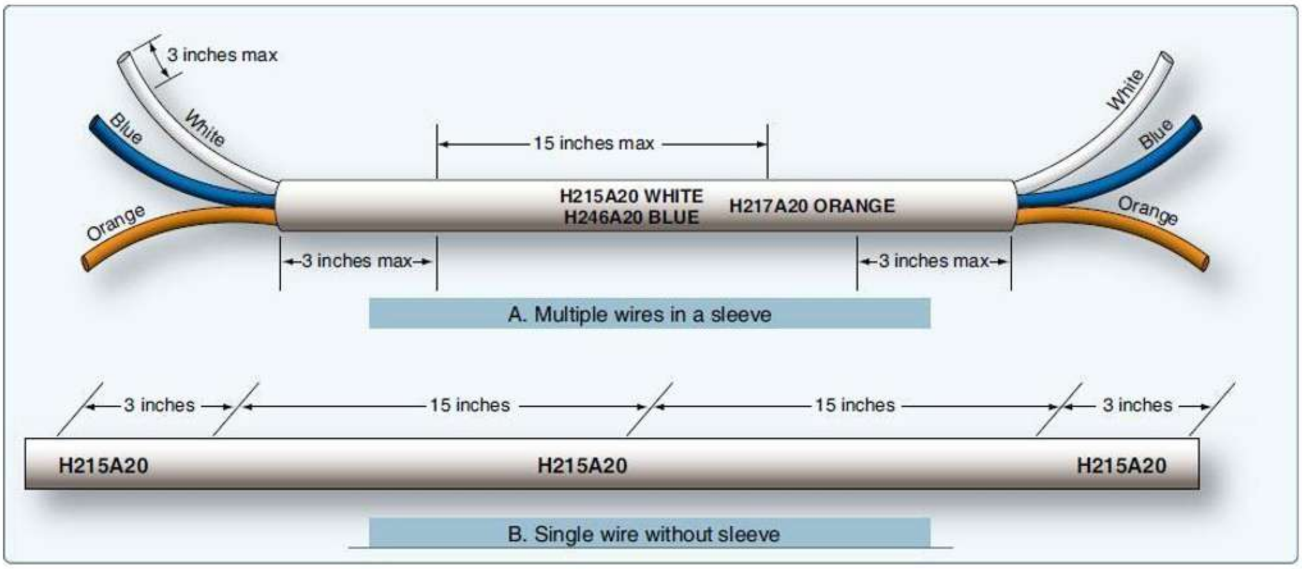
Identification markings should be placed at each end of the wire and at 15-inch maximum intervals along the length of thewire.

Wires less than 3 inches in length need not beidentified.

Wires 3 to 7 inches in length should be identified approximately at thecenter.

Added identification marker sleeves should be located so that ties, clamps, or supporting devices need not be removed to read theidentification.

The wire identification code must be printed to read horizontally (from left to right) or vertically (from top to bottom), along the length ofwire.



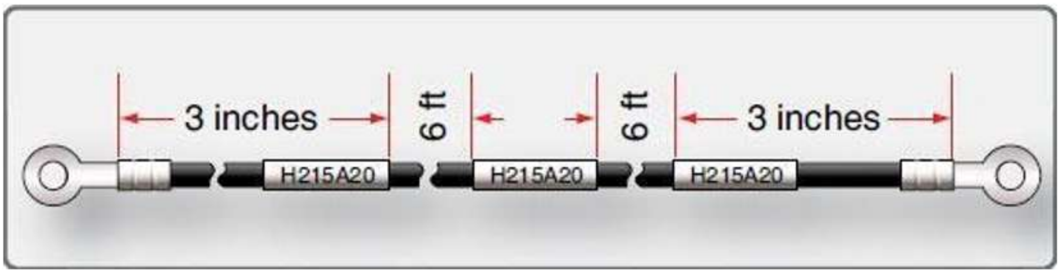
The two methods of marking wire or cable are as follows:

Direct marking is accomplished by printing on the cable's outercovering.

Indirect marking is accomplished by printing on a heat-shrinkable sleeve and installing the printed sleeve on the wire or cables outercovering.

Indirectly-marked wire or cable should be identified with printed sleeves at each end and at intervals not longer than 6feet.

The individual wires inside a cable should be identified within 3 inches of their termination.



Types of wire markings:

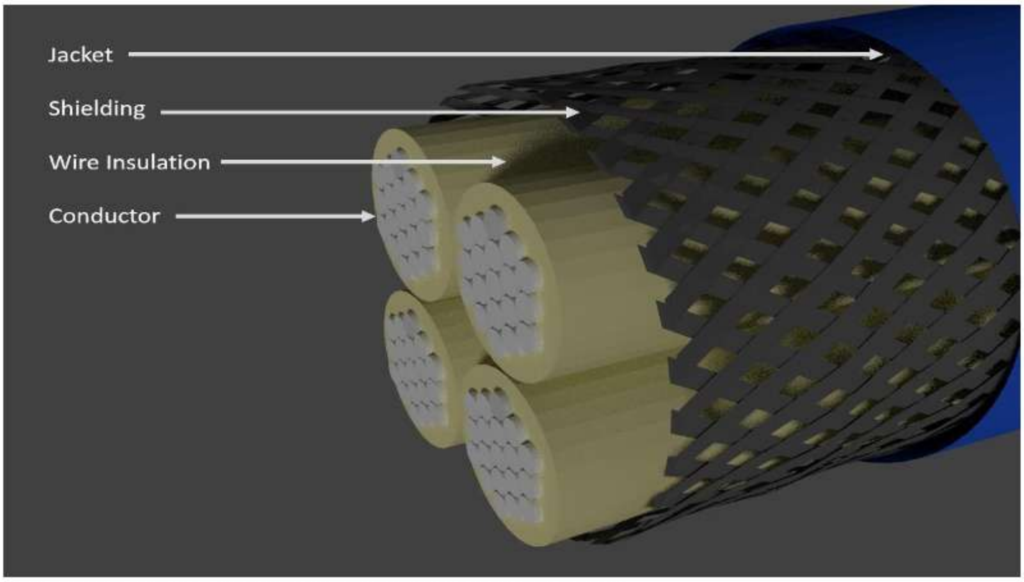
The preferred method is to mark directly on the wire without causing insulation degradation.
Teflon-coated wires, shielded wiring, multi-conductor cable, and thermocouple wires usually require special sleeves to carry identificationmarks.
There are some special wire marking machines available that can be used to stamp directly on the type wires mentionedabove.
Whatever method of marking is used, the marking should be legible and the colour should contrast with the wire insulation orsleeve.
Several different methods can be used to mark directly on the wire: hot stamp marking, ink jet printers, and laser jetprinters.
The hot stamp method can damage the insulation of wire that utilizes thin insulators. Fracture of the insulation wall and penetration to the conductor of these materials by the stamping dies haveoccurred.
Wire markings with sleeves:

Flexible sleeving, either clear or opaque, is satisfactory for generaluse.
When color-coded or striped component wire is used as part of a cable, the identification sleeve should specify which colour is associated with each wire identificationcode.
For sleeving exposed to high temperatures (over 400 °F), materials, such as silicone fiberglass, should beused.
Polyolefin sleeving should be used in areas where resistance to solvent and synthetic hydraulic fluids isnecessary.
Sleeves may be secured in place with cable ties or by heatshrinking.

Shielding / Screening:

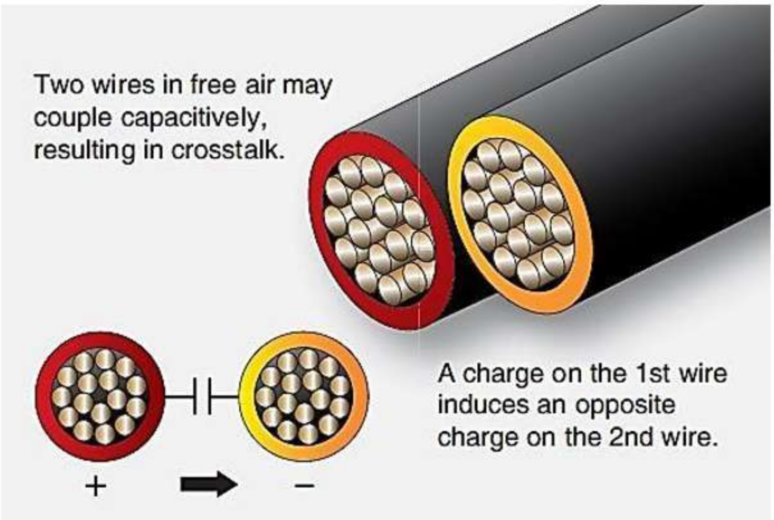
With the increase in number of highly sensitive electronic devices found on modern aircraft, it has become very important to ensure proper shielding for many electric circuits.
Shielding is the process of applying a metallic covering to wiring and equipment to eliminate electromagnetic interference(EMI).
Note: EMI is caused when electromagnetic fields (radio waves) induce high frequency (HF) voltages in a

wire or component. The induced voltage can cause system inaccuracies or even failure.



Use of shielding with 85 percent coverage or greater isrecommended.

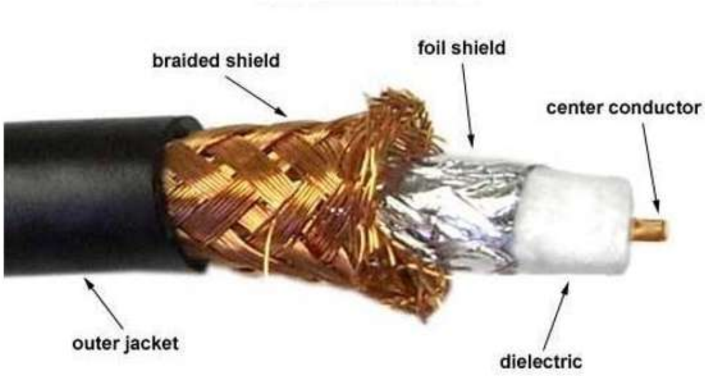
Coaxial, triaxial, twin axial, or quadriaxial cables should be used, wherever appropriate, with their shields connected to ground at a single point or multiple points, depending upon the purpose of theshielding.
Wire is normally shielded when it is anticipated that the circuit can be affected by another circuit in the wireharness.
When the wires come close together, they can couple enough interference to causea detrimental upset to attached circuitry. This effect is often calledcrosstalk.
Wires must come close enough for their fields to interact, and they must be inan operating mode that produces the crosstalkeffect.
However, the potential for crosstalk is real, and the only way to prevent crosstalk isto shield the wire.



Co-axial cables:

A specialized version of the shielded wire is the coaxialcable.
The inner conductor is solid or stranded; it can be plain copper or plated. The outer conductor forms a shield and is a single wire braid made from fine strands of copper or steel.
The inner and outer conductors are separated by a solid insulation, forming adielectric.
The outer sheath or jacket provides protection against fluid contaminants.

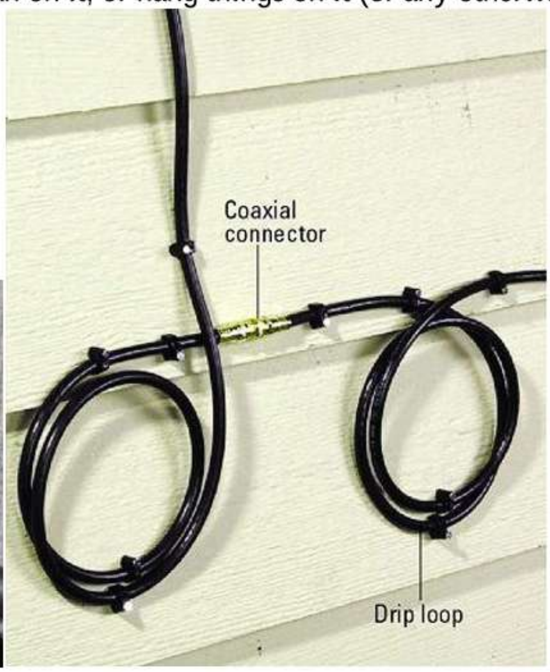
Coaxial cables are normally used to guide radio-frequency (RF) energy between antennas and receivers ortransmitters.



The inner conductor is shielded from electric and magnetic fields by the braiding. The conductor's own field is contained within the sameshield.
The net result is that fields from the inner and outer conductors cancel each other out. In most practical RF applications, coaxial cable radiation and susceptibility are virtually eliminated.

Co-axial cables – Precautions:

Never kink coaxialcable.
Never drop anything on coaxialcable.
Never step on coaxialcable.
Never bend coaxial cablesharply.
Never loop coaxial cable tighter than the allowable bendradius.
Never use coaxial cable for a handle, lean on it, or hang things on it (or any otherwire).



Drip loops has to be made in areas, where by any chance if any liquid leaks, the leaked liquid should flow downwards away from the connector rather than towards the connector to the equipment.

Co-axial cables – Testing:

Simple coaxial cable testing can be done with an ohmmeter.
It can be performed before the end terminals are installed to simply check the cable itself. Or, the check can be made with the end terminals installed so as to check the integrity of the entire cableassembly.
There must always be low resistance, basically zero resistance, when the ohmmeter probes are touched to the innerconductor.
However, there should always be infinite resistance when the probes are touched to the conductor and theshielding.
In other words, the shielding and conductor should be electrically isolated at alltimes.
Continuity is required throughout the shielding as well and there should be no resistance between the shielding andground.

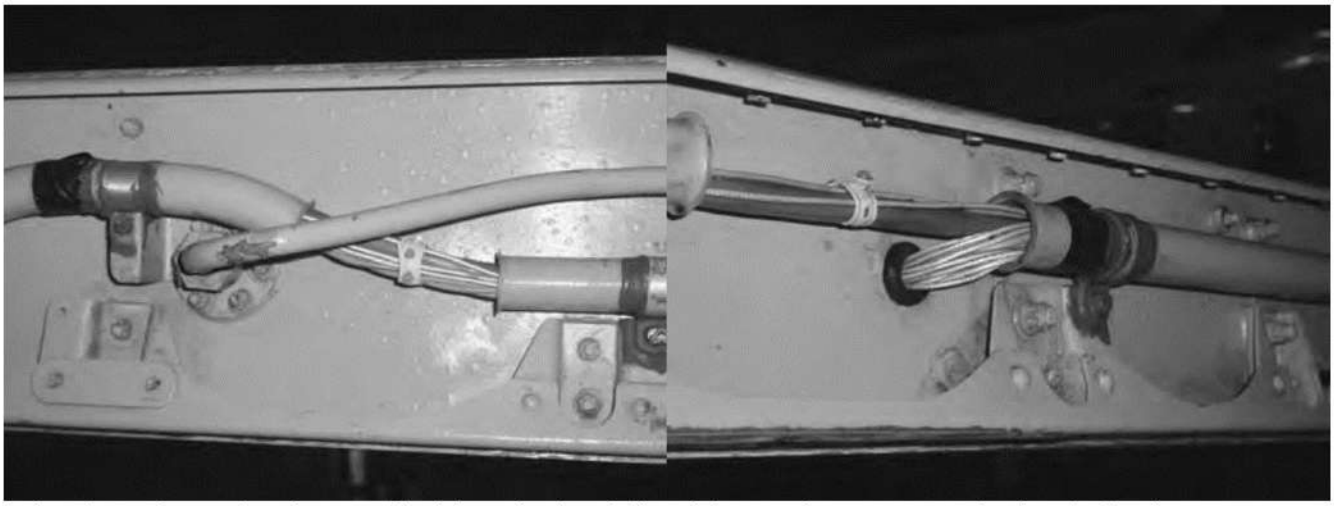
Conduits:

Conduit is manufactured in metallic and non-metallic materials and in both rigid and flexibleforms.
Primarily, its purpose is for mechanical protection of cables orwires.
Conduit size should be selected for a specific wire bundle application to allow for ease in maintenance, and possible future circuit expansion, by specifying the conduit inner diameter (ID) about 25 percent larger than the maximum diameter of the wirebundle.
Provide drain holes at the lowest point in a conduit run. Drilling burrs should be carefullyremoved.

Conduits are used in specific areas, e.g. wing leading edges to protect wiring loom from rain and other fluids; these conduits are made from plastic ormetal.

Rigid Conduits -Maintenance:

Kinked or wrinkled bends in rigid conduits are not recommended and should be replaced.
Tubing bends that have been flattened into an ellipse and have a minor diameter of less than 75 percent of the nominal tubing diameter should be replaced, because the tube area has been reduced by at least 10percent.



Tubing that has been formed and cut to final length should be deburred to prevent wire insulationdamage.
When installing replacement tube sections with fittings at both ends, care should be taken to eliminate mechanicalstrain.

Flexible Conduits -Maintenance:

Flexible aluminum conduit conforming to specification MIL-C-6136 is available in two types: Type I, bare flexible conduit, and Type II, rubber-covered flexibleconduit.
Flexible brass conduit conforming to specification MIL-C-7931 is available and normally used instead of flexible aluminum where necessary to minimize radio interference. Also available is a plastic flexibletubing.

Flexible conduit may be used where it is impractical to use rigid conduit, such as areas that have motion between conduit ends or where complex bends arenecessary.
The use of transparent adhesive tape is recommended when cutting flexible tubing with a hacksaw to minimize fraying of thebraid.
The tape should be centred over the cutting reference mark with the saw cutting through thetape.
After cutting the flexible conduit, the transparent tape should be removed, the frayed braid ends trimmed, burrs removed from inside the conduit, and coupling nut and ferrule installed.

Heat shrink wrapping:

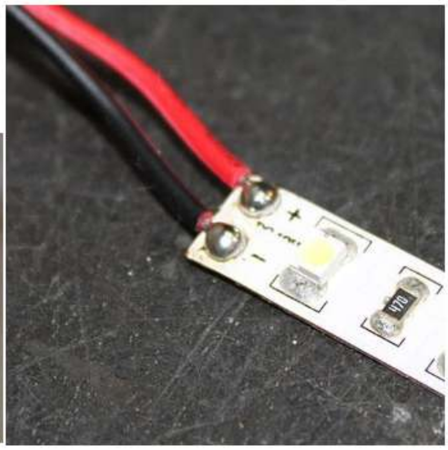
In certain applications, heat shrinkable tubing may be an appropriate alternative to flexibleconduit.
Various types are available for different purposes such as identification and colour coding, strain relief of wires and terminations, and cable jacketing and repairwork.
Each type has a dielectric rating and operating temperature range which must be considered beforeusage.
Heat shrink wrap comes in a variety of diameters so that it can be slipped over the wire(s) or cable yet when heated, the wrap shrinks to a snug fit aroundthem.
Once the proper size and material of heat shrink wrap is selected and cut to length, position the tubing as required over the item to becovered.

Use a hot-air gun or compressed air heater as the heatsource.
Apply the heat evenly over the full length of the wrap until it shrinks and conforms to the component being covered. Allow it to cool beforehandling.
Use caution to not overheat the wrap or the wires inside. Polyurethane coated wires, for example, release irritating gases when the temperature exceeds 315deg.Cel.

Crimpedterminations

Means of Terminating a wire

There are several methods by which cables are terminated, but the one most commonly used is the solderless or crimpedtermination.
The soldered method is also used, but is generally confined to the joining of internal circuit connections of consumer equipment and in some cases, to the connection of single core cables and plug and socketcontacts.



Quiz to test your previous knowledge:

What type of plier can be used to crimp electricalwires?
Before crimping a aluminium bonding cable with a connector / lug, the joining wire area should becoatedwith__to prevent corrosion and to promote goodconduction

The following steps indicates the procedure for crimping

Cut the wire square and clean without deforming the wireconductor.
Strip the insulation to the rightlength.
Twist the wire, ifrequired.
Connect to the suitable terminal lug / strip /connectors

Wire stripping:

Before cables can be assembled to connectors, terminals, crimps, etc., the insulation must be cut back and stripped from the connecting ends to expose the wire conductors. The maximum length of wire conductor that can be stripped of insulation and exposed, to connect a terminal should be about 0.8 mm(1/32-inch).
Care should be taken when stripping cable that the conductor strands are not cut or nicked.
If the lay (arrangement) of the wire conductor strands is disturbed, it should be reimposed by a light twistingaction. Excessive twisting should be avoided as this will increase the diameter of the cable and may result in a defectivejoint.
On small diameter cables, only the recommended stripping tools should be used for removing the insulation. On no account should a knife or side cutting pliers be used because of the high risk of damage to the conductorstrands.
For size 8 or larger diameter cables a knife may be used to make lengthwise cuts partially through the outer covering and insulation; these should then be bent back and cut off with side cutters orscissors.
The stripped cable should be examined for signs of damage, severed strands and cleanliness, before it is connectedup.
The following general precautions are recommended when stripping any type of cable:

When using any type of cable stripper, hold the stripper so that the cutting blade is square to thecable.
Follow the manufacturer's instructions when adjusting automatic stripping tools, to avoid damaging the conductor strands by cutting or nicking; this is especially important for aluminium cables and the smaller sizes of copper cables. Cut-off and re-strip (if length is sufficient), or reject and renew any cable which has been sodamaged.
Ensure that the outer covering and the insulation are clean cut, with no frayed or ragged edges.
When using hand operated strippers to remove lengths of insulation longer than 19 mm (0·75 in), the stripping should be accomplished in two or moreoperations.
Re-twist conductor strands by hand, or with pliers, if necessary, to restore the natural lay and tightness of the conductorstrands.

The following general procedures describe the steps for stripping wire with a hand stripper.

1. Insert wire into exact center of correct cutting slot for wire size tobe
stripped. Each slot is marked with wiresize.
2. Close handles together as far as they will go.
3. Release handles, allowing wire holder to return to the openposition.
4. Remove stripped wire.

Stripping a Aluminium cable:

The use of aluminium cables in aircraft has been brought about chiefly by the weight advantage of this metal over copper. However, in order to obtain satisfactory electrical connections, certain special installation techniques arenecessary.
Aluminium cables should be stripped very carefully, since individual conductor strands will break very easily after beingnicked.
Bending of aluminium cables will cause 'work hardening' of the conductor strands, resulting in failure or

breakage of strands much sooner than in cables with copper conductors.

Aluminium, when exposed to the atmosphere, forms an oxide film which acts as an insulator. This film can, if left untreated, cause corrosion at connecting joints and as it also increases in thickness as heat is generated by current flow, it will further increase the electrical resistance of thatjoint.

Only aluminium or bimetal (AICu) terminations should be used to terminate aluminium cables and the cable should be stripped immediately prior to making thejoint.

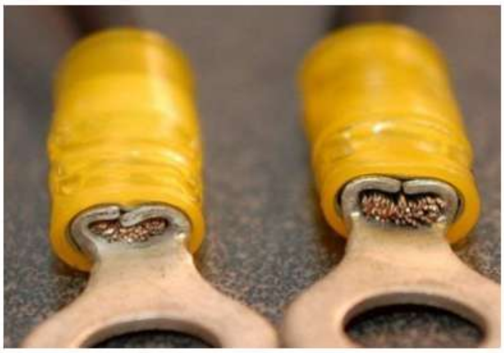
Crimped connections:

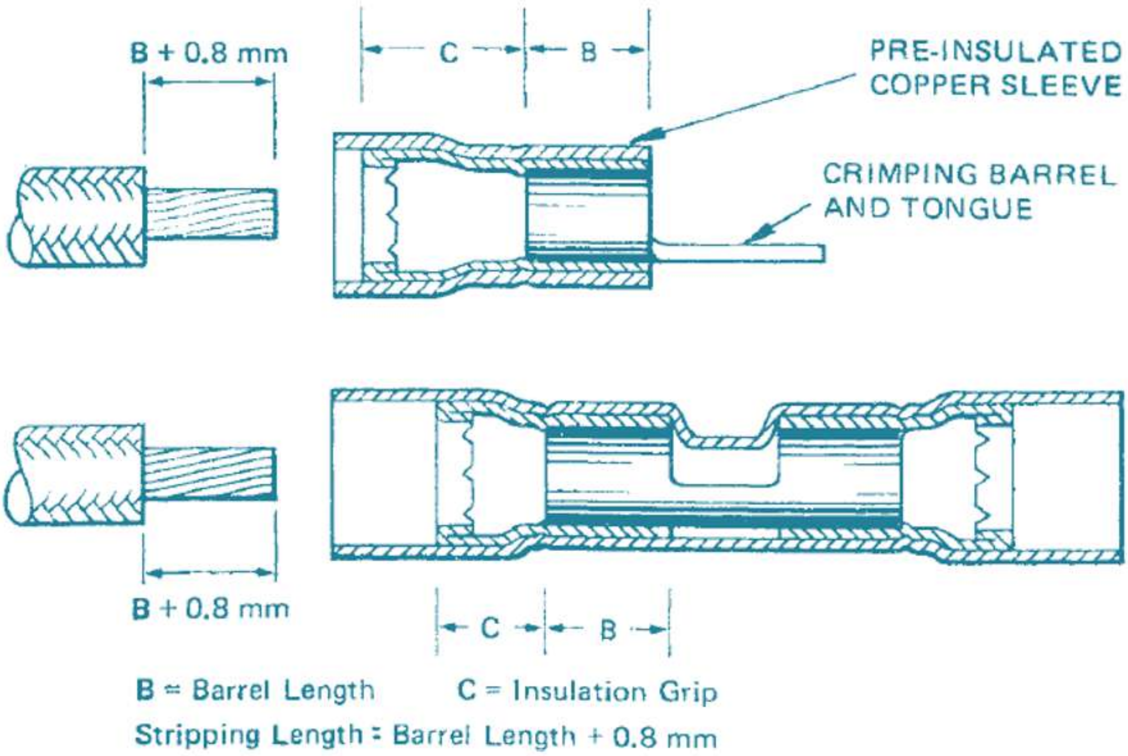
A crimped connection is one in which a cable conductor is secured by compression to a termination so that the metals of both are held together in closecontact.

A typical crimp termination has two principal sections, crimping barrel and tongue, together with, in some types, a pre-insulated copper sleeve which mates with the crimping barrel at one end and is formed, during the crimping process, so as to grip the cable insulation at the other in order to give a measure ofsupport.

The barrel is designed to fit closely around the cable conductor so that after pressure has been applied a large number of points of contact aremade.

The pressure is applied with a hand or hydraulically operated tool fitted with a die or dies, shaped to give a particular cross-sectional form to the completedjoint.



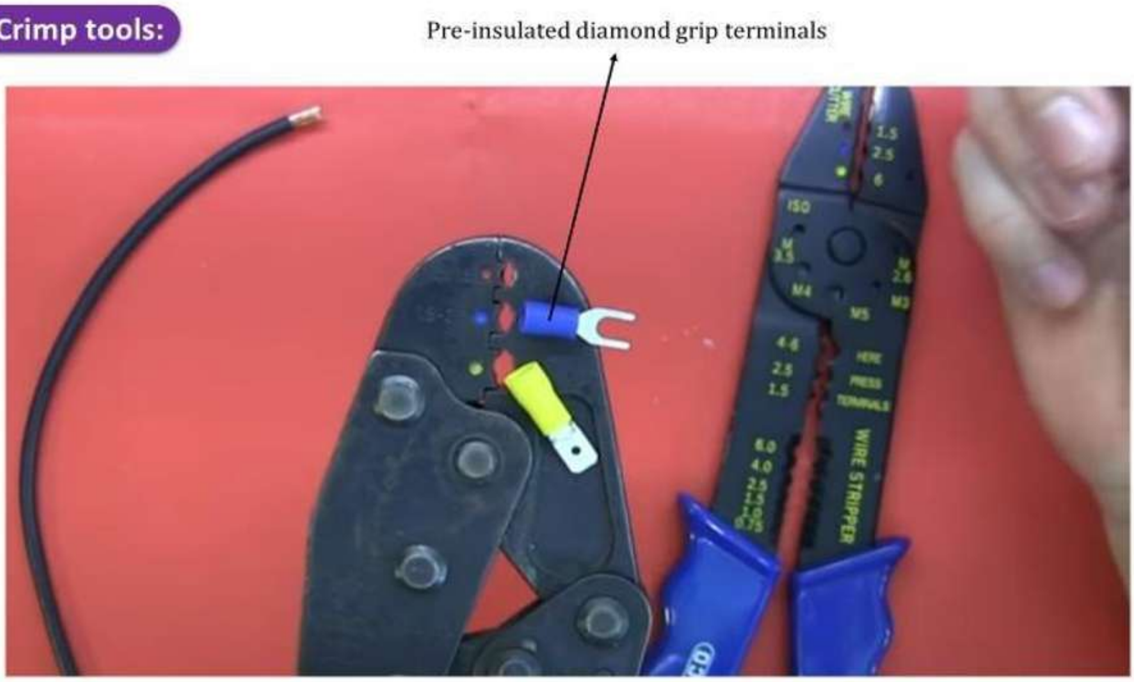


Crimp tools:

Hand crimping tools normally have a self-locking ratchet which prevents opening of the tool until the crimping action iscomplete.
Some tools are equipped with a nest of various size dies to allow for a range of different sizes and types of terminations, while others are suitable for one size and typeonly.
In addition, many of the tools and/or dies are colour coded to correspond with the colour marking used on someterminations.
It is essential that the recommendations and instructions of the relevant aircraft or equipment manufacturer should be strictly complied with when undertaking work of thisnature.
There is a vast range of terminations available, many of which are colour coded, suitable for use only with specific types of aircraft cable. It is, therefore, vital that the appropriate manufacturer's instructions regarding the use of cables and terminations are followed.

This insulation is coloured red, blue or yellow depending on size; this colour coding relates to the specific crimping pliers required for the operation.

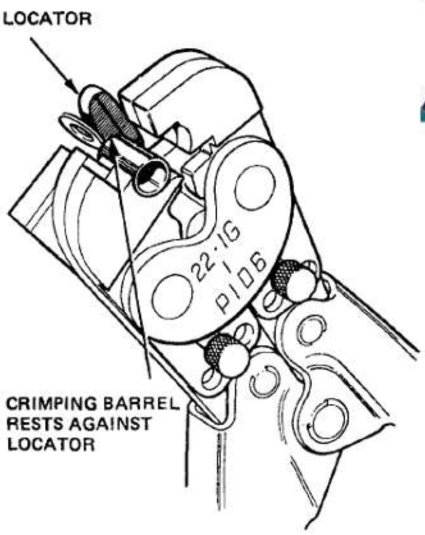
Wiresizingindicatesthediameterofthemetal conductor of the wire and is based

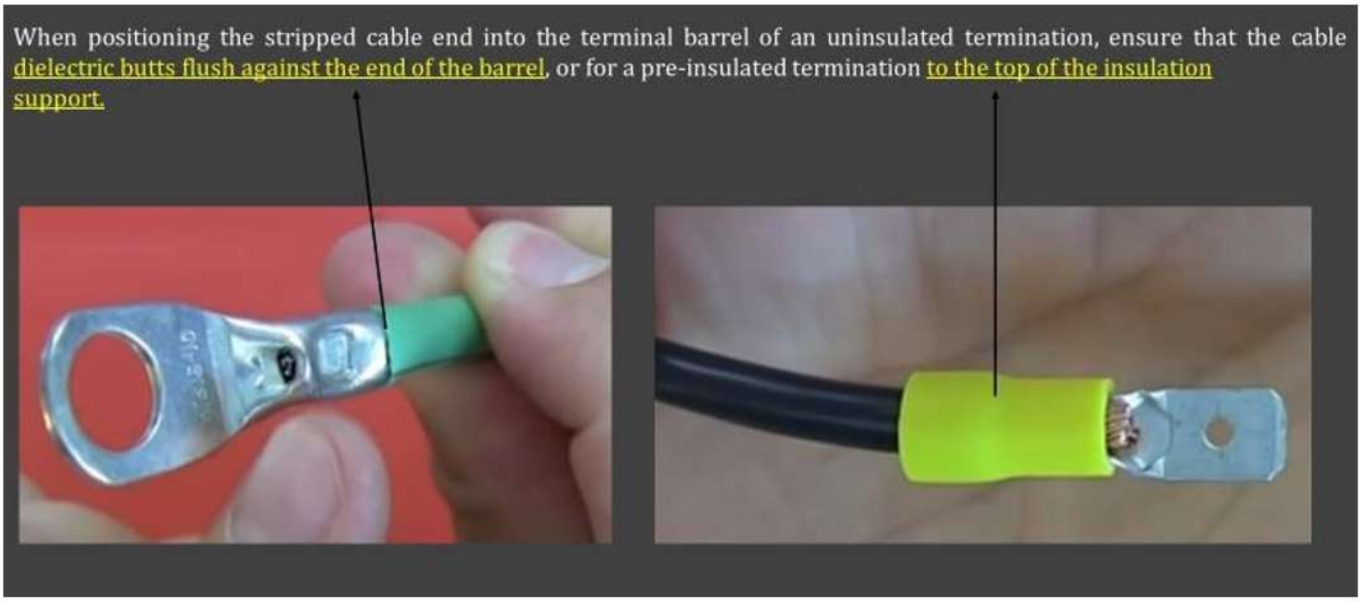


wire gauge system (AWG)

The following general precautions are recommended when making crimped cable joints:

First insert the appropriate termination tongue, into the barrel crimping jaws of the crimpingtool.
Ensure that the termination barrel butts flush against the tool stop /Locator.
Hold the termination barrel with lightpressure.





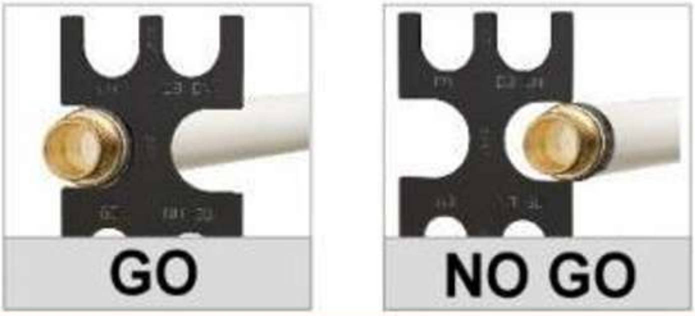
Ensure that the tool handles of a hand operated tool are squeezed fully together, or in the case of power operated tools, the pressure relief valve has operated, to ensure that the crimp has been completed and allow release of the jaws.
Once the crimp is completed, the bypass valve opens and the ram returns to neutral position.

Crimp Inspection:

Properly crimped joints should be verystrong.
The wire and insulation should not slip or move when a tension load isapplied.
The tensile strength of the wire-to-terminal joint should be at least equivalent tothe tensile strength of the wireitself.
Resistance of wire-to-terminal joint should be negligible, relative to the normal resistance of thewire.
The correct combination of wire, terminal end, and proper crimping with thedepth mark in the correct location should all beevident.
Both the conductor and insulator must be correctly inserted in the terminal endfitting.
Only conductor material should be in the crimpbarrel.
Neither the conductor or insulator should appear damaged in any way withinsulator material gripped by the insulation crimp so that the conductor is notvisible.
Crimp Inspection:

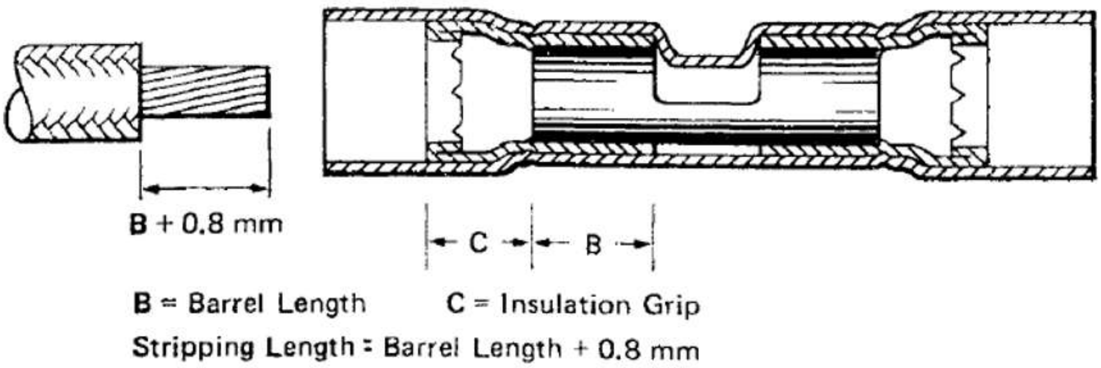
Crimping tools should be inspected annually and on condition if excessive play is detected.
Crimps made with the tool can be checked using go/no-go gauges supplied by the tool manufacturer.

Tensile strength and voltage carrying capability of crimps made with a specificcrimping tool can be tested in theshop



Terminal splices:

Connections can be made to terminate a cable with a ring-tag (Terminal lug), or join two cables together with a splice.
General rules for the use of splices will be given in the relevant aircraft documents; these will addressthe:
spacing of splices in the samewire
maximum number of splices in a given length ofwire
splices should not be located in curvedsections
Both tags and splices have a plastic or nylon insulating sleeve covering the shank (barrel).
This insulation is coloured red, blue or yellow depending on size. This colour coding relates to the specific crimping pliers required for theoperation.



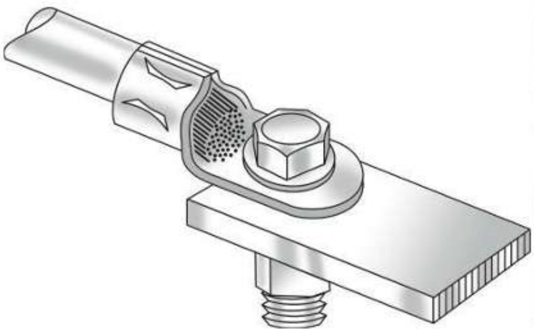
Heat shrink sleeve:

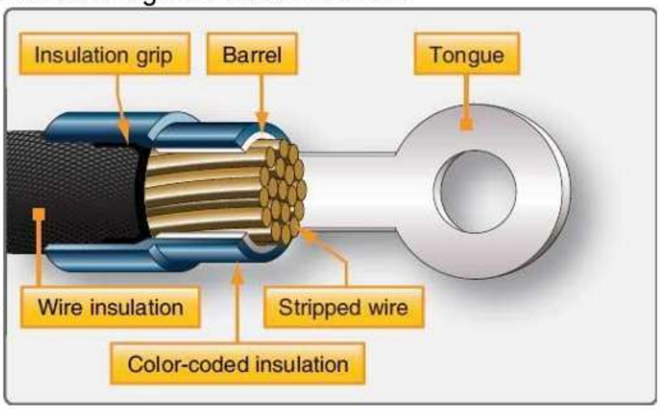
Once formed, the tag can be attached to terminal blocks with connections made to respectivecircuits.
Some terminations benefit from a heat-shrink sleeve; this provides extra mechanical protection andsupport.
Heat-shrink material is polythene based and reduces to a pre-determined diameter (but not length) whenheated.

The majority of cable and wire terminations in the airframe are made by attaching crimp tags / terminal lugs for use with terminal blocks or pin and sockets within connectors.
There are two types of crimp: dimple and confined; the latter is the type normally used on aircraft.
Terminal strip / block - Safety requirements:

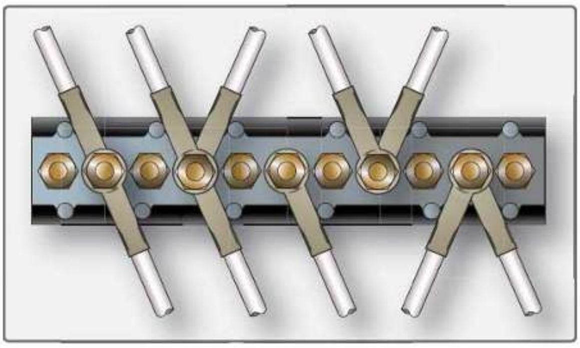
Wires are usually joined at terminalstrips.
A terminal strip fitted with barriers may be used to prevent the terminals on adjacent studs from contacting eachother.
Studs should be anchored againstrotation.
In all cases, the current should be carried by the terminal contact surfaces and not by the studitself.
Defective studs should be replaced with studs of the same size and material since terminal strip studs of the smaller sizes may shear due to overtightening thenut.
The replacement stud should be securely mounted in the terminal strip and the terminal securing nut should betight.
Terminal strips should be mounted in such a manner that loose metallic objects cannot fall across the terminals orstuds.
It is good practice to provide at least one spare stud for future circuit expansion or in case a stud isbroken.
Terminal lug - Safety requirements:

Terminal lugs should be selected with a stud hole diameter that matches the diameter of thestud.
However, when the terminal lugs attached to a stud vary in diameter, the greatest diameter should be placed on the bottom and the smallest diameter ontop.
Tightening terminal connections should not deform the terminal lugs or thestuds.
Terminal lugs should be positioned so that bending of the terminal lug is not required to remove the fastening screw or nut, and movement of the terminal lugs tends to tighten theconnection.





Wire terminal lugs should be used to connect wiring to terminal block studs or equipment terminalstuds.
[No more than four terminal lugs], or [three terminal lugs and a bus bar], should be connected to any onestud.
The total number of terminal lugs per stud includes a common bus bar joining adjacent studs.
Four terminal lugs plus a common bus bar are not permitted on onestud.



Connectors

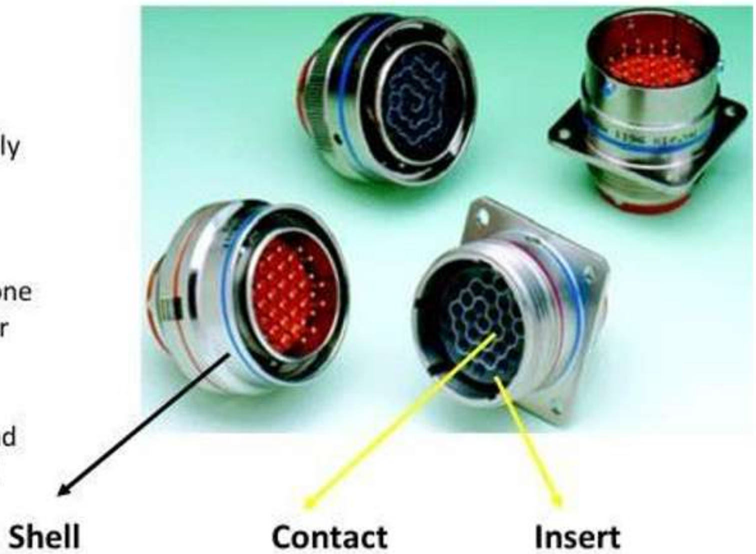
It is highly unlikely that a single wire or cable will be routed from the power source directly to theload.
It will invariably pass through bulkheads viaconnectors.
Certain areas in the aircraft are not suitable for the routing of wires (e.g. zones exposed to high temperature orEMI).
Wiring is invariably installed in sections and joined atintervals.
Terminations and connection types used will depend on a number of factors driven by cost and continued airworthinessrequirements.


(b)

Wires and cables also have to be routed through bulkheads or production breaks; this is normally achieved by using quick-releaseconnectors.
General aviation connectors (D-shaped) are the same type as used on personalcomputers.
Larger aircraft use circular quick-releaseconnectors.

Connector set consists of two parts: a plug assembly and a receptacleassembly.
The receptacle is usually the "fixed" part of the connector, attached to a wall, bulkhead, or equipment case. The plug is the removable part of the connector usually attached to a cable.
When the two parts are joined, the electric circuit is made by pin-and-socket contacts inside theconnector.
The "live" or "hot" side of the circuit should have socket (female)contacts.
Connectors may be grouped into types, classes, and series depending on their manufacture, assembly, and application.

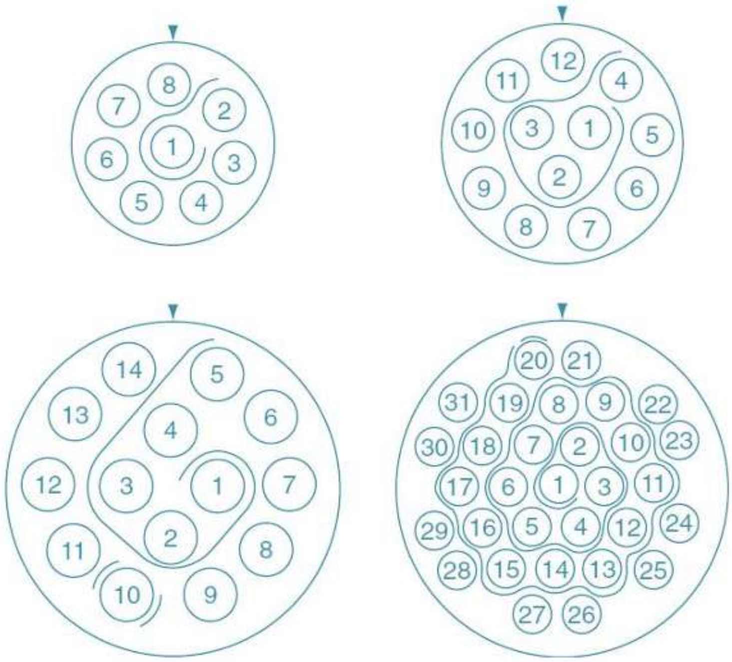
- The contacts are held in place and insulated from each other and from the shell by a dielectric insert.
- Insert and contacts are housed in a metal shell.
- **Contact** – Placed on end of each wire and held in place with a crimp or solder. Typically made of highly conductive gold plated copper
- **Insert** – This holds all the contact in a specific orientation for correct mating and insulates them one another. Typically made of reinforced epoxy resin or other composite material
- **Outer shell** – the enclosure that holds the insert and contacts. Typically made of die-cast aluminium and plated or anodized for corrosion protection



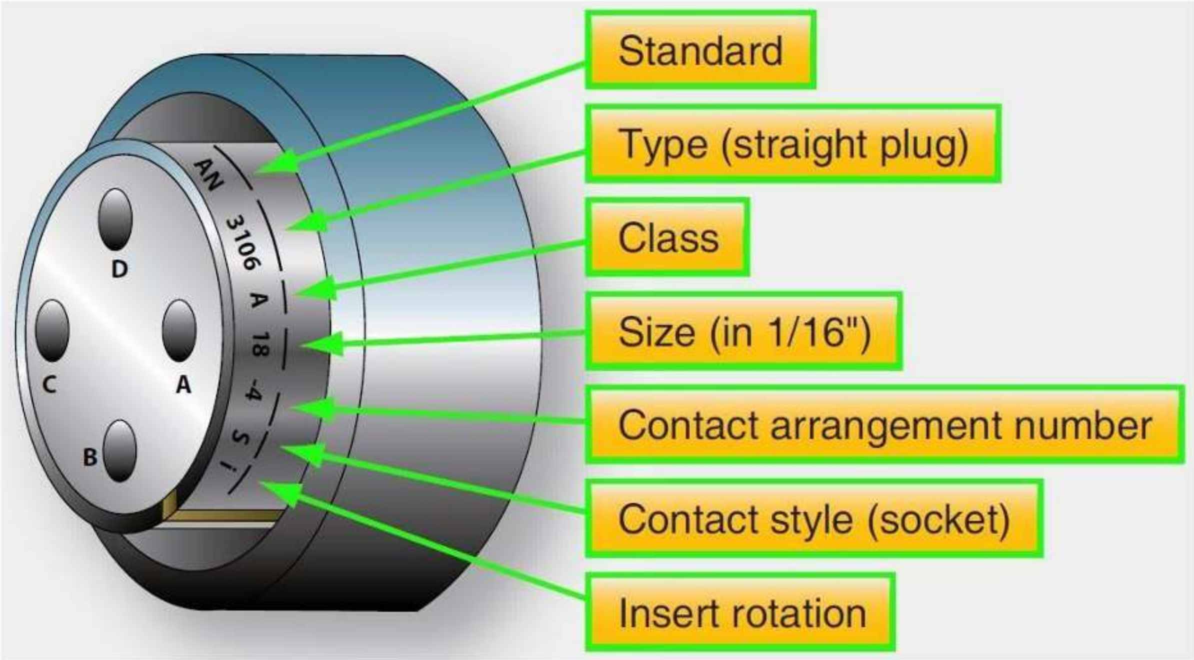
- Connectors are used on electrical wiring harnesses and are essentially enclosures (i.e., shells) which house contacts with wires.
- It facilitate maintenance when frequent disconnection is required
- The shell and insert may be moisture resistant or a hermetic (air proof) seal
- The inserts in each connector must be oriented for correct mating, and the shell or insert usually contains a keying feature to prevent miss-mating that could damage the connector or result in an electrical problem.
- Plugs have prolonged connecting pins which fit into the mating socket (the Receptacle). A receptacle connector is sometimes called a jack.

Connectors – Pin and socket identification for repair:

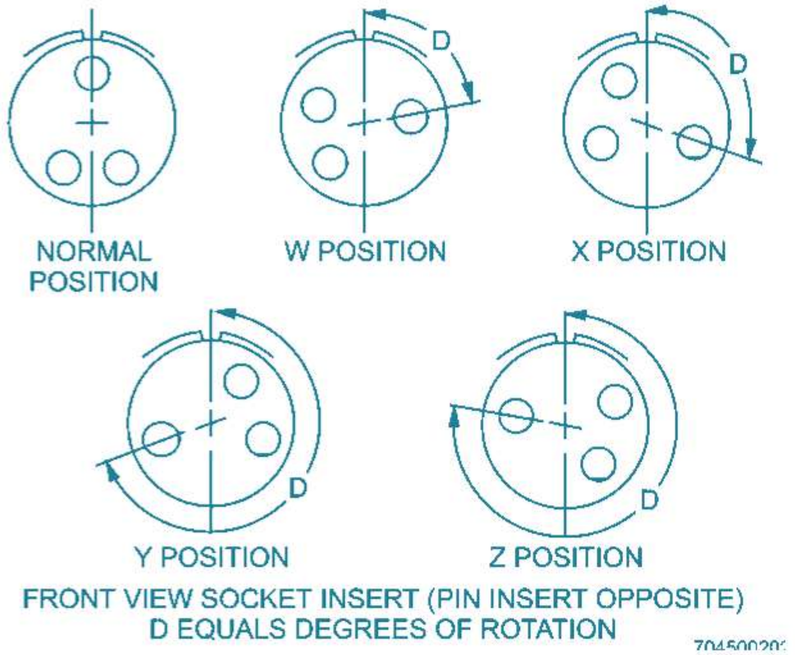
When a pin/contact is removed for inspection or repair or replacement of the particular wire connecting a pin/contact, then it has to be connected back in the right arrangement.
Otherwise, mismatching will happen while pin and socket is connected and the desired current will not travel to the right component which in turn creates unimaginableerrors.



Connector Identification



Alternate Insert Position (Polarization)



Connectors – Protection:

To prevent damage and the entry of dirt, the protective caps which are provided with connectors should be fitted at all times other than when the connectors are being workedon.
During work protection may then be in the form of a linen or plastic bag, totally enclosing the connector and secured to thecables.
This temporary protection should only be removed just prior to connection being made in theaircraft.
All unused holes in the connector should be fitted with an approved sealantplug.

Miniature Connectors – Protection:

- ✓ Extreme care should be taken when handling and connecting miniature and sub-miniature connectors.
- ✓ Both plugs and sockets should be checked for any signs of dirt, bent pins or physical damage to the shells before attempting to connect.

- ✓ If connectors will not mate, check for the reason, and rectify or renew.

On no account should force be used to effect mating.

Connectors – Proper clamping:

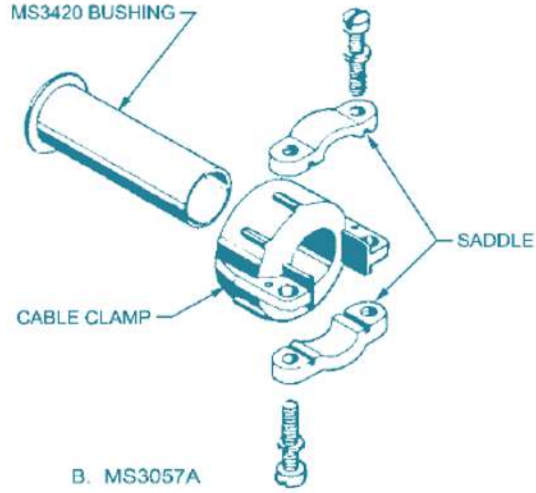
For connectors with cable clamps which are not provided with resilient (elastic) bushings, it may be necessary to increase the diameter of the cables to enable a firm clamp to be obtained without distorting the cables.
This may be achieved by one or more of the following methods, but whichever method is used, care should be taken to ensure that cables are not forced against any metal parts of the clamp; that the clamp is not over-tightened so as to crush or deform the cables.
A plain insulation sleeve may be fitted over the cablebundle.

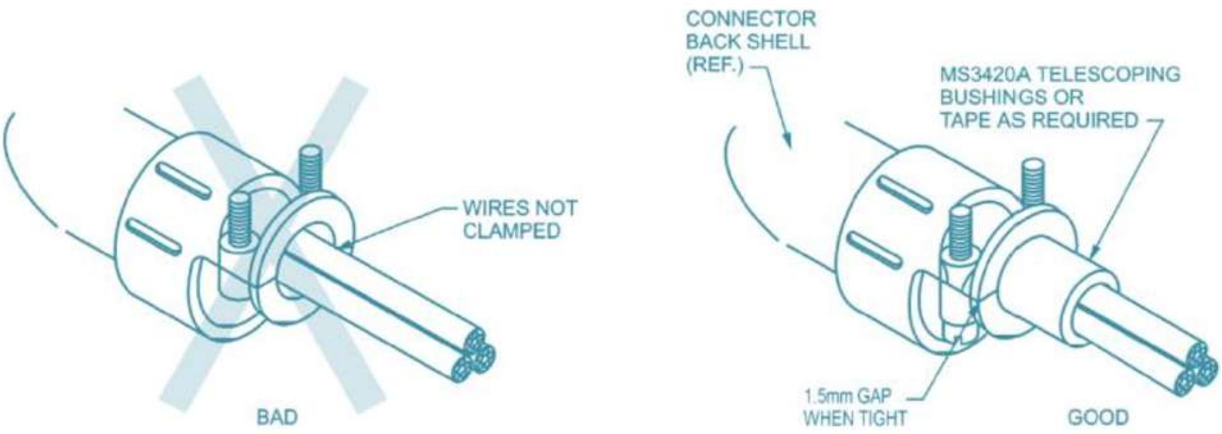
A plain insulation sleeve may be fitted over each individualcable.

The cable bundle may be wrapped around with a number of turns of a suitabletape.

A small roll of a suitable tape may be placed in the centre of the cablebundle.

Where cable clamps are fitted with resilient bushings, care should be taken to ensure that the bushings used are of such size that the cables are firmly held in place but do not crush or deform the cable insulation when the clamp istightened





General Maintenance and Repair:

Preparation

The cable damp securing screws should be loosened and any packing should be discarded.
The threaded backshell should be unscrewed and eased back over thecables.

Removal of WiredContacts.

The appropriate extraction tool should be positioned over the contact to be removed and, with the central plunger of the tool held back, pushed into the plug or socket to release the contact retentionsystem.
Depressing the central plunger of the extraction tool will eject the contact rearwards, out of the plug orsocket.
Extreme care should be taken when using this type of tool as their tips are easily damaged, which unless identified and replaced with a serviceable one, can cause damage to inserts andcontacts.
In repair operations only one contact at a time should be removed and repaired, so as to avoid the possibility ofmisconnection.

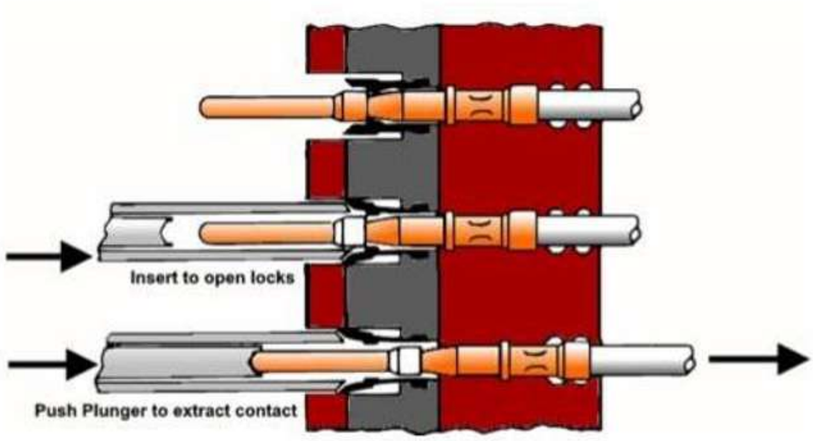
Removal of WiredContacts.

There are two basic types of contact retention used in plug and socket connectors in aircraft, one with the contacts being released for removal from the rear of the contact insert and the other from thefront.
Each system requires the use of different types of insertion/extraction tools, therefore, it is essential that the correct procedures and tools are used for a particular type of plug or socket.
Note: - The contact extraction tool can be used on front or back of the connector, depending on the tool.

But a contact insertion tool can be inserted only through back of the connector.

Connectors – Contact removal:

Plastic extraction tools are used to prevent damage to contact retaining clips and insert materials.
They are color-coded for contact size, i.e. Red, size 20; Blue, 16 and Yellow 12 and 22. In composite tools the extractor is alwaysWhite.



Connectors – Unwired contact removal:

The sealing plug should be removed and the appropriate unwired contact extractor should be slid slowly, and straight, into the contact inserthole.
Stopping of the extractor will indicate that it has bottomed on the contactshoulder.
The contact should then be removed by slowly pulling the extractor and contact from the plug orsocket.

Connectors – Sealing from Moisture:

Moisture entry through the rear of the connector must be avoided by correctly matching the wire's outside diameter with the connector's rear grommet sealingrange.

It is recommended that no more than one wire be terminated in any crimp style contact.
The use of heat-shrinkable tubing to build up the wire diameter, or the application of potting (insulating gel lie epoxy) to the wire entry area as additional means of providing a rear compatibility with the rear grommet isrecommended.

These extra means have inherent penalties and should be considered only where other means cannot beused.
Unwired spare contacts should have a correctly sized plastic pluginstalled.

Potted

Wiringtechniques

Proper wiring techniques involve:

Wire bundles and routing
Slack in wirebundles
Twistingwires
Spliced connections in wirebundles
Bend radii
Protection against chafing
Protection against hightemperature
Protection against Solvents andfluids
Protection of wires in wheel wellareas
Protection withclamps

Certain areas of the aircraft will experience high vibration. Wiring in these areas will be subjected to a harsher environment. These areas include:
wheelswells
empennage
wing roots
wing trailingedges
wing leadingedges
engine pylons andnacelles.
The wiring in these areas will be exposed to severe wind and moisture problems (SWAMP);

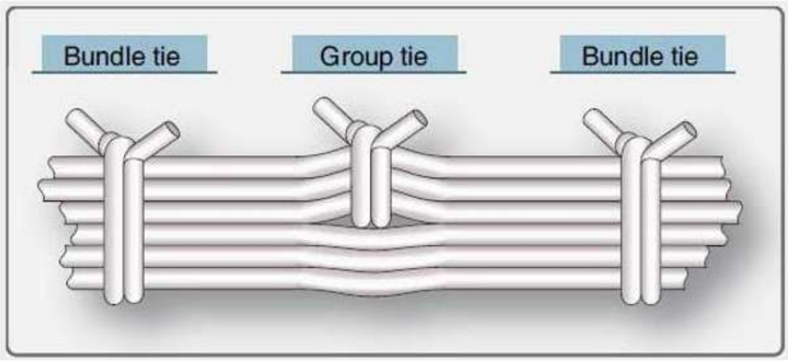
wiring specifications and inspection requirements must be adhered to.

Definitions:

Open wiring—any wire, wire group, or wire bundle not enclosed in conduit.

Wire group—two or more wires in the same location, tied together to identity the group.

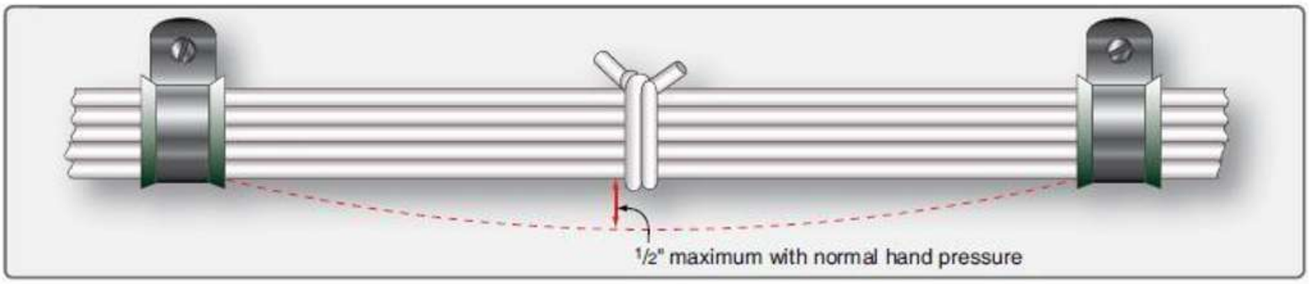
Wire bundle—two or more wire groups tied together because they are going in the same direction at the point where the tie is located. The bundle facilitates maintenance.



Wires are often installed in bundles to create a more organized installation. These wire bundles are often called wireharnesses.
Wire harnesses are often made in the factory or electrical shop on a jig board so that the wire bundles could be preformed to fit into theaircraft.
Wire bundles should generally be less than 75 wires, or 1 ½ to 2 inches in diameter where practicable.

Slack in wire bundle

Wiring should be installed with sufficient slack so that bundles and individual wires are not undertension.
Wires connected to movable or shock-mounted equipment should have sufficient length to allow full travel without tension on thebundle.
Normally, wire groups or bundles should not exceed ½-inch deflection between support points.



Wiring at terminal lugs or connectors should have sufficient slack to allow re-termination without replacement of wires.
Twisting wires

When specified on the engineering drawing, or when accomplished as a local practice, parallel wires must sometimes be twisted. The following are the most common examples:
Wiring in the vicinity of magnetic compass or fluxvalve.

Three-phase distributionwiring.

Certain other wires (usually radio wiring) as specified on engineeringdrawings.

Twist the wires so they lie snugly against each other, making approximately the number of twists per foot as mentioned in wiring diagram manual.

Spliced connections in wire bundles

Splicing is permitted on wiring as long as it does not affect the reliability and the electromechanical characteristics of thewiring.

Splicing of power wires, coaxial cables, multiplex bus, and large-gauge wire must have approveddata.

Splicing of electrical wire should be kept to a minimum and avoided entirely in locations subject to extremevibrations.

Splicing of individual wires in a group or bundle should have engineering approval, and the splice(s) should be located to allow periodicinspection.

Splice connectors:

Use of a self-insulated splice connector is preferred; however, a non-insulated splice connector may be used provided the splice is covered with plastic sleeving that is secured at bothends.

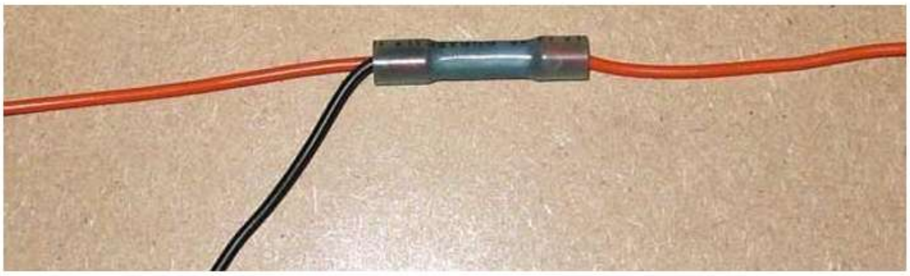
Environmentally sealed splices that conform to MIL-T-7928 provide a reliable means of splicing in SWAMPareas.

However, a non-insulated splice connector may be used, provided the splice is covered with dual-wall shrink sleeving of a suitablematerial.

Splicing requirements:

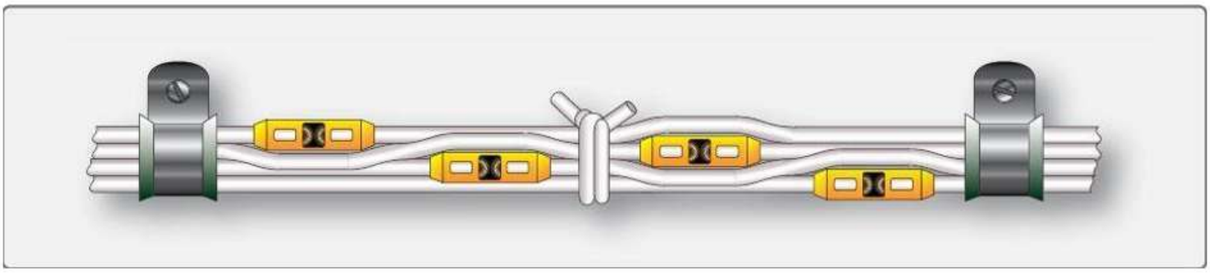
There should be no more than one splice in any one wire segment between any two connectors or other disconnectpoints.

Exceptions include when attaching to the spare pigtail lead of a potted connector, when splicing multiple wires to a single wire, when adjusting wire size to fit connector contact crimp barrel size, and when required to make an approvedrepair.



Splices in bundles must be staggered to minimize any increase in the size of the bundle, preventing the bundle from fitting into its designated space or causing congestion that adversely affectsmaintenance.

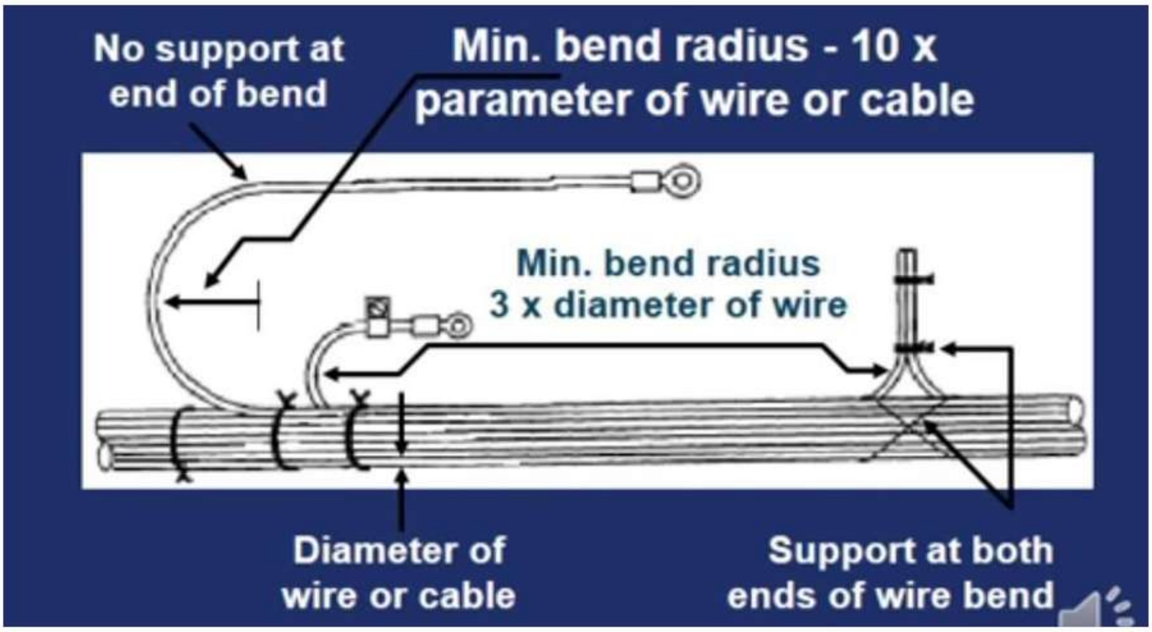
Splices should not be used within 12 inches of a termination device, except when attaching to the pigtail spare lead of a potted termination device, to splice multiple wires to a single wire, or to adjust the wire sizes so that they are compatible with the contact crimp barrelsizes.



Bend Radii

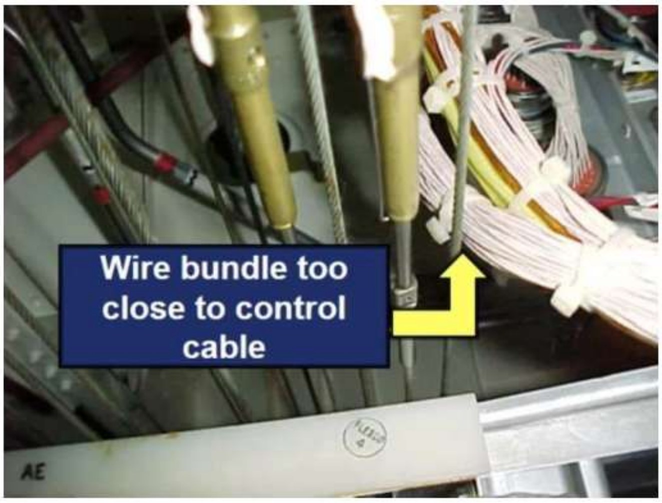
Bending requirements:

The minimum radius of bends in wire groups or bundles must not be less than 10 times the outside diameter of the largest wire or cable, except that at the terminal strips where wires break out at terminations or reverse direction in abundle.
Where the wire is suitably supported, the radius may be three times the diameter of the wire orcable.
Where it is not practical to install wiring or cables within the radius requirements, the bend should be enclosed in insulatingtubing.
The radius for thermocouple wire should be done in accordance with the manufacturer's recommendation and shall be sufficient to avoid excess losses or damage to thecable.
Ensure that RF cables (e.g., coaxial and triaxial) are bent at a radius of no less than six times the outside diameter of thecable.



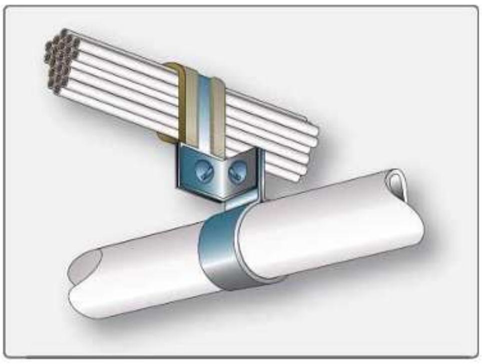
Protection againstchafing

Wires and wire groups should be protected against chafing or abrasion in those locations where contact with sharp surfaces or other wires would damage the insulation, or chafing could occur against the airframe or othercomponents.
Damage to the insulation can cause short circuits, malfunction, or inadvertent operation of equipment.


Wire bundle too close to control cable
AE

Protection against Solvents & Fluids

An arcing fault between an electrical wire and a metallic flammable fluid line may puncture the line and result in afire.
Every effort must be made to avoid this hazard by physical separation of the wire from lines and equipment containing oxygen, oil, fuel, hydraulic fluid, oralcohol.
Wiring must be routed above these lines and equipment with a minimum separation of 6 inches or more wheneverpossible.
When such an arrangement is not practicable, wiring must be routed so that it does not run parallel to the fluidlines.
A minimum of 2 inches must be maintained between wiring and such lines and equipment, except when the wiring is positively clamped to maintain at least 1/2-inch separation, or when it must be connected directly to the fluid-carryingequipment.



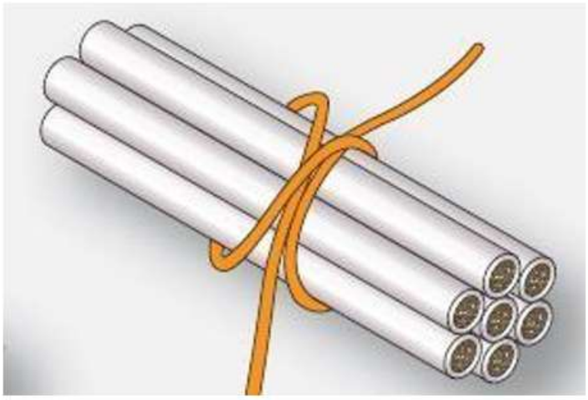
Wires, or groups of wires, should enter a junction box, or terminate at a piece of equipment in an upward direction wherepracticable.
Ensure that a trap, or drip loop, is provided to prevent fluids or condensation from running into wire or cable ends that slope downward toward a connector, terminal block, panel, or junction block.
Where wires must be routed downwards to a junction box or electrical unit and a drip loop is not possible, the **entrance should be sealed according to manufacturer's specifications** to prevent moisture from entering the box/unit. [Eg; Using potted connectors]

A drip loop is an area where the wire(s) are made to travel downward and then up to theconnector.
Fluids and moisture will flow along the wires to the bottom of the loop and be trapped there to drip or evaporate without affecting electrical conductivity in the wire, junction, or connecteddevice.

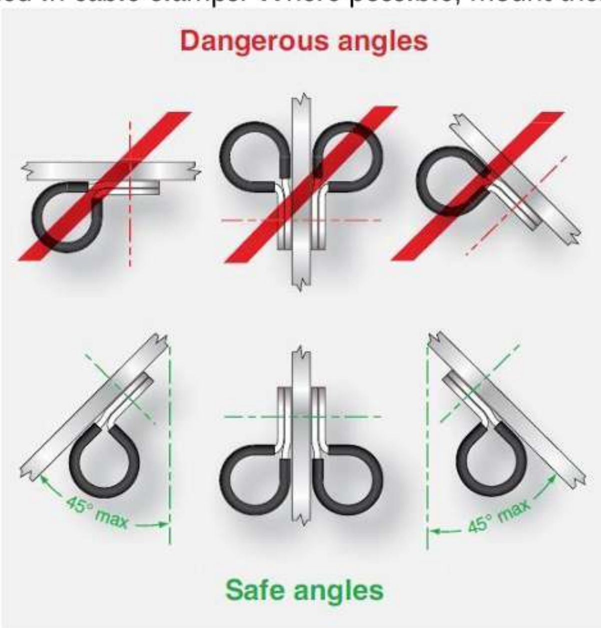
Clamp installation

Wires and wire bundles must be supported by clamps or plastic cablestraps.
Clamps and other primary support devices must be constructed of materials that are compatible with their installation and environment, in terms of temperature, fluid resistance, exposure to ultraviolet (UV) light, and wire

bundle mechanicalloads.
They should be spaced at intervals not exceeding 24inches.
Clamps on wire bundles should be selected so that they have a snug fit without pinching wires.
The use of metal clamps on coaxial RF cables may cause problems, if clamp fit is such that RF cable's original cross section isdistorted.
Clamps on wire bundles should not allow the bundle to move through the clamp when a slight axial pull isapplied.
Clamps on RF cables must fit without crushing and must be snug enough to prevent the cable from moving freely through the clamp, but may allow the cable to slide through the clamp when a light axial pull isapplied.
The cable or wire bundle may be wrapped with one or more turns of electrical tape when required to achieve thisfit.
Clamps must be installed with their attachment hardware positioned above them, wherever practicable, so that they are unlikely to rotate as the result of wire bundle weight or wire bundlechafing.
Clamps lined with non-metallic material should be used to support the wire bundle along therun.
Tying may be used between clamps, but should not be considered as a substitute for adequate clamping.
Adhesive tapes are subject to age deterioration and, therefore, are not acceptable as a clampingmeans.

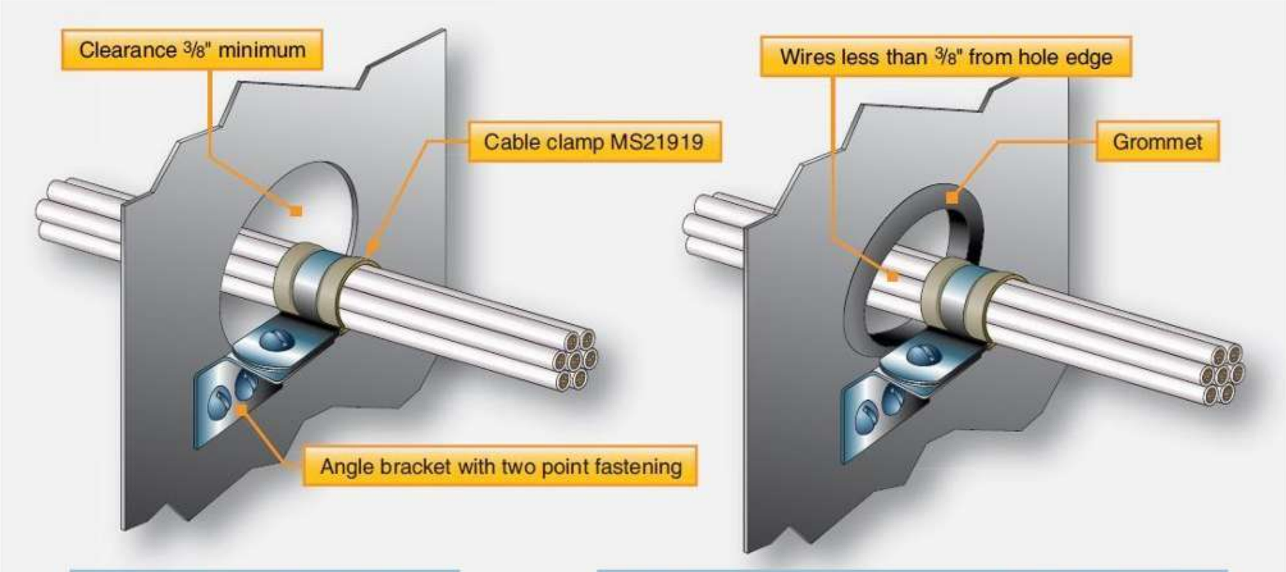


Cable clamps should be installed with regard to the proper mountingangle.
The mounting screw should be above the wire bundle. It is also desirable that the back of the cable clamp rest against a structural member wherepracticable.
Be sure that wires are not pinched in cable clamps. Where possible, mount them directly to structuralmembers



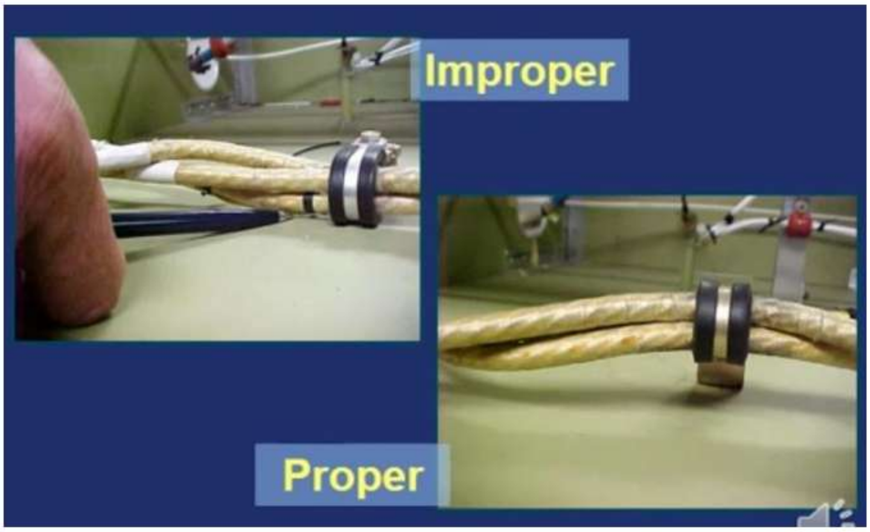
Where wires or wire bundles pass through bulkheads or other structural members, a grommet or suitable clamp should be provided to preventabrasion.

If wires come closer than 3/8-inch to the edge of the hole, a suitable grommet is used in thehole.
The grommet may be cut at a 45° angle to facilitate installation, provided it is cemented in place and the slot is located at the top of thecut-out.

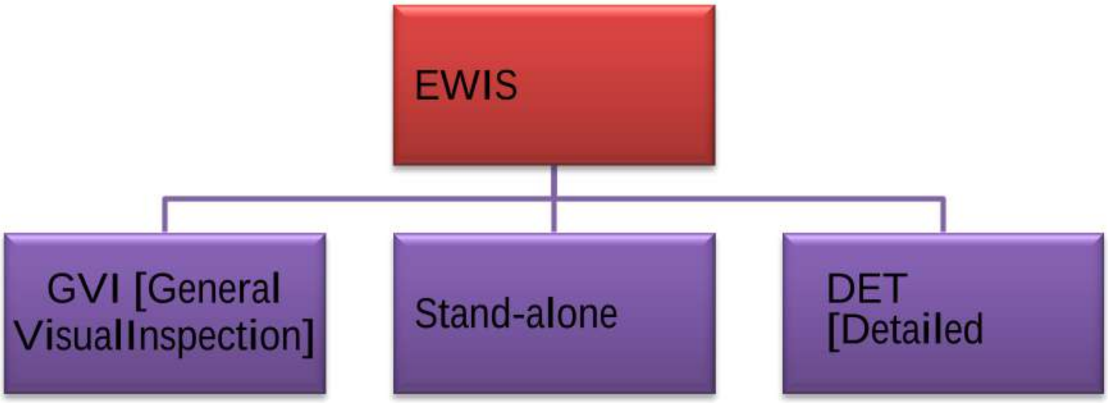


A. Cushion clamp at bulkhead hole
B. Cushion clamp at bulkhead hole with MS35489 grommet

Use metal stand-offs to maintain clearance between wires andstructure.
Tape or tubing is not acceptable as an alternative to stand-offs for maintaining clearance.



EWISInspection

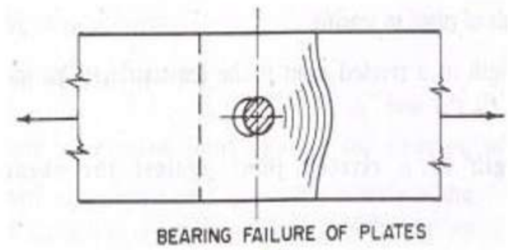


A GVI includes a visual examination of an interior or exterior area, installation or assembly to detect obvious damage, failure, orirregularity.
A stand-alone GVI is an inspection of a particular area, installation or assembly that is not part of a general zonal inspection. In fact, even when a particular zone of an EWIS is inspected, a separate stand-alone GVI may be called for with its own paperwork to insure attention to the stand-aloneitem.

A DET or detailed inspection of a specific item or assembly may be specified in the manufacturers ICA (Instructions for continued airworthiness) or maintenance manual. Follow the instructions to accomplish thisinspection.

–Riveting

- Rivet is a Temporary Or Permanent fastener?
  - Permanent (Since, it has be destroyed to remove)

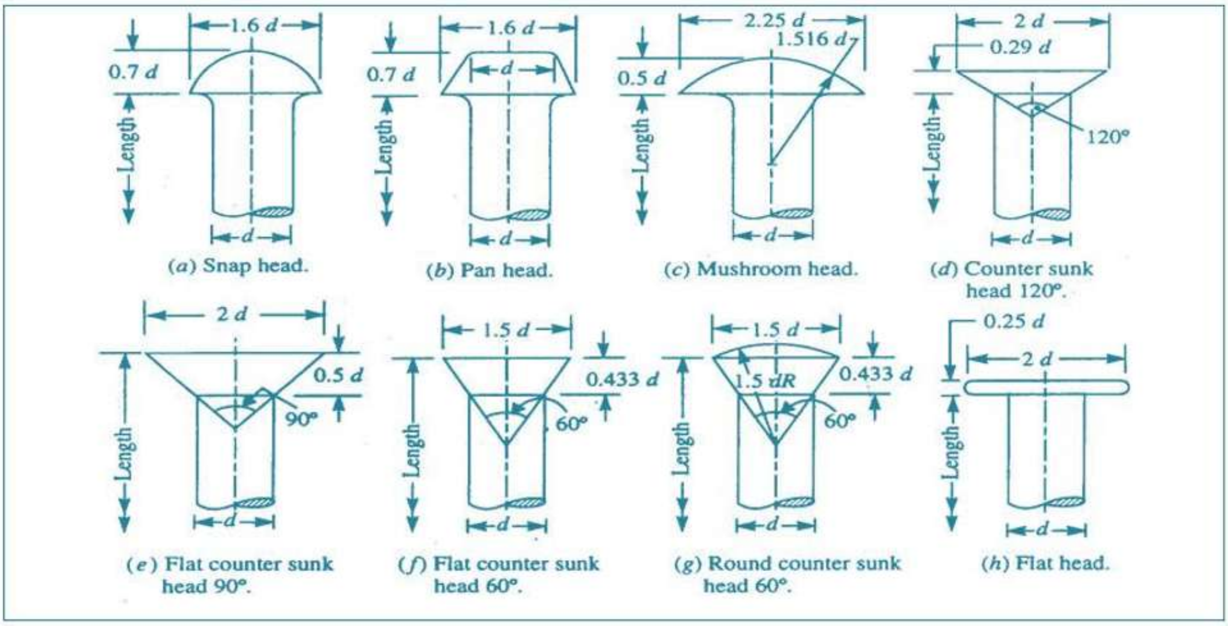


- What kind of load Rivets can take?
  - Bearing strength – Resistance of the hole/Plate
  - Shear Strength – Resistance of the Rivet

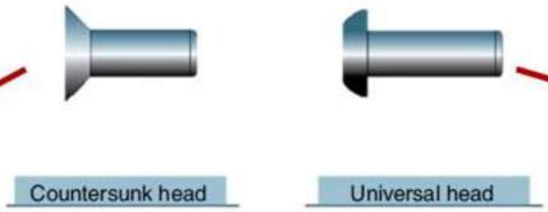
- Are they airtight / watertight?
  - Provided Seals, they can be!

Solid shank rivet:

Before installation, the rivet consists of a smooth cylindrical shaft with a factory head on one end. The opposite end is called thebucktail.
To secure two or more pieces of sheet metal together, the rivet is placed into a hole cut just a bit larger in diameter than the rivet itself
Once placed in this predrilled hole, the bucktail is upset or deformed by any of several methods from handheld hammers to pneumatically driven squeezingtools.
This action causes the rivet shank protruding through the sheet metal to form a shop head of approximately 1-½ times the diameter of the rivet and reduces the length to ½ times the diameter of therivet.



100° has been adopted as standard because this head style provides the best possible compromise between tension/ shear strength and flushness requirements



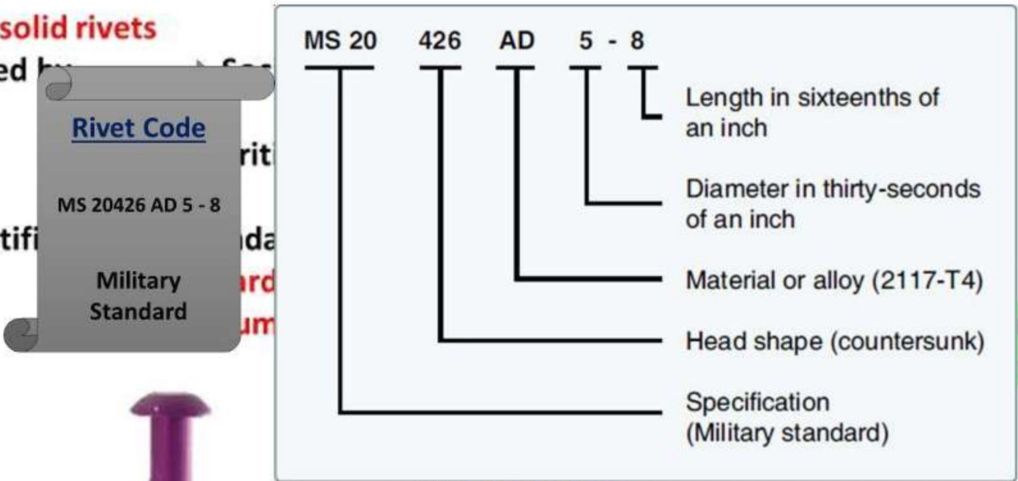
Used on aircraft interiors & primarily where the protruding head has **no aerodynamic significant**

Primarily intended for use when **aerodynamics smoothness is critical**, such as on the external surface of a high-speed aircraft.

British solid rivets

➢ **Issued**

➢ **Identifi**



m x 10)
mm)

SP 157-40-16

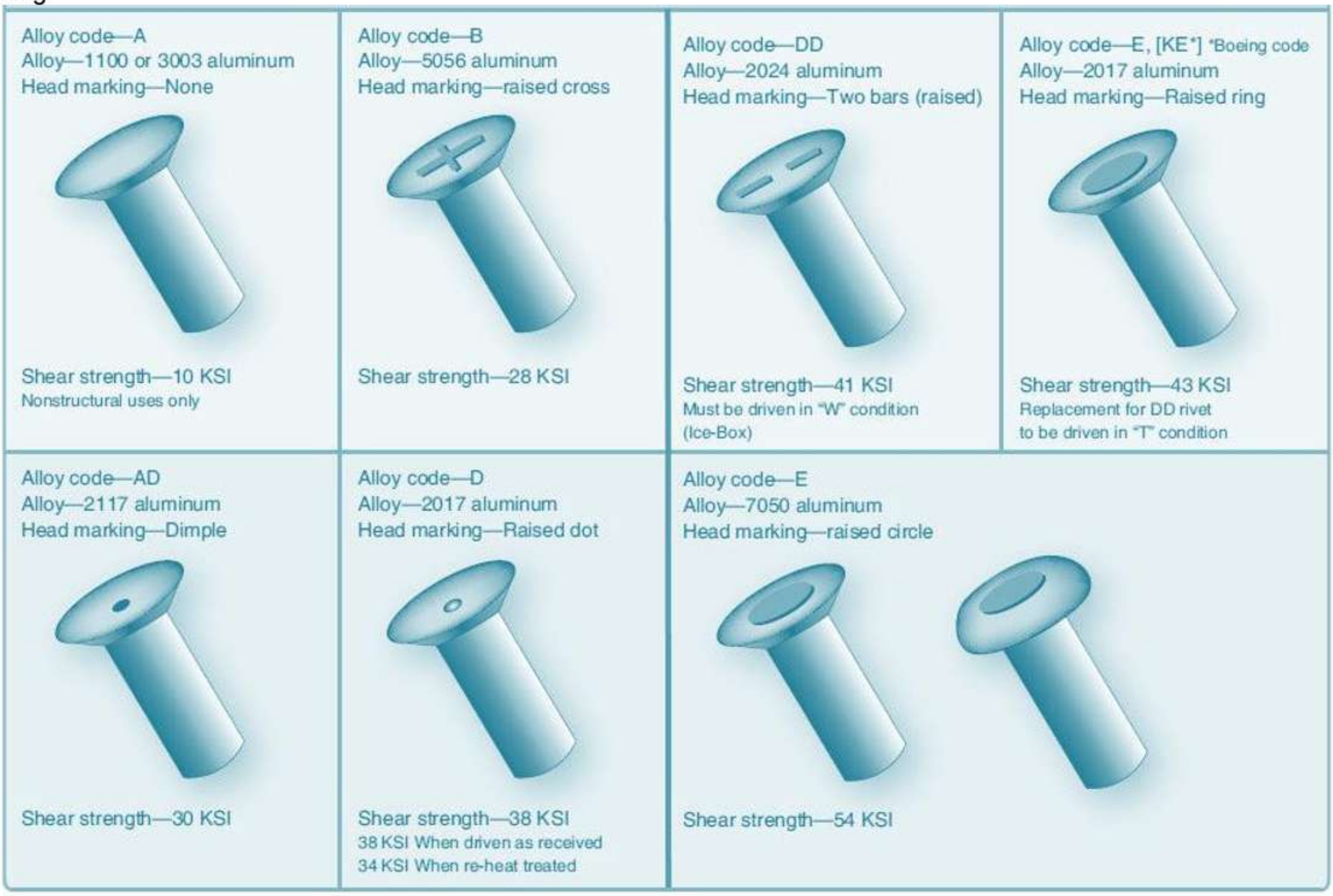
Ex: AS162 408

Standard number (AS162)

Part Number (4/32 is Shank dia, 8/16=1/2 is length) (408)

Rivet

coding



The most frequently used repair rivet is the AD rivet because it can be installed in the receivedcondition.
Some rivet alloys, such as DD rivets (alloy 2024-T4), are too hard to drive in the received condition and must be annealed before they can beinstalled.
Typically, these rivets are annealed and stored in a freezer to retard hardening, which has led to the nickname "ice boxrivets."
They are removed from the freezer just prior touse.
Most DD rivets have been replaced by E-type rivets which can be installed in the received condition

Choosing a rivet:

– Standard &Material

Choose a rivet that's made of the same material as the items you are going to fasten. For example, if you are fastening two steel plates together, use a steel rivet.

– Choosing Diameter based on Shear Strength & Thickness of thematerial

The rivet diameter should be approximately three times the thickness of a single sheet of the material beingjoined.
Ex: A material thickness of 0.040 inch multiplied by 3 equals 0.120 inch. In this case, the rivet diameter selected would be 1/8 inch (0.125 inch), for protruding heads. For countersunk heads, it should be multiplied by1.5.
When rivets are to pass completely through tubular members, select a rivet diameter equivalent to at least 1/8 the outside diameter of thetube.
If thickness of the material is less than half the diameter of the rivet used, then failure of the joint will depend on the bearing stress rather than on the shear stress in therivets
If rivets of reduced diameter have to be substituted during repair work total number of rivets must be increased to provide equivalent cross-sectional area. Shear strength of the rivet is proportional to its cross-sectional area and not itsdiameter.
Eg; Four rivets of 1/16-inch diameter must be used to replace one rivet of 1/8-inch diameter.
– Length

Select the correct length for your rivet.

According to The Sheet Metal Handbook, the length of a rivet is measured from the underside of the head to the tip of the stem /shank.
The head itself is not included in thismeasurement.
The length of the rivet should be equal to the thickness of both objects you are fastening, plus 1.5 times the diameter of the rivet's stem.[L=t+1.5(d)]
Forexample,a1/2-inchdiameterrivetbeingusedtofastentwoone-inchthickplates

will have to be 2inches long. –
Note: it should be borne in mind that an increase in the size of the rivets does not necessarily increase the strength of a joint; indeed, if the rivet sizes are increased beyond a certain amount, a reduction in strength will result.

Rivetingtechniques
Information on the size and type of rivets to be used, and the spacing to be employed for a particular repair, is normally specified in an approved repair scheme for a particular aircrafttype.
Unless otherwise stated the repair should follow the system of riveting used elsewhere on that aircraft at similarlocations.
It must be appreciated that the original pattern of riveting has been deliberately selected.
In carrying out any repair of major structural components, such as pressurised cabins and integral fuel tanks, the same type of riveting and a comparable quality of riveted assembly are vital to the integrity of thestructure.
If departure from the normal methods of construction is necessary, for example, different rivets or rivet spacing, approval of the manufacturer should be sought, since the strength of the repair might beaffected.
Provided that the approved repair scheme is followed in every detail, and that drilling and riveting techniques are of a high standard, the integrity of the structure will not be degraded.
On completion, the repair should beinspected.

Repair layout:

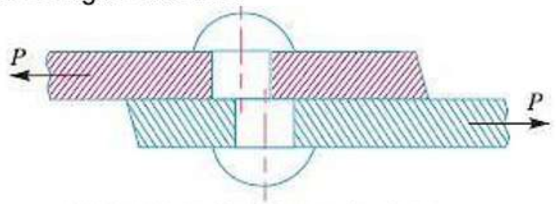
Repair layout involves determining the number of rivets required, the proper size and styleofrivetstobeused,theirmaterial,temperconditionandstrength,thesizeofthe
holes, the distances between the holes, and the distance between the holes and the edges of the patch. Distances are measured in terms of rivetdiameter.

Rivet length:

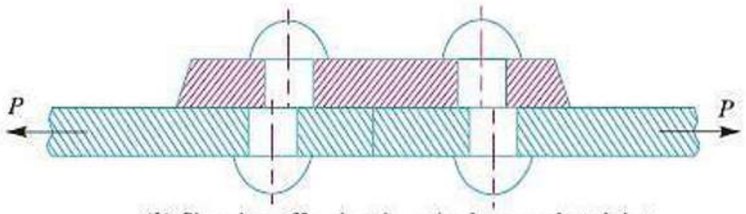
To determine the total length of a rivet to be installed, the combined thickness of the materials to be joined must first be known. This measurement is known as the grip length.
The total length of the rivet equals the grip length plus the amount of rivet shank needed to form a proper shophead.

Stresses applied to rivet:

Shear is one of the two stresses applied torivets.
The shear strength is the amount of force required to cut a rivet that holds two or more sheets of materialtogether.
If the rivet holds two parts, it is under single shear; if it holds three sheets or parts, it is under double shear.
Tension is the other stress applied torivets.
The resistance to tension is called bearing strength and is the amount of tension required to pull a rivet through the edge of two sheets riveted together or to elongate thehole.



(*a*) Shearing off a rivet in a lap joint.



(*b*) Shearing off a rivet in a single cover butt joint.

Fig. 9.15. Shearing of rivets.

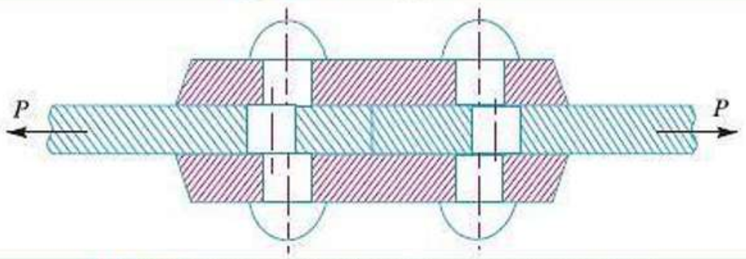
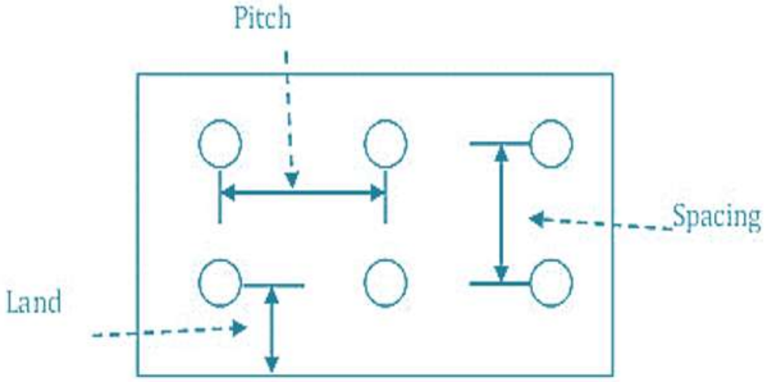


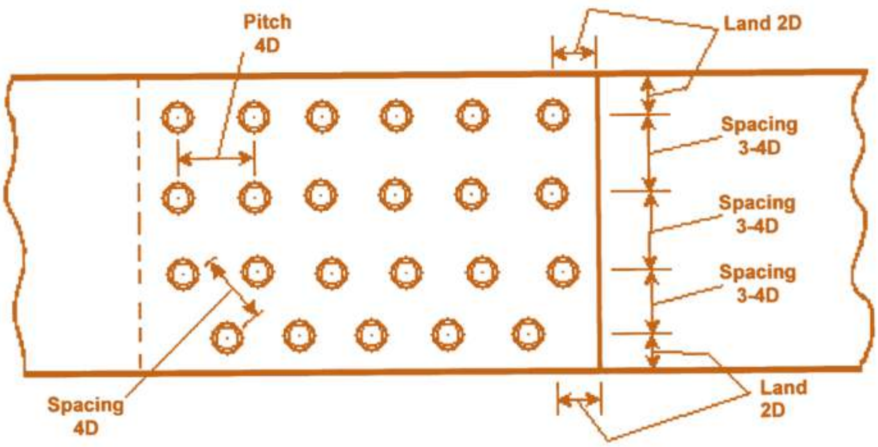
Fig. 9.16. Shearing off a rivet in double cover butt joint.

Rivet Spacing / Transfer Pitch:

Rivet spacing is the Perpendicular distance between two rivet rows & it is 75% of the RivetPitch.
The minimum spacing between protruding head rivets shall not be less than 3½ times the rivetdiameter.
The minimum spacing between flush head rivets shall not be less than 4 times the diameter of therivet.
These dimensions may be used as the minimum spacing except when specified differently in a specific repair

procedure or when replacing existingrivets.





Rivet Pitch:

Rivet pitch is the distance between the centers of neighbouring rivets in the samerow.

The smallest allowable rivet pitch is 3 rivet diameters. The average rivet pitch usually ranges from 4 to 6 rivet diameters, although in some instances rivet pitch could be as large as 10 rivetdiameters.

Rivet spacing on parts that are subjected to bending moments is often closer to the minimum spacing to prevent buckling of the skin between therivets.

The minimum pitch also depends on the number of rows ofrivets.

One-and three-row layouts have a minimum pitch of 3 rivet diameters, a two-row layout has a minimum pitch of 4 rivetdiameters.

The pitch for countersunk rivets is larger than for universal head rivets. If the rivet spacing is made at least 1/ 16 inch larger than the minimum, the rivet hole can be oversized without violating the minimum rivet spacingrequirement.

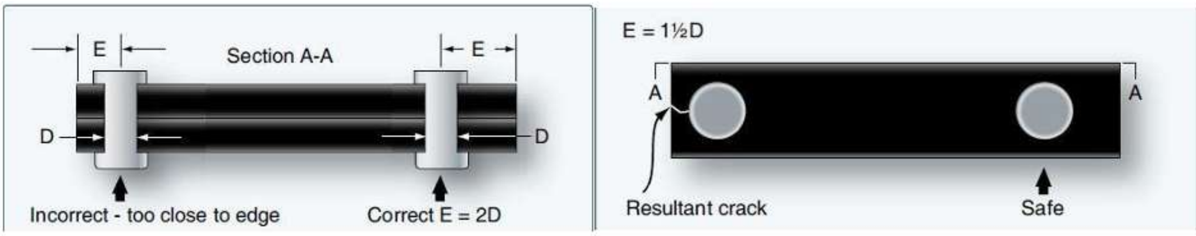
Edge distance / Land:

Edge distance, also called edge margin by some manufacturers, is the distance from the center of the first rivet to the edge of thesheet.

It should not be less than 2 or more than 4 rivet diameters and the recommended edge distance is about 2½ rivetdiameters.

The minimum edge distance for universal rivets is 2 times the diameter of the rivet; the minimum edge distance for countersunk rivets is 2½ times the diameter of the rivet.

If rivets are placed too close to the edge of the sheet, the sheet may crack or pull away from the rivets. If they are spaced too far from the edge, the sheet is likely to turn up at theedges.



Preferred Edge distance:

It is good practice to lay out the rivets a little further from the edge so that the rivet holes can be oversized without violating the edge distanceminimums.
Add 1/16 inch to the minimum edge distance or determine the edge distance using the next size of rivetdiameter.
Two methods for obtaining edge distance:

The rivet diameter of a protruding head rivet is 3/32 inch. Multiply 2 times 3/32 inch to obtain the minimum edge distance, 3/16 inch, add 1/16 inch to yield the preferred edge distance of ¼ inch.
The rivet diameter of a protruding head rivet is 3/32 inch. Select the next size of rivet, which is ¾ inch. Calculate the edge distance by multiplying 2 times ¾ inch to get ¼inch.

Edge Distance/Edge Margin	Minimum Edge Distance	Preferred Edge Distance
Protruding head rivets	2 D	2 D + 1/16″
Countersunk rivets	2½ D	2½ D + 1/16″

Holepreparation
1 – Marking out:-

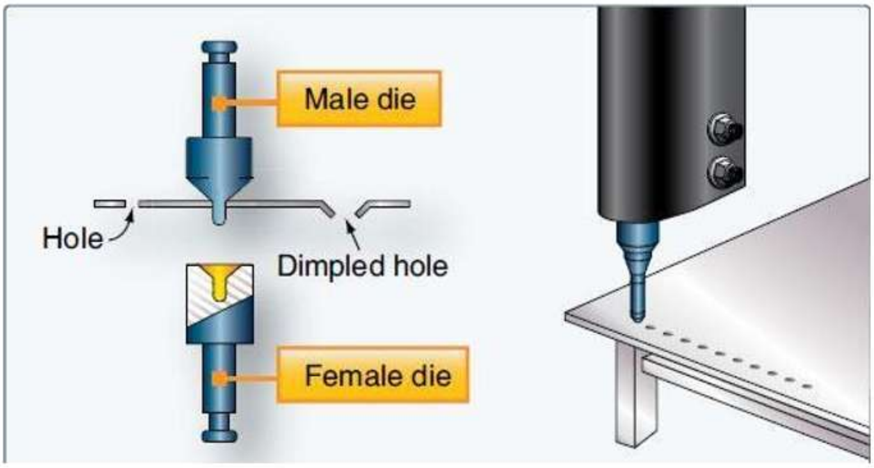
Careful marking out is a prerequisite for accuratedrilling.
Aluminium alloy parts used on aircraft should not be marked out with a scriber or other tool which will scratch the surface, unless the marks are subsequently machined off or otherwise removed.
A thin coat of zinc chromate primer makes a suitable background for pencil lines, but it may be preferable to manufacture a template which can be used as a drilling jig on the aircraft.

2– Hole size:-

A clearance must exist between the rivet and the hole in which it is fitted to accommodate expansion of the shank duringforming.

If the clearance is too small the sheets will tend to buckle, whereas if the clearance is too large separation of the sheets mayoccur.
The selection of the correct size rivet countersink, dimple and rivet hole, should be made by reference to tables published by the aircraftmanufacturer.

In order to allow for slight misalignment during assembly work, it is usual to drill pilot holes at positions where rivets are to be fitted. Then the part can be assembled with a temporary fastener like Clecofastener.
When the assembled structure is ready for riveting, the holes should then be opened out (enlarged) to the requiredsize
When a structure has to be dimpled to accommodate countersunk rivets, the holes should first be drilled undersize, since the dimpling action enlarges thehole.
After the dimple is formed the hole may then be drilled or reamed out to the appropriate size; this action must also remove any small radial cracks which have formed round the hole during the dimplingoperation.



3– Drilling technique:-

Care must also be taken to ensure that the drill is held perpendicular to the work surface, and it may be advisable in certain circumstances to use a drilling jig to prevent error.

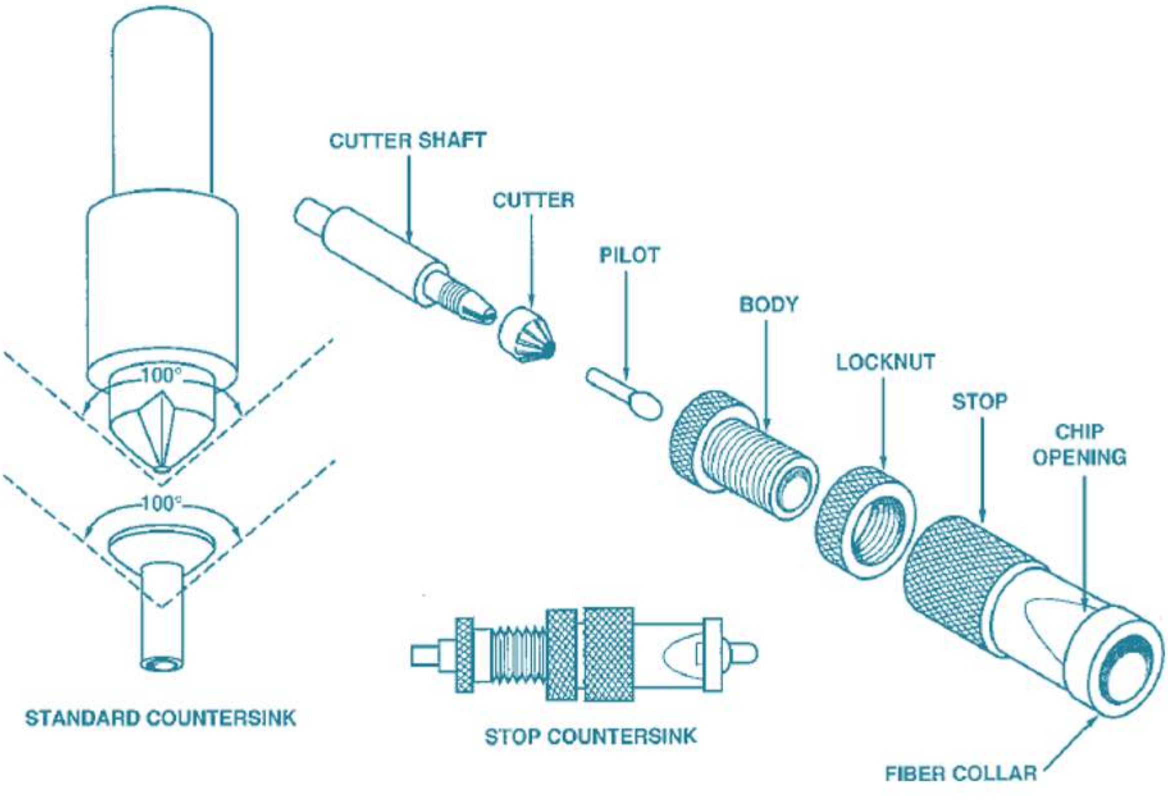
A badly drilled hole will prevent accurate riveting and may result in failure to meet the design strength requirements of a joint. Keep in mind to deburr the edges always after drilling.
When drilling out rivets on complete aircraft care must be taken to prevent damage to pipes, wiring looms or subsidiary structure, and precautions taken to prevent the ingress and facilitate recovery of swarf and pieces ofrivets.

Countersinking:

When countersunk rivets are to be fitted, there are two methods of accommodating the rivet head to ensure a flushfit.
Cut-countersinking is employed where sheet thickness is greater than the depth of the rivet -head, but for thinner sheets dimpling isnecessary.
Where sheets of different thicknesses are joined together it may be found that both methods are used, a thin outer sheet being dimpled into a countersunk thick inner sheet.

Stop countersinking tool:

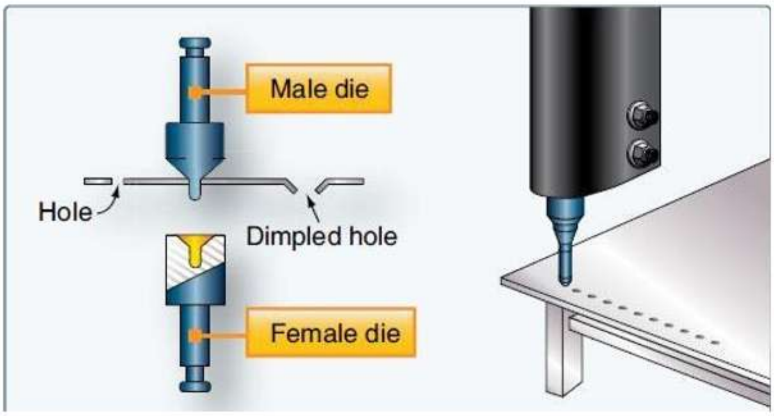
Aircraft manufacturers usually specify a tolerance on head protrusion after riveting, and this is usually of the order of 0·005 inch above the skin surface.



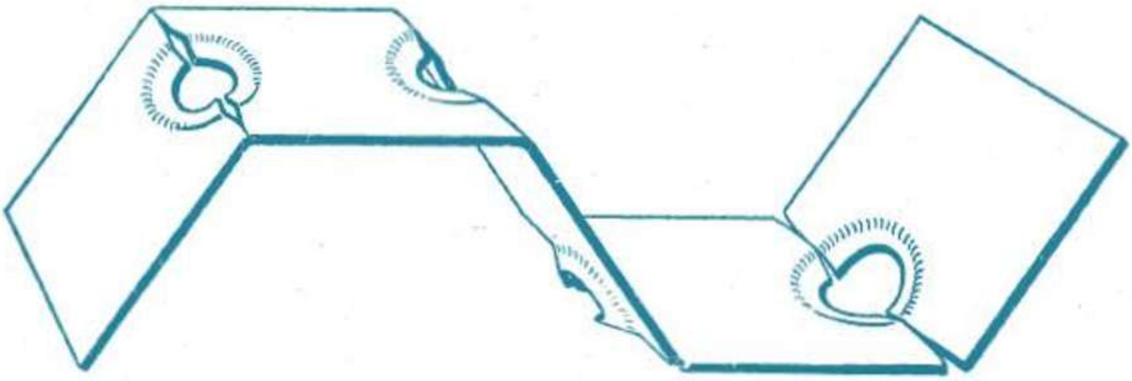
A stop countersink allows you to countersink a series of holes exactly the correct depth for the fastener beinginstalled.
A stop countersink has an adjustable stop which ensures the material is countersunk to the correctdepth.
When the fiber collar contacts the skin being countersunk, the mounted cutter can go no deeper. The depth can be adjusted by changing the distance, the cutter protrudes from thestop.
The stop countersinks have provisions for using different-sized pilots to match the diameter of rivet beinginstalled.
To determine the correct adjustment of the stop, make some test countersinks in scrap material until the recess is just deep enough for the top of the fastener being installed to be flush with the surface of themetal.

Dimpling:

This is a process for indenting thin sheet material (not normally thicker than 16 s.w.g.) around a drilled hole to accommodate a countersunkrivet.
If correctly preformed, dimpling has a beneficial effect on the strength of a joint, but the method of dimpling must be related to the ductility of the material to prevent overstressing andcracking.



Dimpling is done with a male and female die, or forms, often called punch and dieset.
The male die has a guide the size of the rivet hole and is bevelled to correspond to the degree of countersink of the rivethead.
The female die has a hole into which the male guide fits and is bevelled to a corresponding degree of countersink.
When dimpling, rest the female die on a solid surface. Then, place the material to be dimpled on the female die. Insert the male die in the hole to be dimpled and, with a hammer, strike the male die until the dimple isformed.
Two or three solid hammer blows should be sufficient. A separate set of dies is necessary for each size of rivet and shape of rivethead.
Dimpling dies for light work can be used in portable pneumatic or hand squeezers. SampleDimpling:
Before dimpling any aircraft material of which the dimpling characteristics are uncertain, either because of lack of familiarity with the material itself or because of the use of a new dimpling technique or tool, tests should be made on sample material of the same gauge, specification and heat treatmentcondition.
Specimens of the material should be cut approximately 8 inches long and 1 inch wide, and dimpled along the centreline of the strip at the pitch to be used on theaircraft.
Before any method of dimpling is approved for production, its suitability for the particular combination of material, gauge, dimple and rivet size should be assessed by the DesignDepartment.
When the strip is bent across the dimples as shown in Figure, cracks across the dimples at the bend may be expected and are acceptable, but if other radial or circumferential cracks develop, the process must be consideredunsatisfactory.



Punch dimpling:

This is the simplest method of dimpling but is generally only suitable for minor repairs in sheet steel or soft aluminiumalloys.
The type of tool used is similar to a centre-punch but has a spigot which engages in a female tool of the sameform.
The hole should first be drilled to the spigot size and then the male die should be driven or squeezed into the female die to form thedimple.

Coin Dimpling – with countersink rivet:

The coin dimpling, or coin pressing, method uses a countersink rivet as the male dimplingdie.
Place the female die in the usual position and back it with a buckingbar.
Place the rivet of the required type into the hole and strike the rivet with a pneumatic rivetinghammer.
Coin dimpling should be used only when the regular male die is broken or not available.
Coin pressing has the distinct disadvantage of the rivet hole needing to be drilled to correct rivet size before the dimpling operation isaccomplished.
Since the metal stretches during the dimpling operation, the hole becomes enlarged and the rivet must be swelled slightly before driving to produce a closefit.
Because the rivet head causes slight distortions in the recess, and these are characteristic only to that particular rivet head, it is wise to drive the same rivet thatwas used as the male die during the dimplingprocess.
Do not substitute another rivet, either of the same size or a sizelarger.

Coin Dimpling – Hot dimpling:

Dimpling is required for sheets that are thinner than the minimum specified thickness for countersinking.
However, dimpling is not limited to thin materials. Heavier parts may be dimpled without cracking by specialized hot dimplingequipment.
The temper of the material, rivet size, and available equipment are all factors to be considered indimpling.
There are basically two methods of hotdimpling.
In the first method, sometimes known as 'coin dimpling', electrically heated dies are used; in the second, the sheet is heated by its resistance to the passage of an electric current.
In order to obtain consistent results during aircraft construction, large static machines with automatically controlled temperature, current and tool pressure are often used but for repair work portable hot squeeze-dimpling tools are generallysatisfactory.
The metal being used is an important factor because each metal presents different dimplingproblems.
For example, 2024-T3 aluminum alloy can be satisfactorily dimpled either hot or cold, but may crack in the vicinity of the dimple after cold dimpling because of hard spots in the metal. Hot dimpling prevents suchcracking.
7075-T6 aluminum alloys are always hotdimpled.
Magnesium alloys also must be hot dimpled because, like 7075-T6, they have low formabilityqualities.
Titanium is another metal that must be hot dimpled because it is tough and resists forming.

Spin dimpling:

This is the most widely used method ofcold-dimpling.
The sheet is first pre-drilled and backed by a female die as for punch dimpling, then a rotating male die is pressed into thehole.
The metal around the rivet hole is stretched over the edge of the female die and, if the material is clad, the aluminium cladding is spread by the spinningaction.
The cladding may form a ridge around the outside of the dimple but this will only be slight; and should not beremoved.

Tools used for Solid Rivet installation

Points to remember:

Each rivet must carry its share of the total load in an aircraft structure. If a rivet is not installed properly, it can force the adjacent rivets to carry more load than they are designed to take, ultimately causing a structure tofail.
In addition to the proper preparation of a hole for a rivet, the strength of a riveted joint is determined by the way the rivets aredrawn.
When installing rivets, it is important to install the rivets with as few impacts as possible so the material will not work harden andcrack.

The shop head of the rivet should be concentric with the shank and flush with the surface withouttipping.
In addition, the formed or bucked head should be fabricated to proper dimension. Use of sealants:
After components have been prepared for riveting the mating surfaces are normally given a coat of jointing compound or sealant before finalassembly.

The purpose of the jointing compound is to inhibit electrolytic action between materials of different electrical potential and prevent the ingress of moisture,whereas
a sealant (normally a polysulphide type synthetic rubber) is used to seal joints in fuel tanks and pressurised compartments.
Jointing compound should be applied in a thin even film, just sufficient to ensure that all mating surfaces, including rivets, are adequately covered, but sealant should normally be applied in a layer approximately 0·030-inch-thick so that it exudes from the joint when the rivets areclosed.
It may be recommended that rivets are dipped in the compound before use but the exposed shanks of some types of rivets should, after insertion, be carefully wiped clean to ensure correct closing of the rivet.
Riveting must be completed before the compound or sealant has set and any excess material on external surfaces should be wiped off or to a prescribed fillet while stillwet.
Allowance for closing the rivet:
The length of protruding shank which is flattened to close a rivet is known as the 'allowance', and is expressed in terms of the rivet diameter'D'.
For normal reaction riveting the allowance is 1.5D, .and this is sufficient to form a flat head 1.5D in diameter and 0·5D thick; for this type of riveting these are the dimensions to be aimedat.
On the rare occasions on which hand riveting may be required, an allowance of 1 ·5D is sufficient to form a snap head and 0·75D is sufficient to form a countersunkhead.
Rivets should always be used which are manufactured to the length required; cutting rivets to length is not recommended, since any tool marks in the rivet tail are possible sources of cracks when the tail ishammered.

HandHammering
(Hammer +Dolly)

Pneumatic hammering
Rivet squeezingle

Methods of riveting:

Hand Hammering:

Riveting by hand is only appropriate to certain types of older aircraft and elementary repairs to simplestructures.
When solid rivets are closed with a hand hammer, the manufactured (pre-formed) head should be supported by a suitably shaped dolly and the tail hammered to a thickness of0·5D.
If a snap head is required on the shank end, the tail should first be partly formed by hammer blows, then finished with a suitably shapedsnap.
It is most important that the dolly is backed by a heavy block or holder, and as few hammer blows as possibleused.
A large number of light blows will work-harden the rivet and result in cracks in the tail or difficulty informing.

Hand driving Aircraft rivets:

The process used for hand driving aircraft rivets is not the same as that used by some other commercial sheet metalprocess.
Aircraft rivets driven in flat sheets are never peened over. Instead, the shank is collapsed with a handset in much the same manner as other aircraft rivetingtechniques.

To drive a rivet by hand, the material to be joined is prepared by drilling and deburring a hole, and a rivet is inserted to extend 1.5D (one and half times the diameter of rivet) through themetal.
A special metal bucking bar that has a recessed contour approximately the shape of the rivet head is then mounted in a vise with the recess facingupward.
The rivet is placed through the hole in the metal and the rivet head is put in the recess of the metalbar.
A draw set/tool with hole is slipped over the rivet shank and tapped slightly with a hammer to draw the sheets of metal tightlytogether.
A hand-set is then placed on top of the rivet shank and struckwithahammertoforcetherivettocompressto
the proper dimensions. **Don’t directly hit the rivet shank with hammer.**

Note:It is important to strike the set hard enough that the rivet compresses with only three orfour strikes of the hammer to prevent work hardening the rivet.

Pneumatic hammering (Reaction riveting):

In some instances, it may be specified that a similar procedure should be used for pneumatic hammering as given for handhammering.
However, since the preformed rivet head is invariably on the outside of the aircraft and access to the interior often restricted, a type of riveting known as reaction riveting is more generallyused.
A suitably shaped snap (or 'set') is held in the riveting gun and a dolly (or bucking bar) held against the tailend.
When the riveting gun is operated the tail is spread by the reaction of thedolly.

Remember:

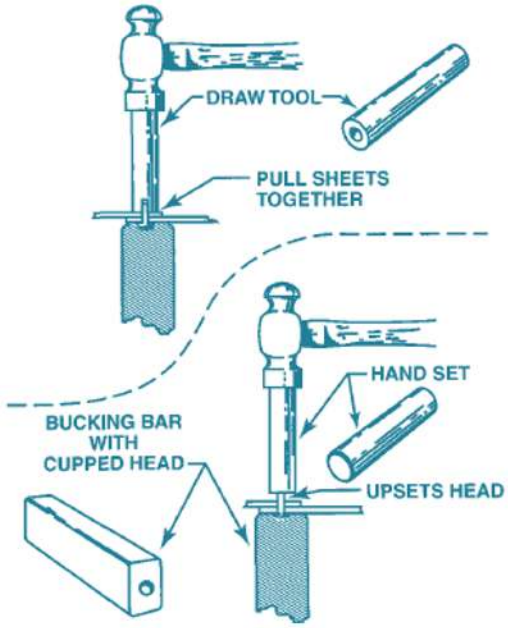
To prevent damage to the surface of the work when protruding head rivets are being closed, the radius of the recess in the snap should be slightly greater than the radius of the rivethead.
For this reason, since rivets to different specifications (e.g. SP. or AS) have slightly different shaped heads, use of the correct snaps isimperative.
When flush rivets are being closed a flat snap should be used, but it may be found advantageous to use one with a slightly convex surface to prevent damaging the surroundingskin.
The dolly should be as heavy as practicable, bearing in mind the space available, and should have a smooth surface to prevent damage to the rivettail.
The type of gun to use will depend on the size and type of rivets, but generally on aircraft work a fast-hitting type is used on rivets up to ¼-inch diameter and a single- blow or slow, long-stroke type for largerrivets.
As with hand hammering a few heavy blows are preferable to a large number of light blows.

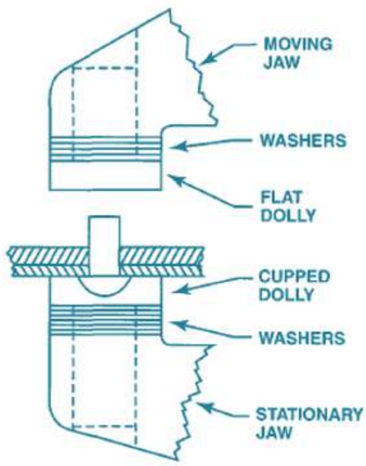
Squeeze Riveting machine: [https://www.youtube.com/watch?v=vb5_6z3XSN4]

On large modern aircraft, extensive use of squeeze riveting is made when securing spanwise stringers to preformed wingskins.
It is part of an automatic process using large tape-controlled machines which drill, countersink, deburr, rivet and mill flush in one continuousaction.
This method of riveting is also used for the production of small assemblies or, when both sides of the work are accessible, during repairwork.
Squeeze riveting is also preferred when bonded laminated structures are to be riveted since, unless skill and care are exercised, reaction riveting tends to damage thebond.
The rivets are closed by hydraulically or pneumatically operated machines, of which both static and portable types areavailable.
Sample squeeze riveting:

Before riveting with squeeze tools, the working pressure should be adjusted, by experiment, to obtain the optimum value for the work inhand.

😮 😮 😮

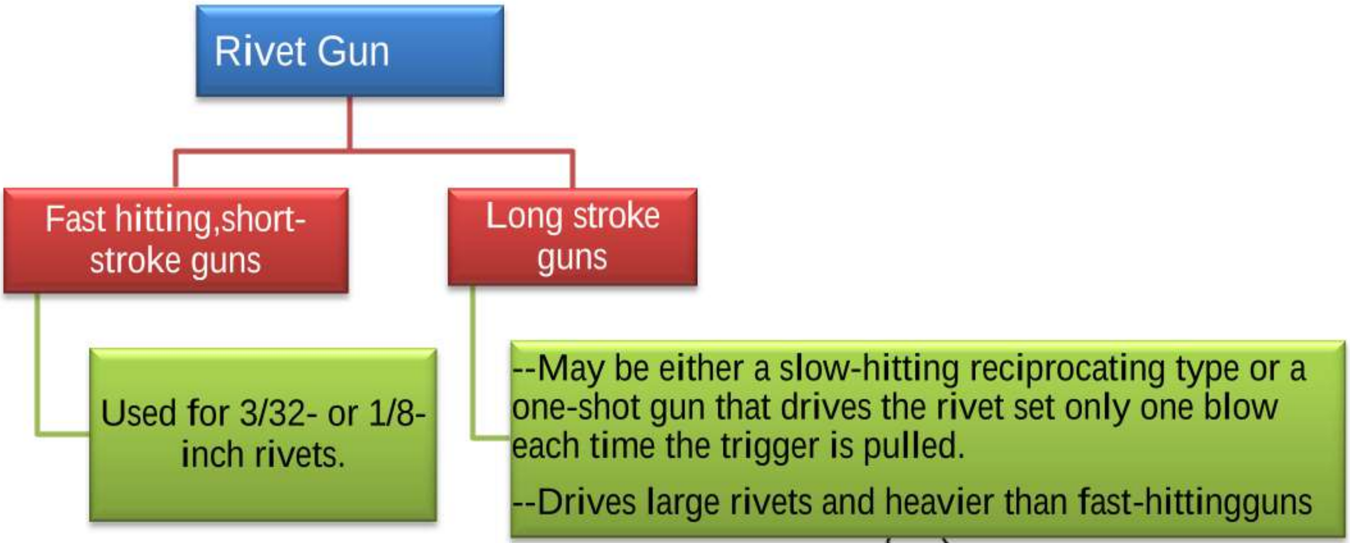


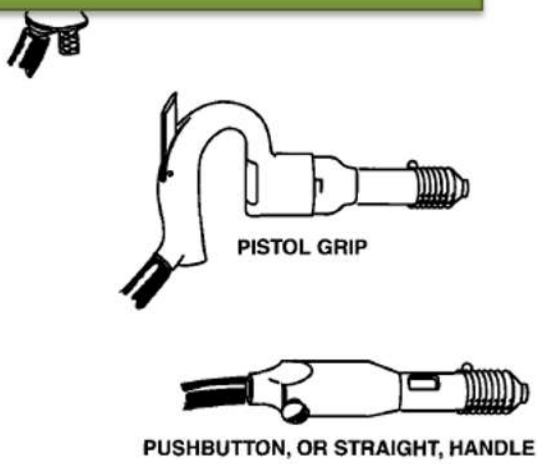


Test pieces of the same materials, thickness and rivet diameter as the work in hand should be used and may be sectioned across the rivets to study the plastic distortion to which the rivets and sheets have beensubjected.
Once adjusted the tools may be used for all work for which similar conditions apply, but must be readjusted if any changes occur in material, thickness or rivetsize.

Compression riveting / Hand Squeeze riveting: [https://www.youtube.com/watch?v=YS-ivwcfQVE]

A squeeze riveter consists of a pair of jaws; one stationary and other moved by a piston in an aircylinder.
A dolly milled with a recess similar to the shape of the rivet head, is put into the stationary jaw, and a flat dolly is placed in the movablejaw.
When a handle or trigger is depressed, air flows into the cylinder and squeezes the jaws together to compress the shank of the rivet in a uniformmotion.
To adjust the height of the shop head formed by a squeeze riveter,addorremovewashers/shimsbetweenthedolliesand the jaws.

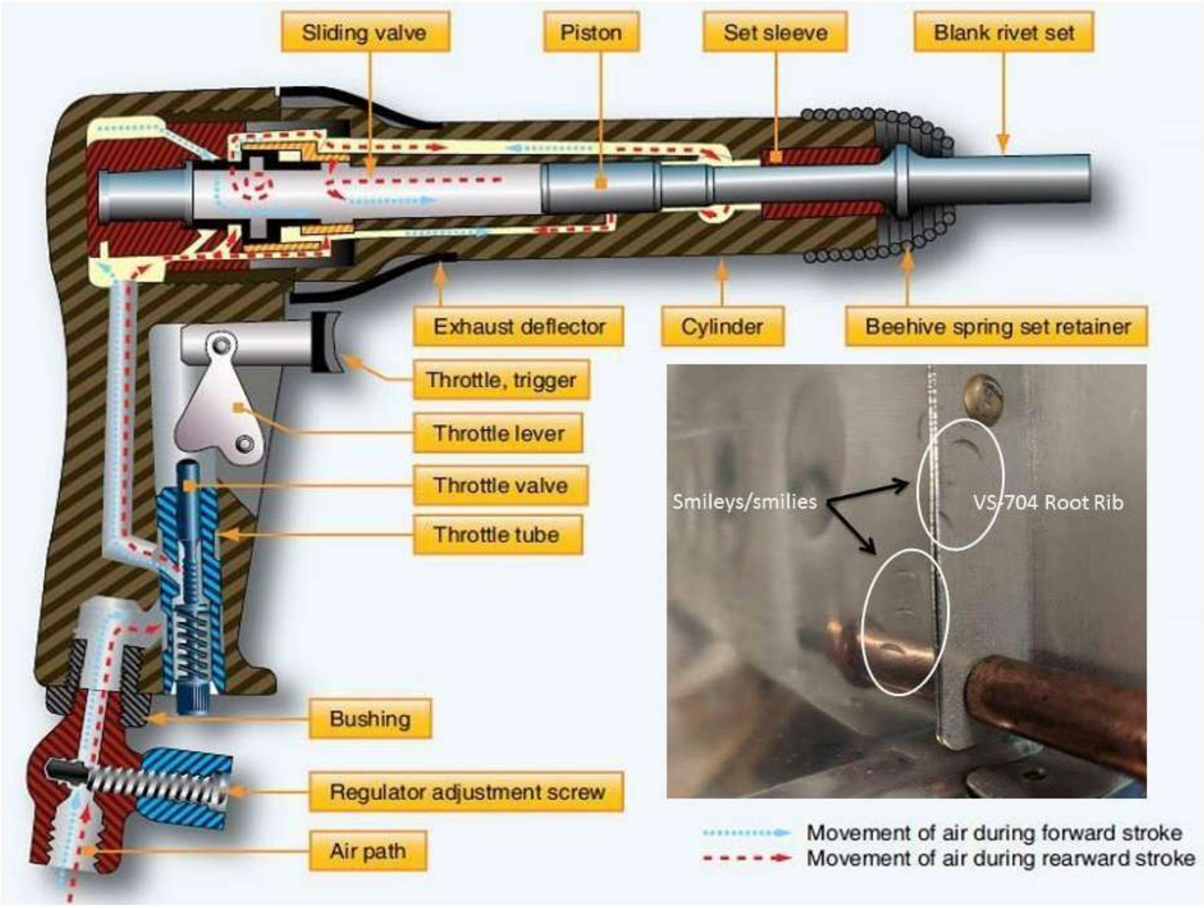




Rivet gun handle styles

Thepistolgripandoffsethandlearethemostpopularstyles,withapushbuttontype available for special applications where neither style fits because of clearance problems.

Pneumatic Rivet Gun: [https://www.youtube.com/watch?v=sTmuFxEN1Mk]



When a trigger/throttle is pushed, air enters a sliding vane and drives a piston forward against the stem of a rivetset.
When the piston reaches the end of its stroke, a port is uncovered by the valve, and the air moves backward which moves the piston backwards as shown infig.
As long as the trigger is held down, the gun will hammer on the rivetset.
The regulator that comes with the hose or with the gun handle, restricts the flow of air into gun thereby controls the speed ofhammering.

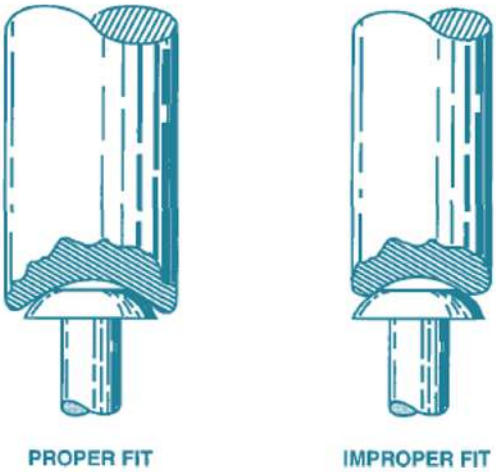
Rivet sets

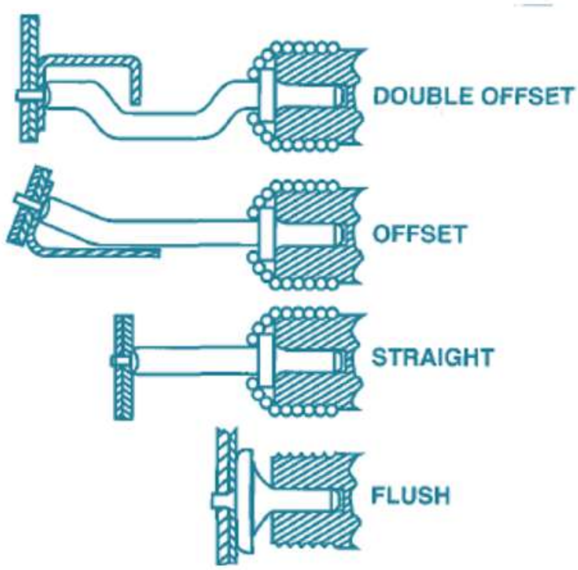
The gun has a provision whereby different sets can be installed for different sizes and head styles ofrivets.
Rivet set at the end of the piston holds the factory head of rivet safely and pushes the shank against bucking bar that the technician holds on opposite side of work to form shophead.
When selecting rivet sets, the radius of depression in the set must be larger than that of the rivet, but not so large that the set contacts the sheet metal duringdriving.
If the set is too large, it will produce small indentations in the sheet metal around the rivet head. These indentations are called smiles (See fig) because of the shape they leave in themetal.
On the other hand, if the set is too small, it will damage the rivethead.
Because the structure inside an aircraft sometimes makes it difficult to align the gun exactlywiththerivet,rivetsetsaremade

with

offset

design of various angles.





Bucking bars / Dolly:

When a rivet is driven, the actual compression of the rivet is not performed by the action of the rivet gun. Instead, the rivet is backed up by a metal bar that compress the rivet bucktail in response to the beats of the rivetgun.
This tool is used by holding it against the shank end of a rivet while the shop head is beingformed.
Always hold the face of the bucking bar at right angles to the rivetshank.
Failure to do so causes the rivet shank to bend with the first blows of the rivet gun and causes the material to become marred with the finalblows

Rivet cutter: [https://www.youtube.com/watch?v=Y_jVBZ6sUUw]

The rivet cutter is used to trim length of rivets when rivets of the required length are unavailable.

To use the rotary rivet cutter, insert the rivet in the correct hole, place the required number of shims under the rivet head, and squeeze the cutter as if it were a pair of pliers.
Rotation of the disks cuts the rivet to give the right length, which is determined by the number of shims inserted under thehead.
When using a large rivet cutter, place it in a vise, insert the rivet in the proper hole, and cut by pulling the handle, which shears off therivet.
If regular rivet cutters are not available, diagonal cutting pliers can be used as a substitute cutter.
Microshaver: [https://www.youtube.com/watch?v=CNEQrEL6rek]

A Microshaver is used if the smoothness of the material (such as skin) requires that all countersunk rivets be driven within a specifictolerance.
This tool has a cutter, a stop, and two legs or stabilizers. The cutting portion of the microshaver is inside thestop.
The depth of the cut can be adjusted by pulling outward on the stop and turning it in either direction (clockwise for deepercuts).
The marks on the stop permit adjustments of 0.001 inch. If the microshaver is adjusted and held correctly, it can cut the head of a countersunk rivet to within 0.002 inch without damaging thesurrounding
material. Shear head rivets should never be shaved

larger to dimple them both together.

Once dimpled separately, they will be assembled and riveted with a gun and adolly.

Combination pre-dimple and countersunkmethod:
If top sheet is too thin and bottom sheet is too thick, they will be separately dimpled and countersunk and then assembled and rivetedtogether.
It should be noted that the countersunk angle should be the angle of outer dimple of top sheet so both can sit tightly.

Closing different types of hollow rivets

Hollow rivets:

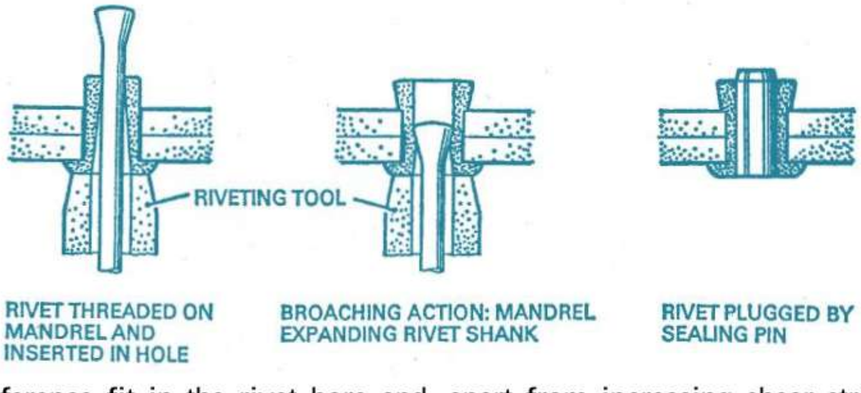
Hollow rivets may be broadly classified into two main groups, those which are closed by drawing (pulling) a mandrel through the bore and those which are closed by hammering.
The first group are known as 'blind' rivets, because they may be installed when only one side of the rivet hole isaccessible.

Blind rivets may only be used to replace solid rivets when this is permitted by the repair scheme.

In the absence of specific instructions, it is important to ensure that the rivet is either of the same material as the original solid rivet or, if dissimilar, has the minimum potential difference with the material being riveted, otherwise there may be a risk ofcorrosion.
Blindrivets:

The blind rivets are all closed by pulling a mandrel through thebore.
In some cases, the mandrel also plugs the rivet, but in others a separate sealing pinmust be driven in after the rivet has beenclosed.
– Chobert rivets: [https://www.youtube.com/watch?v=UCWWhZjm5u4]

Chobert rivets are manufactured with either snap or countersunk heads and are normally supplied in tubes for ease of assembly on themandrel.
The action of closing a Chobert rivet - Initial movement of the mandrel down the tapered bore forming the head and subsequent movement expanding the shank fill the rivethole.

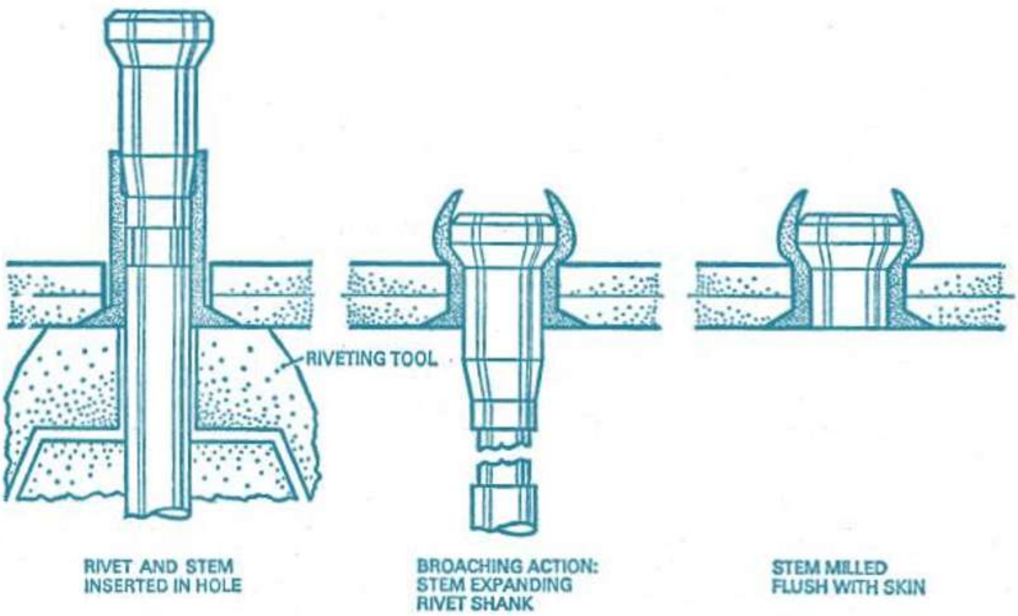


Sealing pins are an interference fit in the rivet bore and, apart from increasing shear strength, will prevent the ingress ofmoisture.

Note:It is advisable to use a repetition gun when a large number of rivets have to be closed (check the video link). The mandrels in these tools may be threaded into a tube contain in approximately thirty rivets, and these are automatically positioned as each rivet is closed. High rates of closing are easily obtained.

– Avdel rivets: [https://www.youtube.com/watch?v=1I-zBd3rLI4#action=share]

These rivets are similar to Chobert rivets, but each is fitted with its own stem (mandrel), the component parts being referred to as the body and stemrespectively.
The stem is pulled into the body to close the rivet and, at a predetermined load, breaks below the manufactured head, leaving part of the stem inside the body in the form of a plug.
Excess stem material may be nipped off and milled flush with the rivet head when required, e.g. on external surfaces, but stainless steel and titanium rivet stemsbreak
flush with the rivet head at the maximum grip range limit, and milling may not be necessary.

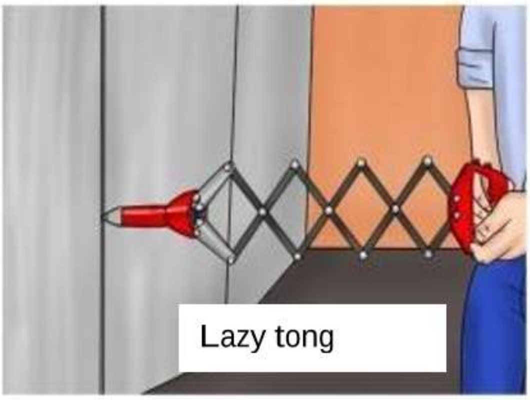


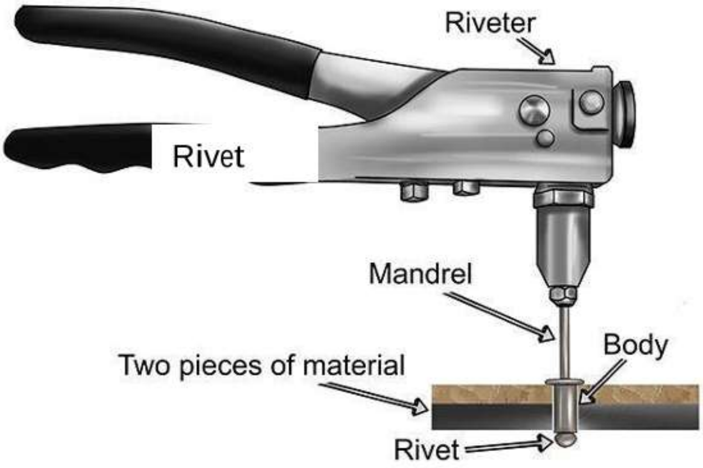
Testing Avdel rivet after closing:When the rivets have been closed, the tightness of the stem should be checked with an Avdel Pin Tester, which is a tool having a retractable spring-loaded pin. The pin is pushed against the stem, and tightness may be considered satisfactory if there is no stem movement when the spring is fully compressed.

– Tucker 'Pop' rivets: [https://www.youtube.com/watch?v=9aoXmzdSf_I]

Tucker 'Pop' rivets are manufactured with either domed or countersunk heads, and some are supplied threaded on individualmandrels.
There are, basically, two different types of rivets, known as 'standard' (open) and 'sealed.
Theserivetsaremostoftenclosedbyhandtoolsofthe**'lazytong'**typewhenusedfor

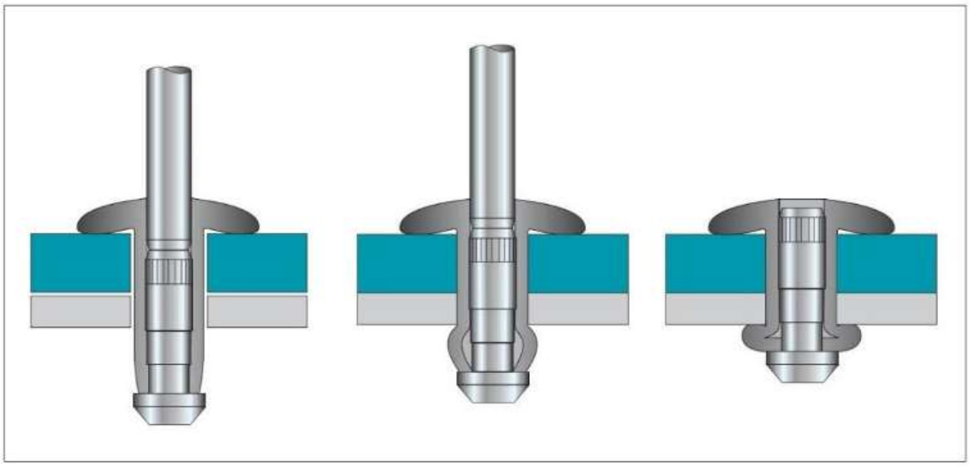
repair work, although other types of hand and



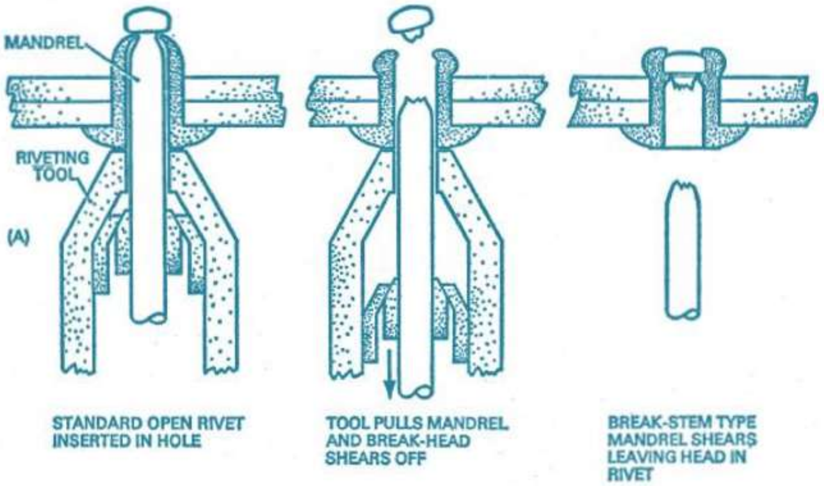


power tools are also available.

[https://www.youtube.com/watch?v=jNzx-ACrqXE]
They are frequently used for assembly and non-structural applications and in areas that are not taking moderate or heavyloads.
They are commonly called pop rivets because of the sound they makes when the mandrel breaks whileriveting.

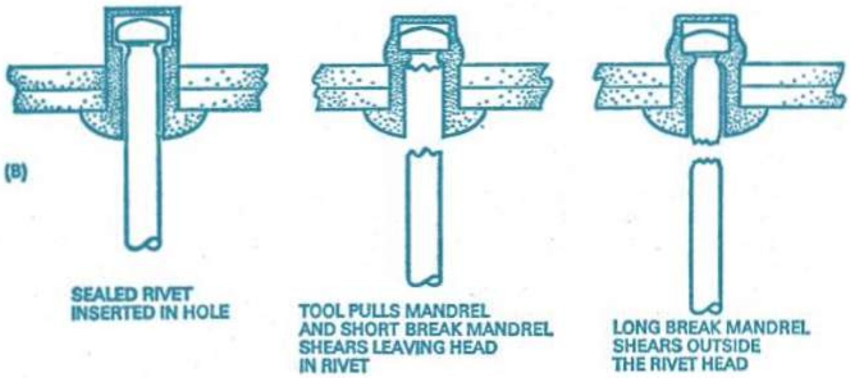


former type the mandrel head separates from the formed rivet, but with the latter the head is retained in the rivet bore and provides a measure of sealing.
The break head rivets are not widely used on aircraft due to the difficulty of recovering broken mandrelheads.



The mandrels of sealed type rivets are also of two types, the short break and the long break.

The short break mandrel breaks immediately under the head, but the long break mandrel breaks outside the rivet thus greatly increasing shear strength of the rivet and providing a flush finish when the protruding stem is nippedoff.



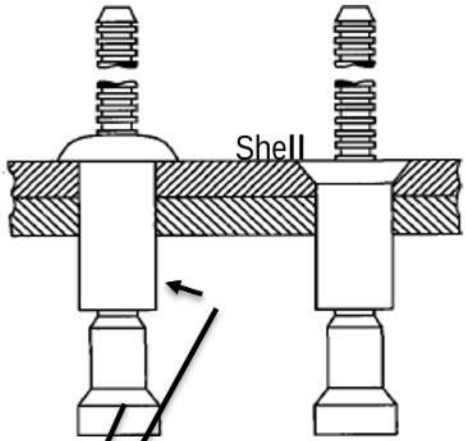
A wide variety of tools is available for closing 'Pop' rivets, ranging from plier type hand tools to pneumatically or hydraulically operated powertools.

A range of interchangeable heads for these tools permits closing the rivets where access isrestricted.

– Cherry friction-lockrivet:

One of the early forms of rivet that was the first to be widely used for aircraft construction and repair was the cherry friction-lockrivet.
Available in two styles: Hollow shank pull-through, and Self-pluggingtype.
The pull-through type is no longer common; however, the self-plugging cherry friction-lock rivet is still used for light aircraftrepairs.
Closing the friction-lock rivet:

It consists of a shell and mandrel (pullingstem).
The stem is pulled until the header forms a buck-tail on the blind side of therivet.
At this point, a weak point built into the stem shears and the stem breaks off. The remaining stem is cut close to therivet.
Shortcoming: Due to vibration, the stem may fall off as it is just held inside the shell without support. A cherrylock rivet can be used in such places.

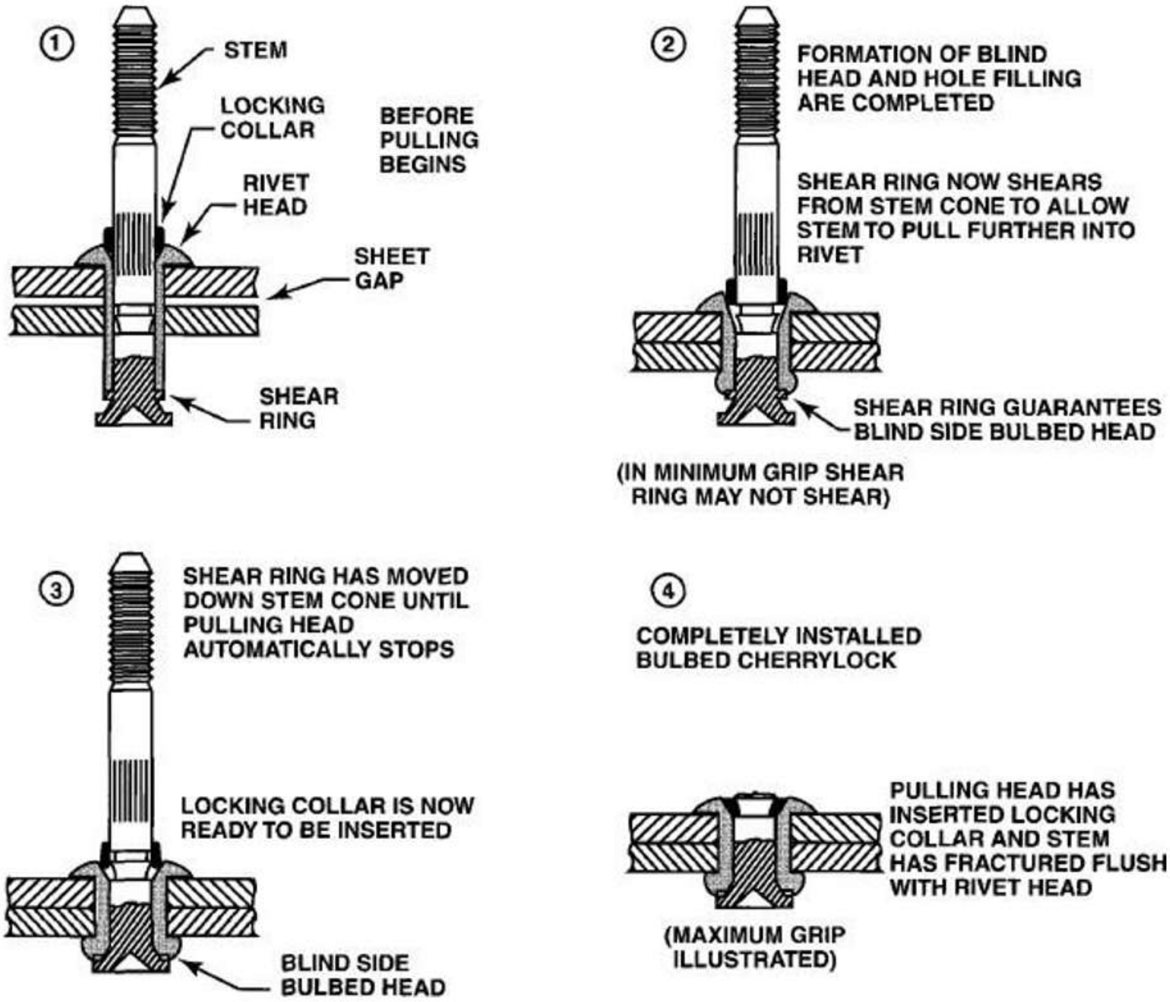


– Cherry mechanical-lock rivets(CherryLOCKS):

[https://www.youtube.com/watch?v=bYzRFo0fWUw]

These are rivets of American manufacture and are very similar to Avdel rivets, except that the stem is positively locked in the rivet bore with a lock ring. This results in shear and bearing strengths that are high enough to allow CherryLOCKS as a replacement for solid shank rivets.
During the final stages of forming, a locking collar, located in a recess in the rivet head, is forced into a groove in the stem, and prevents the stem from furthermovement.
Alternative types of blind head may be formed, and these are known as 'standard' and 'bulbed'.
The only practical difference between these types is that the bulbed rivet stem has a steppedhead,andthefinishedblindheadisflatterandbroaderthanthestandardhead.

Closing a CherryLOCK rivet - After forming, the stem protrudes slightly beyond the rivet head and this excess stem plus part of the locking collar, may be milled off to provide a flushfinish.



Checks - Before:A gauge is supplied by the manufacturer of these rivets, which may be inserted into the rivet hole to measure the thickness of material to be riveted. The maximum grip of each rivet is marked on the rivet head, in sixteenths of an inch, and this figure should correspond to the gauge reading.

Checks - After:To check the stem locking, a stem tester should be pressed against the sheared end of the stem; as with Avdel rivets, the stem locking may be considered satisfactory if no movement results when the tester is· fully compressed.

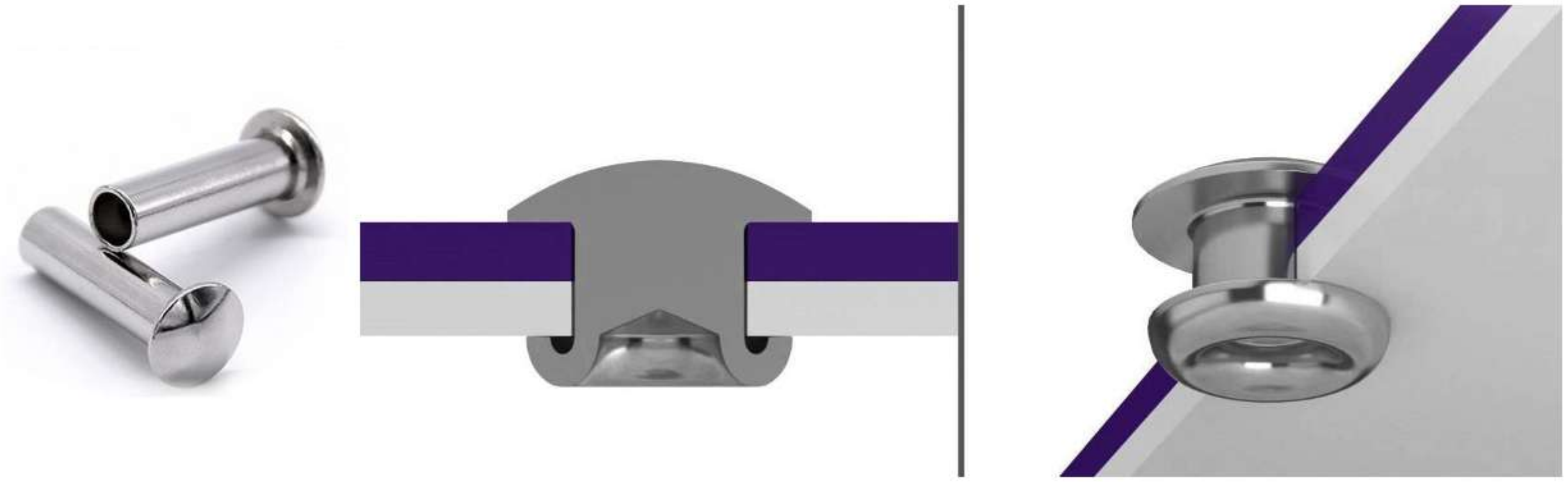
– CherryMAXRivets:

One disadvantage of CherryLOCK rivet is that it requires a special pulling tool for each different size and head shape. In such cases, CherryMAX can be installed as one size puller can be used for installation of all sizes of CherryMAX rivets.

Tubular rivets: [https://www.youtube.com/watch?v=I40ISVkF08s]

[https://www.youtube.com/watch?v=YPSBtvfBVw0]

Tubular rivets were, at one time, quite often used on tubular structures, such as engine mountings or fuselage frames, for joining tubes to fittings, or for repairwork.
These parts are now more often welded or fixed with taper pins, but tubular rivets may still be found on a number ofaircraft.
These rivets are closed by hammering, using specially shaped punches and snaps (dollies), and care is necessary to prevent buckling the rivet ortube.

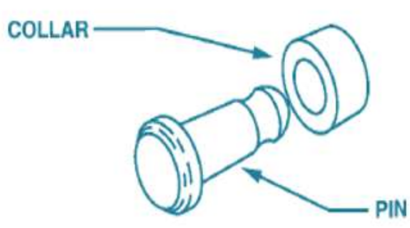


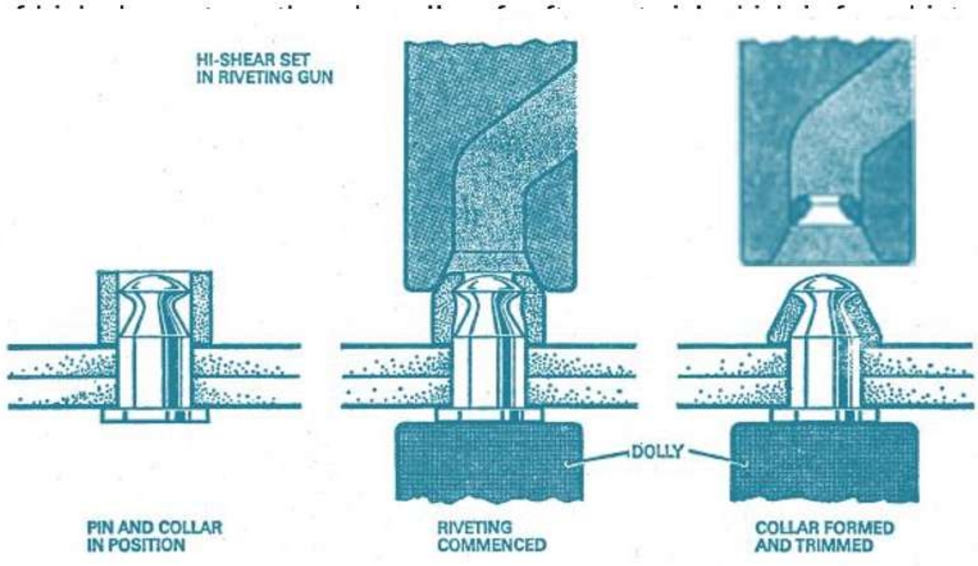
Closing Special fasteners:

The special fasteners discussed here are closed by means of a collar which is swaged into grooves in the fastener shank or expanded over the shank to form a blind head. The fasteners are generally used instead of bolts and present a considerable saving inweight.

Hi-shear rivets: [https://www.youtube.com/watch?v=IAEAmcMbv5Q]

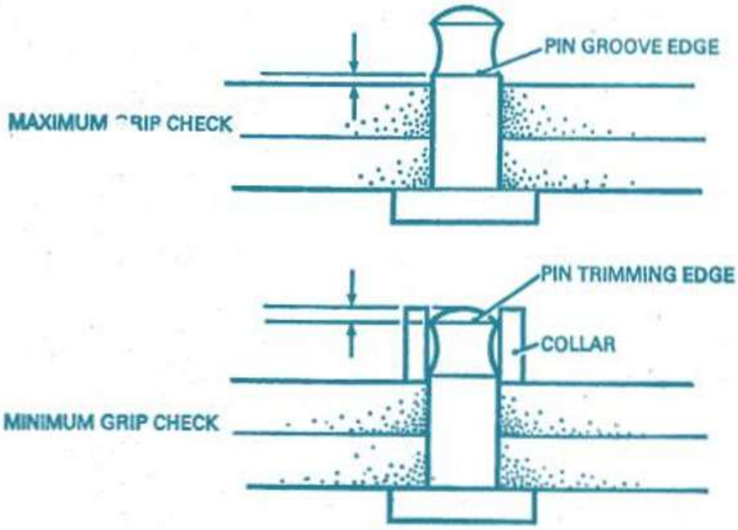
Hi-shear rivets were developed in the 1940s to meet the demand for fasteners that could carry greater shear loads as the nameimplies.
The Hi-shear rivet has the same strength characteristics as a standard AN bolt. In fact, the only difference between the two is that a bolt is secured by a nut and Hi-shear rivet is secured by a crushedcollar.
The Hi-shear fastener consists of a pin
the pin groove by the rivetingaction.
The pins are supplied with standard or c
(the '100' series which uses aluminiur
ofmaterials).





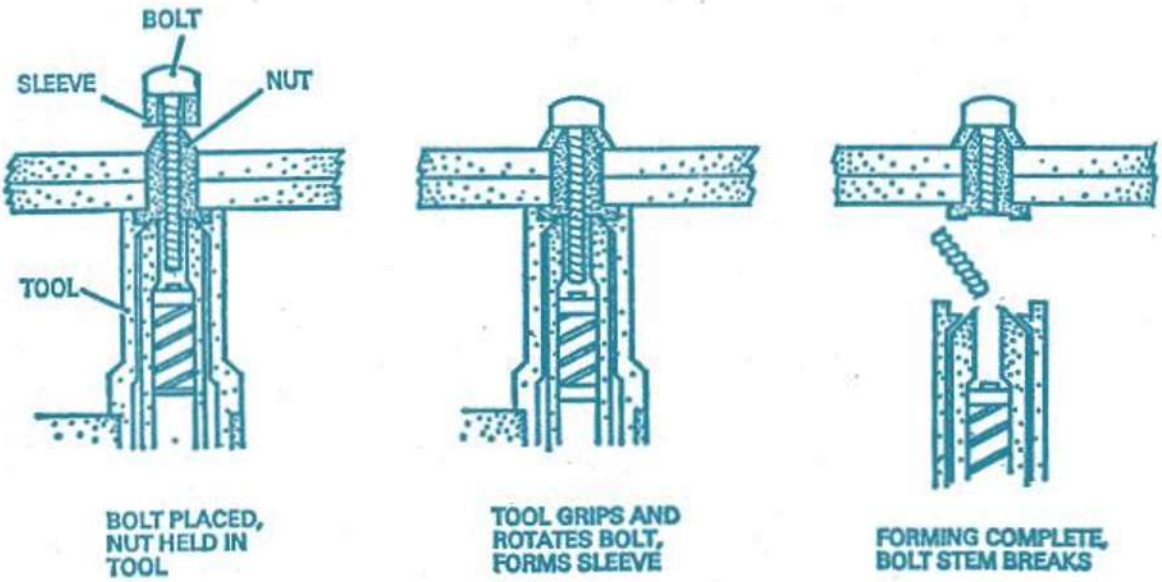
Hi-shear pins are placed using a special hi-shear rivet set which forms and trims the collar.
Checks:

With these fasteners a simple check may be carried out to ensure that the pin is the correct length for the work to be joined. With the pin inserted in the hole, the edge of the pin groove
should be proud of the work surface, and with the collar fitted, the pin trimming edge should be inside the collar as shown in Figure below.



Jo-Bolts: [https://www.youtube.com/watch?v=fztEdLEtvBQ]

Although Jo-bolts may be classified as blind rivets, the method of closing is different from the methods previouslydiscussed.
The complete item consists of a threaded bolt with a round head, a rivet shaped nut and a sleeve, assembled as illustrated in Figure.
Rotation of the bolt forces the sleeve up the tapered nut shank, clamping the materials to be joined, and at a predetermined load the bolt shears just inside the nut head leaving, virtually, a solid steel rivet in thehole.



The tool used to close these fasteners consists of an outer portion to prevent the nut from turning and an inner portion by means of which the bolt isrotated.
Rotation of the bolt (which has a left-hand thread) forces a sleeve up the tapered nut shank to form a blind head; when the work is securely clamped, continued rotation shears the bolt inside the nuthead.
Checks:

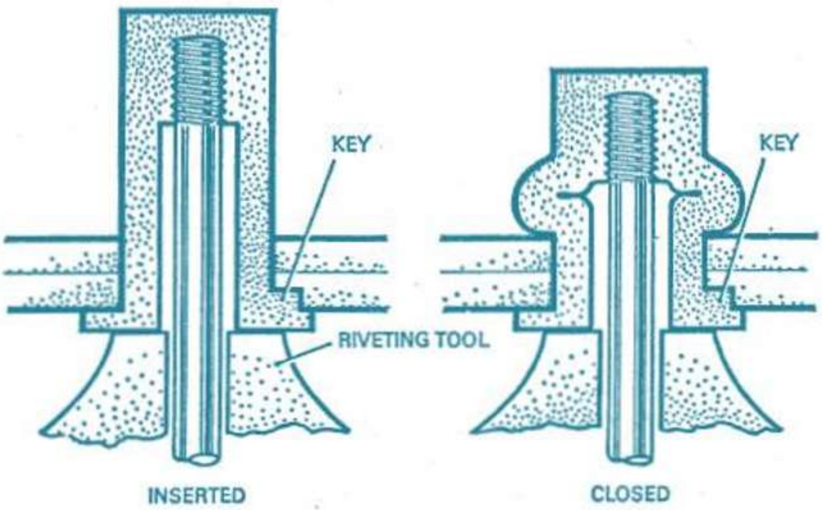
Due to the method of closure of these fasteners it is particularly important that the nut length is suitable for the thickness of the work. If the maximum grip of the fastener exceeds the thickness of work by more than 1/16-inch then the sleeve may not be properly expanded and a loose fastener couldresult.

Rivnuts: [https://www.youtube.com/watch?v=tgL3Kfc7p1M]

Rivnuts were originally developed for securing rubber de-icing boots to the leading edges of aerofoil sections but they are now also used, for example, for securing floor coverings and other non-structuralparts.
They are a form of blind rivet which can be used as an anchor nut, the internal bore being threaded to receive a bolt or screw.

Rivnuts are installed with a special tool fitted with a threaded mandrel; the mandrel is screwed into the rivnut, and when the gun is operated the shank expands as shown in Figure.

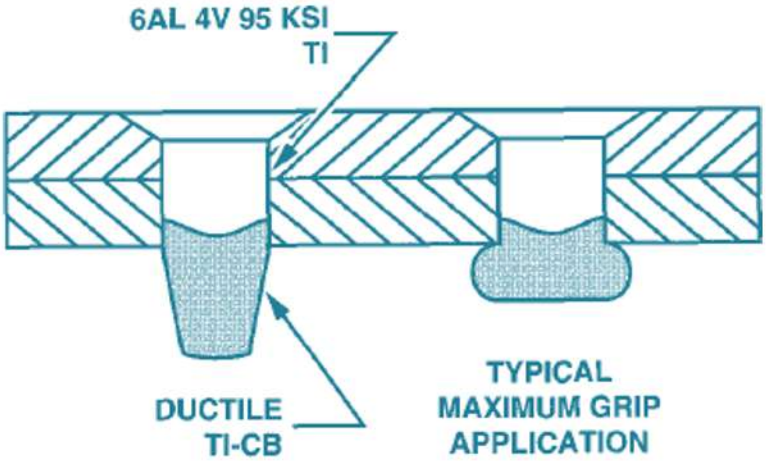
When Rivnuts have a locating key to prevent rotation, the keyway should be cut in the joining sheet with a special



tool supplied by the nutmanufacturer.
To close Rivnuts the threaded mandrel of the special tool is screwed into the nut, and when the tool is operated the nut shank bulges towards the far side of the work to form a blindhead.
When the mandrel is removed a fixed nut is left in the structure and may be used for the attachment of de-icing boots,etc.

CherryBUCK Rivets:

The cherryBUCK is a one-piece special fastener that combines two titaniumalloys which are bonded together to form a single strong structuralfastener.
Since it is a one-piece fastener, it can be installed in jet engine intakes with nodanger of foreign objectdamage.
This type of damage often occurs when multiple piece fasteners lose theirretaining collars and ingested into compressorinlet.



Inspection of Rivets:

Inspection of riveted structures:

Riveted structures should be inspected after each of the following operations: -

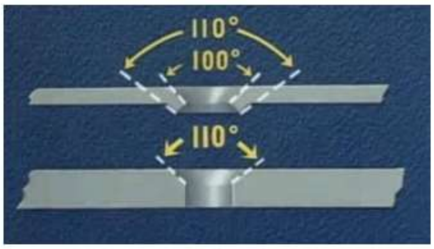
After marking-out, to ensure conformity with the repair scheme or the riveting methods used elsewhere on theaircraft.
After drilling, to confirm the position of holes and ensure that hole size and condition are suitable for the type of rivets to beused.
After countersinking or dimpling, to check the mating of the parts involved, the condition of the countersink or dimple, and the flushness of rivetheads.
After final assembly prior to riveting, to confirm the fit of the component and condition of any protectivetreatments.
After riveting, to ensure that rivets are satisfactorily formed, that there has been no significant distortion of the parts and, where specified, that jointing compound has been correctlyapplied.

Pre-riveting inspection:

Particular attention should be paid to the following points when inspecting parts prior to riveting.
Holes should be round, drilled at right angles to the work surface, have a diameter within the limits quoted by the aircraft manufacturer for the type of rivet, and sharp comers should be removed but not excessively.chamfered.
In certain instances, a surface roughness may be specified by the manufacturer, and this should be checked by accepted methods. Normally, a finish consistent with good workshop practice and without axial scores, issatisfactory.

A countersunk surface must be coaxial with the hole and cut to the required angle. The depth must be such that the rivet will comply with the flushness requirements of the aircraft manufacturer and on no account may the rivet head be below the skin surface. As with ordinary holes a surface roughness may bespecified,butprovidedthecountersunksurfaceisfreefrom
'chatter' marks a finish consistent with good workshop practice is normally adequate.

Dimples should be free from scores and should be of the correct angle. In this respect it should be noted that if several sheets are dimpled for a countersunk rivet, the angle of the dimples in successive sheets should vary to ensure correct nesting. Small radial cracks round the hole are generally acceptable in tertiary structures which have been dimpledfrom



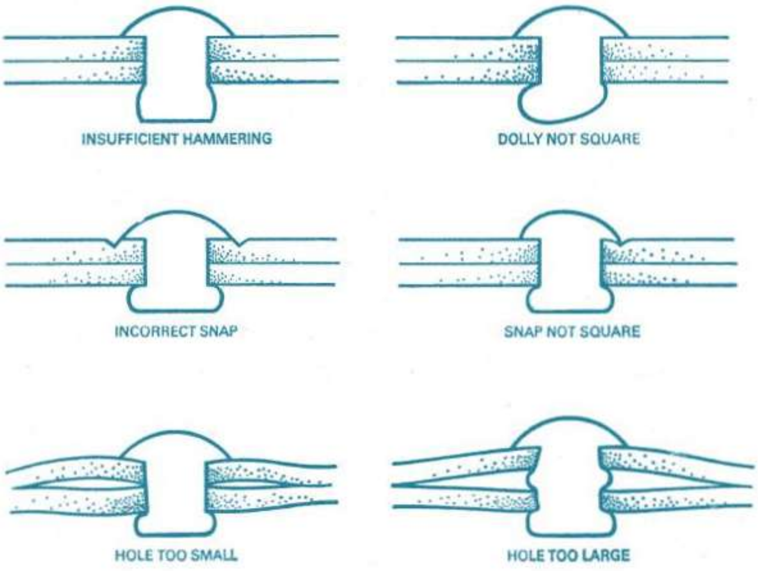
final size holes, but circumferential cracks round the dimple are cause for rejection.

Inspection of rivets:

After the rivets have been closed, they should be inspected to ensure that they are tight and fullyformed.
Rivet heads must not be deformed or cracked, and the surrounding area should be free from distortion and undamaged by the rivetingtools.
Rivets which are obviously not performing their function should be replaced, but replacement of rivets which are found to be only slightly below standard might do more harm than leaving them in position, particularly in thinmaterials

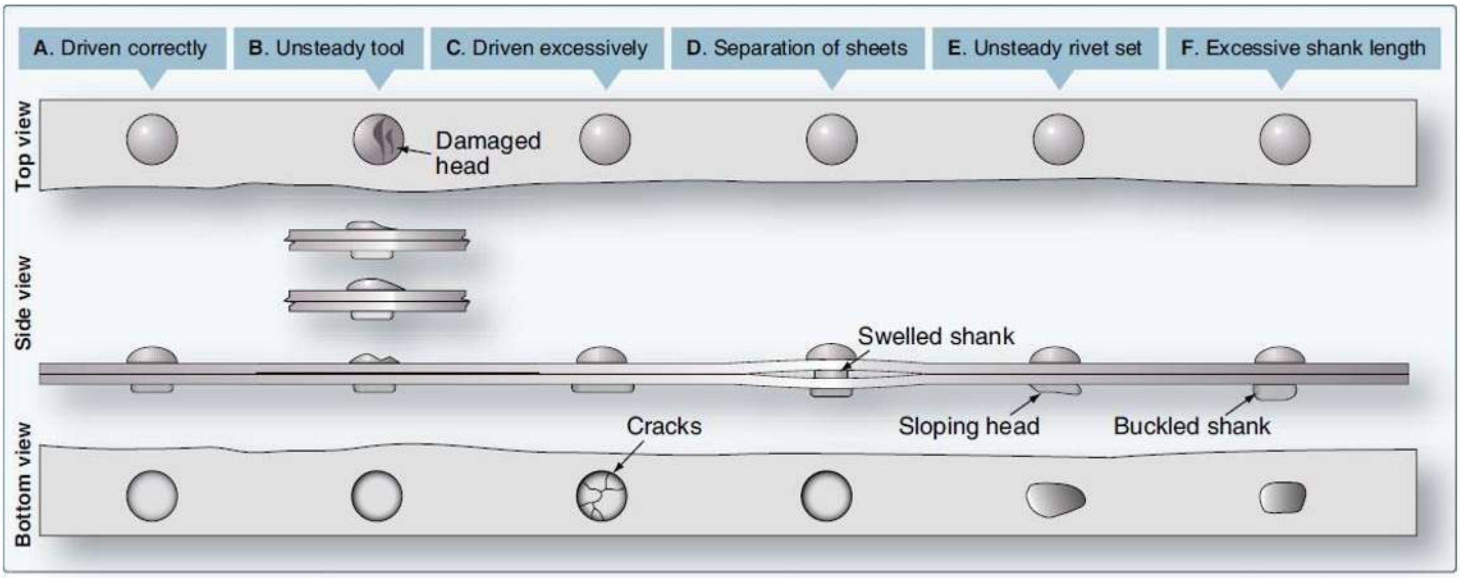
Solidrivets:

Figure shows some of the faults which may be found with solidrivets.



Superficial cracks round the periphery of the head are usually acceptable, but not if intersecting cracks could lead to part of the head breakingoff.
Cracks in the inner area of the head, corresponding to the shank diameter, are not permitted.
If snap heads are formed on the tail of the rivet a number of further faults mayoccur.
These include a 'flash' round the rivet head if the shank was too long, and a small head, possibly accompanied by snap marks on the skin, if the shank was tooshort.

Common damages due to improper riveting:



	Imperfection	Cause	Remedy	Action
A	None	None	None	None
B	Cut head	Improperly held tools	Hold riveting tools firmly against work	Replace rivet
C	Excessively flat head, resultant head cracks	Excessive driving, too much pressure on bucking bar	Improve riveting technique	Replace rivet
D	Sheet separation	Work not held firmly together and rivet shank swelled	Fasten work firmly together to prevent slipping	Replace rivet
E	Sloping head	a. Bucking bar not held firmly b. Bucking bar permitted to slide and bounce over the rivet	Hold bucking bar firmly without too much pressure	Replace rivet
F	Buckled shank	Improper rivet length, and E above	E above and rivet of proper length	Replace rivet

Blindrivets:

The blind heads formed when these rivets are closed are not usually accessible for visual inspection and in some cases radiological examination may bespecified.

Visual inspection is normally limited to ensuring that the head is square to and in contact with the skin surface, that the locking collar (Cherry rivets) is properly engaged, and that no damage or buckling has been caused to the surroundingarea.

Where required, the flushness of countersunk rivets should also bechecked.

Post repair inspections:

When a riveted repair has been completed and finally checked for freedom from swarf and foreign matter, consideration should be given to the necessity for tests or inspections to determine whether the component is fit once again forservice.

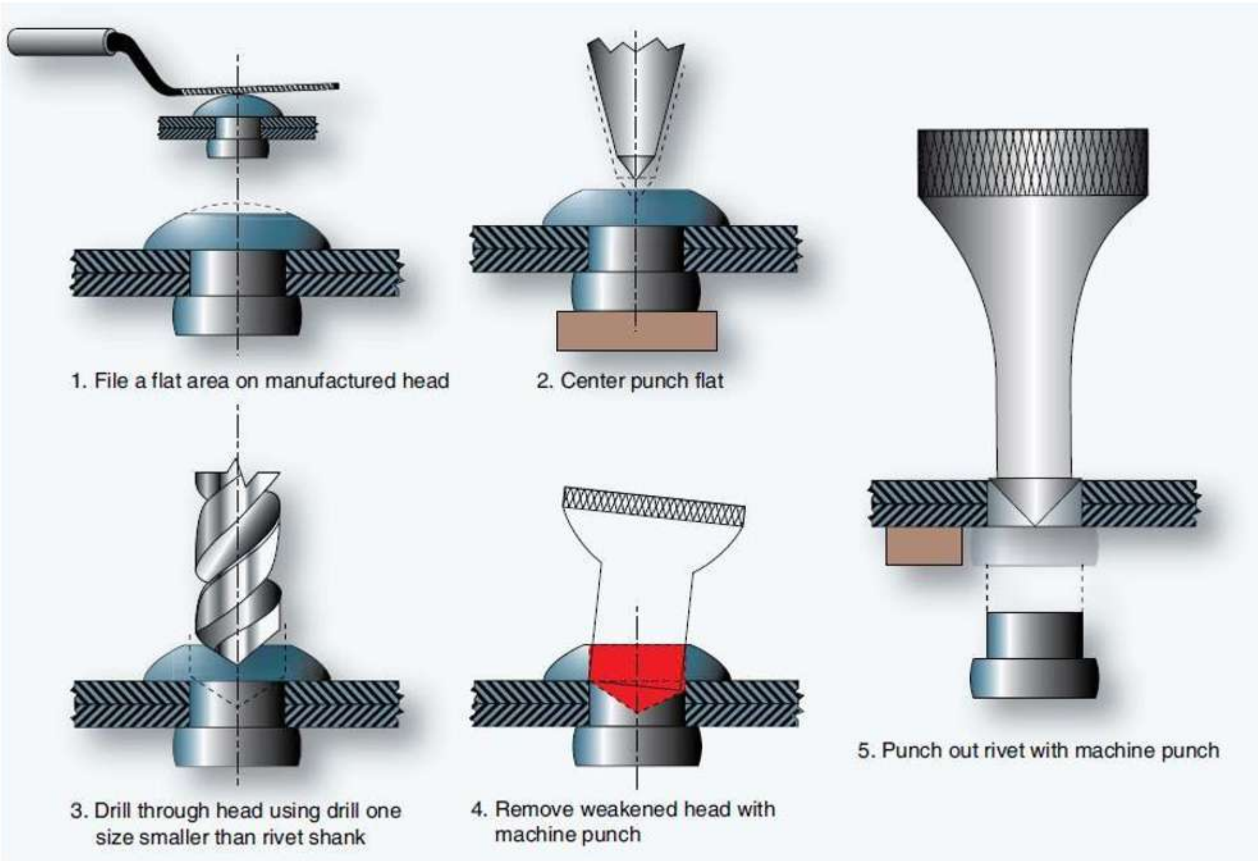
The nature of the test or inspection will depend on the type of component repaired, but one or other of the following examples may be applicable: -
Flying control surfaces should be checked for balance andoperation.

Pressure cabins may require a pneumatic inflation and leak test or proof pressure test in accordance with the approved aircraftmanual.
Integral fuel tanks should be given a pressure test, followed by a flow test or other test relevant to therepair.
Structure adjacent to moving mechanisms. The moving parts should be operated through their complete range of movement to ensure freedom from fouling. In some cases, a minimum clearance may be specified to allow for flexing during aircraftoperation.

Removal of rivets:

The usual method of removing solid rivets is as follows:

The utmost care should be taken when drilling and punching, to ensure that the original hole is notenlarged.
When removing rivets from assemblies which include bonded laminations or reinforcements it is essential not to apply shear loads liable to part thebond.
A different method of removing solid rivets, which is specified by some aircraft manufacturers, is to drill off the tail of the rivet with a drill slightly larger than the rivet shank and then punch out the shank and manufacturedhead.



Removing blind rivets:

Cherry rivets may be removed by punching out the stem from the locked end, then drilling off the head and

punching out the shank with a parallelpunch.
If the rivets are installed in thin sheet, however, the locking collar should be removed first by drilling into the stem with a pilot drill, then opening up the hole to shank diameter and prizing out thecollar.
Other types of blind rivet may be removed by drilling off the head with a drill the same size as the hole and punching out the remainder of therivet.

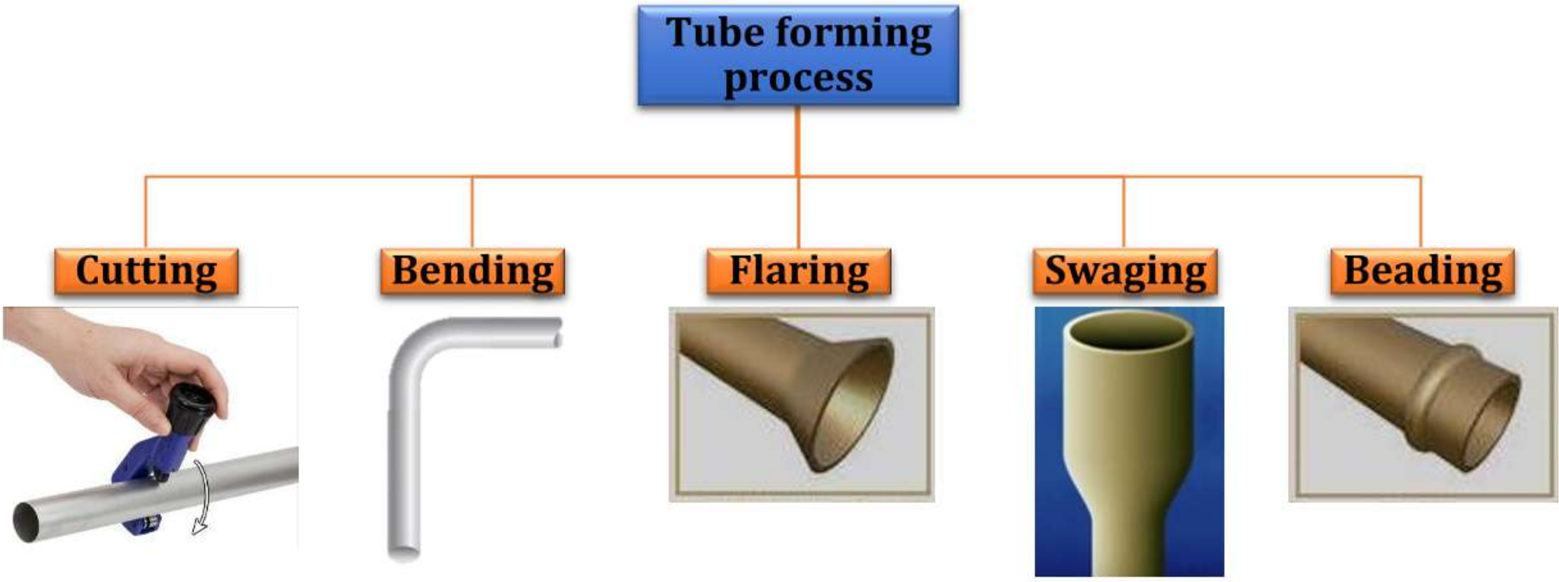
Removing Special rivets: [https://www.youtube.com/watch?v=EOuKOvjNLbw]
Using a hollow mill with an internal diameter slightly larger than the fastener shank, the collar should be milled off to just above the skin surface. The fastener may then be driven out, using a hollow dolly to support thestructure.
The head should be removed by the method described for removing solid rivets and the remaining pin and collar punchedout.

7.9 – Rigid Pipes:

A single aircraft typically contains several different types of rigid fluid lines. Each type of line has a specific application. However, as a rule, rigid tubing is used in stationary applications and where long, relatively straight runs are possible. Systems that typically utilize rigid tubing include fuel, oil, oxygen and instrument system.

Fabricating / Forming Rigid tubing:

When it is necessary to replace a rigid fluid line, you may obtain a replacement tube assembly from the aircraft manufacturer or fabricate a replacement in theshop.
Most shops have the necessary tools to fabricate replacement lines, and as a technician you must be familiar with their operation andlimitations.



- Tube cutting: [https://www.youtube.com/watch?v=x0_nfMdX37g]
When cutting a new piece of tubing, you should always cut it approximately 10% longer than the tube beingreplaced.
This provides a margin of safety for minor variation inbending.
After determining the correct length, cut the tubing with either a fine-tooth hacksaw or a roller-type tube cutter as shown in abovefigure.
A tube cutter is most often used on soft metal tubing such as copper, aluminium or aluminium alloy. However, they are not suitable for stainless-steel tubing because they tend to work harden thetube.

How to use:

Place the tubing in the cutting tool, with the cutting wheel at the point where the cut is to bemade.

Rotate the cutter around the tubing, applying a light pressure to the cutting wheel by intermittently twisting the thumbscrew.

Too much pressure on the cutting wheel at one time could deform the tubing or cause excessiveburring.

After cutting the tubing, carefully remove any burrs from inside and outside thetube.

Use a knife or the burring edge attached to the tubecutter.

The deburring operation can be accomplished by the use of a deburringtool,showninFigure.Thistooliscapableof removing both the inside and outside burrs by just turning the tool end for end.

Caution:When performing the deburring operation, use extreme care that the wall thickness of the end of the tubing is not reduced or fractured.

Very slight damage of this type can lead to fractured flares or defective flares which will not seal properly.

Use a fine-tooth file to file the end square and smooth.

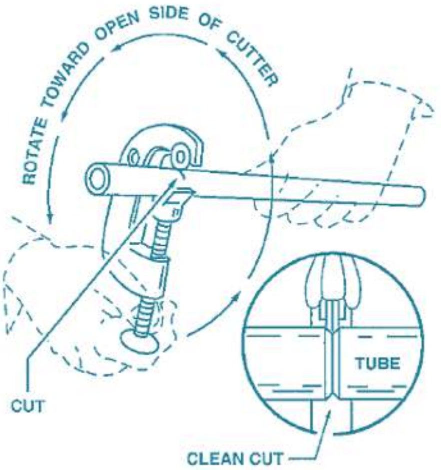
Holding a tube:

An easy way to hold small diameter tubing, when cutting it, is to place the tube in a combination flaring tool and clamp the tool in avise.

Make the cut about one half inch from the flaring tool. This procedure keeps sawing vibrations to a minimum and prevents damage to the tubing if it is accidentally hit with the hacksaw frame or file handle whilecutting.

Be sure all filings and cuttings are removed from thetube.

- Tubebending:

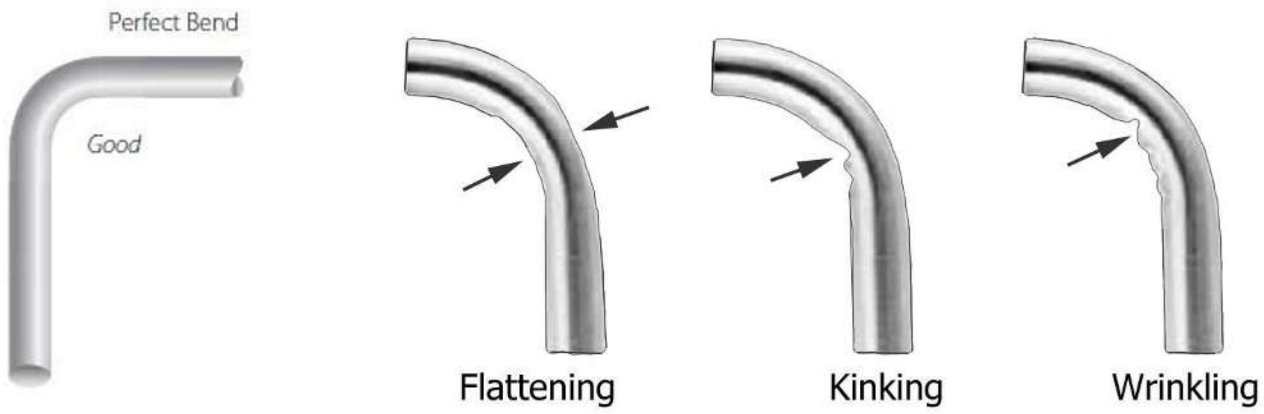


Problems during bending tubes:
Bend the tubing carefully to avoid excessive flattening, kinking, orwrinkling.
A small amount of flattening in bends is acceptable, but the small diameter of the flattened portion must not be less than 75 percent of the original outsidediameter.
Tubing with flattened, wrinkled, or irregular bends should not beinstalled.
Wrinkled bends usually result from trying to bend thin wall tubing without using a tube bendeExces
Flattened portion must not be less than 75 percent of the original outside diameter.

Procedures to follow before bending (to avoid such problems):

Fusible filler alloys:
Inordertobendatubewithoutsuchmentionedproblemsofflattening,kinks,wrinkles,
a tube has to be filled / loaded with fusible alloys before bending it.
Fusible alloys used for tube bending usually contain lead, tin, bismuth, andcadmium.
The material must be ductile, have a low melting point and should tend to expand on solidifying.
Resin, lead or bituminous fillers should not be used when bending pipes which are intended for use on aircraft systems because of the difficulty of ensuring that every trace of the filler has beenremoved.
Fusible alloy of the type recommended for use on aircraft pipes has a melting point below 100°C. Boiling water can, therefore, be used to melt the alloy for loading and unloading.

The bending operation must take place as soon as the fusible filler alloy has solidified. After bending, the tube should b immersed again in the boiling water to melt and remove thefillers.
Lubricating the tube before loading the filler alloy:



Before filling the tube, the bore of the tube must be thoroughly clean and dry; it should then be coated with a continuous film of lubricating oil, or lubricating oil and paraffin, as may be prescribed by the makers of the fusiblealloy.
Oiling should be done either by completely filling the tube or immersing the tube in an oil bath; an oily wad drawn through the tube is notsatisfactory.
It is essential that only clean oil is used for thispurpose.
A straight mineral lubricating oil of viscosity equivalent to SAE 10 is usually recommended, as detergent additives in engine oils tend to cause sticking of the alloy on emptying thetube.

Loading the filler alloy:
When the tube has been lubricated it should be plugged at one end and immersed in hot water to within a few inches of the openend.
When the tube has acquired the temperature of the water and while still immersed, the fusible alloy should be poured gently into the open end of thetube.
It is essential not to damage the oil film or to create air pockets during this filling operation.
Immediately after filling, the whole tube should be cooled by immersion in coldwater.
To prevent the formation of cavities the cooling should take place progressively from the pluggedend.
The ductility of filler alloys depends on rapid, efficient quenching. After quenching, the loaded tubes should be allowed to attain room temperature before bending commences.

Unloading the filler alloy and cleaning the tube:
After a tube has been bent to the desired shape, it should be unloaded by completely immersing it in boiling water to melt the filleralloy.
The hot water enters the tube at this stage and care must be taken to preserve the protective oilfilm.

Violent agitation of the tube and contents should beavoided.
Breaking of the oil film will cause the fusible alloy to adhere to the bore either as beads or in the form of tinning (spreading) which, once formed on a tube, may be impossible to remove.
Even without breaking the oil film, beads of fusible alloy may form around particles of dirt.

These beads can be removed only when they are in the solid condition, and any attempt to remove them in the molten condition may cause tinning(spreading).
A stiff, rotating wire brush may be used for cleaning some tubes, but must be of a type which will not damage thebore.
Alternatively, a steam jet may be used, but it is important to ensure that the steam is notsuperheated.
As a final cleaning operation, and where neither of these methods is considered advisable, a tight-fitting felt pull-through (a cloth) should be passed through the pipe in bothdirections.
Alternative to oiling:
As an alternative to oiling, a thin plastics sheathing can be used to prevent contact of thefilleralloywiththeinteriorofthetube,therebyeliminatingthepossibilityoftinning.
The plastics sheath is passed through the tube and is secured by expanding it over the end of thetube.
Sheathing should not exceed 0·010-inch wall thickness, otherwise the rate of quench will be retarded, adversely affecting the ductility of the filleralloy.
Plastics sheathing should be examined after removal to ensure that it is still intact and that no leakage of filler has occurred which may adhere to the inside of thepipe.
Note:As visual examination of the bores of bent pipes is impracticable, if contamination is suspected, radiographic inspection techniques should be used. If contamination is found the manufacturer of the fusible alloy should be consulted.

Pipe Bending machines:

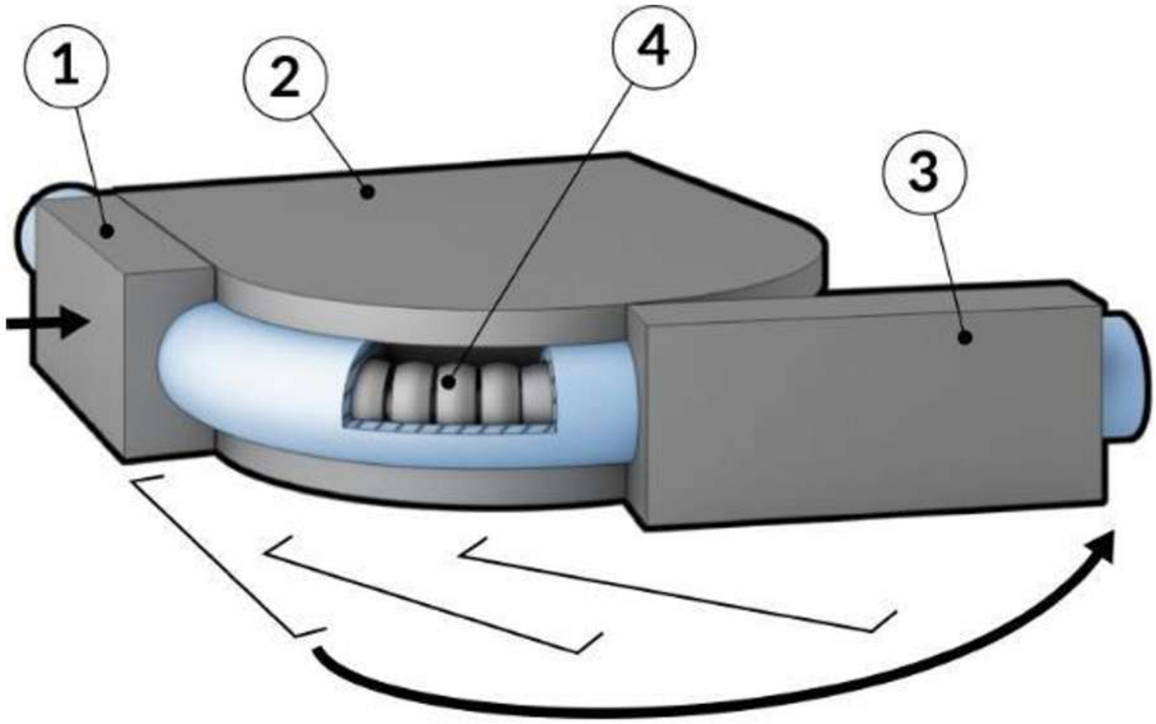
These are normally either compression or mandrel machines and may be hand operated, power assisted or fullyautomatic.

Compression bending machines:

[https://www.youtube.com/watch?time_continue=71&v=0-gDZw5uYT8&feature=emb_logo]

Compression bending machines are provided with circular formers (2) in various diameters, grooved around their circumferences to fit a particular diameterpipe.

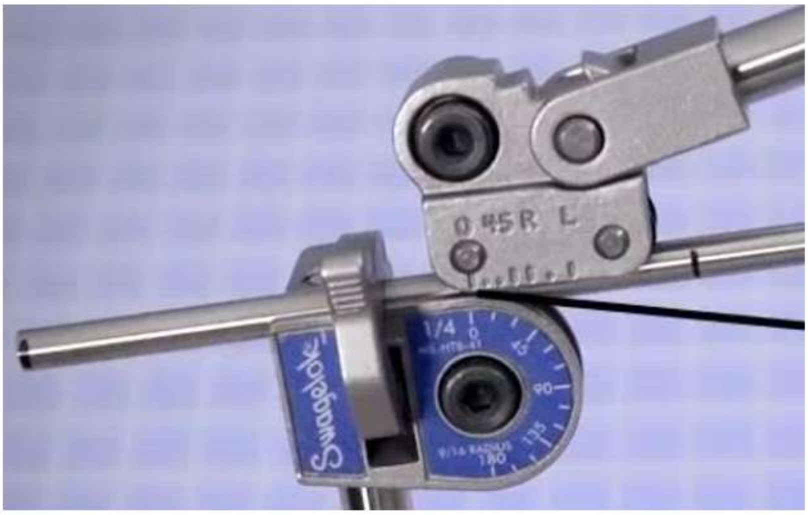
The pipe is bent by rolling a similarly grooved guide (3) round the former, the semi-circular grooves exactly fitting the outside diameter of the tube and preventing distortion from takingplace.

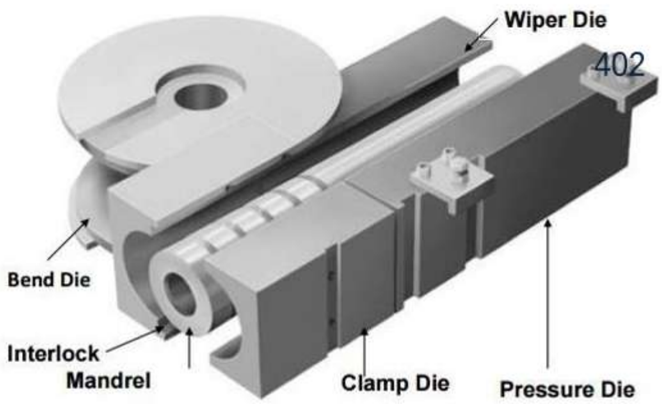


Note:When the mean radius of the bend is larger than four times the outside diameter of the pipe, bending is possible on a compression bender without using a filler but the insertion of a close-fitting spring (4) may be recommended.
A compression bender can also be used when the mean radius is less than four times the outside diameter provided that a fusible filler alloy is used to maintain fullbore.

Mandrel bending machines: [https://www.youtube.com/watch?v=QoUyFcDA27M]
When it is required to produce full bore bends without the use of a filler on mean radii less than four times the outside diameter of the pipe, mandrel benders areused.
These machines are also provided with interchangeable formers grooved to receive any particular size of tube but, in addition, plain or articulated mandrels are used which are machined to closely fit the inside diameter of the tube and support it at the bend.
The method of bending called for on the drawing will, however, depend largely on the material from which the tube is made, its diameter and the wallthickness.
Note:According to the tube material, heat treatment may be required before or after bending, but in all cases the actual bending operation is carried out at room temperature.
Hand Bender tool: [https://www.youtube.com/watch?v=Eo95bjm7WFM]
Tubing under 1/4-inch in diameter usually can be bent without the use of a bending tool. For larger sizes, either portable hand benders or production benders are usually used.

Using a hand bender, insert the tubing into the groove of the bender, so that the measured end is left of the form block.





Align the two zeros and align the mark on the tubing with the L on the form handle. If the measured end is on the right side, then align the mark on the tubing with the R on the formhandle.

With a steady motion, pull the form handle until the zero mark on the form handle lines up with the desired angle of bend, as indicated on the radius block
(90deg as shown
in fig)

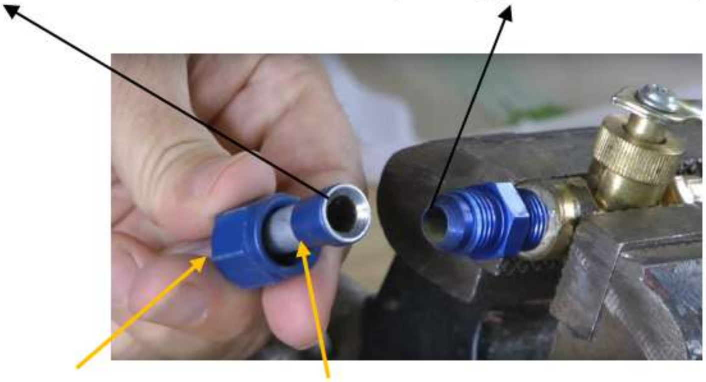
Joining methods:

Sections of rigid tubing can be joined to another tube or to a fitting by several methods. These include single and double-flare connectors, flareless connectors, or a hose and clamps over a beaded tube.
The type of fittings used is determined by the pressure range, the routing, and the material being used for the lines. Whenever you must replace a fitting, make sure you select a fitting made of the same material as original.

Tube Flaring:

Flaring is necessary to fit certain standard types of pipecouplings.

The flared end of the pipe must seat on the coned face of an adaptor nipple or externally conedadaptor.



By means of a collar (B-nut) and union nut (sleeve), the flared end and coned face are joined together, forming a connection capable of holding considerable fluidpressure.

The sleeve provides added strength and supports the tube so that vibration does not concentrate at the flare. The collar fits over the sleeve and when tightened, draws the sleeve and the flare tightly against a male fitting to form aseal.

The close fit between the inside of the flared tube and the flare cone of the male fitting provides the actual seal. Therefore, these two surfaces must be absolutely clean and free of cracks, nicks andscratches.

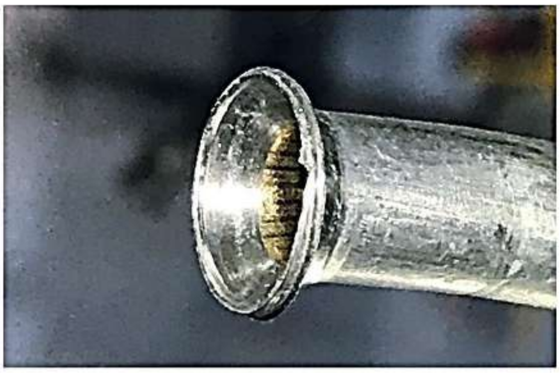
Aircraft fittings have a flare angle of 37°, and are not interchangeable with automotive- type fittings, which have a flare angle of45°.

Precautions before flaring operation:

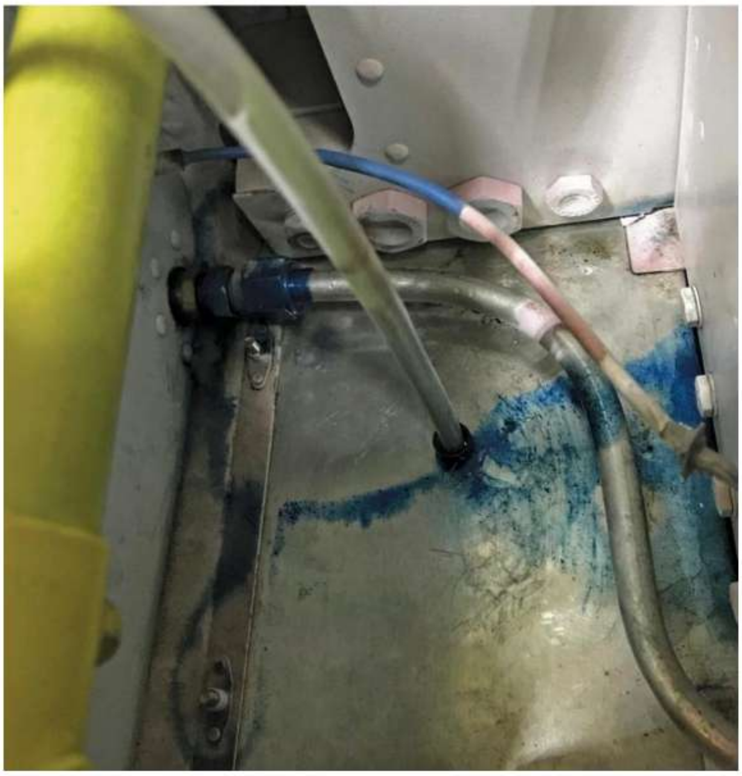
If bending has to be done, then it is advisable that the pipe should be bent to shape beforeflaring.

The pipe end should be square, smoothly finished and clean; a rough or burred edge may cause the pipe to split whenflared.

Activity: [Incident due to improper maintenance with pipe]



A major fuel leak was discovered on this airplane not long after the first flight. The majority of the fuel in the tank leaked out overnight. The culprit was a cracked flare at the tank pickup, as well as the use of an improper flaring tool. Standard AN fittings require a 37-degree flare, not the typical 45-degree flare used in the automotive industry.



Types of flare: [https://www.youtube.com/watch?v=XCr2YTg5mKo]

There are two types of flare used in aircraft plumbing system: Single flare and Double flare.

Single flare forming with Impact-type flaring tool:

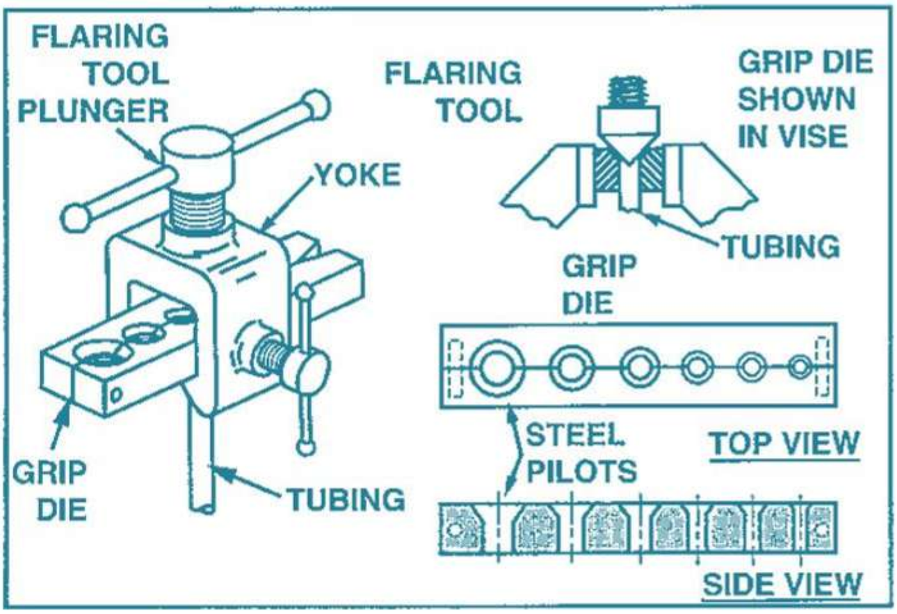
First the tube must be cut squarely and the endpolished.
Before the tube is flared, a B-nut and sleeve are slipped on the tube.

The tube is then placed in the proper size hole between the halves of the flaring blocks and the plunger is centered over the tube.

Once centered, project the end of the tube about 1/16-inch above theblocks.

The blocks are then clamped in a vise and the plunger is driven into the tube with several light blows of hammer, making sure the plunger is rotated one-half turn after each blow.

Too many blows can work harden thetube.



Single flare forming with Roll-type flaring tool:

These flaring tools are self-contained and produce a goodflare.

It can flare tubing from 1/8 to 3/4-inches outsidediameter.

The tool consists of a flaring block or grip die, a yoke, and a flaringpin.

The flaring block is a hinged double bar with holes corresponding to various sizes of tubing. These holes are countersunk on one end to form the outside support against which the flare isformed.

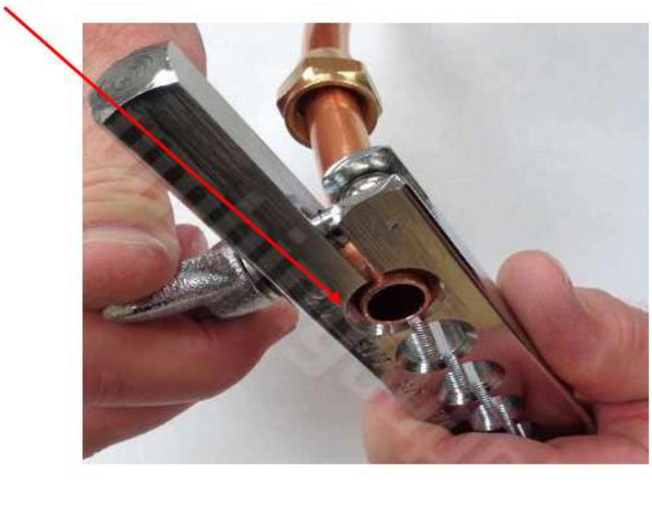
Use these tools only to flare soft copper, aluminum, and brass tubing. Do not use with corrosion resistant steel ortitanium.

Cut the tube squarely and remove all burrs. Slip the fitting nut and sleeve on the tube. Loosen clamping screw used for locking the sliding segment in the dieholder.

This will permit theirseparation.

The tools are self-gauging; the proper size flare is produced when tubing is clamped flush with the top of the dieblock.

Insert tubing between the segmentsof the die



block that correspond to the size of the tubing to be flared.
Advance the clamp screw against the end segment and tightenfirmly.

Move the yoke down over the top of the die holder and twist it clockwise to lock it intoposition.
Turn the feed screw down firmly, and continue until a slight resistance is felt. This indicates an accurate flare has beencompleted.

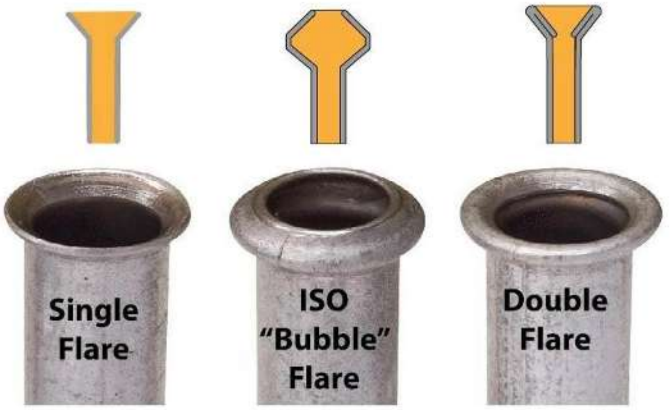
Proper Flaring:

Flares are frequently subjected to extremely high pressures; therefore, the flare on the tubing mustbe properly shaped or the connection will leak orfail.
A flare made too small produces a weak joint, which may leak or pull apart; if made too large, itinterferes with the proper engagement of the screw thread on the fitting and will cause leakage.
A crooked flare is the result of the tubing not being cutsquarely.
If a flare is not made properly, flaws cannot be corrected by applying additionaltorque when tightening the fitting (Do not overtighten a leakyfitting).

Double flare [https://www.youtube.com/watch?v=Irmh7B7OnHQ]

A double flare is **used on soft aluminum alloy tubing 3/8" outside diameter and under**.
This is necessary to prevent cutting off the flare and failure of the tube assembly under operatingpressures.
A double flare is smoother and more concentric than a single flare and therefore seals better.
It is also more resistant to the shearing effect oftorque.

How to do:

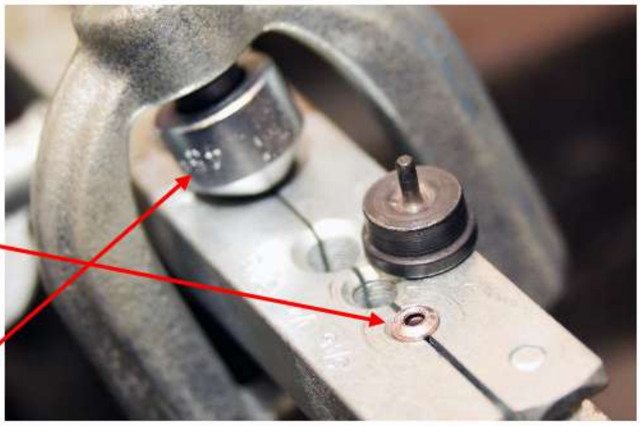


Deburr both the inside and outside of the tubing to be flared. Cut off the end of the tubing, if it appearsdamaged.
Anneal brass, copper, and aluminum by heating to a dull red and cool rapidly in coldwater.
Open the flaring tool by unscrewing both clamping screws. Select the hole in the flaring bar that matches the tubing diameter and place the tubing with the end you have just prepared, extending above the top of the bar by a distance equal to the thickness of the shoulder of the adapterinsert.

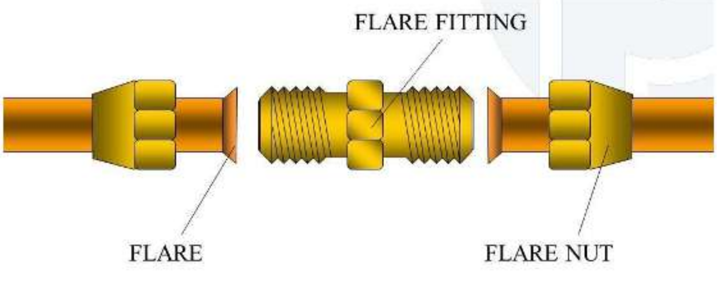
Tighten clamping screws to hold tubingsecurely.
Insert pilot of correctly sized adapter into tubing. Slip yoke over the flaring bars and center over adapter.
Advance the cone downward until the shoulder of the adapter rests on the flaring bar. This bells out the end of thetubing.
Next, back off the cone just enough to remove the adapter. After removing the adapter, advance the cone directly into the belled endof
the tubing. This folds the tubing on itself and forms an accurate double flare without cracking or splitting thetubing.
To prevent thinning out of the flare wall, do not overtighten.

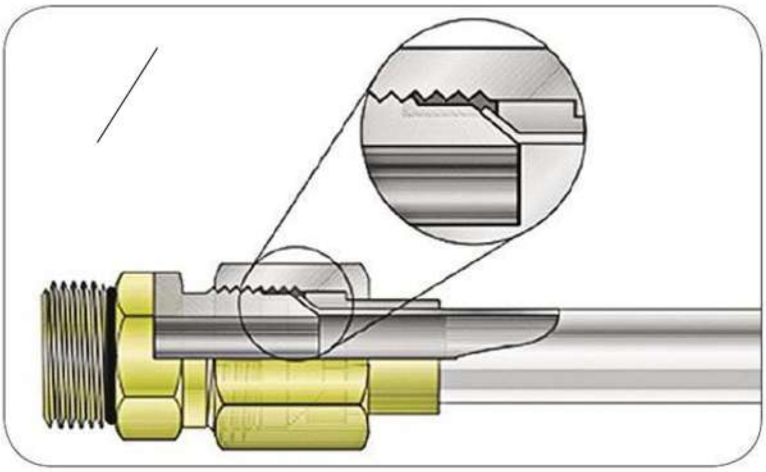
Fittings:

Flared tube fittings – High pressure coupling:



Nipple with parallel





All couplings now use a similar method of assembly, a flared pipe, adaptor nipple, collar, outer sleeve and inner sleeve being the basic components in the high-pressurejoint.
The parallel extension should always be inserted into the flared pipe which is fitted with a collar (flare nut) and outer sleeve as shown in abovefigure.

Flareless fitting: [https://www.youtube.com/watch?v=ItBNIgtLprs]

The flaring operation leaves the tube end in a stressed condition and, since it is the flare which carries the load in a fitting, vibration may eventually result in fatiguefailure.

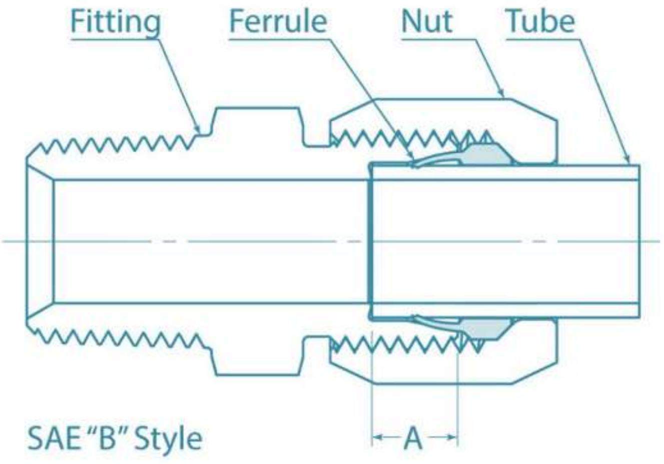
To prevent pipe couplings from failing in this way a different type of coupling known as the 'flareless' coupling was devised and is in common use on civilaircraft.

The heavy wall tubings used in some high-pressure systems is difficult to flare and for this, a flareless fitting provides a leak-freeattachm

The individual parts of the coupling are assembled as shown in Figure and thenut screwed on to its fitting until it is fingertight.

The nut is then turned a further full turn with a spanner, this action bowing the sleeve (ferrule) and causing it to bite (bottoming) into the tube at its forwardend.

It is important that the final tightening commence at the point where the nut just begins tobottom.
Use a wrench and turn the nut one-sixth turn (one flat on a hex nut) or one-third turn (two flats on the hex nut). Use a wrench on the connector to prevent it from turning while tightening thenut.
Never tighten the nut beyond one-third turn (two flats on the hex nut); this is the maximum the fitting may be tightened without the possibility of permanently damaging the sleeve andnut.
When the nut is slackened (loosened) the sleeve remains permanently bowed and attached to the pipe. This is called pre-setting (setting theferrule)
This pre-setting operation may be carried out using the fitting which is to be used in service, but a special hardened steel fitting is often used for pre-settingpurposes.
After pre-setting, the pipe should be inspected to ensure that the sleeve is correctly bowed and that the sleeve end has bitten into thepipe.



The pilot (tip of ferrule) should be close to or touching the pipe, and end play (axial clearance or movement) should be less than 0·010 inch. It is permissible for the sleeve to rotate on the pipe.
Note:After the tube assembly is installed, the system should be pressure tested. If leakage still occurs after tightening the nut a total of one-third turn, remove the assembly and inspect the components for scores, cracks, presence of foreign material, or damage from over tightening. Several aircraft manufacturers include torque values in their maintenance manuals to tighten the flareless fittings.

Beading: [https://www.youtube.com/watch?v=EGjExCGunEQ]
In the case of attachment to a hose, it may be necessary to bead the rigid tube so that a clamp can be used to hold the hose onto the tube. Used in low pressure connections like large diameter lines carrying low-pressure fluids such as engine return oil and cooling air.

Tools for beading:
A hand beading tool is used with tubing having 1/4-inch to 1-inch outsidediameter.
The bead is formed by using the header frame with the proper rollersattached.
The inside and outside of the tube are lubricated with light oil to reduce the friction between the rollers duringbeading.
The sizes, marked in sixteenths of an inch on the rollers, are for the outside diameter of the tubing that can be beaded with therollers.

The hand beading tool works somewhat like the tube cutter in that the roller is screwed down intermittently while rotating the beading tool around thetubing.
In addition, a small vise (tube holder) is furnished with thekit.

Exposed Locations:

Maintenance and Repair:

Pipes which are attached to the structure of an airframe may often be in a shielded position and will not normally be subject to accidental damage, but other pipes are located in exposed positions where they may be highly susceptible to damage or corrosion.
Pipes located in a wheel bay, or attached to an undercarriage leg, could easily be damaged by stones, mud or detached rubber thrown up from the tyres or corroded by regular contact withwater.
In other positions pipes maybe subject to abuse from carelessly performed, unrelated servicingactivities.
Special care must, therefore, be taken when inspecting pipes in exposedlocations.

Leaks:

The presence of a leak from a pipe connection in a liquid system will often be shown by the presence of liquid or an accumulation of dust or dirt on the outside of the pipe or connection.

Leakage from a gas system may only be detected by the loss of system pressure, but the position of the leak may usually be detected by bubbles after painting the pipes and connections with a solution of water and acid-freesoap.

Repair of Rigid pipes:

Minor dents and scratches in tubing may berepaired.

Scratches or nicks not deeper than 10 percent of the wall thickness in aluminum alloy tubing, which are not in the heel of a bend, may be repaired by burnishing with hand tools.

The damage limits for hard, thin walled corrosion-resistant steel and titanium tubing are considerably less than for aluminum tubing, and might depend on the aircraft manufacturer.

Consult the aircraft maintenance manual for damagelimits.

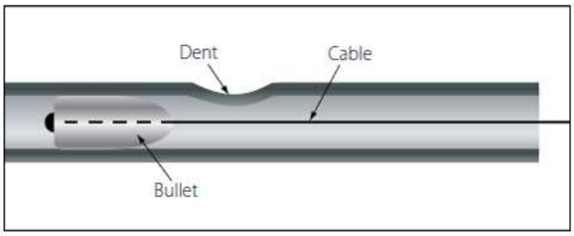
Replace lines with severe die marks, seams, or splits in the tube. Any crack or deformity in a flare is unacceptable and is cause forrejection.

Dent repair:

A dent of less than 20 percent of the tube diameter is not objectionable, unless it is in the heel of a bend.

To remove dents, draw a bullet of proper size through the tube by means of a length of cable, or push the bullet through a short straight tube by means of a dowelrod.

In this case, a bullet is a ball bearing or slug normally made of steel or some other hard metal. In the case of soft aluminum tubing, a hard wood slug or dowel may even be used as abullet.



Repair using standard couplings:

Damage to rigid pipes which is outside the specified limits for acceptable damage, will usually necessitate the removal of the affected pipe and the fitting of a new or reconditioned item. However, in some cases repairs may be permitted, either by the insertion of a new portion of pipe or by the insertion of a coupling, depending on the extent of the damage.

These repairs will normally involve removal of the damaged pipe, since the pipe ends will have to be flared or flareless couplings fitted, and will usually be applied only to straight sections ofpipe.

However, the addition of a pipe coupling could change the resonant frequency of that portion of pipe, and this could lead to vibration and fatigue; these repairs should thus only be used when specified in the relevant MaintenanceManual.

Method 1:

A circumferential crack or deep score may be repaired by cutting out the small damaged section of pipe and inserting a union body and twoconnections.

Care should be taken to ensure that the final length of pipe is correct and that the couplings will not foul parts of the structure wheninstalled.

The pipes should be thoroughly cleaned after preparation of the ends, and pressure tested beforere-installation.

Method 2:

If the damage is in excess of that which could be repaired as outlined in Repair method 1, the damaged portion of pipe should be cut out and a new section inserted, using two new union bodies and connections, or, if the damaged portion includes one existing end fitting, by replacing that fitting and joining the new section to the old with a union body and twoconnections.

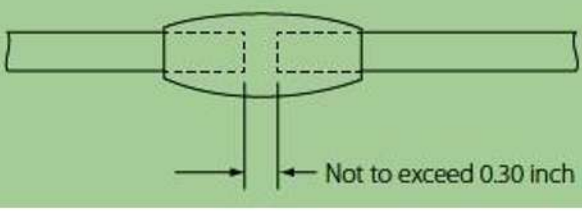
Repair using Swaged fittings:

External Swaging process [https://www.youtube.com/watch?v=T33O_NtUTM8]

The damage which can be repaired by this process is broadly as outlined in above repair methods 1 and 2 and the repair consists of a tubular fitting which is swaged over a pipe joint.

The gap between the pipe ends can be up to 8 mm (0·3 in), thus permitting a degree of latitude when replacing a damaged portion of pipe. Typical repairs are illustrated below:-

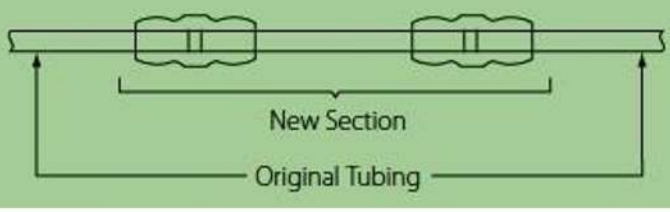
1. Pin hole leak or circumferential crack in tubing.



1. a. Make 1 or 2 cuts as necessary, to remove damaged section. If 2 cuts are required, the distance between them shall not exceed 0. 30". If distance is more than 0.30 inch, go to repair method 2.

b. Swage 1 tube-to-tube union in tube section under repair.

2. Longitudinal crack in tubing (crack length in excess of 0.30").



2. a. Make 2 cuts to enable removal of damaged section.

b. Remove damaged section and duplicate.

c. Swage replacement section into tubing under repair using 2 tube-to-tube unions.

The equipment necessary for carrying out externally swaged repairs is a hydraulically operated swaging tool with pairs of dies to cover the range of pipediameters.

GO/NO GO gauges enable checking of the swaging operation to be carriedout.

Testing, Installation, Inspection & Repair:

Testing before Installation:

Bore test:

Pipes should be tested to ensure that the bore is clear and dimensionally correct after forming.

One method of satisfying this requirement is to pass a steel ball, with a diameter of 80 per cent of the internal diameter of the pipe, through the pipe in bothdirections.

When, owing to the design of the pipe or the size of the end fittings, this test is impracticable, or when a more searching test is required, the drawing will normally require a flow testto beperformed.

In this test it must be demonstrated that the pipe is capable of passing a specified quantity of fluid, in the time, and under the conditions stipulated on thedrawing.

Pressure test:

Before Pressure testing, verify that

The test equipment and instruments are adequate for the tests specified on the drawing.

The test fluid is clean and suitably safeguarded by filters against the ingress ofdirt.

The test equipment and instruments are checked at regularintervals.

A record should be kept of the checks and theresults.

Fitting flared pipe assemblies to a test rig: -

The component parts of a flared coupling require bedding-in to ensure freedom from leaks, and the following procedure should be adopted when fitting flared pipe assemblies to a test rig: -

Assemble the component parts of the coupling and· run tip the union nut byhand.

Using a suitable spanner to prevent rotation of the union, tighten the union nut to the specified torquevalue.

Slacken the nut a half to one turn then retighten to specified torquevalue.

Should the, connection fail to seal properly the coupling should be critically examined for likely causes such as scratches or dirt. The specified torque should never be exceeded as this may damage the joint.

Hydraulic pressure testing:

After coupling to the appropriate pressure delivery point on the test rig, the pipe to be tested must be checked for full bore flow by pumping fluid through it and checking the flow at the open end.
Ifsatisfactory,theopenendshouldbesuitablyblanked.Thepressureshouldthenbe

built up to that prescribed on the drawing, which is usually 1times the maximum –
working pressure of the pipe in service.
The pressure should be maintained long enough to ascertain that no leaks occur, or for such a period of time as may be specified on thedrawing.
Note:The fluid used for hydraulic pressure testing may be either oil, paraffin or water. It is, however, recommended that, whenever possible, the fluid should be the same as that used in the completed system.

Testing Pneumatic and Oxygen Pipes:
Pneumatic and oxygen pipes are normally given a hydraulic pressure test using water as the test medium, followed by a compressed air test which is limited to maximum system pressure.
Test condition Using high pressure air can be extremely dangerous and the pipes should be located behind a heavy plastics screen and submerged in water during the test.

Test rig:
The pneumatic test rig should include a pressure regulator, pressure gauge, relief valve, oil and water trap, and adequate filters to ensure that the air supplied during test is not contaminated.
All of these components should be inspected at frequent intervals and every precaution taken to prevent the entry of dirt or grease into the pipe beingtested.

When conducting the test, the relief valve and regulator should be set at test pressure, and air slowly introduced into thepipe.

Test pressure should normally be maintained for a period of five minutes and the pipe examined for leakage, indicated bybubbles.

Cleaning after test:
After a pipe has been tested it should normally be flushed through with white spirit or other similar solvent, dried with a jet of Clean, dry air and securely blanked.
Special care:
Special care must be exercised when cleaning pipes used in high pressure air and gaseous or liquid oxygen systems; these pipes must be scrupulously clean and free from any possible contamination by oil orgrease.
It is usually recommended that pipes for use in these systems are flushed with trichloroethylene, blown through with double filtered air, and blanked-off immediately.
Pipes should never be blanked with adhesive tape orrag.

Marking:
Pipe assemblies should be marked to indicate that they have passed the prescribed pressuretest.
The marking should conform to the method specified for the identification of pipes by the aircraft manufacturer, and will usually be by rubber stamp on the pipe itself or by metal stamping on a label attached to thepipe.
Note:Where the drawing requires identification labels to be attached by soldering, the solder must be continuous round the whole label. Serious corrosion may occur if spot soldering is employed or if gaps are present in the solder fillet.

Installation:

Pre-Installation checks:

Before a pipe assembly is fitted into an aircraft, it should be checked to establish that it is of the specified type and that there is evidence of prior inspection and testing. The inspector's stamp should normally appear adjacent to the partnumber.

Prior to assembly, all pipes should be blown out with clean, dry air and, where applicable, flushed with clean, filtered fluid of the type to be used in the particular system in which the pipes are to beinstalled.

For pipes used in oxygen systems an additional approved degreasing process should also be used, since oil or grease in contact with oxygen under pressure may cause an explosion.

If a pipe is not to be installed immediately, its ends should be blanked following pre- installation inspection and tests, using the blanks fitted during storage or suitable alternatives.

Plugs and blanks to standard specification are generally suitable for tins purpose, but in instances where standard blanks cannot be fitted it must be ensured that the blank used is so made that it cannot be left in position when the pipe isinstalled.
Rag, tape or paper should not be used for blankingpurposes.

Installation:
Pipes should be loosely fitted into position in the supporting clamps and adjusted so that the connections meet correctly. The connections should be completed, the clamps tightened and bonding attached as specified.
Pipe supports:

Clamps are used to secure fluid lines to the aircraft structure, or to the assemblies in the engine andnacelle.
In addition to the providing support, these clamps prevent chafing and reduce stress. The three commonly found clamps in aircraft are; Plain clamp, Rubber-cushioned clamp and bondedclamps.
The rubber cushioned clamp secure lines which are subjected tovibration.
In areas subject to contamination by fuel or phosphate ester type hydraulic fluid, cushioned clamps utilizing Teflonsare used, which highly resistdeterioration.

In instances where packing is required between the pipes and clamps, the material used should be that specified in the relevant manual ordrawing.
Typical packing materials are cork sheet, tinned copper or stainless-steel gauze and various types of tape or low-friction liners, but leather should not be used since it may cause corrosion of thepipes.

The plain clamp is used in areas that are that are not subject to vibration and typically consists of a metal band formed into acircle.

A third type of clamp used to secure metal fuel, oil, or hydraulic lines is the bonded clamp.
Bonded clamps have an electrical lead that is connected to the aircraft structure to ground atube.

When installing bonded clamp, be sure to remove any paint or anodizing from the tube where the bonding clamp is fastened. Unbonded clamps should be used only to secure wirings.

Where individual pipes require support, standard clips are usually specified and usually have a moulded rubber lining which obviates the need forpacking.
Where individual pipes run close together a double type of 'P' clip is often used to avoid contact between the pipes and to providesupport.
Clearance:
A minimum clearance of 6 mm (0·25 in) from fixed structure, 18 mm (0·75 in) from control rods and rigid moving parts, and 25 mm (1 in) from control cables, must be maintained, otherwise vibration and movement may causechafing.
A gap of 6 to 12 mm (0·25 to 0·5 in) should exist between the pipes to prevent contact when flexingoccurs.
Particular care is necessary to ensure that adequate clearance is maintained between pipes and moving parts, and tests should be carried out to ensure that clearance is satisfactory throughout the full range of movement of the associatedpart.
Consideration should also be given to effects which it may not be possible to simulate, such as an increase in tyre diameter due to centrifugal force, or in width due toageing.

Connection:
Two spanners should always be used when tightening (or disconnecting) a pipe coupling; one to hold the sleeve or adaptor and one to turn the unionnut.

Overtightening should be avoided since many standard pipe couplings are made of aluminium alloy, which can easily bestrained.
Any special tightening techniques or tightening torque values specified in the relevant publication should be carefully observed.

Tests after Installation:
All pipes will have been pressure tested following manufacture, but it is usually necessary to carry out pressure and flow tests after installation of a pipe, to ensure that there are no leaks from the pipe and its connections and that, where essential to the correct operation of the associated system, the required flow rate is obtained.
Power for carrying out the tests may be provided by the aircraft engine-driven pumps or by an external test rig suitable for the systemconcerned.

Clearance test:
While the associated system is pressurised, and while the services are being operated, the pipelines should be inspected for flexing or displacement to ensure that the required clearances aremaintained.
The pipe supports should also be checked for security of attachment and the pipes should be checked for local distortion at the clampingpoints.
Leakage test:
Leakage from pipes in liquid systems (e.g. hydraulic systems) can usually be detected by careful visual inspection, and leakage from gas systems (e.g. pneumatic systems) can usually be detected aurally or, after painting the pipes and connections with a solution of water and acid-free soap, be detected by the appearance ofbubbles.
If the soap solution is used it should be washed off immediately after thetest.
If leakage from a connection is apparent, the connection may be tightened, but should not be over-tightened in an attempt to cure theleak.
Leaks are often caused by solid particles at the mating faces of a joint, by misalignment of a nipple, or by damage to one of the components in thejoint.
Loosening and re-tightening of a coupling will often cure a leak but if it does not do so, the coupling should be disconnected and the cause of the leakageascertained.
Po
st-test: After all tests have been completed satisfactorily, it is important to ensure that any liquid which may have leaked or been spilled on the airframe structure or components isremoved.
In addition to any fire hazard, aircraft liquids may also have deleterious effects on some of the alloys and compounds with which they come intocontact.
When the work of installing and testing a pipe is complete, the connections should, where applicable, be locked in the appropriatemanner.

Flexible hoses – Storage & Installation:

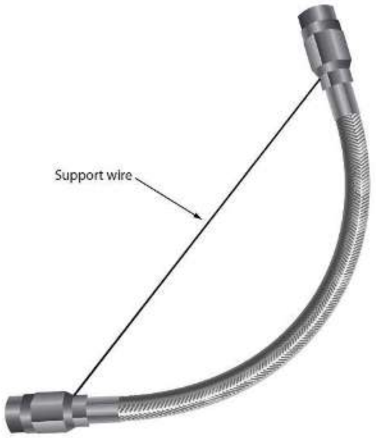
The term "hose" is used to describe a flexible tube which may be used on its own in some locations and the term "hose assembly" is used to describe the hose complete with end fittings.
Hoses are used extensively on aircraft to connect stationary parts to moving parts and in areas of highvibration.
Construction:

It generally consists of an inner liner covered with layers of reinforcements (wire braids, either moulded or sandwiched between the synthetic rubber of the tube, or woven on the surface of the tube) to provide strength and an outer cover to protect them from physicaldamage.The end fittings on a hose assembly are designed to exert a grip on both the tubes and wire braids so as to resist high pressure, twisting and vibrating loads, and to provide an electrical bond throughout theassembly.
Inner layer:

There are basically four different synthetic rubber compounds used in the construction of the inner liner.
Neoprene and Buta-N – Used to carry petroleumproducts.
Butyl – Made from petroleum raw materials and therefore breaks down if used with petroleum products. Butyl is best suited for fluid lines carrying phosphate ester-base hydraulic fluids such asSkydrol.
Teflon – Tetrafluoroethylene & Polytetrafluoroethylene (PTFE) has an extremely broad operating temperature range (-65°F to +450°F) and is compatible with nearly every fluid used.
PTFE is widely used for the manufacture of hose for engine and hydraulic systems.
This material is chemically inert and normally has an unlimited shelflife.

Storage of hose and hose assemblies:
PTFE hose does not normally have a specified storage life, but rubber or synthetic rubber hose normally has a storage life, depending on the formulation of the material, of between three and five years.
Note:The storage life of hose supplied in bulk is calculated from the cure date, and the storagelife of hose assemblies is calculated from the date of manufacture or assembly.

Storage conditions:
Bulk supplies of hose are generally stored in coils of large diameter, but hose assemblies should be stored flat and relieved ofstress.
Hose and hose assemblies should be stored away from strong light and running electric motors, andair should



be permitted to circulate freely about the parts unless they are contained in plastics envelopes.

The temperature should be controlled between 10°C and26°C.
Preformed hose assemblies and PTFE hose assemblies which are being stored after removal from an aircraft system must be stored in such a way that the required or assumed shape is maintained; no attempt should be made to straighten or bend these hoses.
A length of locking wire may be attached between the end fittings to prevent the hose from straightening.

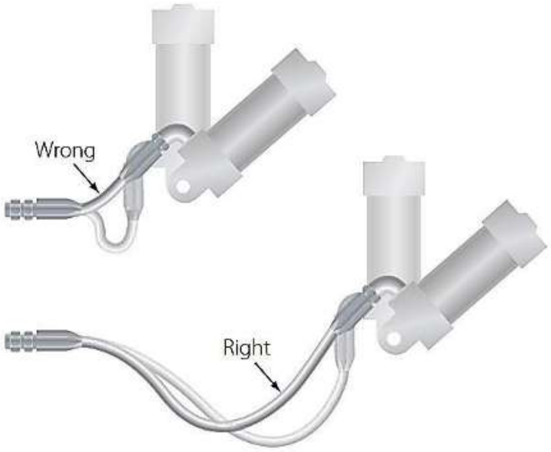
Sealing blanks:
During storage, the correct sealing blanks should be fitted. In instances where the standard blanks cannot be used, blanks should be so designed that they cannot enter the end fitting or be left in position when the assembly isconnected.
It is also important to ensure that the material used for blanking will not "pick-up" or otherwise tend to leave small particles inside the end fitting after long periods of storage.
Tape or rag must not be used for blankingpurposes.

Bore protection:
In some special cases, to prevent deterioration of the bore or inner lining of the hose, it may have to be stored filled with the liquid which it is intended to contain in service; special instructions concerning such assemblies will normally be attached by the manufacturer.
If a hose assembly is issued in an airtight plastics envelope, this should not be removed until the part is'fitted.
Should the envelope become damaged during handling, any desiccant contained within should be checked for condition and the envelope should be re-sealed orrenewed.

Pre-Installation checks:
Where possible, every hose assembly should be examined internally to ensure that the bore is free from obstruction ordamage.
Straight hose assemblies may be examined by looking through them with a light positioned at the opposite end, but preformed hose should be checked by means of a balltest.
If the end fittings have been welded, brazed or silver soldered, they should be examined for any corrosion which may have developed duringmanufacture.
An Introscope or similar inspection instrument should be used in cases where direct viewing isimpractical.
The hose bore should be examined for cleanliness, blown through with clean, dry compressed air as necessary and, when recommended by the manufacturer, flushed with clean fluid of the type used in the system to which the hose assembly is to be fitted.

Installation:
Caution:When installing a hose assembly, it should be ensured that there is adequate clearance between the hose and other parts of the aircraft structure, so as to prevent chafing or electrolytic corrosion.
It must be borne in mind that hose may flex (move like a snake) when internal pressure is applied, and considerable 'whip' may occur under surge conditions; the force exerted when a hose 'whips' may be sufficient to cause damage to the hose assembly and to surroundingcomponents.
Bend Radius:
The serviceability and life of a hose assembly is considerably affected by the degree of bending of the hose and a check should be carried out to ensure that the bend radius is not less than the minimum specified by the manufacturer.
There are two classes of minimum bend radii recommended by hose manufacturers for each hosediameter.
The minimum bend radii recommended for hose in locations where there is no relative movement, are smaller than those recommended for hose in locations where there is relative movement between endfittings

E.g.A hose assembly connected to a control surface actuator would have a larger radius bend than a hose assembly connecting two rigid couplings at differentangles.



The flexing radius should, in general, be twice the bend radius of a staticinstallation.
It should also be noted that the recommended minimum bend radii for PTFE hose may vary from those recommended for rubberhose.

Slack:Flexible hose contracts in length and expands in diameter when pressurized. To allow for shrinkage, vibration, movement of parts and 'whip', all straight hose assemblies should be at least 3 % longer than the maximum distance between the fittings (length of the assembly) to which they are connected. In no circumstances may a hose assembly be under any form of tension.
Note:A lay line (as shown in above figure) in the hose indicates whether a hose is straight ortwisted after installed.
Install the hose so that flexure does not occur at the endfittings.

(A) CORRECT—MINIMUM LENGTH 3 PER CENT GREATER THAN MAXIMUM DISTANCE BETWEEN END FITTINGS

(B) INCORRECT—HOSE TWISTED AND UNDER TENSION

To avoid sharp bends in the hose assembly, use elbowfittings.
The hose must remain straight for at least two hose diameters from the endfittings.
Avoid clamp locations that will restrict or prevent hoseflexure.

Twisting:Hoses must be installed without twisting to avoid possible rupture of the hose or loosening of the attaching nuts.
Use of swivel connections at one or both ends will relieve twist stresses. Twisting of the hose can be determined from the identification stripe (lay line) running along its length. This stripe should not spiral around the hose.

Lubrication of couplings:

If the lubrication of coupling threads is specified to avoid 'picking up', it is essential to use the lubricant specified by the manufacturer, and to ensure that it does not enter the bore of the hose assembly; this can be done by applying lubricant to the external threadsonly.

For connections in oxygen systems, where the presence of oil or grease is very dangerous, only specified -lubricants may beused.

Tightening of couplings:

When fitting a hose assembly, it is most important to prevent it from twisting when the connections aretightened.

In the case of hose with a metal braided outer cover (where lay line can't be printed), twist may be detected by distortion of the braid pattern in a helical direction, but careful tightening or loosening of the union nuts is the only safe way of avoiding twist and strain in the hoseassembly.

Clamping:

Flexible hose should be installed so that it will be subject to a minimum of flexing during operation.

Although hose must be supported at least every 24 inches, closer supports are desirable. Flexible hose must never be stretched tightly between twofittings.

To ensure proper sealing of hose connections and to prevent breaking hose clamps or damaging the hose, follow the hose clamp tightening instructionscarefully.

When available, use the hose clamp torque-limiting wrench. These wrenches are available in calibrations of 15 and 25 in-lblimits.

In the absence of torque limiting wrenches, follow the finger-tight-plus-turns method. Use good judgment when tightening hose clamps by thismethod.

Since hose connections are subject to "cold flow" or a setting process, a follow-up tightening check should be made for several days afterinstallation.

Note:The term "cold flow" describes the deep, permanent impressions in the hose produced by the pressure of hose clamps orsupports.

Support clamps are used to secure the various lines to the airframe or powerplant assemblies. Several types of support clamps are used for thispurpose.

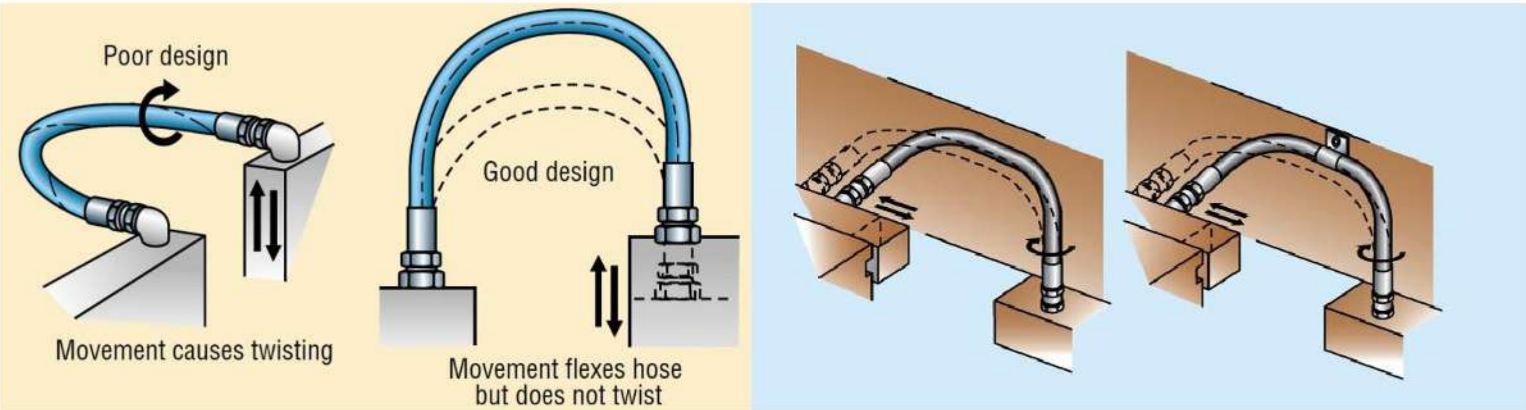
Taping:Where taping of a hose is considered necessary as a protection against fouling (touching nearby parts), this should be reduced to a minimum, since, apart from restricting the hose flexibility, deterioration of the hose under the tape often occurs.

On no account should leather be used for this purpose, since acid from the leather will corrode any metal parts with which it comes into contact.

Movement of hose assemblies:

Where a hose assembly is connected to a moving part, it is important to ensure that the hose can only move in the plane or planes intended in the design.

In the case of a hose assembly having movement in more than one plane, torsional loads will be imposed on the hose at the endfittings.



If such movement is the design intention, a hose which has no metal braid or wire spiral in its construction is generally used, otherwise the torsional effect would result in earlydeterioration.
In such instances special attention should be given to the locking of endfittings.

Protective sleeves:
In certain areas, the flexible hose must be protected from wear caused by abrasion or extreme heat. For example, if a fluid line must pass near a hot exhaust manifold, the line must be protected with a suitable fireshield.
On the other hand, if a fluid line rubs against another part, an abrasion sleeve is appropriate.
Some of the most common protective sleeves include heat shrink, nylon spiral wrap, andTeflon.

Flexible hoses – Inspection and Testing:

Life of a hose assembly:
The life of a hose assembly varies largely according to environmental and operating conditions, but may also be affected by storage conditions and the care taken during its installation.
The life is assessed from experience with a particular installation, and it may be specified in a number ofways.
Some hose assemblies are given a definite life after which they are scrapped regardless of their apparent condition, some are given an overhaul life which usually coincides with the aircraft overhaul periods, and some are renewed only "on condition"; the life applicable to a particular hose assembly will be specified in the approved Maintenance Schedule.

Inspection
The inspection of hose assemblies should normally be carried out in aircraft's position, at the intervals specified in the approved Maintenance Schedule. During each inspection the date of manufacture of hose should be checked to ensure that its prescribed life will be valid until the next inspection, and the assembly should be examined for defects as givenbelow:
General condition:
General deterioration of a hose may be recognised by discoloration, flaking, hardening, circumferential cracking or crazing of the outercover.
These defects do not render the hose unserviceable unless the cracks penetrate to the braid.
Installation:
Theinstallationofah ... atitisnottwi

stressed, or bent through too sharp an angle, and that any clips or supports are correctly fitted and not chafing or imposing stress on the hose.

Chafing and cuts:

Light chafing and cuts in the outer cover are generally acceptable if the braiding is not exposed, but the reasons for the damage should be ascertained andcorrected.

In the case of hose assemblies which have no outer covering over the braid, any damage to the braid will normally entail rejection, but some manufacturers permit the acceptance of isolated brokenstrands.

Chafing which occurs under clips may entail changing both the hose and theclips.

Kinks:

This defect is usually caused by incorrect installation or bymishandling.

It shows up as a sharp increase in radius at one point in a bent hose, and is usually easy to detect visually unless the hose has a protective cover; finger pressure should be used to check this type ofhose.

Any kinked hose must be considered to be permanently damaged and must bescrapped.

Contamination:

Contamination of a hose with an outer rubber cover will show up as swelling, sponginess, hardening or disintegration of the surface, and is notacceptable.

Hose which is contaminated should be rejected andrenewed.

Overheating:

The overheating of rubber covered hose is apparent as scaling, crazing, or discoloration of thesurface.

Hose with an outer wire braid may assume an overall golden-brown colour when exposed to normally high temperature, and this is acceptable; patches of discoloration caused by overheating are not acceptable.

Blistering / bulging:

Blisters may form on the outer synthetic rubber cover of hoses, but these do not necessarily affect the serviceability of the hoses provided they are able to withstand the applicable test described in (a) or (b).

Certain factors must be taken into consideration, however,e.g.ifthehoseisexposedtosprayfrom

the tyres, puncturing of the outer cover may allow corrosive elements to attack the wire braiding.

Hose assemblies in Pneumaticsystems:

Remove the hose assembly from the aircraft and puncture the blister with a needle having a chisel point. The needle should be inserted parallel with the outer cover of the hose so that it penetrates the outer cover only. The blister should thencollapse.

Pressurise the hose at 1times working pressure under water.

When the hose is pressurised, the air supply should be turned off. Bubbles will appear from air trapped beneath the outer cover but eventually disappear, and if no further bubbles appear, the hose isserviceable.

A constant flow of air bubbles indicates a leak and can be observed as a pressure drop on the pressure gauge. A leaking hose must bescrapped.

Hose assemblies in Hydraulicsystems:

Remove the hose from the aircraft and puncture the blister as outlined in(a).

If fluid emerges from the pin hole the hose must bescrapped.

A hose assembly should be checked for leakage with pressure in the associatedsystem.

A leak may be detected by the presence of fluid on the hose, end fittings or adjacent structure, or by the appearance of blisters on thehose.

When a protective sleeve is fitted, stains may appear on the sleeve or fluid may emerge from the ends of the sleeve, but if the leak is small and no fluid is visible, the presence of fluid may sometimes be detected by squeezing thesleeve.

Hose assemblies in pneumatic systems may be checked by applying, externally, a noncorrosive soapy water solution, by the use of special test equipment, or by carrying out a leak ratecheck.

If there is any doubt the hose assembly should be removed from the aircraft and subjected to a pressuretest

A leaking hose must bescrapped.

Pressure test

When specified in the approved Maintenance Manual or Schedule, or whenever the serviceability of a hose assembly is in doubt, a pressure test should be carried out.

Test equipment:

Before pressure testing a hose assembly the following points should be verified.

The test equipment available is adequate for the proposed tests, and located in such a position as to preclude cross-contamination with dissimilarfluids

The test medium is clean and suitably protected against the ingress ofdirt.

The test equipment and instruments are checked at regular intervals, and a record kept of these checks,and

That before any tests are made, either in the aircraft or on separate components, the test figures are ascertained from the appropriate drawings ormanual.

Caution:To prevent injury to personnel in the event of a hose failure during the pressure testing of a hose removed from an aircraft, the hose should be located behind a heavy plastics screen. For tests using air as the test medium the hose should also be submerged inwater.

Test Medium:

Pressure tests are usually made with a fluid similar to that which the hose will carry in service.

However, there are some exceptions, for example, paraffin is usually recommended for testing petrol hoses as it issafer.

Pneumatic and oxygen hoses are usually tested with water then thoroughly dried out with a warm airblast.

This is followed by a further test with clean, dry air, in which pressure is limited to maximum systempressure.

Oxygen pipes must not be contaminated with oil, and should not be connected to a compressor for testpurposes.

Hose Flexing:

When under test, the hose should be restrained (bend) to approximately the shape it assumes in service.

If the hose is non-flexing (not moving) in service it should be flexed approximately 15° from its normal shape several times each way and the pressure should be maintained for at least twominutes.

Low pressure non-flexing hoses used in regions of high ambient temperature should be regarded as exceptions and should not be subjected to flexing during pressure testing, since such hoses, having been subjected to extremes of heat during service, will automatically be rendered unserviceable if treated in thismanner.

Hoses which are subject to flexing in service should be tested in a similar manner but, in addition, should be flexed through their normal flexing angle plus 15° eachway.

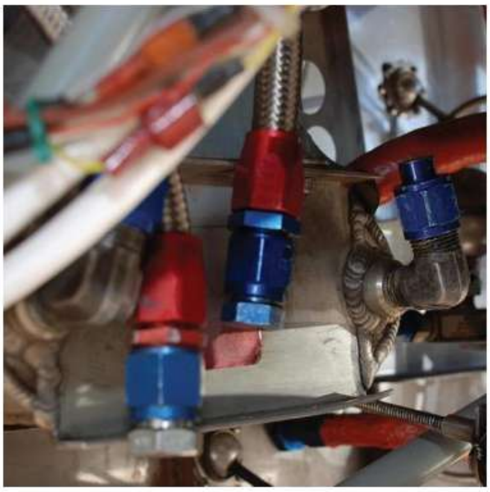
No leakage or malfunction should occur during any of thesetests.

Test Pressure:

Unless otherwise stated on the appropriate drawing or in therelevantmanual,hosesshouldbepressuretestedto

1times their maximūm working pressure.

In some instances, hose assemblies are tested in situ, in which case one end should be properlyblanked.

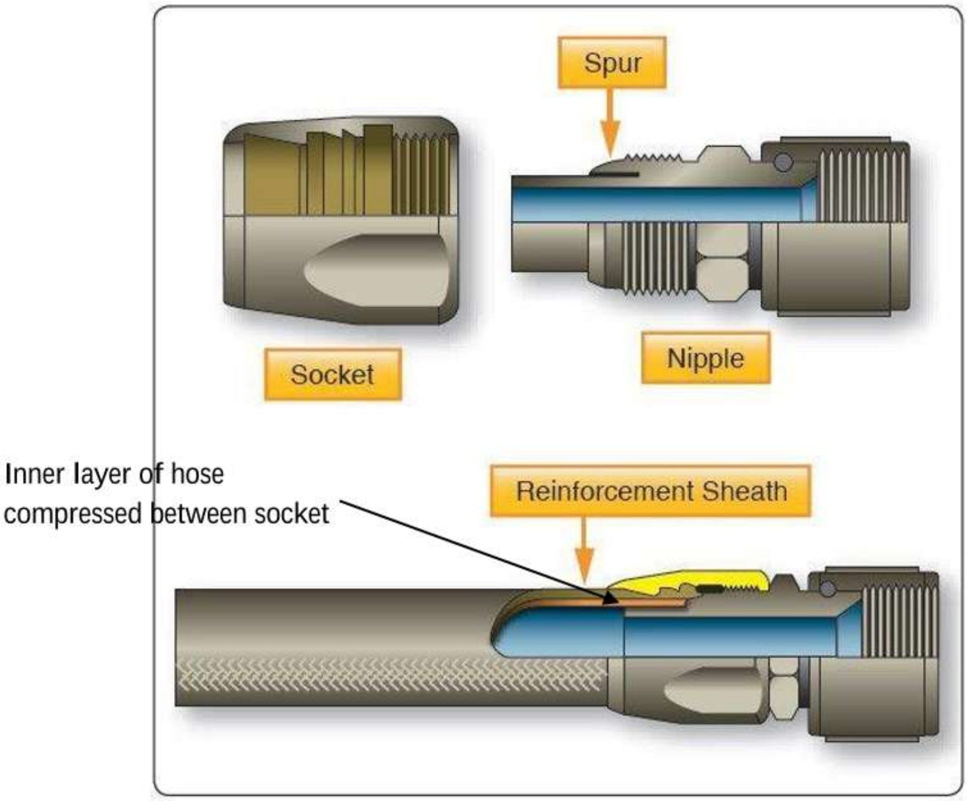


Flexible hoses – End fittings:

Re-using the end fittings:

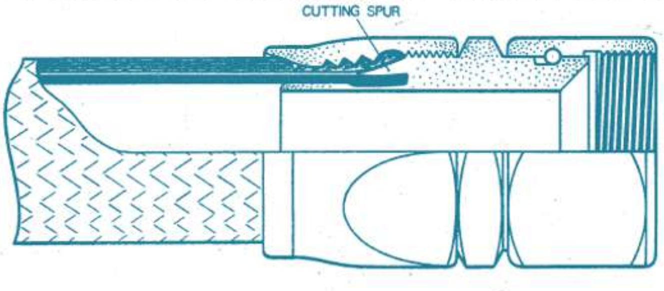
The purpose of re-usable end fittings on hose assemblies is to save the cost of renewingacompleteassemblywhenonlythehose portion is unserviceable.

An end fitting consists basically of two or more components; a socket fits tightly over the hose, and a tapered nipple (or insert), when screwed into the hose bore, expands the hose and clamps it firmly against the socket. This is the most common method and is known as a 'compression seal'(as shown in figures).



But a somewhat different method of attachment, known as a 'lip seal'(as shown in below figure), is used by some manufacturers; the nipple in this case has a cutting spur or separate collar which separates the inner hose from the braid during_ the assemblyoperation.

The re-use of end fittings is satisfactory if precautions are taken to ensure that no damage is caused to the hose bore during the assembly operation and the manufacturer's instructions are followed with regard to both assembly



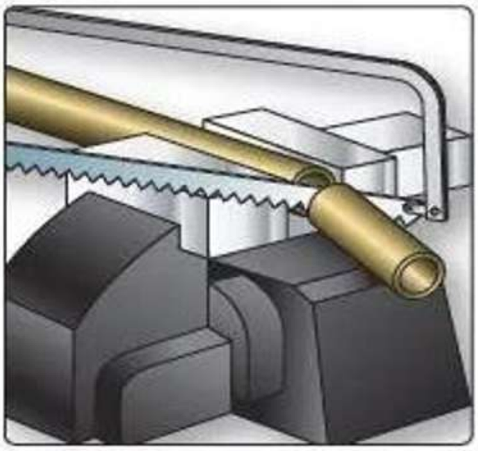
andtesting.

Installation of a Hose with a fitting

Hose:

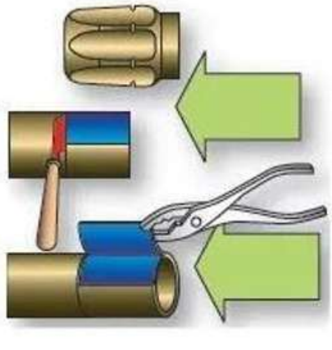
The new hose must first be carefully measured and cut to length with a fine-tooth hacksaw or specialised cutting equipment, ensuring that the cut-ends are square and smooth.

It should then be thoroughly cleaned and blown out with dry compressedair.



To minimise fraying when cutting off hose which has a cloth or metal sheath, it is advisable to wrap the hose with masking tape and saw through thetape.

High pressure hose usually has a metal braid sheath and, when this has a protective rubber cover, the cover must often be removed to enable the hose to enter thesocket.



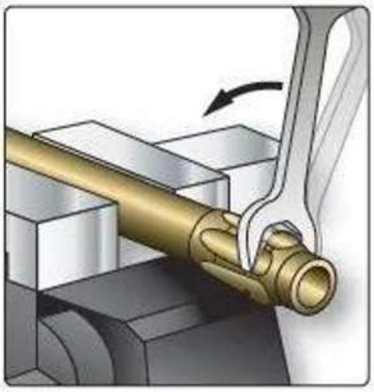
Using a sharp knife, the cover should be cut off to the depth of the socket and the exposed braid carefully cleaned with a wirebrush.
Care must be taken to avoid damage or displacement of reinforcementwires.

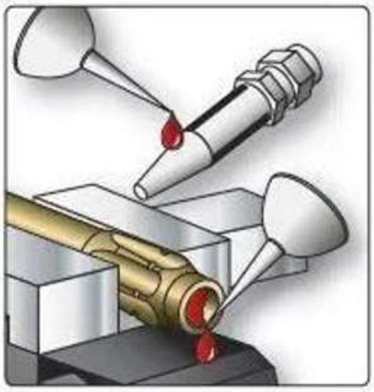
Fitting sockets:

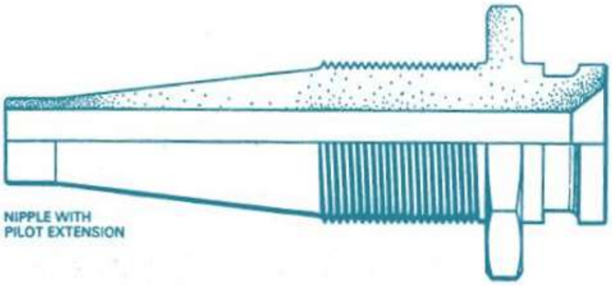
Sockets usually have a form of coarse left-hand internal thread to grip the outside of the hose, and threads at the outer end of the bore which mate with threads on thenipple.
To prevent the ingress of moisture on hoses which have a metal braid sheath, it is sometimes recommended that a sealant is applied to the braid and socket bore before assembly.
Actual assembly of the hose and socket is carried out by holding the socket firmly in a vice and screwing the hose into the socket until itbottoms.
Note:Some manufacturers recommend that, after screwing the hose fully into the socket, it should be unscrewed a quarter turn to allow for expansion when the nipple is inserted.
After assembly of the hose to the socket it is recommended that the hose is marked with a grease pencil, paint or tape, at the pointwhereitentersthesocket;inordertoprovideameansof
checking that the hose is not forced out of the socket during subsequent insertion of the nipple.

Fitting nipples:

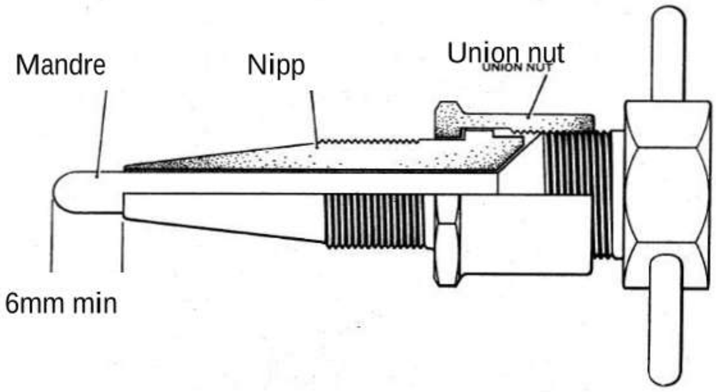
To complete the hose assembly, nipples must be screwed into the previously assembled hose andsocket.
This operation must be carried out with extreme care, as misalignment of the nipple could easily result in its tapered end cutting into the hose wall; slices of rubber dislodged in this way have been known to cause malfunction of associatedcomponents.
Nipples are usually tapered over approximately half their length and are often provided with a plain pilot extension to guide the nipples accurately into thehose.







When the nipple does not have a pilot extension, an assembly mandrel should be used and should extend at least 6 mm (1 in) beyond the end of thenipple.



The assembly mandrel also acts as a means of turning a nipple which does not have an integral hexagon orflats.

Note:Because of their design, lip seal fittings do not require the use of an assembly mandrel.

Inspection

Sockets and nipples which have been removed from an unserviceable hose should be inspected for damage and corrosion; and any traces of hose adhering to the threads must beremoved.

Before re-using a lip-seal type of nipple all traces of rubber should be removed from under the lip and, subject to limitations laid down by the hose manufacturer, the lip should be restored to its originalprofile.

Afterthehoseassemblyhasbeenmadeupitshouldbethoroughlycleanedanddried,

examined and pressure tested to 1times maximum system pressure, to ensure that it will withstand the pressure existing in the system with which it is to be used.

Bonding test: Where hose assemblies have metal wire braid reinforcing or embody any form of metal in their construction (such as a wire spiral) a bonding test will be specified. An approved type of bending tester should be used, and the resistance recorded should not exceed 0·050 ohm or 0·025 ohm per foot length, whichever is thegreater.

SPRINGS

INSPECTION AND TESTING OF SPRINGS

Springs will generally require little in the way of maintenance.
It is important that any exposed springs are carefully inspected for signs of corrosion and overheating. Corrosion occurs on static springs and reduces the capacity of the loads that the spring cancarry.

It is important that any exposed springs are carefully inspected for signsof corrosion and overheating. Corrosion occurs on static springs and reduces the capacity of the loads that the spring cancarry.

Overheating is evidenced as blistering of the surface protection and, in extreme cases, a change of color of the metal due to the loss of temper. When overheating is detected, it must be assumed that the spring is not suitable for the designed task.

The most common check done on a coil spring is static (length) measurement. The manufacturer publishes the exact dimension of the unloaded spring with a small range of tolerance.

Another common check, usually completed in a workshop environment, is the load/deflection check. This check is done on the springs which are used in more critical services, such as piston engine valve springs.

A series of loads are subsequently applied to the spring and the relevant deflections noted. Upon completion, the figures are compared to a graph, published by the spring manufacturer, to establish the serviceability of the spring. If a
spring fails any of these checks it is simply replaced with a serviceable item.

Aspecial test rig is used, to load the spring with either a compressive, tensile or a torsional loading and a meter
on the rig will display the load versus deflection figures

–Bearings

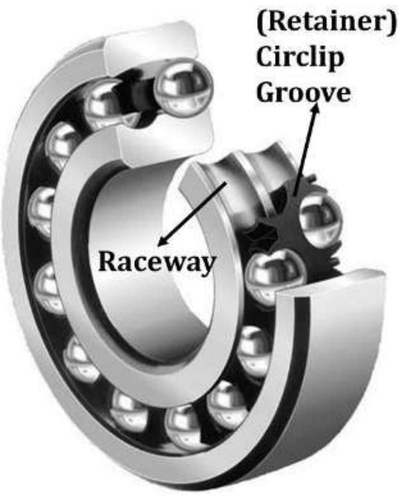
Types, Lubrication and Installation:

Types of bearings:
Bearings are broadly classified by the type of rolling element used in theirconstruction.
Ball bearings employ steel balls which rotate in grooved raceways, whilst roller bearings utilise cylindrical, tapered or spherical rollers, running in suitably shapedraceways.

Use:Both types of bearings are designed for operation under continuous rotary or oscillatory conditions, but, whilst ball bearings and tapered roller bearings accept both radial and axial loads, other types of roller bearings accept mainly radial loads.

Ball Bearings:
Radial Ball bearings:
This is the most common type of rolling bearing and is found in all forms of transmission assemblies such as shafts, gears and control-rod endfittings.
The bearings are manufactured with the balls in either single or double rows, rigid for normal applications, or self-aligning for positions where accurate alignment cannot be maintained.

Such bearings may also be provided with metal shields or synthetic rubber seals to prevent the ingress of foreign matter and retain the lubricant, and with a circlip groove or flange for retentionpurposes.



The balls are often retained in a cage, but in some cases filling slots in the inner and outer rings permit individual insertion of the balls, thus allowing a larger number of balls to be used and giving the bearing a greater radial load capacity; however, axial loads are limited due to the presence of the raceway interruptions like circlip groove or shield orcage.

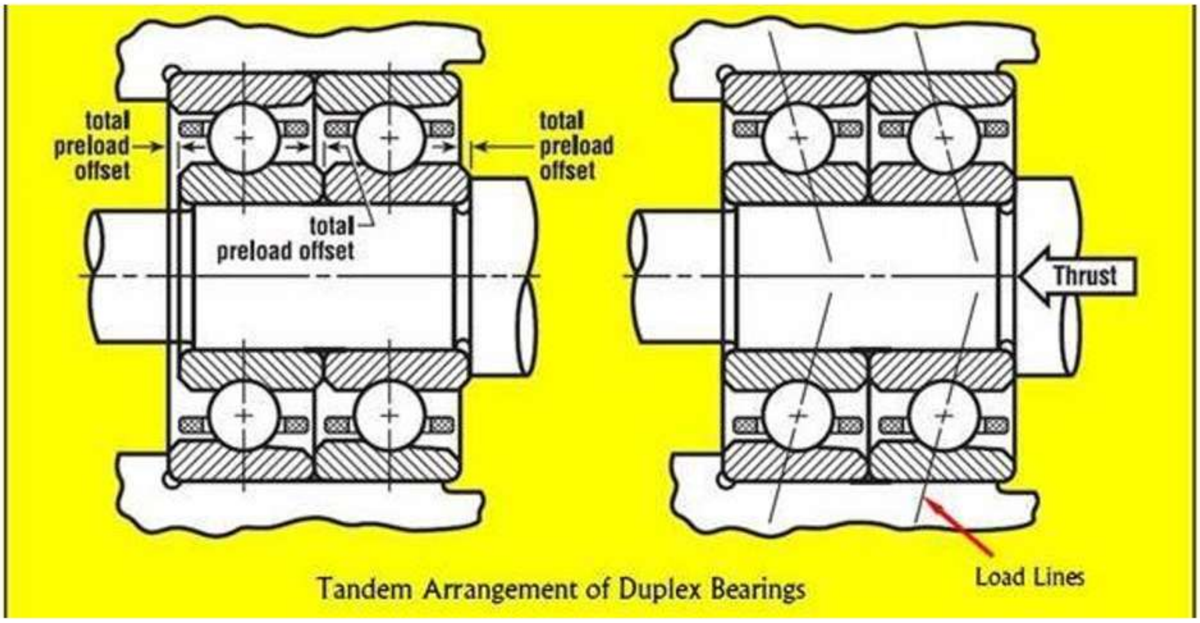
Caged bearings are in general use for engine applications and in equipment with rotational speeds in excess of approximately 100 rev/min.

Angular contact bearings:
These bearings are capable of accepting radial loads, and axial loads in onedirection.
In applications where, axial loads will always be in one direction, a single angular contact bearing may be used, but where axial loads vary in direction an opposed pair of bearings is often used, and adjusted to maintain the required axialclearance.

A particular type of angular contact bearing, known as a duplex bearing, is fitted with a split inner or outer ring, and is designed to take axial loads in either direction.

The balls make contact with two separate raceways in each ring, and one essential condition of operation is that the bearing should never rununloaded.

The bearings are not adjustable, and radial loads should always be lighter than axialloads.
This is a most efficient form of thrust bearing and is not speedlimited.



Thrust bearing – Washer type:

Thrust bearings are designed for axial loading only, and are normally used in conjunction with a roller bearing or radial ballbearing.

The balls are retained in a cage and run between washers having either flat or grooved raceways.

Centrifugalloadingontheballshasanadverseeffectonthebearingsandtheyare,

therefore, most suitable for carrying heavy loads at low speeds.

Roller Bearings:

Cylindrical roller bearings: These bearings are capable of carrying greater radial loads than ball bearings of similar external dimensions, due to the greater contact area of the rolling elements.

Tapered roller bearings: These bearings are designed so that the axes of the rollers form an angle with the shaft axis. They are capable of accepting simultaneous radial loads and axial loads in one direction, the proportions of the loads determining the taper angle.

Maintenanceofbearings Lubrication:
Adequate lubrication is essential for all types of rollingbearings.

The purposes of the lubricant are to lubricate the areas of rubbing contact, e.g. between the rolling elements and the cage, to protect the bearing from corrosion, and to dissipate heat.

Grease and oil:For low rotational speeds, or for oscillating functions such as are found in a number of airframe applications, grease is a suitable lubricant. At higher rotational speeds grease would generate excessive temperatures because of churning, and so oil is more suitable.

Because of the variety of uses to which rolling bearings are put, and the varying requirements of different locations, it is important that only those lubricants recommended in the approved Maintenance Manual should beused.

External bearings on aircraft are often of the pre-packed, shielded or sealed types, and are usually packed with anti-freeze grease because of the low temperatures encountered; these bearings cannot normally be re-packed with grease, and when unserviceable must berejected.

Wheel bearings are normally tapered roller bearings, and should be re-packed with the correct grease when refitting thewheel.

Bearings fitted in engines and gearboxes are generally lubricated by oil spray, splash;· mist, drip feed, or controlled level oil bath, and loss of lubricant is prevented by the use of oil retaining devices such as labyrinth seals, felt or rubber washers, and oilthrowers.

Excessive greasing should be avoided, however, since grease is expelled from the bearing as soon as it begins to rotate, and, if insufficient space is left, churning and overheating may occur, causing the grease to run out and the bearing to fail; as a rough guide, the bearing should be approximately one thirdfull.
Grease application:
Grease nipples are provided for some open bearings so that the grease may be replenished at specified intervals, or when grease is lost through the use of solvents, paint strippers, detergents or de-icingfluid.

Nipples should be wiped clean before applying the grease gun, to prevent the entry of dirt into thebearing.
Grease forced into the bearing will displace the old grease, and any surplus exuding from the bearing should be wiped off with a clean lint-freecloth.

Installation:
The majority of bearing failures are caused by faulty installation, unsatisfactory lubrication, or inadequate protection against the entry of liquids, dirt or grit.

Type of fit:
Where bearings carry axial loads only, the rings need only be a push fit in the housing or on the shaft, as

appropriate, but bearings which carry radial loads must be installed with an interference fit between the revolving ring and its housing or shaft, otherwise creep or spin may take place and result in. damage to bothcomponents.

In instances where light alloy housings are :used, the bearing may appear to be a loose fit during installation owing to the need to control bearing fit in the housing at the low temperatures experienced at highaltitude.

Before installation:
In some cases, bearings are packed with storage grease, which is unsuitable for service use and must be removed by washing in a suitablesolvent.

All open bearings should be lubricated with the specified oil or grease before installation.

Assembly:
Bearings must be assembled the right way around, i.e. as specified in the appropriate drawing or manual, and should be seated squarely against the shoulders on shafts or housings so that raceways are at right angles to the shaftaxis.
Damage to the shoulders or bearing rings, or the presence of dirt, could prevent correct seating, impose uneven stress on the bearing and promote rapidwear.
It is important, therefore, to ensure that there is no damage likely to prevent correct seating of the bearing rings, and that all mating surfaces are scrupulouslyclean.
Note:Some bearings are supplied as matched pairs, and it is important that they are mounted correctly.

Installation:
Bearings may often be installed using finger pressure only, but where one ring is an interference fit (usually the rotating inner ring), an assembly tool or press should be used; in some instances, it may also be necessary to freeze the shaft or heat the bearing in hot oil, depending on the degree of interferencespecified.
If these tools are not available, the use of a soft steel or brass tube drift may be permitted in some instances; any force necessary must be applied only to the ring concerned, since force applied to the companion ring may result in damage to the rolling elements, or brinelling of theraceways.
Note:If a drift is used, the tube must be a close fit over the shaft and must not transmit force to the ring ribs.
Light taps from a hammer should be distributed evenly round the top of the drift, to prevent misalignment. On no account should a copper drift be used, as work-hardening could result in chips of copper entering the bearing.

Inspection

Inspection in-situ (on installation):
Frequent removal of bearings from shafts or housings may result in damage to either the bearing rings or mating surfaces, and for this reason a routine inspection of a bearing is normally carried out in situ; wheel bearings, however, are normally inspected when the wheel isremoved.

If doubt exists as to the serviceability of a bearing, it should be removed, cleaned and inspected.
It may not often be possible to examine the rolling elements and raceways while a bearing is in position, but it is usually possible to examine the rings externally for overheating, damage and corrosion, and to examine the cage for loose rivets and damage, after removing surplus grease with a clean lint-freecloth.
In all cases a bearing should be checked for wear as follows:
Actuate the moving parts slowly to check for smoothness ofoperation.
Roughness may result from grit in the bearing or surface damage to the rolling elements or raceways, caused by corrosion or excessivewear.
Check for wear by moving the inner race or shaft in both axial and radialdirections.
The amount of clearance will depend to a large extent on the initial grade of fit of the bearing, but some wear will be acceptable with all classes of fit and may only be considered as unsatisfactory if it leads to excessive backlash in controls, or vibration duringoperation.
Check shielded bearings to ensure that there is no rubbing contact between the stationary and rotatingcomponents.
Contact between the shield and inner ring is evidence of excessive wear in the bearing and could lead to contamination of the lubricant by particles of metal rubbed off theshield.

With some bearings, creep or spinning of the races may occur and lead to damage to the shaft or outer ring housing. Where housing end covers or shaft nuts can be removed, these faults may be recognised by polishing of the ringfaces.
The internal condition of a bearing may sometimes be revealed by an examination of the lubricant exuding from the bearing. Metal particles reflect light, and give a rough feeling when the lubricant is rubbed into the palm of thehand.
A problem frequently encountered with airframe bearings is moisture contamination, which may result in freezing and inability to operate a control in low temperatureconditions.
Every precaution should be taken to prevent the entry of liquids into bearings, and relubrication of open bearings is often specified afterwashing.
During inspection, particular attention should be given to rust stains, which may be a good indication of the presence ofmoisture.
The condition of landing wheel bearings on small aircraft, on which wheels are changed at infrequent intervals, may be checked by rocking and spinning the wheel. This check would normally be impractical and unnecessary on larger aircraft, since the wheels are changed more frequently in order to replace worntyres.

Inspection after removal & cleaning
Removal of bearings:
Many roller bearings are made in two parts, which can be separated for cleaning and inspectionwithoutremovingtheouterringfromitshousingortheinnerringfromits
shaft; all that is necessary is partial dismantling of the associated components to allow the bearing to be inspected and rotated.
When it is necessary to remove separated rings or complete bearings, care is necessary to ensure that they are notdamaged.
A suitable extractor should normally be used, but if this is not available, light hammer blows

transmitted through the medium of a soft tubular drift may proveeffective.
Any force necessary should be applied to the ring concerned, since force applied to the companion ring may result in damage to the raceways and rollingelements.
Force should not be applied to the ribs of a roller bearing as this may result in fracture or damage, which would necessitate the rejection of thebearing.

Cleaning bearings:
Bearings to be cleaned for further examination should first be wiped free of all grease adhering to the outer surfaces; dry compressed air will assist in dislodging it from the cage and rolling elements, but the bearing should not be allowed torotate.
The bearings should then be soaked or swilled in white spirit to remove any remaining grease ordirt.
It is permissible to oscillate or turn the races slowly to ensure that all foreign matter has been removed, but the bearing should not be spun in this condition, otherwise the working surfaces may become damaged due to the lack oflubrication.
If a bearing cannot be completely cleaned by the above method, a forced jet of white spirit may be used to advantage. The jet may be obtained by fitting a pump to the washing tank, but an efficient filler must beprovided.
Jet cleaning can be considerably assisted if the bearing is mounted on a tapered mandrel so that the inner ring will remain stationary, whilst allowing the outer ring to revolve slowly as a result of the action of the fluid from the jet passing through the bearing.
After cleaning, the bearing should be dried with clean, warm, dry compressed air, taking care to permit only very slow rotation, arid lightly lubricated with oil to prevent corrosion.
The bearing should be slowly rotated during oiling to ensure that all surfaces are covered.

Inspection after removal and cleaning:
After removal and cleaning, bearings should be inspected for corrosion, pitting, fracture, chips, discolouration and excessive internalclearances.
With self-aligning bearings or bearings having detachable rings, the condition of the rolling elements and raceways can be seen by swivelling the outer ring through 90° or by separating the outer ring, asappropriate.
With bearings having non-detachable rings, the raceways and balls or rollers are sometimes accessible for visual examination, but if not, their condition may be judged by holding the inner ring and oscillating the outerring.
Provided there is no foreign matter inside the bearing, any roughness will indicate internaldamage.

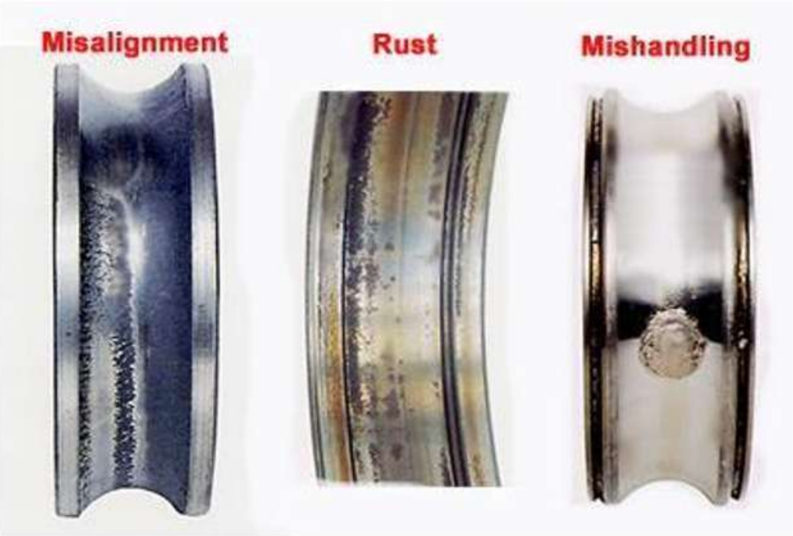
Common conditions of a bearing that are cause for rejection are as follows:
Galling-caused by rubbing of mating surfaces. The metal gets so hot it welds, and the surface metal is destroyed as the motion continues and pulls the metal apart in the direction ofmotion.
Spalling-a chipped away portion of the hardened surface of a bearing roller orrace.

Overheating-caused by lack of sufficient lubrication results in a bluish tint to the metal surface. The ends of the rollers shown were overheated causing the metal to flow and deform, as well as discolour. The bearing cup raceway is usuallydiscoloured.

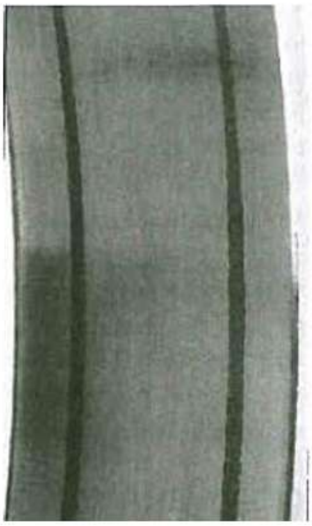
Brinelling-caused by excessive impact. It appears as indentations in the bearing cup raceways. Any static overload or severe impact can cause true brinelling that leads to vibration and premature bearingfailure.

False Brinelling-caused by vibration of the bearing while in a static state. Even with a static overload, lubricant can be forced from between the rollers and the raceway. Sub microscopic particles removed at the points of metal-to-metal contact oxidize. They work to remove more particles spreading the damage. This is also known as frictional corrosion. It can be identified by a rusty colouring of thelubricant.

Staining and surface marks-located on the bearing cup as greyish black streaks with the same spacing as the rollers and caused by water that has gotten into the bearing. It is the first stage of deeper corrosion thatfollows.
Etching and corrosion-caused when water and the damage caused by water penetrates the surface treatment of the bearing element. It appears as a reddish/browndiscoloration.
Bruising-caused by fine particle contamination possibly from a bad seal or improper maintenance of bearing cleanliness. It leaves a less than smooth surface on the bearingcup.



Electric currentdamage
Causes: When an electric current passes through a bearing, proceeding from one ring to the other via the rolling elements, damage will occur.
At the contact surfaces the process is similar to electric arc welding. Such electric currents can be of a low level but last for considerable lengths of time (such as voltage leakage from a motor or generator) or be very high level for a short duration (such as that caused by a lightning strike of theaircraft).
Equal amounts of damage can occur from bothsituations.
Appearance: The appearance of the damage is dark brown or greyish black fluting (corrugation) or craters in raceways and rollers. Balls have dark discoloration only.
It can be difficult to distinguish between electric current damage and vibrationdamage.



A feature of the fluting caused by electric current is the dark bottom of the corrugations, as opposed to the bright or rusty appearance at the bottom of the vibration induced fluting.
Another distinguishing feature is the lack of damage to the rolling elements of bearings with raceway fluting caused byvibrations.

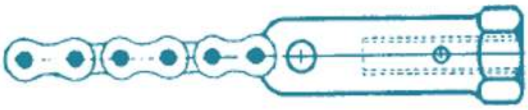
Testing:
Radial internal clearance may be determined by mounting the inner ring on a shaft and measuring, with a dial test indicator, the average radial movement obtained at various angular positions of the outerring.
It is important that the outer ring is moved in the same plane as the inner ring, or an incorrect reading willresult.

Storage:
If a cleaned bearing is not going to be installed immediately, it should be coated in rust- preventing inhibiting oil or other treatment specified by the manufacturer, wrapped in greaseproof paper, boxed andlabelled.
The bearing should always be stored horizontally, in a clean dry atmosphere and it is recommended that, after one year in storage, the bearings should be inspected for corrosion andre-protected.

–Transmissions

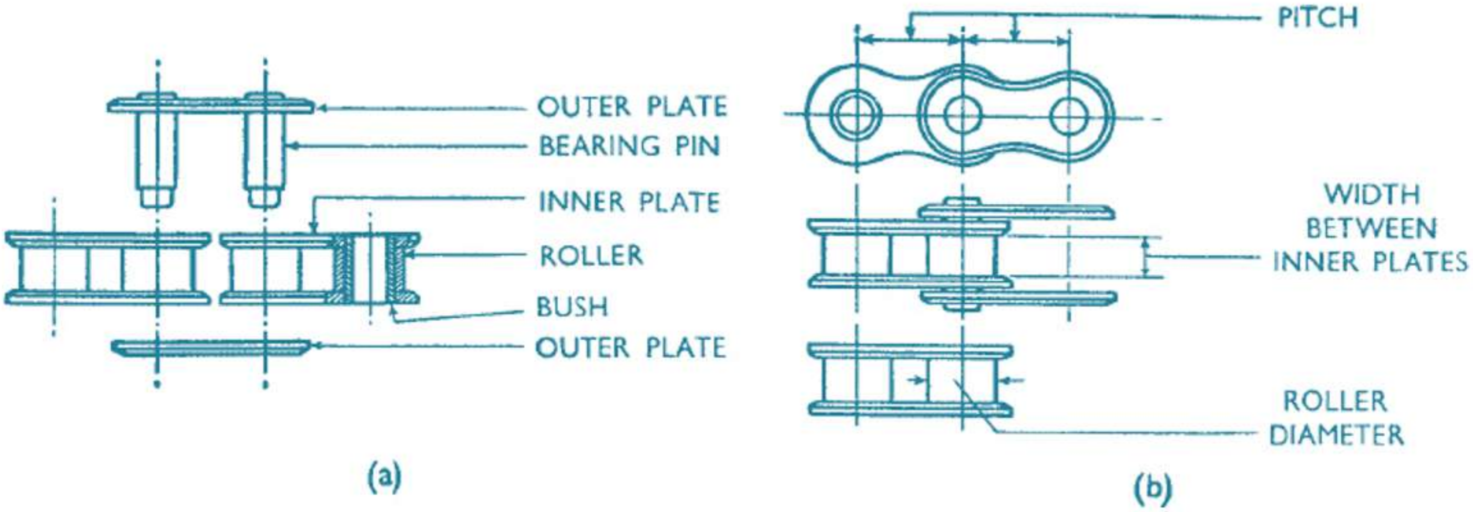
Chains and Chain assemblies:

Chains provide strong, flexible and positive connections and are generally used wherever it becomes necessary to change the direction of control runs in systems where considerable force is exerted, e.g. aileron and elevatorcontrols.
The change of direction is achieved by the use of chain wheels or pulleys. Chains may be found in, control column installations, aileron controls and elevator controls and in trim controlsystems.
Chains used for aircraft purposes are generally of the simple rollertype.



Chain Assemblies:

A simple roller chain consists of outer and inner plates, rollers, bearing pins and bushes; the component parts are shown in Figure(a).
The chain has three principal dimensions (known as gearing dimensions since they are related to the size of the wheels on which the chains run), these being pitch, width between inner plates and rollerdiameter.

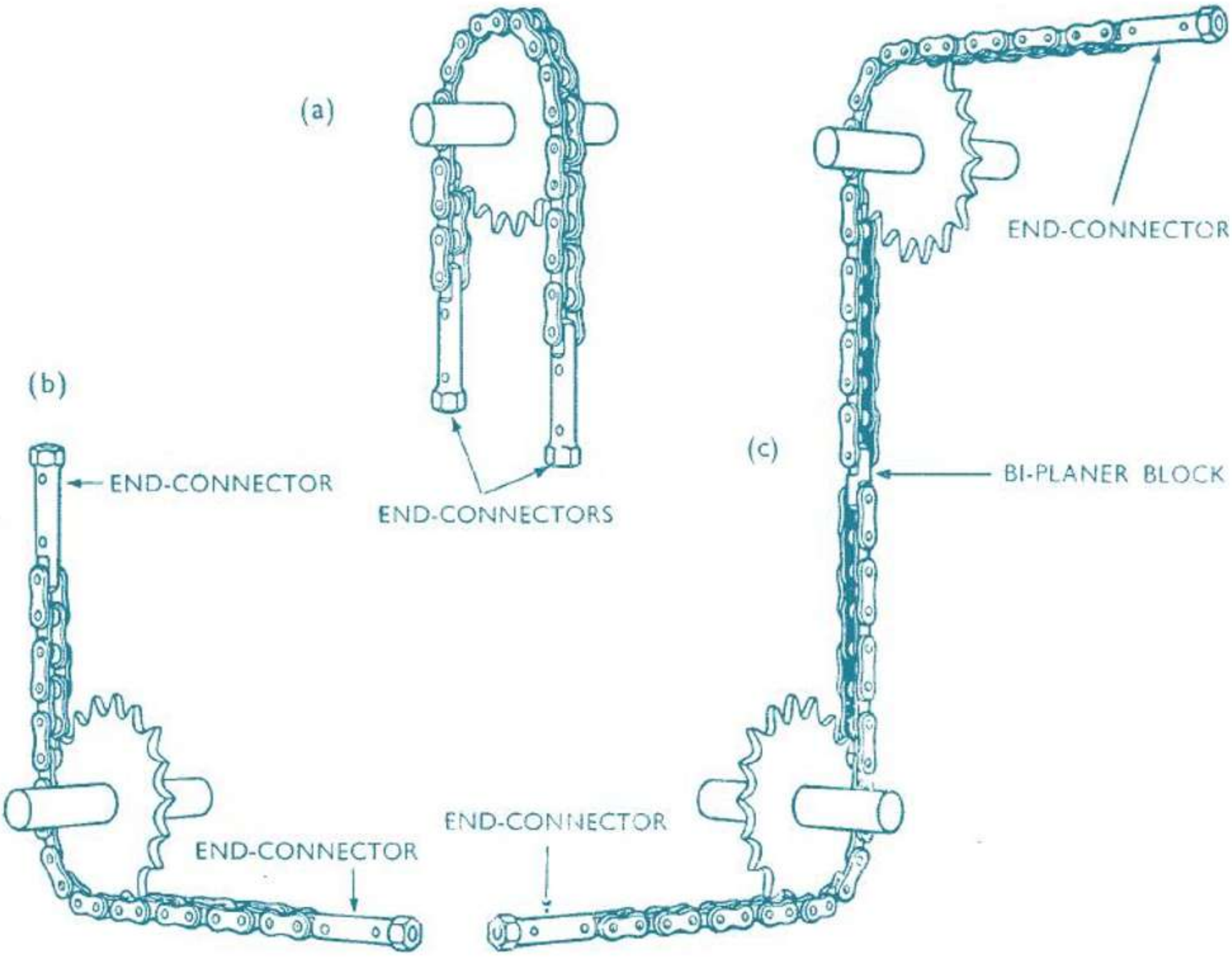


The positions at which these dimensions are measured are shown in Figure(b).
The pitch of the chain is the distance between the centres of therollers.
Chain assemblies for aircraft systems should be obtained as complete, proof-loaded units from approved chain assembly manufacturers and no attempt should be made to break and reassemble riveted links or rivetedattachments.
If it is necessary to disconnect the chain, this should be undertaken only at the bolted or screwed attachments. Split pins must not be re-used and this applies also to nuts and bolts which have beenpeened.
The use of cranked links for the attachment of the chain to end fittings, etc, is not permitted, thus, when a chain is required to terminate in a similar manner at each end, the length should be an odd number ofpitches.
For the same reason, an endless chain should have an even number ofpitches.
The use of spring clip connecting links is prohibited and the attachment of chains to other parts of the system should be effected by positive methods such as pre-riveted or boltedjoints.

Installation of chain assemblies:

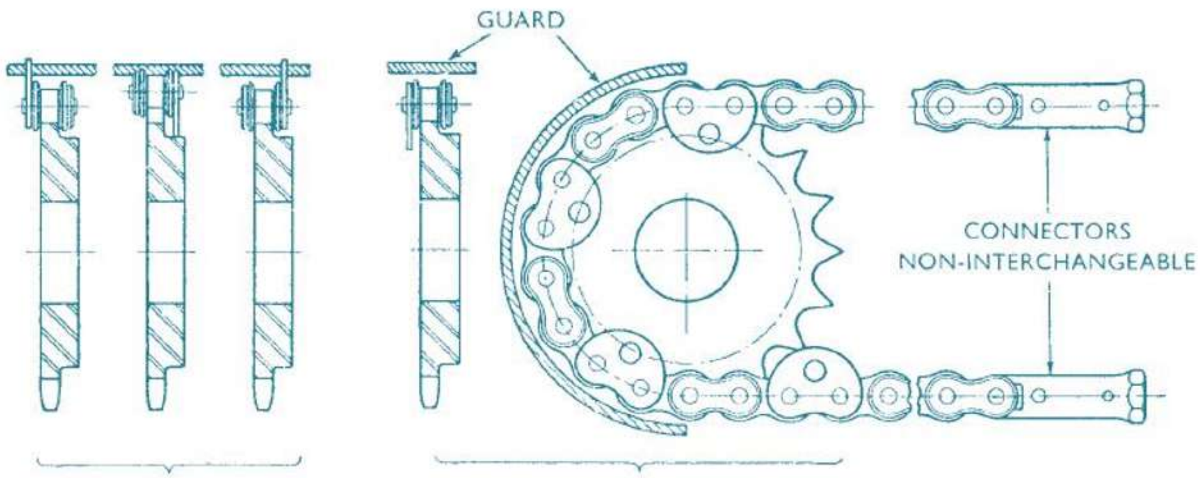
Figure illustrates typical arrangements of chain assemblies. Figure (a) shows the simple transfer of straight-line to rotary motion, Figure (b) illustrates how a change of direction ofstraight-linemotionisobtained,whilstFigure(c)showsachangeofdirectionof

motion in two planes by the use of a bi-planer block.



Non-reversible chains:

They prevent the possibility of reversing the chain end to end on its wheel and the possibility of the chain being assembled to gear on the wrong face where two wheels are operated by the samechain.
Non-reversible chains are similar to standard chains except that every second outer plate is extended in one direction in order to break up the symmetry of thechain.



It will be seen from Figure that by providing a shroud on one side of the wheel and by making use of the chain guard, the reversing of the chain end to end on its wheel is not possible.

Inspection after assembly:

After installation in the aircraft, the chain should be examined for freedom from twist, particularly in instances where the attachment is made to threaded rods by means of screwed end connectors, or where a twist may inadvertently be applied to the chain during the locking of theassembly.
Care should be also taken to ensure that the chain is not pulled out of line by the chain wheel; the chain should engage smoothly and evenly with the wheel teeth and there should be no tendency for the chain to ride up theteeth.

The pre-tensioning of chains should not be excessive, as this will cause friction, but should be just sufficient to prevent any back-lash in thesystem.

The guarding should be checked to ensure that jamming could not occur and that the chain would not come off the wheel should it becomeslack.

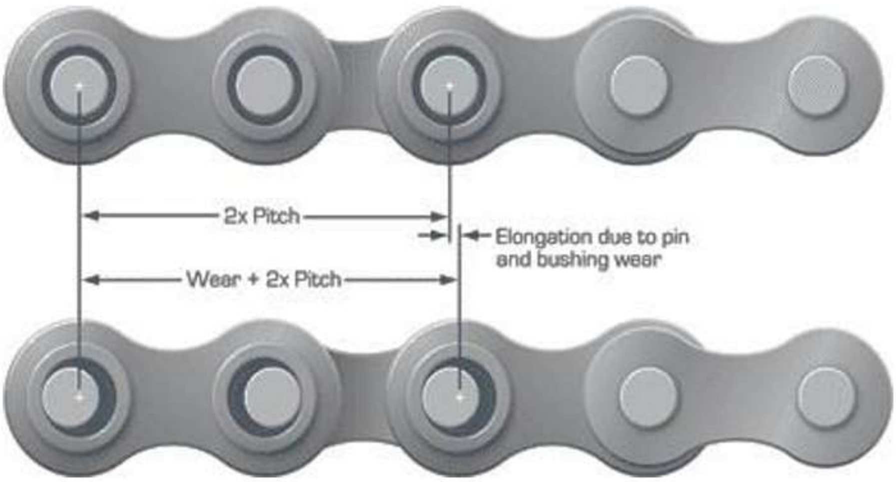
The security of end connections should be checked, care being taken to ensure that the split pins in the chain connecting bolts are correctlylocked.

The initial lubricant on new chains should not be removed and the chains should be further lubricated after assembly by brushing all over, particularly on linkedges.

Inspection of chain assemblies:

Chain assemblies should be removed from the aircraft for complete inspection at the periods specified in the appropriate Maintenance Schedule. When it is necessary to disconnect the chains, the assemblies must be removed at design breakdown points.
Checking elongation:

Chain wear happens in pins and bushings when they articulate over sprockets. If elongation through wear is suspected, the following procedure should be adopted:



The chains should be cleaned by immersion in clean paraffin and brushing with a stiff brush; after cleaning, the chains should be dried immediately by hot air to ensure that no paraffin remains, otherwise the chains will corrode. The chains should be measured when clean but before any oil isapplied.
The chains should be placed on a flat surface and stretched by the application of a tensile load. Table indicates the load applicable to the various sizes of chains. The length should then be measured between the centres of the bearing pins, elongation being calculated by the formula given in sub-paragraphc).

Chain Pitch	BS No.	Tensile Load (lb)
8 mm	1	12
0·375 in	2	16
0·50 in	4	28
0·50 in	6	28

c) The percentage extension over the nominal length should be calculated by the following formula:

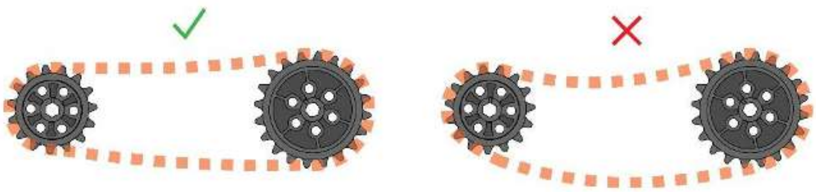
$$\text{Percentage extension} = \frac{M - (X \times P)}{X \times P} \times 100$$

where

M = Measured length under load in inches.
X = Number of pitches measured.
P = Pitch of chain in inches.

If the extension is in excess of 2% on any section of the chain the whole run of chain should bereplaced.
Should localised wear be likely to occur in a chain run, additional checks should be made on such sections and the percentage extension ascertained from the formula given in paragraph c). If the extension in such sections is in excess of 2%, the chain should be rejected.
The chain should be checked for kinks and twists by suspending it freely and sighting along the length; if kinks or twists exist the chain should berejected.

Checking Articulation / Joint:



The chain should be checked for tight joints by articulating each link through approximately180°.
The most suitable method is to draw the chain over afinger.
Tight joints may be caused by foreign matter on the bearing pins or between the inner and outer plates; this may be remedied by cleaning as describedbefore.
If cleaning is not successful, the end of the bearing pin may be very gently tapped with a light hammer, but if this does not clear the joint, the chain should berejected.
Tightness may also be caused through lack of clearance between the inner and outer plates due to damage; if this is so, the chain should berejected.

Proof loading:

Proof load is the maximum tensile load that can be applied to a chain that will not result in plastic deformation / elongation. Chains are tested for proof load and the proof-load for a chain should be one-third of the minimum breaking load.
It is not necessary to proof load a chain after removal for routine examination. However, if it is desired to replace a portion of the assembly, proof loading of the complete assembly is necessary. The proof load (Table) should be evenly applied and unless this can be assured, it is considered preferable to fit a complete new assembly.

Chain Pitch	BS No.	Minimum Breaking Load	Proof Load (lb)
8 mm	1	800 lb	267
0·375 in	2	1900 lb	634
0·50 in	4	1800 lb	600
0·50 in	6	3500 lb	1166

Gears, Belt & Pulleys, Push-Pull rod system:

A transmission is a mechanism for transferring power. Transmission is achieved through the use of gears, belts and pulleys, chains and sprockets, jackscrews, levers, and push-pull rods. Aircraft have numerous transmission devices the most notable of which is the reduction gearbox between an engine and a propeller.

Gears:

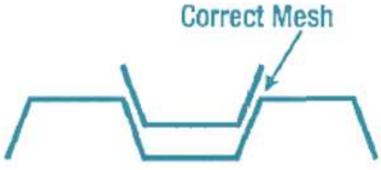
The purpose of a gear is the transmission of power throughmotion.
The contact and movement within a gear system result in stress and wear. Therefore, it is important to visually examine all gears for cracked or chipped teeth and the presence of pitting or excessivewear.
Deep pit marks or excessive wear on gear teeth are reasons for rejecting and replacing a gear.
Minor scratches and abrasions on a gear's bearing surfaces can normally be dressed out with a fine abrasive cloth, however, deep scratches or scoring isunacceptable.
Correct gear backlash must be checked and maintained to ensure proper gearmesh.

Backlash and Pattern:

In general, backlash in gears is the play between matingteeth.
If the teeth of one gear are set too tightly into the teeth of another, there will be no lash and the gears will not be properly lubricated because a film of oil must be present between the teeth of the gears as theymesh.
If the gears are meshed too high in relation to the teeth, the load will be transmitted to the smallest portion of the tooth, breaking the teeth because of the loadarea.

The Teeth Will Break

The Teeth Will Not Be Lubricated



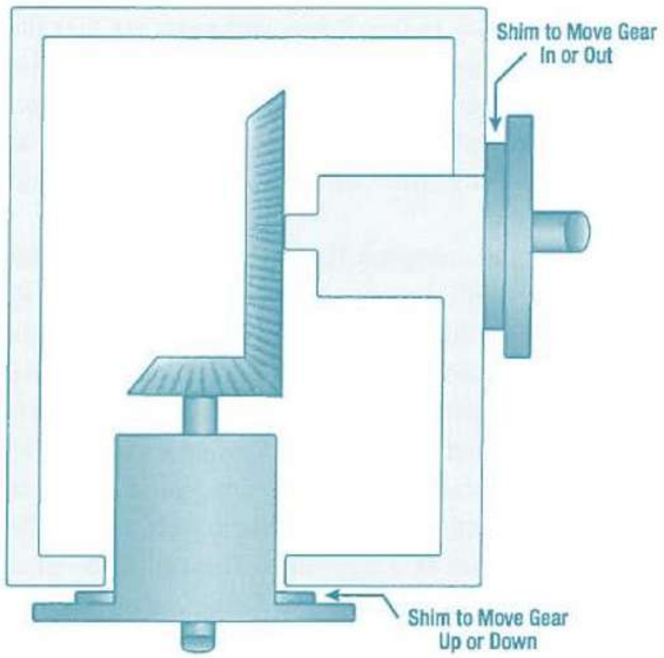
Tooth Will Be Lubricated Contact
Is At Mid Tooth

The ideal placement of the teeth is in the middlearea.
At this position the teeth will receive proper lubrication andloading.
At this point a measurable amount of lash may sometimes be felt by holding one gear and trying to move the othergear.

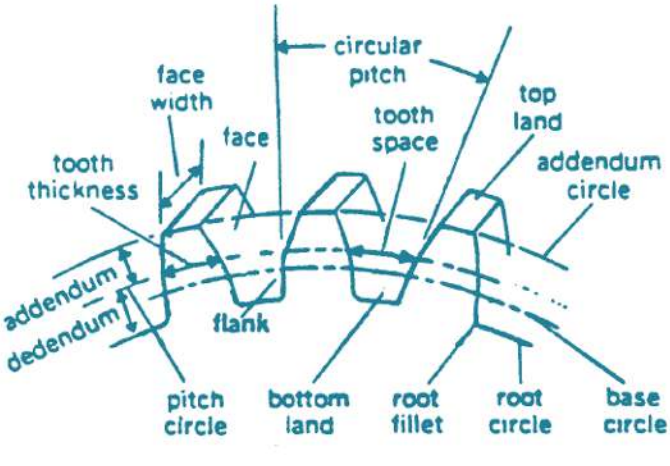
In most instances this is a minute amount of lash and will be measured with a backlashflag and a dialindicator.
A typical gear may have 0.003 to 0.004 lash. In all instances the amount of lash will be given in the maintenance manual and must befollowed.
Pattern

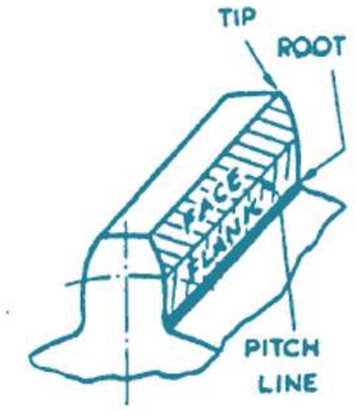
The gear pattern is the contact area of one gear withanother.
Application of a dye to the gears before operating them under specified load conditions allows the die to colour the gear in the area where two gears contact eachother.
Ideally, this contact pattern will be located in the middle of the gearteeth.
Testing and adjusting gear backlash and pattern must always be done in accordancewith manufacturer'sinstruction.

Shims or spacers are often used to obtain the correct relationship between the gears.



If you are going to be involved at any time with the inspection of gears, then it is essential that you should be aware of at least some of the terms used:





Circular Pitch - the distance between two corresponding points on two adjacentteeth around the pitchcircle.
Pitch circle - A circle, the radius of which is equal to the distance from the gear axis tothe pitchpoint.
Pitchpoint-thepointofcontactwhichtransmitsthemotiontoothtotooth(thepointat which two pitch circlesmeet)

Addendum-theradialdistancebetweenthepitchcircleofagearwheelandtopofthe tooth.

Dedendum - the radial distance between the pitch circle and the root circle (depth of tooth below pitchcircle)
Clearance – the difference between the addendum anddedendum.

Whole depth - the sum of addendum anddedendum.
Working depth - the maximum depth that the tooth extends intothe tooth space of the matinggear.
Face - the surface of the tooth between the pitch circle and top of thetooth
Flank - the surface of the tooth between the pitch circle and the bottomland
Pinion - the term applied to the smaller of two matinggears.
Tooth thickness - the thickness of a tooth measured along the pitchcircle.
Tooth space - the distance between two adjacent teeth measured along the pitchcircle.

Belts and Pulleys:

Many piston engine aircraft powerplants use a belt and pulley arrangement to drive the alternator or vacuumpump.
They might also be used in some other accessory on largeraircraft.
In Picture:- Belt and pulley used to transmit power from crankshaft to supercharger.

Belts must be inspected for wear anddegradation.
Cracking, chipping, fraying or splitting are cause forreplacement.
Pulleys must be aligned correctly so that the belt cycles without any vibration or excessivewear.
A drive belt must operate at a designedtension.

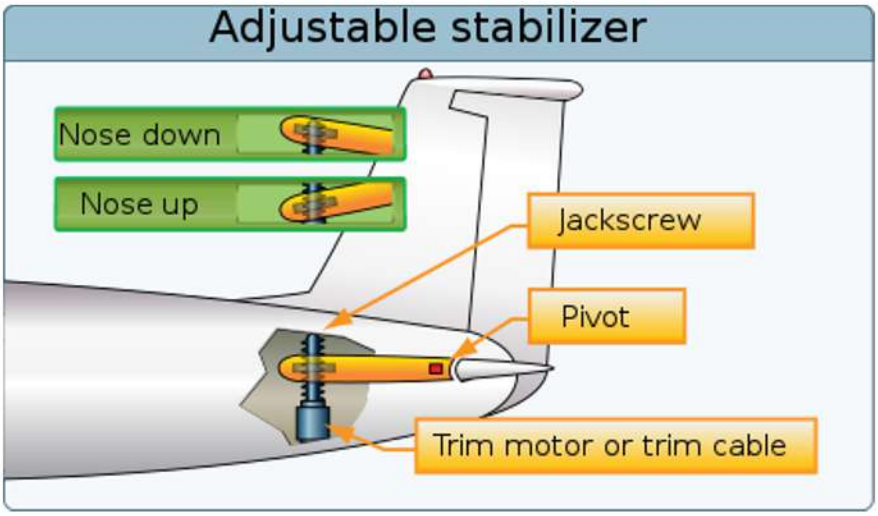
The tension can often be tested by pushing on the belt in an unsupported location and observing

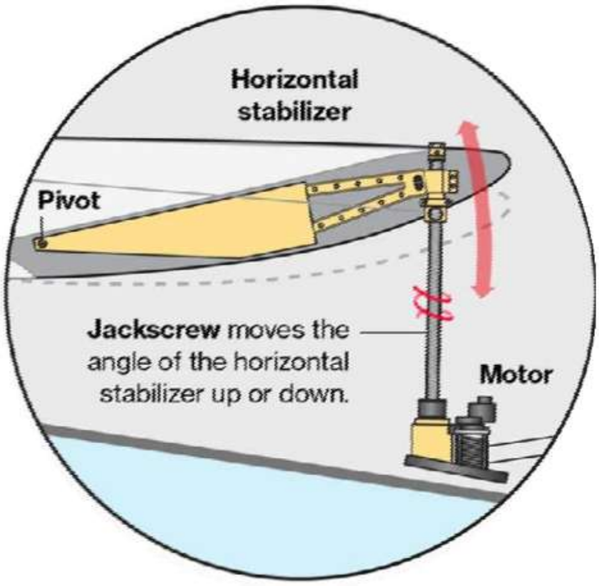
itsdeflection.
An adjustment is typically made by moving the alternator and its pulley location via an adjusting bolt on the mounting bracket. In addition to a condition inspection before each flight, belts are inspected during regular maintenanceinspections.

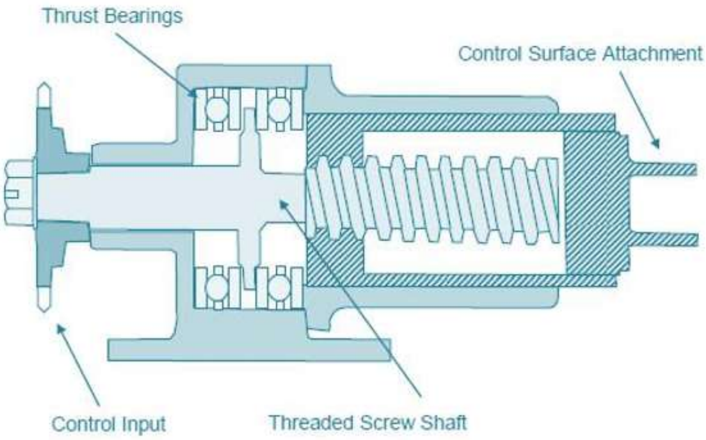
Belts may be life-limited parts that are changed periodically despiteappearance.
Follow the manufacturer's instruction when maintaining a belt and pulley transmission. Always replace a belt with a belt of the exact same partnumber.

Jackscrews:

A jack screw transmission of power is common on aircraft. It is often used as the drive for lowering and raising flaps and on stabilizer and rudder trimmechanisms.
A gear arrangement or gearbox is used to transfer the power to the jack screw.
A ball nut attached to the moving component is rotated which follows the helically ground jack screw until the component is in the selected position.
Lubrication and backlash are the two primary maintenance concerns with a jack screw arrangement.
The jackscrew must be cleaned before lubricating or making clearanceadjustments.
Regular lubrication intervals are specified in maintenance data due to the environmental exposure of many jackscrewinstallations.
Ball nut wear is possible and is also checked. Use of jigs or special measuring tools is common.



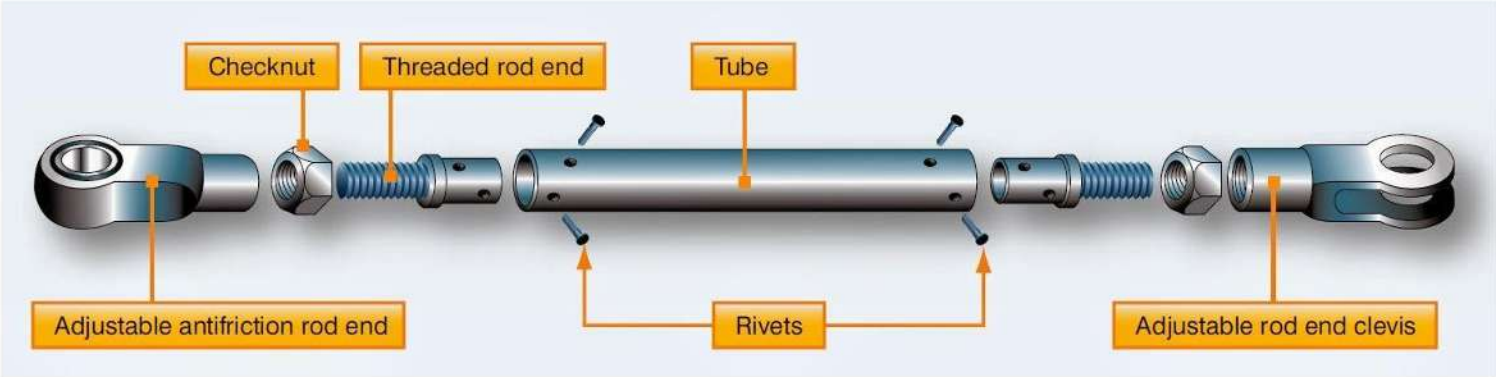




Screw Jack Actuator

Push-Pull rod system:

Push-pull tubes are used as linkage in various types of mechanically operatedsystems.
This type of linkage eliminates the problem of varying tension and permits the transfer of either compression or tension stress through a singletube.
A push-pull tube assembly consists of a hollow aluminum alloy or steel tube with an adjustable end fitting and a check nut at eitherend.



The check nuts secure the end fittings after the tube assembly has been adjusted to its correct length.
Push pull tubes are generally made in short lengths to prevent vibration and bending under compressionloads.
Inspection of push pull rods includes ensuring that they are perfectly straight (unless designed otherwise).
When installed, the assembly should be correctly aligned and should movefreely.
The spherical rod end bushing are either sealed or are .fitted with a .fitting to belubricated.
The bolt or pin installed through the rod end should be in good condition and safetied properly.
The bores through which the rod end bolt connect the rod to an assembly must also be inspected.
The bolt may have to be removed for inspection. Rod ends do fail and should be inspected frequently and replaced whenrecommended.
This is particularly important since push-pull tube assemblies are often used in flight controls and landinggear.
There should be a smooth movement in the push pull rod assembly free frombinding.
Anything else should prompt furtherinspection.

CONTROLCABLES

SWAGING OF END FITTINGS
All cables, used in aircraft controls runs, have some form of end fittings attached to each end of the cables. These end fittings are usually ‘swaged’ onto the cable, meaning that the end fitting is slid over the cable before being squeezed, to reduce its diameter, and cause it to grip the cable verytightly.
During production of these cables, the completed end fitting will be carefully checked, using a Go/No-Go gauge, to ensure that the cable has been gripped satisfactorily. The finished cable assembly will also be proof tested to confirm its suitability for use as an aircraft control cable.

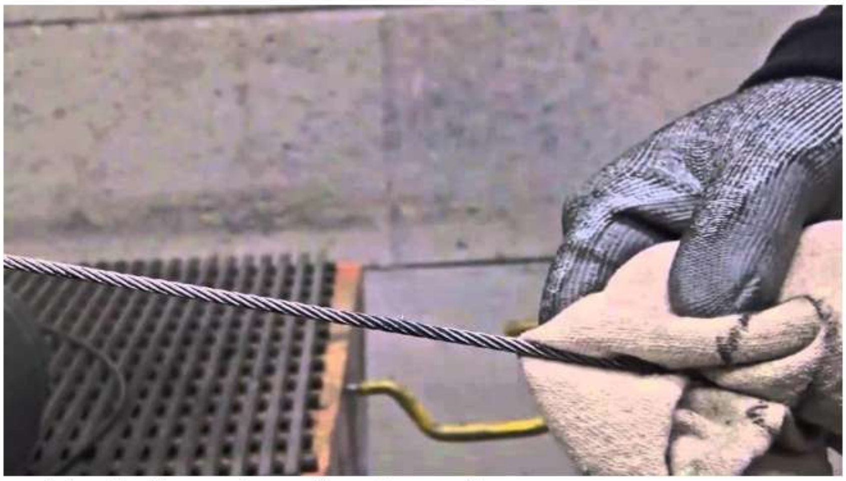
TERMINALS

When swaging terminals onto cable ends, observe the following procedures. Cut the cable to the proper length allowing for growth during swaging.

NOTE: Never solder cable ends to prevent fraying,
since the presence of the solder will greatly increase the tendency of the cable to pull out of the terminal.

Insert the cable into the terminal approximately 1 inch, and bend toward the terminal, then push the cable end entirely into the terminal barrel. The bending
action puts a kink or bend in the cable end, and provides enough friction to hold the terminal in place until the swaging operation can be performed

INSPECTION AND TESTING OF CONTROL CABLES
Once in service, the cables will be inspected regularly for a variety of possible faults, whilst the swaged end fittings will require minimal inspection. In some installations, red paint is applied at the junction of the end fitting where the cableemerges, leading to a gap showing if the cable has slipped within the swaged end fitting during normal service.
Some individual ferrules, fitted to non-critical cables, may be inspected for signs of cracking whilst in service.
It is rare for cables to be removed from service to have a scheduled proof load test. If there is any doubt to



the possibility of the cables lasting a long time in service,

they will be either checked for stretch by measuring their length under load, or they will be given a finite life and replaced when that life is reached.
Cable systems have to receive regular inspections due to their being subject to a wide variety of environmental conditions and wear. Their degradation, due to wear, can take the form of wire/strand breakage (which is fairly easy to detect), or may exist as less visible (internal) wear, or as corrosion and distortion.

CableWear

Critical areas for strand breakage are where the cable passes over pulleys orthrough fairleads. Examination of cables will normally involve passing a cloth alongthe length of the cable, which will both clean any dirt from it and detect brokenstrands if the cloth 'snags' on the projecting wires.There will be limits, published by the manufacturer, which say how many strand per unit length can be broken. Removed cables can be bent through a gentle radius,which may show up broken internal strands that would not be visible wheninstalled and tensioned.External wear (refer to Fig. 1) will extend along the cable, equal to the distance thecable moves at that location and may occur on one side of the cable or over itsentire circumference. The limits of permitted wear will be found in theAMM.
Internal wear occurs in similar places in the wire to external wear, around pulleysand fairleads and is much more difficult to detect. Separating the strands, afterremoving the cable, is the only way to detect internal wear and this only permitslimited inspection.
Generally any signs of internal wear within a cable will mean its replacement.

Broken strands on a cable at a location not adjacent to a pulley or fairlead, could bean indication that the breakage was due to corrosion.The inspection of a cable for internal corrosion should be done off aircraft, and willinvolve rejection of the cable if corrosion is found.The maintenance carried out on cable runs usually involves both regularinspections and preservative measures. With the majority of cables being steel-based, it is vital that cables, passing through high risk areas such as battery bays,toilets and galleys,

receive regular rust preventative treatments in addition to visualinspections.
Most cables have external corrosion preventative compounds applied in varyingamounts, whilst internally they will have been soaked in some form of thin greaseor low- temperature oil to resist the formation of the difficult to detect internalcorrosion.
Normally in dry and desert atmospheres, the application of certain compounds tocables is not permitted. This is because the adhesive properties of these compounds will cause the sand and dust to stick to the cable and, thus, cause extremely high rates of wear.

Bowden andTeleflexCableSystems

A typical Bowden cable control might be a brake lever on the control columnoperating a remote brake control valve.Maintenance of Bowden cable systems is usually restricted to cleaning and
lubrication of the inner cable at regular intervals and adjustment of the outer conduit (e.g. if the brakes needed adjustment). The lubrication would keepmoisture out of the cable to prevent it freezing at low temperatures.
The Teleflex cable system is more complex than the Bowden cable system in thatthe operating cable, within the conduit, is actually a number of spirally woundcables which surround a core tension cable, giving it support. This allows the cable to transmit a push force as easily as a pull force, doing away with the need for anyform of return spring.
A typical use of a Teleflex system might be a throttle lever to engine fuel controlsystem connection.
The Teleflex cable system is a snug fit within the conduit and, because there mightbe the chance of it becoming seized, due to foreign objects, dirt or freezing, it is vitalthat the inner cables are regularly removed, cleaned and lubricated with lowtemperature grease. It is also important that the conduits are thoroughly cleanedusing a form of ‘pull-through’, prior to the inner cable being installed.

BOWDEN CABLE

At longer intervals, it might become necessary to inspect the outer conduit for signs of damage or kinking; which can cause the control to become tight or 'notchy'.

TEFLEX CABLESYSTEM

INSPECTION OF CONTROL CABLE PULLEYS

When inspecting cables for the previously mentioned wear and breakages, the complete cable runs must be examined for incorrect routing, fraying, twisting or wear at fairleads, pulleys and guards.
Pulleys must be inspected for wear (refer to Fig. 2), to detect indications of seizure, flat spots, embedded foreign material and excessive tension. Any signs of contact with adjacent structure, pipe-work, wiring and other controls must also be thoroughly investigated.

MATERIALHANDLING

MATERIAL HANDLING
SHEET METAL WORK

Before a part is attached to the aircraft during either manufacture or repair, it has to be shaped to fit into place. This shaping process is called forming.

While the majority of metals can be rolled into sheet form, consideration is confined here solely to the working with sheets of the light alloys, which are encountered on aircraft and, in particular, those formed from aluminium alloy ingots.
Safe working procedures were covered adequately, in the 'Workshop and Hangar Safety' Section of the SAFETY PRECAUTIONS topic, but there are several additional points, which need highlighting, with regard to working with sheets of aluminium alloy.

By definition, sheets of aluminium alloy are comparatively thin in cross-section and, as such, they not only pose a health hazard, through cuts, when being handled but they are, also, prone to buckling and creasing if handled carelessly.

Large sheets of aluminium alloys are, usually stored upright, on their longest edge and supported, clear of the floor, in a wooden framework so they are protected from damage and corrosion. Care must be taken when removing a large sheet from its storage rack – a task which normally involves at least two persons – and good communication between the carriers is important so that the task is completed in a safe manner and no damage is done to the sheet metal.

Some sheets are covered, on one or both surfaces, with a thin protective plastic membrane and, if possible, it may be beneficial to leave at least the underneath protection in place while the marking out is done, to minimise the possibility of thesurface sustaining undesirable scratch marks. If no protective membrane is applied to the sheet, then care must be taken over the condition of the surface of the table,or workbench, upon which the sheet is to be laid for the marking out procedures.

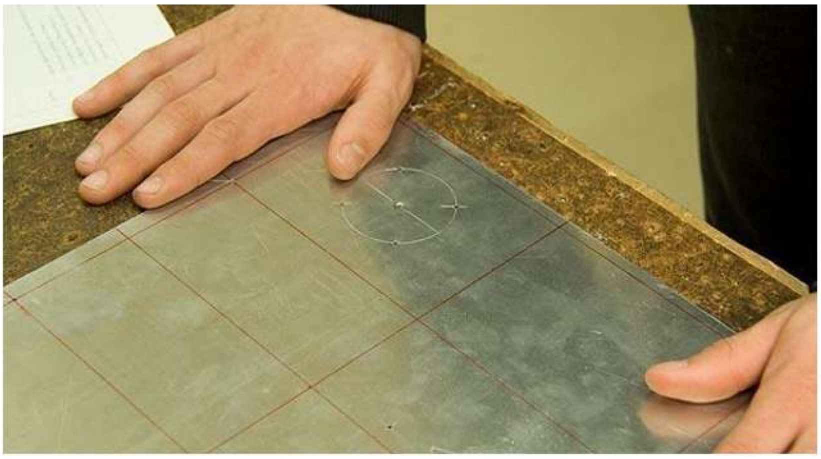
Other factors, which should be considered (as with all work) concern the requirements to ensure that:

Material wastage is kept to a minimum The task is done correctly, first time, so that valuable time, also, is not wasted.
The first point is usually obvious, due to the cost of the materials involved, but the second point quite often gets forgotten, when work is being done, but the actual labour costs far outweigh the material costs on a high percentage of tasks.

Repair or modification drawings must be studied very carefully, to ensure there is no doubt about the data and dimensions provided, so that the marking out is correctly done and the approved metal is shaped in exactly the manner that the designer of the drawing intended.

MARKING OUT
The drawing surface of the metal should be cleaned of any protective oil (or plasticmembrane) before marking out commences and the sheet should be laid flat on a clean, firm workbench or table in good lighting conditions.

It must be remembered that, the metal should be cut so that any identification markings remain on the larger piece, for future users of the sheet and that scribers must only be used to mark lines which are going to be removed from the surface.



Scribed lines penetrate the aluminium cladding of ‘Alclad’ alloys, which can lead not only to subsequent corrosion, but also can create stress raisers and the initiation of cracks in the material.The drawing of the outline is achieved by establishing a datum line or point on thesurface of the metal and taking all dimensions from the datum so that errors, due to ‘chaining’ of dimensions, are eliminated.

In some instances it may be advantageous to rub chalk on the surface or to apply a thin coat of zinc chromate, to make it easier to distinguish the marking out lines, which (if they are not going to be removed) should be made with a ‘soft’ pencil.

Once the outline is completed, the sheet may be (carefully) moved to the squaring shears, or guillotine and the outline cut from the main sheet. The square edge, created by the squaring shears, will make the use of such tools as engineers’ squares, combination sets and Vernier protractors etc. easier, to achieve parallel and appropriately angled lines during completion of the marking out.

FORMING OF SHEET METAL PARTS

Once the marking out has been verified as being correct, the forming of the final shape of the sheet metal component can be achieved by the use of appropriate cutting and, if necessary, bending tools.

Cutting

While metal-cutting tools were discussed in the earlier topic on TOOLS, mention is made here of the manner in which the relevant tools should be used when working with sheet aluminium alloys.

The squaring shears has already been used to produce a convenient size uponwhich to work and, of course, to provide an accurate straight edge from which to make measurements.

Note: The squaring shears must only be used to cut metal of the approved thickness (recommended by its manufacturer) and must never be used on sheets (or strips) of metal thicker than those specified. The alignment of the blade will be distorted and the accuracy of its cut will be degraded if this caution is ignored.

When using shears (whether squaring or the hand type), then the cut must be made slightly above the line. This allows for filing down to the line, which will eliminate the possibility of stress raisers being formed at the edges of the metal, due to the shearing action of the various types of shears.

Care must be taken when drilling aluminium sheet, due to the danger of cutting enlarged holes in the soft, thin metal and to the tendency to distortion, caused by the application of too great a weight on unsupported aluminium sections.

Twist drills must be of the correct type and size, with accurately-ground points, and their passage, through the metal, must be carefully controlled at all times. Off cuts of scrap wood should be placed behind (or underneath) sheet metal parts while drilling is in progress and both the backing piece and the part must be firmly held, to prevent movement during the drilling procedures.

Bending and Calculation of Bend Allowance

As previously stated, the sheet metal used for aircraft construction and repair, is generally formed from an ingot of aluminum alloy that has been processed througha series of rollers.
This process reduces the thickness of the material to a dimension that meets therequirements of the design drawing. As a result of this process, the metal assumes a grain structure, which can easily be detected in a sample of sheet aluminum alloy.

When planning any sheet metal work process, the orientation of the metal is to be taken into account so that any bends formed will, where practical and achievable, be made across the grain. Where, however, strength is required along the length of a long, channel section, then, regardless of any bends, the grain should flow along the length of the channel.

Great care must be taken, before bending aluminium alloy, to ensure that it is of the correct designation and heat-treatment standard. The subject of the heat-treatments of aluminium alloys
Some alloys must be subjected to either an annealing, or to a solution treatment procedure before (and, again, after) bending but, as this is, usually, beyond the scope of maintenance technicians, mention of it is merely made here to draw attention to its requirement and for the need for vigilance when bending sheets of aluminium alloy.

Bending of aluminium alloys is achieved either by the use of:

Specially-shaped bending bars: used for small pieces and larger angles and between which, the sheet is clamped, in a vice, while the metal is bent, byhitting with a hide-faced or similarly soft-headed hammer

is clamped and A large, free standing, bending machine (or bending brake): in which the metal sheet
the bend made, in one movement, by means of a hinged bending leaf.

Caution must also be exercised when forming a bend, using the bending bars and soft-headed hammer method, because too many blows with the hammer will cause work-hardening of the metal, or the metal, in the bend, will become too thin and stretched. Subsequent cracking of the metal will result from these faultsFor this reason the bending brake is preferred but, in a similar manner to thesquaring shears, only the approved thicknesses of metals should be bent in thesemachines, as any distortion will destroy the accuracy of the bends.

Square (or sharp) angles, in aluminium alloys, are only formed by adhesive, casting,extrusion or welding methods. Whether it be the bending bars or the bending brake method, which is used to bend aluminium alloy sheet, the bend will always be formed around a radius, as it is not possible to create square angles by bending without cracking the metal.

It is recommended that the radii of bends, in aircraft-grade, aluminium alloy sheets, be not less than three times the thickness (3t) of the metal, in sheets thicker than 22 SWG (0.7 mm) and should, preferably, be greater if possible.

INSPECTION OF SHEET METAL WORK

When visually inspecting sheet metal work for damage, remember that there may be other kinds of damage than that caused by impact from foreign objects or collision.

A rough landing may overload one of the
landing gear, causing it to become sprung; this would be classified as load damage

shock occurring at one end of a member is transmitted throughout its length; therefore, closely inspect all rivets, bolts, and attaching structures along the complete member for any evidence of damage.

Whether specific damage is suspected or not, an aircraft structure must occasionally be inspected for structural integrity. The following paragraphs provide general guidelines for this inspection. When inspecting the structure of an aircraft, it is very important to watch for evidence of corrosion on the inside. This is most likely to occur in pockets and corners where moistureand
salt spray may accumulate; therefore, drain holes must always be kept clean.

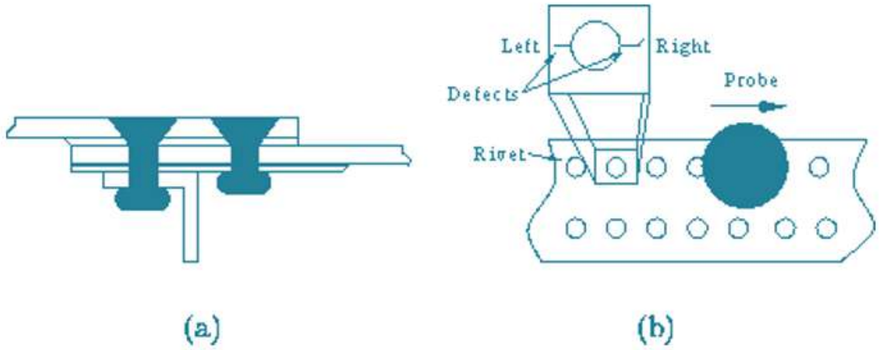
A working rivet is one
that has movement under structural stress, but has notloosened to the extent that movement can be observed. This situation can sometimes be noted by a dark, greasy residue or deterioration of paint and primers around rivet heads. External indications of internal injury must be watched for and correctly interpreted. Whenfound,aninvestigation of the substructure in the vicinity should be made and corrective action taken.

INSPECTION OF RIVETED JOINTS

Inspection consists of examining both the shop and manufactured heads and the surrounding skin and structural parts for deformities.

During the repair of an aircraft structural part, examine adjacent parts to determine the condition of neighboring rivets. The presence of chipped or cracked paint around the heads may indicate shifted or loose rivets. If the heads are tipped or if rivets are loose, they show up in groups of several consecutive

rivets and are probably tipped in the same direction. If heads that appear to
be tipped are not in groups and are not tipped in the same direction, tipping may have occurred during some previous installation.



Inspect rivets that are known to have been critically loaded, but that show no visible distortion, by drilling off the head and carefully punching out the shank. If upon examination, the shank appears joggled and the holes in the sheet misaligned, the rivet has failed in shear.

joggle in removed rivet shanks indicate partial shear
failure. Replace these rivets with the next larger size.

Airframe cracking is not necessarily caused by defective rivets. It is common practice in the industry to size rivet patterns assuming one or more of the rivets is not effective.

COMPOSITE AND NON-METALLIC

BONDING PRACTICES

Composite materials can be used to structurally repair, restore, or enhance aluminum, steel, and titanium components.
Bonded composite doublers have the ability to slow or stop fatigue crack growth, replace lost structural area due to corrosion grind-outs, and structurally enhance areas with small and negative margins. This technology has often been referred to as a combination of metal bonding and conventional on-aircraft composite bonded repair. Boron prepreg tape with an epoxy resin is most often used for this application.

ENVIRONMENTAL CONDITIONS

Control of the repair environment is directly related to the integrity and endurance of the repair. Cleanliness is critical. Bonded areas must be kept clean for fullpotential of adhesion to be realized.

Precured laminates undergoing secondary bonding usually have a thin nylon or fiberglass peel ply cured onto the bonding surfaces.
While the peel ply sometimes hampers nondestructive inspection of the precured laminate, it has been found to be the most effective means of ensuring surface cleanliness prior to bonding. When the peel ply is stripped away, a pristine surface becomes available.

Light scuff sanding removes high resin peak impressions produced by the peel ply weave which, if they fracture,
create cracks in the bond line. Bonded repair of or with composite materials is done at room temperature or elevated temperature. Elevated
temperatures are preferred with most repair methods which produce the highest quality bond.
Small parts repaired off the aircraft can be placed in an autoclave or
walk-in curing oven to control the repair environment. On-aircraft repairs may require the use of a heat bonder, heat lamps, hot air or heat blanket usage to elevate and maintain the proper temperature while the bonded
repair cures.

Thermal surveys of the area to be repaired
are conducted to ascertain the heat sink effect of adjacent structures. Compensation in heating is made so that an even prescribed cure temperature can be reachedand
held during bond curing.

INSPECTION OF COMPOSITES

Composite structures should be inspected for delamination, which is separation of the various plies, debonding of the skin from the core, and evidence of moisture and corrosion. Previously discussed methods including ultrasonic, acoustic emission, and radiographic inspections may be used as recommended by the aircraft
manufacturer. The simplest method used in testingcomposite structures is the tap test.

TAP TESTING

Tap testing, also referred to as the ring test or coin test, is widely used as a quick evaluation of any accessible surface to detect the presence of delamination or debonding. The testing procedure consists of lightly tapping the surface with a light hammer (maximum weight of 2 ounces), a coin or other suitabledevice.
The acoustic response or "ring" is compared to that of a known good area.

A "flat" or "dead" response indicates an area of concern. Tap testing is limited to finding defects in relatively thin skins, less than 0.080" thick. On honeycomb structures, both sides need to be tested. Tap testing on only one side would not detect debonding on the opposite side.

WELDING, BRAZING, SOLDERING ANDBONDING

SOLDERING

Soft solder is chiefly used to join copper and brass where a leak proof joint is desired, and sometimes for fitting joints to promote rigidity and prevent corrosion.

Soft soldering is generally performed only in minor repair jobs. Soft solder is also used to join electrical connections. It forms a strong union with low electrical resistance. Soft soldering does not require the heat of an oxy-fuel gas torch .

Soldering differs from welding in that it is done at considerably lower temperatures so that the parent metals do not melt and fuse together.

Instead, a fusible and, usually, non-ferrous alloy (with a lower melting point) is applied between the heated metals of the joint, such that the fusible alloy forms ametallic bond with the parent metals and, on cooling, creates a solid joint.

The word ‘solder’ does, in fact, come from the same stem as the word ‘solid’ (as does the American term, which is pronounced ‘sodder’, for the same process).

METHODS OFSOLDERING

Soldering can be divided into two basic methods, one of which uses higher temperature ranges than the other, but both of which are conducted at temperatures below the melting points of the parent metals of the intendedjoint.

The two basic methods of soldering are:

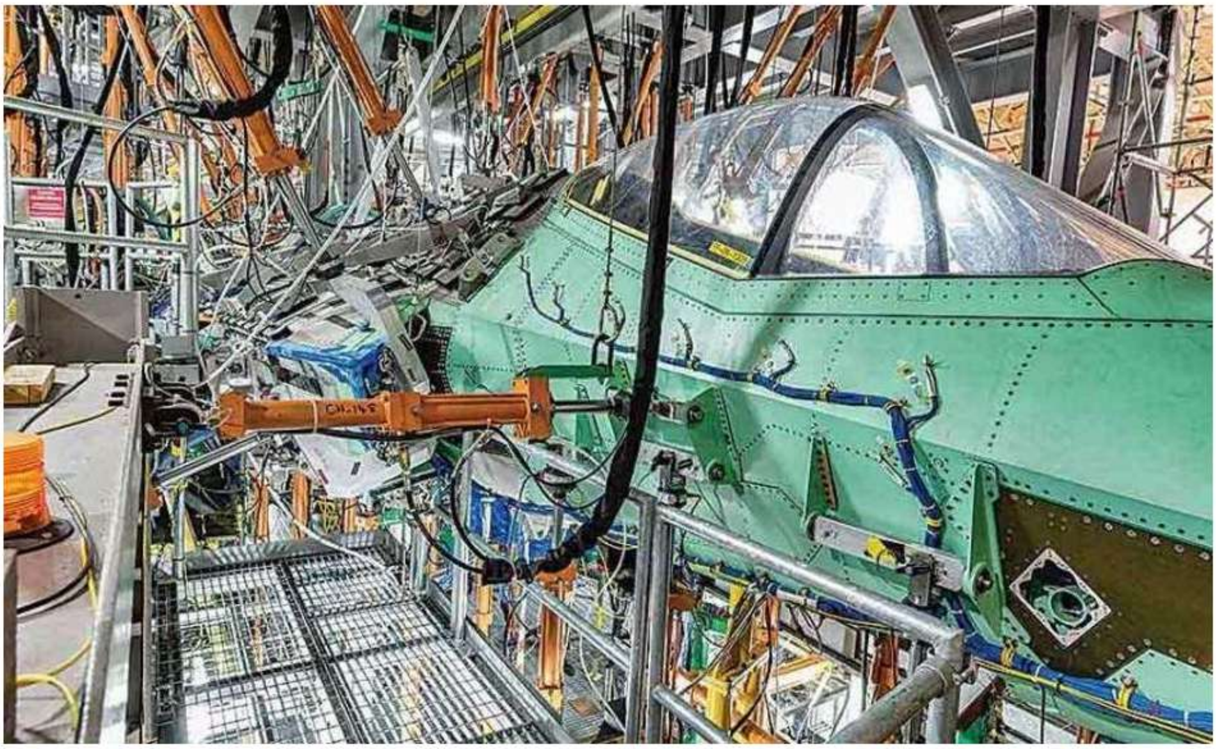
Hard Soldering: done at temperatures in excess of 500°C and which include the processes of Brazing and Silver Soldering

Soft Soldering: done at temperatures within the range of 180°C to 330°C, which, consequently, create joints of lower strength (but less expense) thanthose achieved by the hard solderingmethods.

Note: The hard soldering processes are, normally, beyond the remit of the aircraft servicing technician, so only brief consideration is given to them here, with more attention being given to the soft soldering method.

Hard Soldering (Brazing and Silver Soldering)

Brazing, as the name implies, uses a Copper/Zinc (Brass) alloy, as the filler metal (spelter) between the parent metals of the joint. The degree of alloying will dictate the temperature at which the process is done but the melting point of the brazing alloys can be as high as 880°C.



Brazing is a process of joining in which, during, or after heating, the molten filler metal is drawn into, or retained in, the space between closely adjacent surfaces of the parts to be joined, by capillary attraction.

In general applications, workshops and small factories, a flame, directed onto the joint area, is the source of heat. However, in the more sophisticated applications, used in industry, heating for hard soldering may be provided by a:

Gas, oil or electrically heated, closed furnace High-frequency (HF) induction coil.

As with welding, it is necessary to employ the use of a flux material to assist the fusion of the filler with the parent metals and to prevent oxidation of the joint.

The flux mostly used for brazing processes is borax, which is based on Sodium Borate powder, mixed with water, to a thin paste before being applied, by brush or swab, to the site of the joint. Other fluxes are also available where required.

Silver Soldering entails the use of a Copper/Zinc/Silver or Nickel/Silver alloy as the joining metal and (again depending on the alloy employed), can be done at temperatures of between 650°C to 700°C. Brass, copper, monel metal and stainless steel are typical metals on which silver soldering processes can be used.

SoftSoldering

Soft Soldering involves the use of a Lead/Tin alloy (with traces of Bismuth and Antimony added when required) as the filler metal, which melts at temperatures between approximately 180°C to 330°C, depending on the composition of the alloy.

The lower temperature requirement, of the soft soldering process, allows the use of indirect heat.
In earlier times, the heat was provided by the application of an implement with a wooden handle and a smooth, flat, base or ‘bit’ (originally made of iron). The ‘iron’ was directly heated in a flame, then quickly cleaned, before being applied to thesolder joint, where the transference of its heat would facilitate the melting of the filler metal. This process possibly needed repeating several times (as the iron tended to lose its heat fairly quickly) before a large task could be completed.

It was found that copper is a better heat conductor than iron, is less prone to corrosion and is, therefore, easier to keep clean. Copper, consequently, became the metal most preferred for use as the soldering ‘bit’, though the implement retained its name of the soldering ‘iron’. While needing re-heating less frequently, it remains necessary to regularly reheat the copper bit of the directly heated solderingirons.

AIRCRAFT WELDING

Welding can be traced back to the Bronze Age, but it was not until the 19th century that welding as we know it today was invented. Some of the first successful commercially manufactured aircraft were constructed
from welded steel tube frames.

As the technology and manufacturing processes evolved in the aircraft and aerospace industry, lighter metals, such as aluminum, magnesium, and titanium, were used in

their construction. New processes and methods of welding these metals were developed.
This chapter provides some of the basic information needed to understand and initiate the various welding methods and processes.

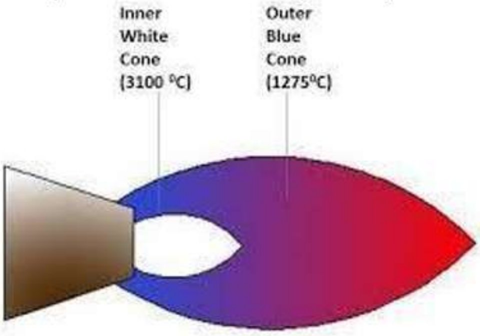
There are three general types of welding: gas, electric arc, and electric resistance. Each type of welding has several variations, some of which are used in the construction of aircraft. Additionally, there are some new welding processes that have been developed in recent years that are highlighted for the purpose of information

METHODSOFWELDING

Welds require the application of sufficient heat energy to melt the metals involved in the joint and the high temperatures are achieved by various methods.

Oxy-Acetylene Flame
The cutting of steel sections and plate material may be done by means of a flame torch, using a mixture of oxygen, with one of the appropriate fuel gases (acetylene,hydrogen, natural gas or propane).

For welding, however, only an oxygen and acetylene mixture will provide a sufficiently, high heat input, needed for the welding process. The temperature of the oxy-acetylene flame is approximately 3150°C.



Natural Flame

The oxy-acetylene method can be used for welding ferrous or non-ferrous metals
but, when welding non-ferrous metals, it is necessary that an additional material (a flux) be used, usually with a filler metal, to assist in the fusion process.

The purpose of the flux is to prevent oxidation of the joint site so that the molten metals can fuse together more easily and, thus, eliminate brittleness in the joint.

Manual Metal Arc

This welding process uses an electric arc as the heat source. The arc is establishedbetween a flux-coated, filler metal rod and the workpiece, which are connected to
an electrical power source so that they are the anode and cathode electrodes of thecircuit. When the power is switched on, the heat, generated by the resulting arc,melts the flux- coated electrode and the edges of the parent material to form a weldpool.
The temperature of the arc is approximately 4000°C to 4500°C. Metal Arc Gas-Shielded (MAGS)
In this semi-automatic welding process the heat source is also an electric arc, butthe electrode is a bare wire, which is consumable and is supplied, from a reel, to thewelding gun, by a wire feed unit. A shielding gas is employed; in place of a flux material, to protect the weld pool. The type of shielding gas, used, will vary with the application. Some of the gases and gas mixtures usedare:
Argon
Carbon dioxide Argon/carbon dioxide Argon/oxygen Argon/nitrogen Helium.
Note: This process may also be referred to according to the type of shielding gas (or mixture of gases) which is being used and whether those gases are inert or active. The two types of this process are:
Metal Inert Gas (MIG) welding: where the shielding is provided by a shroud of inert gas.
Metal Active Gas (MAG) welding: where the shielding is provided by a shroud of active, or non-inert, gas or mixture of gases.

Tungsten Arc Gas-Shielded (TAGS)

This process also uses an electric arc as the heat source, but here a tungsten non- consumable electrode is used to form the arc with the workpiece. An inert shielding gas (argon) is required to protect both the weld pool and the tungsten electrode from the oxygen and moisture in theatmosphere.
For this reason the process is sometimes called argon arc welding and, also, Tungsten Inert Gas (TIG) welding.
A filler rod is usually required to give reinforcement to the weld.
Flash Butt Welding

The components to be joined are set up as opposite poles in an electric circuit and,when the current is switched on, the components are moved into and out of contactwith one another. This action causes an arc to be struck and, when welding temperature is reached, a force is applied to both components, so that their

molten surfaces are fused together.

SpotWelding

A method used to join comparatively thin sheets of metal, spot welding is a form ofresistance welding. The sheets of metal are sandwiched between two, pointed electrodes on which force is exerted as the current is applied. The heat is generated
at a local spot where the resistance to the flow of the electricity is at its highest and
the metal fuses at these spots. The pointed electrodes are made from copper alloy and are usually water-cooled.

SeamWelding

The principle of seam welding is similar to that of spot welding (namely resistanceto the flow of electricity). The main difference is that in place of the pointedelectrodes, this method uses discs or wheels, which are moved along the length ofthe weld. The supply of current is intermittent, so causing a spot weld to overlap its neighbour and, thereby, form a continuous seam weld.

INSPECTION AND TESTING OFWELDS

The wide use of welding in industry has resulted in an increasing demand for standards relating to welded constructions in various branches of engineering.

These standards generally include requirements for certain welding tests to be conducted, primarily for the qualification of welding procedures and operators. Sophisticated methods of non-destructive testing of welds include the use of Radiographic, Ultrasonic and Magnetic Particle testing procedures, all of which aredone by specially trained, and approved, personnel. Specimen welds are also destructively tested, by fracturing or sectioning, to test the integrity of a specific welding procedure.

These methods are beyond the scope of unqualified personnel, so that aircraft maintenance technicians are, usually, constrained solely to the visual inspection ofwelds (following thorough cleaning of the relevant areas).

It may, however, be possible that, after suitable training, some technicians can begranted approval to conduct limited Dye Penetrant inspection procedures on certain welds, which will be specified in the appropriate servicing manual.

BONDING

Another method of joining two pieces of material is to bond them. Generally, the term bonding refers to the use of some sort of adhesive to chemically or
mechanically join materials. The adhesive chosen is a factor of the properties of the materials to be joined and the application of the bonded part. Sealants also are considered to bond materials.

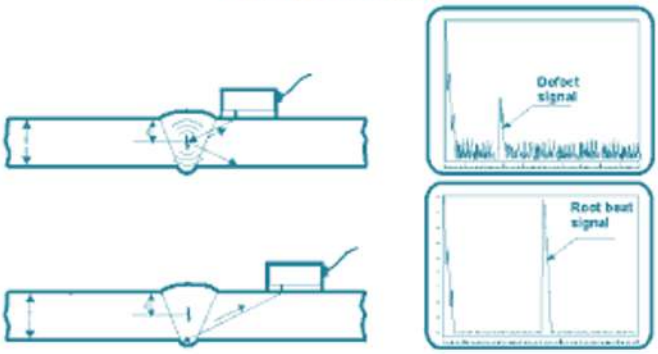
To achieve optimum bonding, performance, and life in service from adhesives and sealants, it is absolutely crucial to follow carefully planned processes and
procedures. The utmost attention must be paid to the quality of work at every stage.

Bonding occurs on aircraft between many different materials and in both structural and non-structural applications. Absolute cleanliness at all stages is essential. Surface preparation of the component is also crucial. To ensure consistent results on structural components,a
purpose-built 'clean room' may be required, in order to reduce contamination to a minimum. Pressure and heat
may also be required. Sophisticated equipment is required to produce pressure over the components in areas where adhesives are applied.
This will often entail vacuumbags, purpose-built ovens, or pressurized curing ovens(autoclaves) when dealing with composite materials.

Follow manufacturer's instructions whenever attemptinga repair by bonding. To prepare, grease, oil or other
contaminants are typically removed with a suitable solvent. Optimum surface roughness must also exist or be produced.
Increasingly, aircraft components are manufactured from non-metallic materials, especially composite materials.

INSPECTION OF WELDED JOINTS
To ensure the airworthiness of any welded area, a visually inspection of the completed weld should be made. The weld should have a smooth seam and uniform thickness. There should be smooth blending of the weldcontour into the base metal and a check for undercut should bemade.

1a. Angle beam technique



The weld tapered smoothly into the base metal is a sign of a good weld.
When inspecting a weld, no oxide should have formed on the base metal more than 1/2 inch from the weld. Thereshould be no signs of blowholes, porosity, or projecting globules. Many industry codes specify acceptable limits of porosity and other types of defects that are acceptable.

The base metal should show no signs of pitting, burning, cracking, or distortion. The depth of penetration should be sufficient to insure fusion of the base metal and the filler rod. The welding scale should be removed. The welding scale can be removed using a wire brush or by sandblasting. Also remove any roll over, cold lab, or unfused weldmetal.

Always inspect the underside of welded joints for defects.
Cracks in parts and materials can vary from tiny microfissures, that are visible only with magnification, to those easily identified by unaided eyes. Micro-fissures are the worst type of defect for two reasons; they are often hard to detect, and they produce the worst form of notch effect/stress concentration. Once a

micro-fissure forms, it propagates with repeated applications ofstress
and leads to early failures.
Every possible means should be used to detect the presence of cracks, and ensure their complete removal before welding operations proceed.

Nondestructive testing (NDT) or evaluation of welds is advisable in critical applications. Nondestructive testing methods such as magnetic particle, liquid
penetrant, radiography, ultrasonic, eddy current, and acoustic emission can be used; however, they require trained and qualified people to apply them. If there isany doubt about the integrity of a welded area, further NDT is required.

INSPECTION OF BONDED JOINTS

Simple non-structural bonded joints can be visually inspected for fit and security. Audible sonic testing is used to test composite material bonds for delimitation and/or disband. In composite and structural bonding, manufacturers may specify NDT methods of inspection such as ultrasound. Follow manufacturer's instruction when inspecting bonded joints

AIRCRAFT WEIGHT ANDBALANCE
AIRCRAFT WEIGHT AND BALANCE

The weight of an aircraft and its balance are extremely important for operating an aircraft in a safe and efficient manner.
The maximum allowable weight is based on the surface area and shape of the wing, and how much lift it will generate at a safe and appropriate airspeed.

A secondary reason for concern about weight and balance, but also a very important one, is the efficiency of the aircraft. Improper loading reduces the efficiency of an aircraft from the standpoint of ceiling, maneuverability, rate of climb, speed, and fuel consumption
The most efficient condition for an aircraft is to have the point where it balances fall very close to, or perhaps exactly at, the aircraft's center of lift

DEFINITIONS

Datum:

The datum is an imaginary vertical plane from which horizontal measurements are taken.
The locations of items such as baggage
compartments, fuel tanks, seats and engines are relevant to the datum. There is no fixed rule for the location of the datum. The manufacturer willnormally
specify the nose of the aircraft, but it could be at the front main bulkhead or even forward of the aircraft nose

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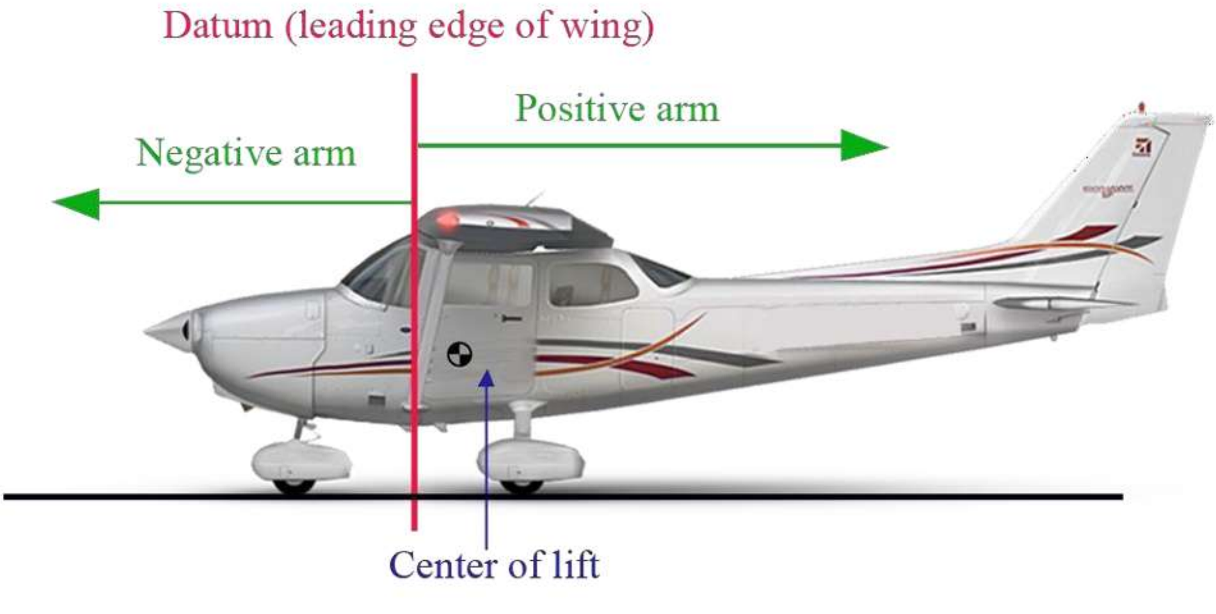
Arm:
The horizontal distance from an item or piece of equipment to the datum. The arm's distance is usually measured in inches (or millimetres) and may be preceded by a plus (+) or a minus (-) sign. The plus sign indicates that the distance is aft of the datum and the minus sign indicates distance is forward of the datum
Moment:
The product of a force multiplied by the distance about which the force acts. In the case of mass and balance, the force is the mass (kg/lb) and the distance is the arm (m/in). Therefore, a mass of 40 kilograms, at 3 metres aft of the datum will have a moment of 40 x 3 = 120 kg/m. It is important to consider whether a value is positive (+ve) or negative (-ve) when moments are calculated and the following conventions are used:
Distances horizontal: aft of the datum (+), forward ofthe datum (-).
Weight: added (+), removed (-).



Centre of Gravity (CG):
This is the point about which all of the mass of the aircraft or object is concentrated. An aircraft could be

suspended from this point and it would not adopt a nose-down nor a tail-down attitude.
Centre of Gravity Balance Limits:
For normal operation of the aircraft, the CG should be between the Forward
and Aft limits as specified by the manufacturer. If the CG is outside these limits, the aircraft performance will be affected and the aircraft may be unsafe.
Dry Operating Mass:
The total mass of the aeroplane, ready for a specific type of operation, excluding all usable fuel and traffic load. This mass includes crew and crew baggage, catering and removable passenger service equipment, potable water and lavatory chemicals.

Maximum Zero Fuel Mass: The maximum permissible mass of an aircraft with no
usable fuel. Fuel contained in certain tanks must be included if this is explicitly mentioned in the aircraft's Flight Manual limitations.
MaximumStructuralTake-OffMass(MTOM):Themaximumpermissible total aeroplane mass at the start of the take-offrun.
Maximum Structural Landing Mass:The maximum permissible total aeroplane mass upon landing under normal circumstances.

Traffic Load: This includes the total mass of passengers, baggage and cargo, including any non-revenue load.

MASS ANDBALANCE

An aircraft operator must specify in the Operations Manual the principles and methods involved in the loading and mass balance system used.
This system must meet the legal requirements of JAR-OPS, and include all types of intended operations, such as charter, cargo and scheduled flights.

The operator has to ensure that, during any phase of operation, the loading, mass and CG of the aeroplane comply with the limitations specified in the approved Flight Manual or the Operations Manual if this is more restrictive.
The operator must establish the mass and CG of an aircraft by actual weighing prior to entry into service and at specified intervals thereafter.

The accumulated effects of modifications and repair on the mass and balance must be accounted for and documented. If the effect of these changes cannot be established the aircraft must be re-weighed.

The Dry Operating Mass must be established by weighing or using standard masses. The influence items included in the Dry Operating Mass and their position on the aircraft must also be established, as are other mass items such as the traffic load,fuel load and ballast.
Methods for calculating crew and passenger mass values are laid down in JAR-OPS and include either weighing the individual crew and their baggage or taking
standard mass values. Whichever method is used must be acceptable to the relevant Authority.

FREQUENCY OF WEIGHING
Aircraft must be weighed before entering service, to determine the individual mass and CG position. This

should be done once all manufacturing processes have been completed.
The aircraft must also be re-weighed within four years from the date of manufacture, if individual mass is used, or within nine years from the date of manufacture, if fleet masses are used.
The mass and CG position of an aircraft must be periodically re-established. The maximum interval between one aircraft weigh and the next, must be defined by the operator, but not exceed the four/nine year limits.
In addition the mass and CG position should be re-established either by weighing or calculation when the cumulative changes in the:
Dry Operating Mass exceed ± 0.5 %
CG position exceeds ± 0.5 % of the MAC.

An aircraft may be transferred from one JAA operator to another without re- weighing provided both have an approved mass control programme.

WEIGHT AND BALANCE DATA

In order to weigh an aircraft and calculate its empty weight and empty weight center of gravity, a technician must have access to weight and balance information
about the aircraft. Possible sources of weight and balance data are as follows:
Aircraft Specifications—applies primarily to aircraft certified under the Civil Aeronautics Administration, when the specifications also included a list of equipment with weights andarms.

Aircraft Operating Limitations—supplied by the aircraftmanufacturer.

Aircraft Flight Manual—supplied by the aircraft manufacturer.

Aircraft Weight and Balance Report—supplied by the aircraft manufacturer when the aircraft is new, and by the technician when an aircraft is reweighed in the field.

Aircraft Type Certificate Data Sheet—applies primarily to aircraft certified under the FAA and the Federal Aviation Regulations, wherethe
equipment list with weights and arms is a separate document.

Some of the important weight and balance information found in a Type Certificate Data Sheet is as follows:

Center of gravityrange
Maximumweight
Levelingmeans
Number of seats andlocation
Baggage capacity
Fuelcapacity
Datumlocation
Enginehorsepower
Oil capacity
Amount of fuel in emptyweight

Amount of oil in emptyweight

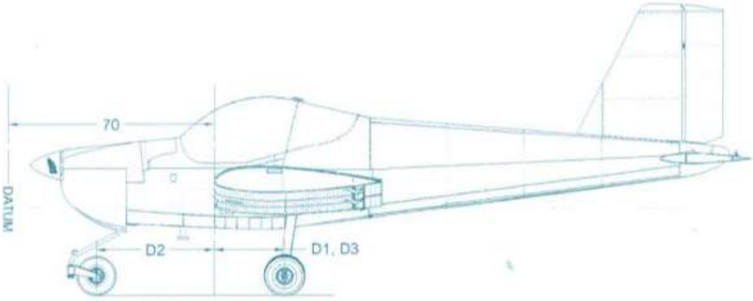


TABLE 1

	LEFT WHEEL	NOSE WHEEL	RIGHT WHEEL
WEIGHT	304.5 lb (W1)	159.0 lb (W2)	322.0 lb (W3)
DISTANCE FROM AXLE CENTER TO LEADING EDGE	23.50 inches (D1)	46.50 inches (D2)	23.50 inches (D3)

TABLE 2

	WEIGHT	ARM	MOMENT
LEFT WHEEL	304.5 lb (W1)	(70+ 23.5 (D1)) = 93.5 (A1) inches	(304.5 (W1))*(93.5 (A1)) = 28,470.75 (M1) in-lb
NOSE WHEEL	159.0 lb (W2)	(70- 46.5 (D2)) = 29.5 (A2) inches	(159.0 (W2))*(29.5 (A2)) = 4,690.50 (M2) in-lb
RIGHT WHEEL	322.0 lb (W3)	(70+ 23.5 (D3)) = 93.5 (A3) inches	(322.0 (W3))*(93.5 (A3)) = 30,107.00 (M3) in-lb

EMPTY WEIGHT = 785.5 lb (W1 + W2 + W3) EMPTY ARM = 80.5452 inches (Empty Moment / Empty Weight)

EMPTY MOMENT = 63,268.25 in-lb (M1 + M2 + M3)

WEIGHT AND BALANCE EQUIPMENT

SCALES

Two types of scales are typically used to weigh aircraft: those that operate mechanically with balance weights or springs, and those that operate electronically with what are called load cells. The balance weight type of mechanical scale, known as a beam scale, is similar to that found in a doctor's office, in which a bar rises up when weight is put on the scale.

Before the weight of the airplane is placed on the scales, each scale switch is turned on and the potentiometer knob turned until the digital display reads zero.

SPIRIT LEVEL

Before an aircraft can be weighed and reliable readings obtained, it must be in a level flight attitude. One method that can be used to check for a level condition is to use a spirit level, sometimes thought of as a carpenter's level, by placing it on or against a specified place on the aircraft. Spirit levels consist of a vial full of liquid, except for a small air bubble.

When the air bubble is centered between the two black lines, a level condition is indicated.

PLUMB BOB

A plumb bob is a heavy metal object, cylinder or cone shape, with a sharp point at one end and a string attached to the other end. If the string is attached to a given point on an aircraft, and the plumb bob is allowed to hang down so the tip just touches the ground, the point where the tip touches will be perpendicular to where the string is attached.

HYDROMETER

When an aircraft is weighed with full fuel in the tanks, the weight of the fuel must be accounted for by mathematically subtracting it from the scale readings. To subtract it, its weight, arm, and moment must be known.

Although the standard weight for aviation gasoline is 6.0 lbs/gal and jet fuel is 6.7 lbs/gal, these values are not exact for all conditions.

PREPARING AN AIRCRAFT FOR WEIGHING

Weighing an aircraft is a very important and exacting phase of aircraft maintenance, and must be carried out with accuracy and good workmanship.Thoughtful

preparation saves time and prevents mistakes.
To begin, assemble all the necessary equipment, such as:
Scales, hoisting equipment, jacks, and leveling equipment.
Blocks, chocks, or sandbags for holding the airplane on thescales.
Straightedge, spirit level, plumb bobs, chalkline, and a measuringtape.
Applicable Aircraft Specifications and weight and balance computationforms

FUEL SYSTEM

When weighing an aircraft to determine its empty weight, only the weight of residual (unusable) fuel should be included. To ensure that only residual fuel is
accounted for, the aircraft should be weighed in one of the following three conditions.
Never weigh an aircraft with the fuel tanks partially full, because it will be impossible to determine exactly how much fuel to account for.

OIL SYSTEM

For aircraft certified since 1978, full engine oil is typically included in an aircraft's empty weight. This can be confirmed by looking at the Type Certificate Data
Sheet. If full oil is to be included, the oil level needs to be checked and the oil system serviced if it is less than full.

MISCELLANEOUS FLUIDS

Unless otherwise noted in the Aircraft Specifications or manufacturer's instructions, hydraulic reservoirs and systems should be filled, drinking and washing water reservoirs and lavatory tanks should be drained, and constant speed drive oil tanks should befilled.

FLIGHT CONTROLS

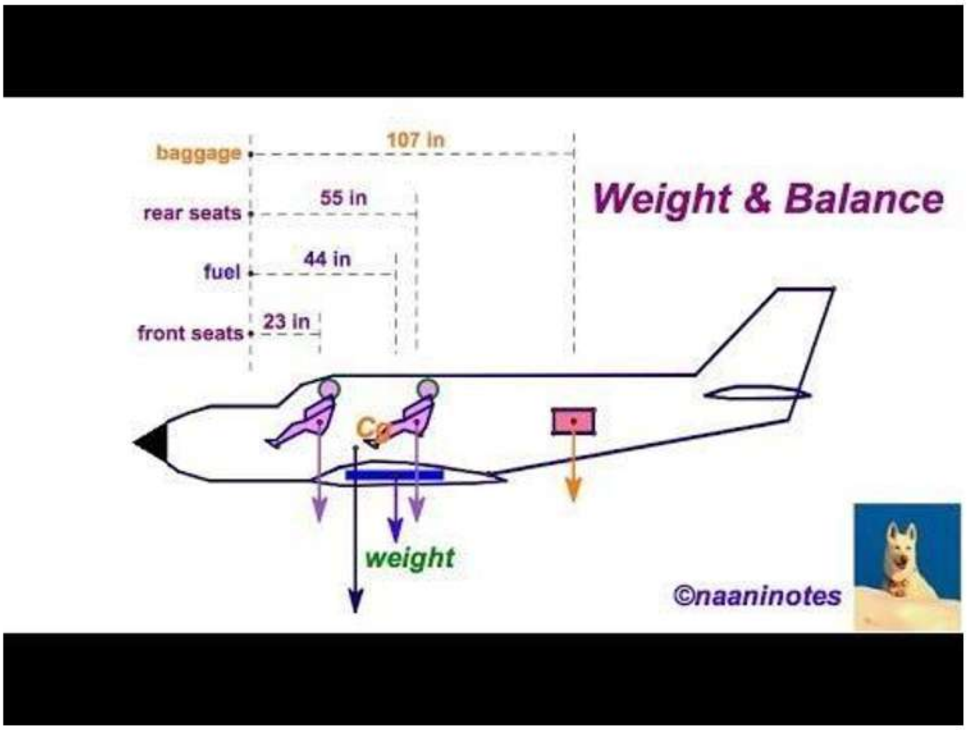
The position of such items as spoilers, slats, flaps, and helicopter rotor systems is an important factor when weighing an aircraft. Always refer to the manufacturer's instructions for the proper position of these items.

OTHER CONSIDERATIONS

Inspect the aircraft to see that all items included in the certificated empty weight are installed in the proper location. Remove items that are not regularly carried in flight. Also look in the baggage compartments to make sure they areempty.

WEIGHING POINTS
When an aircraft is being weighed, the arms must be known for the points where the weight of the aircraft is being transferred to the scales.

If a tricycle gear small airplane has its three wheels sitting on floor scales, the weight transfer to each scale happens through the center of the axle for each wheel. If an airplane is weighed while it is on jacks, the weight transfer happens through the center of the jackpad.



For a helicopter with skids for landing gear, determining the arm for the
weighing points can be difficult if the skids are sitting directly on floor scales.

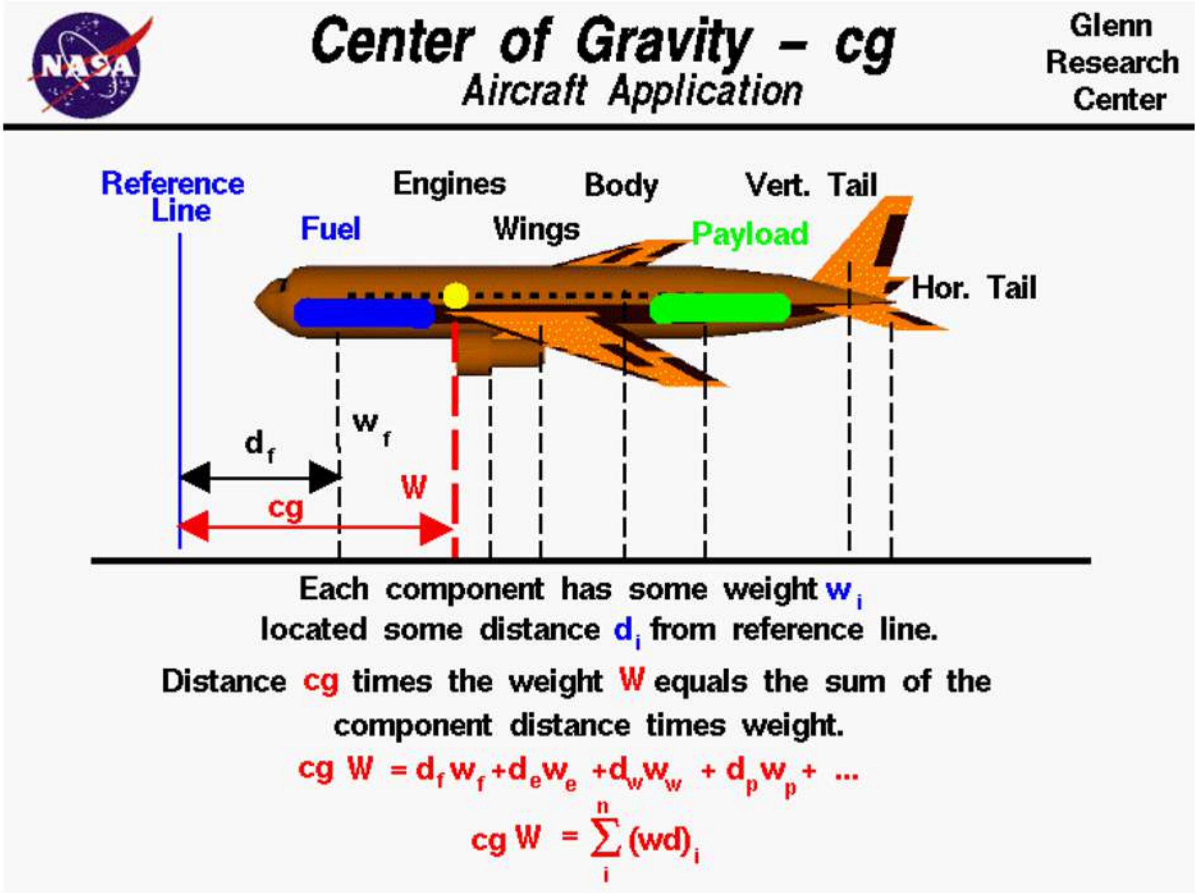
The problem is that the skid is in contact with the entire top portion of the scale, and it is impossible to know exactly where the center of weight
transfer is occurring.

In such a case, place a piece of pipe between the skid and the scale, and the center of the pipe will now be the known point of weight transfer.
STANDARD WEIGHTS USED FOR AIRCRAFT WEIGHT AND BALANCE

Unless the specific weight for an item is known, the standard weights used in aircraft weight and balance are as follows:

Aviation gasoline 6lbs/gal
Turbine fuel 6.7lbs/gal
Lubricating oil 7.5lbs/gal
Water 8.35 lbs/gal

Crew and passengers 170 lbs perperson



WEIGHT AND BALANCE RECORDS

When a technician gets involved with the weight and balance of an aircraft, it almost always involves a calculation of the aircraft's empty weight and empty weight center of gravity.

Only on rare occasions will the technician be involved in calculating extreme conditions, how much ballast is needed, or the loaded weight and balance of the aircraft. Calculating the empty weight and empty weight CG might involve putting the aircraft on scales and weighing it, or a pencil and paper exercise after installing a new piece of equipment.

Current and accurate empty weight and empty weight center of gravity are required to be known for an aircraft. This information must be included in the weight and balance report, which is a part of the aircraft permanentrecords.

The weight and balance report must be in the aircraft when it is being flown.

As it is currently laid out, the form would accommodate either a tricycle gear or tail dragger airplane. Depending on the gear type, either thenose or the tail row would be used.

If an airplane is being weighed using jacks and load cells, or if a helicopter is being weighed, the item names must be changed to reflect the weight locations.

PROCEDURES FOR WEIGHING AN AIRCRAFT GENERAL CONCEPTS

The most important reason for weighing an aircraft is to find out its empty weight (basic empty weight), and to find out where it balances in the empty weight condition.

When an aircraft is to be flown, the pilot in command must know what the loaded weight of the aircraft is, and where its loaded center of gravity is. In order for the loaded weight and center of gravity to be calculated, the pilot or dispatcher handling the flight must first know the empty weight and empty weight center of gravity.

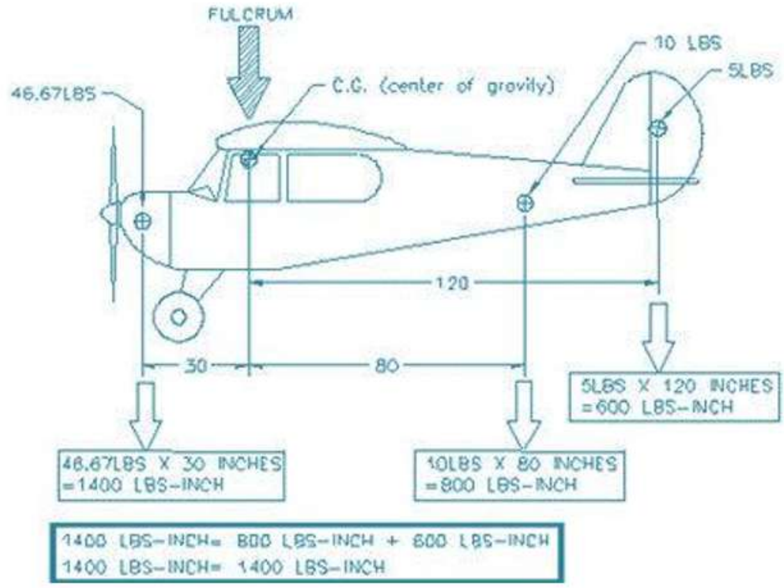
A more realistic way to find the center of gravity for an object, especially an airplane, is to place it on a minimum of two scales and to calculate the moment value for each scale reading.
The Captain (or Commander) of an aircraft, must be satisfied that the load, carried by the aircraft, is of such a weight and is distributed and secured in such a way that it may be safely carried in flight.

To ensure this, the Traffic Loads must be added to the Dry Operating Mass of the aircraft and the Total Mass and CG position calculated.

Loading of an aircraft must be completed under the supervision of qualified personnel, and ensure that the loading of freight is consistent with the data used to calculate the aircraft mass andbalance.

Additional structural limitations such as the maximum load per unit area, maximum mass per cargo compartment and the maximum seating limits must also be
considered when loading the aircraft.

With large passenger carrying and cargo aircraft, the moment of items such as fuel, passengers and cargo are considerable and the calculation of CG can be
complicated. In addition to longitudinal CG calculation, it may also be necessary to distribute fuel and cargo in a transverse direction.
Most operators utilise specialists who deal with loading calculations, and produce a Load Sheet for each flight.



Weighing on Aircraft Jacks

Jacking should be done in accordance with the Maintenance Manual procedures and suitable jacking adapters should be placed at the jacking points. Weighing units of sufficient capacity should be attached to the jacks and the jacks positioned at each jacking point.

Zero indication of each weighing unit should be verified, before the aircraft is raised evenly, until clear of the ground when the aircraft should be levelled.
Readings should be made at each weighing point, and to ensure representative readings are obtained, a second reading should be made.

The Dry Operating Mass of the aircraft may be deduced by adding all of the readings from each weighing point. With the aircraft weight correctly established, it remains only to calculate the CG.

AIRCRAFT WEIGHING METHODS

Aircraft weighing equipment consist of weighbridge scales, hydrostatic weighing units or electrical/electronic strain gauge type weighing equipment. The capacity of the equipment must be compatible with the load, so that accuratemeasurements
may be obtained.
All weighing equipment should be calibrated and zeroed before any weighing commences, with the accuracy of the scale or load cell used depending on its capacity.

Scale or Load Cell capacity Accuracy
< 2000 kg ± 1 %
2000 kg to 20000 kg ± 20 kg
> 20000 kg ± 0.1 %

CENTRE OF GRAVITY LIMITS (CG ENVELOPE)

The certified CG position of an aircraft will have operating margins built into the calculations, and is known as the CG envelope.
This allows for any movement of the CG that may be experienced during flight by passengers and crew moving about the cabin, fuel consumption, landing gear and flaps moving position and any possible weighing errors or unaccounted modifications.

The operator must show that his procedures account for, the possibility of an extreme CG variation at any time during the operation of the aircraft.

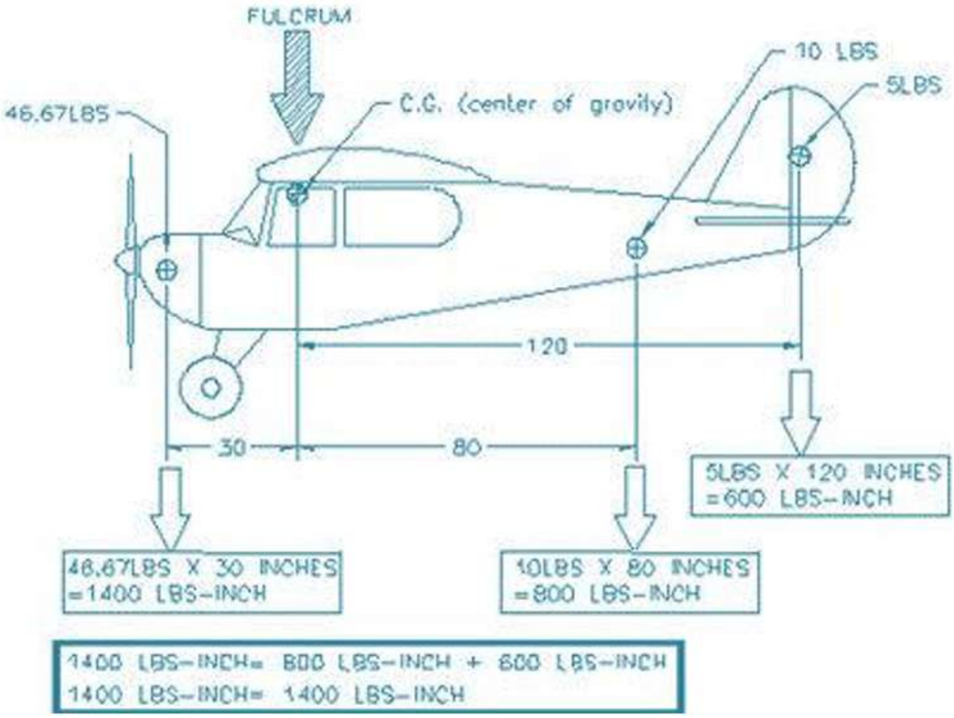
RECORDS

All records of weighing, including the calculations involved, must be available to the authority. The aircraft manufacturer, maintainer or operator must retain weighing records, and when the aircraft is weighed again, the previous records must not be destroyed, but must be retained with the aircraftrecords.

Operators must retain all known weight and CG changes that occur after the aircraft has been weighed. These records are kept for the life of the aircraft.

CALCULATION OF MASS AND CG OF ANY SYSTEM

The position of the CG of any system (refer to Fig. 1) may be found using the following process:
Total Mass is calculated, by adding the mass of each load (plus the mass of the beam)
The moment of each load is calculated, by multiplying the mass by the arm (distance from the reference datum)



AIRCRAFT HANDLING ANDSTORAGE

TIEDOWN PROCEDURES PREPARATION OF AIRCRAFT

Aircraft should be tied down after each flight to prevent damage from sudden storms. The direction in which aircraft are to be parked and tied down is determined by prevailing or forecast wind direction.

Aircraft should be headed as nearly as possible into the wind, depending on the locations of the parking area's fixed tiedown points. Spacing of tie-downs should allow for ample wingtip clearance.

The normal tiedown procedure for heavy aircraft should generally include the following:
Head airplane into prevailing wind whenever possible.
Install control locks, all covers andguards.
Chock all wheels fore andaft.
Attach tiedown reels to airplane tiedown loops and to tiedown anchors or tiedown stakes. Use tiedown stakes for temporary tiedown only. If tiedown reels are not available, 1/4" wire cable or 11⁄2" manila line may be used

PROCEDURES FOR SECURING WEIGHT-SHIFT CONTROL AIRCRAFT

There are many types of weight-shift control aircraft engine-powered and non-powered. These types of aircraft are very suitable to wind damage.
The wings can be secured in a similar manner as a conventional aircraft in light winds. But in high winds, the mast can be disconnected from the wing and the wing placed close to the ground and secured. This type of aircraft
can also be partially disassembled or moved into a hangar for protection.

MOVING METHODS

Normal moving methods of moving aircraft on the ground are by means of:

Hand: by pushing and using a steering arm

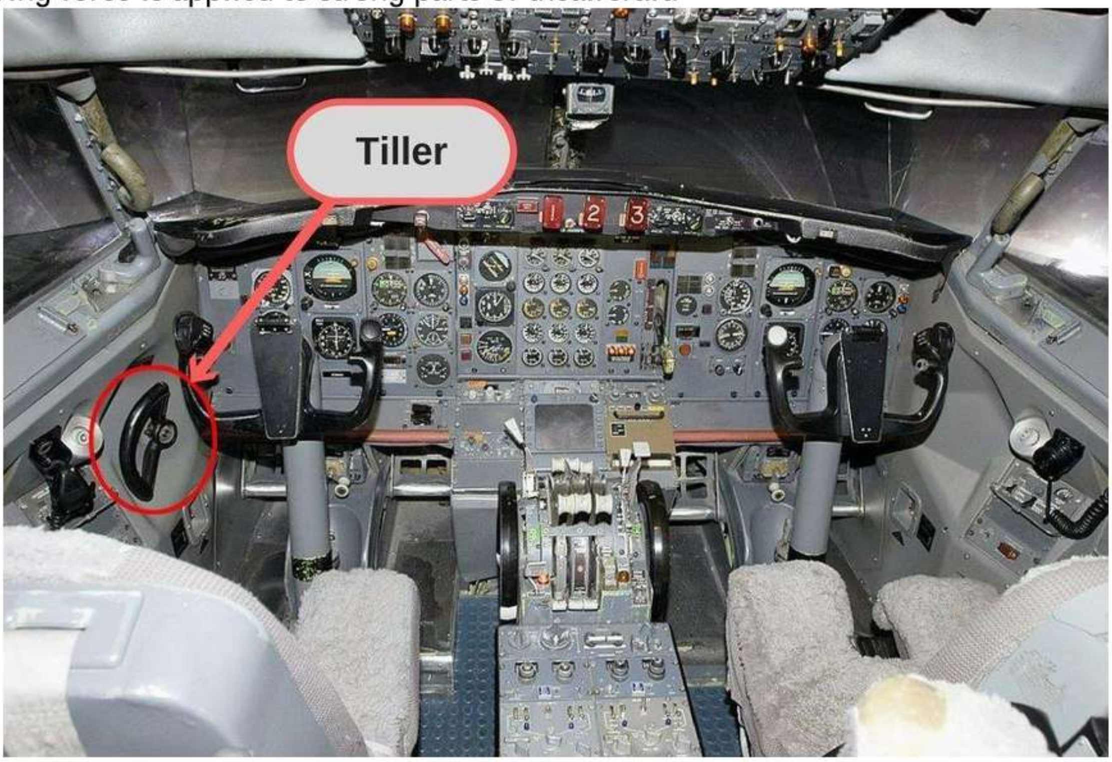
Tractor: using a bridle and steering arm or with a purpose-made towing arm

Taxiing: moving the aircraft, using its own power.

When an aircraft has to be moved from one place to another, either by man- handling, by the use of a tractor (also called a towing 'tug') or by taxiing, there are a number of safety precautions which have to be applied every time.

MovingbyHandandSteeringArm

This method is generally used for moving light aircraft small distances.Care should be exercised, during the move, to avoid damage to the structure,particularly on aircraft constructed from wood and fabric. On aircraft,which have nose-wheel, a steering arm is attached to the wheel axle, in order to guide theaircraft, while the moving force is applied to strong parts of theaircraft.



It is generally better to push the aircraft backwards, since the leading edges arestronger than the trailing edges. It is also permitted to push at the undercarriagestruts and wing support struts. Areas to avoid include:

Flying Control Surfaces

Propellers

Wing and Tail-plane trailing edges.

Using a Bridle and Steering Arm

This method is sometimes used, when the aircraft is to be moved over uneven orboggy ground, because, if normal towing procedures were used, they would belikely to cause an unnecessary strain on the nose undercarriage.Using this alternative method, a special bridle (consisting of cables and attachingshackles) is attached to specific points on each main undercarriage leg and asteering arm is attached to the nose undercarriage for directional control.

The aircraft is normally towed backwards, using a tractor attached to the bridle. Itis normal to tow the aircraft backwards as this reduces the stress on the weakernose undercarriage.
If towing points are not available, then ropes may be passed round the legs, as nearto the top as possible, taking care not to foul on adjacent pipes or structure. Aseparate tractor should then be connected to each main undercarriage and steeringcontrol achieved by using the steering arm.

UsingaPurpose-MadeTowingArm

This is the normal method used on large aircraft. The aircraft is normally towedwith a suitable tractor (or tug) and using the correct, purpose-made towing arm forthe specific aircraft. A person familiar with, and authorised to operate, the aircraftbrake system should be seated in the cockpit (or on the flight deck) to apply thebrakes in an emergency. The brakes should not normally be applied unless theaircraft isstationary.

PrecautionswhenTowingAircraft

Towing speed should be kept to a safe level at all times (walking pace is a safelimit).
A steering limit is often imposed, so that the radii of turns are kept within specifiedlimits, thus minimising tyre scrubbing and reducing the twisting loads on theundercarriage. It is usual to tow the aircraft forwards in a straight line afterexecuting a turn, in order to relieve stresses built up in the turn. The steering limitis often shown by marks painted on the fixed part of the nose leg, but may,sometimes, be overcome by the disconnection of a pin, joining the torque links.

Suitably briefed personnel should be positioned at the wing tips and tail whenmanoeuvring in or around confined spaces, so that obstructions may be avoided.One person shall be supervising the aircraft movement (NOT the tractor driver) andshould be positioned so that all members of the team can be observed.
Particular care should be given, when towing swept wing aircraft, to "wing tipgrowth". This is the tendency of the swept wing to "grow" in a turn and wasdiscussed in ‘Flight-Line Safety’, which is contained in the early topic concerning
Safety Precautions.

Before commencing the towing operation, the brake system should be checked andthe brake accumulator charged as necessary. Brake pressure should be carefullymonitored during the move.
Large, multi-engined aircraft will usually be towed with special-purpose tug and asuitable towing arm that includes a shear pin, designed to shear if a pre- determinedtowing load is exceeded.
In an emergency it may be necessary to move an aircraft from the runway if it hasone or more deflated tyres. Provided there is one sound tyre on the axle the aircraftmay be towed to the maintenance area, but sharp turns must be avoided andtowing speed kept to a minimum.

If there are no sound tyres on an axle, the aircraft should only be moved theshortest distance in order to clear an active runway and serviceable wheels shouldbe provided before towing. After any tyre failure, the associated wheel and otherwheels on the same axle should be inspected for signs of damage.

TaxiingAircraft

When aircraft are to be moved under their own power, whether for groundmovements or prior to flight, a fully certified flight crew must be on the flight deckand in command of the aircraft.
It is usual for the aircraft to have received a dailyinspection before the taxi operation, which ensures items such the oil and fuellevels and brake pressures are sufficient for the task.

It will be necessary for a 'Starter Crew' to be present before engine starting. Thiscrew should include a supervisor (who will be in visual and/or verbalcommunication with the aircraft crew), a fireman with a suitable extinguisher

AIRCRAFT JACKING

The aircraft technician is required to jack the aircraft for certain maintenance and repair operations. Always used the manufacturer's specified jacking equipment
and instructions.

Errors made while jacking an aircraft can be dangerous and costly. An aircraft must be in the proper configuration for jacking. Specific doors may be
required to be closed and certain stressed panels may need to be installed to provide the fuselage vessel with sufficient strength to be raised on jacks without causing structural damage.

The same is true when hoisting the aircraft. Check the manufacturer's instructions for jacking and hoisting and prepare the aircraft as specified.

Most aircraft are designed with jack points located so that 3 or 4 jacks are required for jacking. Some light aircraft may contain a tie-down ring at the rear of the fuselage. By anchoring the empennage to a weight or the hangar floor, this tiedown ring is used with only 2 jacks to lift the aircraft cleanly and completely off the ground.
Wing jacks are normally placed under the wing spars at the jack point specified by the manufacturer. Most aircraft have specified jack points on the airframe.

Jack pads are engineered to insert into the jack points and make contact with the jacks.

When jacking an aircraft it is important to raise and maintain the aircraft in a level position. Some transport category aircraft have a grid over which a plumb bob is hung to guide the pace of jacking at each jack.

Jacking Precautions

As a safety precaution, small aircraft should normally be jacked inside a hangar. Larger aircraft may be jacked outside, provided they are positioned nose into wind; the jacking surface is level and strong enough to support the weight, and that any special instructions, stated in the Maintenance Manual, are observed.

A maximum wind speed, stated for jacking outside, can also be found within the Maintenance Manual. The aircraft to be jacked should be chocked fore and aft and the brakes positioned to OFF (brakes released). If the brakes are inadvertentlyleft
in the ON position (brakes applied) stress could be introduced to the landing gear or to the aircraft structure, due to weight re-distribution as the aircraft is raised.

Jacking Procedures

While the following procedures will, generally, ensure safe and satisfactory jacking of most aircraft, precedence must always be given to the procedures and
precautions specified in the relevant Maintenance Manual.

One person should co-ordinate the operation and one person should control each jacking point. On larger aircraft a levelling station will also need to be monitored and all members of the team may need to be in radio or telephone communication with the co-ordinator.
Checks should be made on the aircraft weight, its fuel state, and centre of gravity, to ensure they are within

the specified limits as detailed in the Maintenance Manual.

The aircraft should be headed into wind (if it is in the open), the main wheels chocked fore and aft, the brakes released and the undercarriage ground locks installed.
It is vital that the earth cable be connect to the earth point on the aircraft and it must be ensured that there is adequate clearance above every part of the aircraft and that there is clearance for lifting cranes or other equipment, which may be required.

Jacking pads should be attached to the jacking points and adapters provided for thejacks as required. Load cells may also be included if needed.

GROUND DEICING AND ANTI-ICING OF AIRCRAFT

The presence of ice on an aircraft may be the result of direct precipitation, formation of frost on integral fuel tanks after prolonged flight at high altitude, or accumulations on the landing gear following taxiing through snow or slush.

The aircraft must be free of all frozen contaminants adhering to the wings, control surfaces, propellers, engine inlets, or other critical
surfaces before takeoff. Any deposits of ice, snow, or frost on the external surfaces of an aircraft may drastically affect its performance.

This may be due to reduced aerodynamic
lift and increased aerodynamic drag resulting from the disturbed airflow over the airfoil surfaces, or it may be due to the weight of the deposit over the whole aircraft.

The operation of an aircraft may also be seriously affected by the freezing of moisture in controls, hinges, valves, microswitches, or by the ingestion of ice into the engine. When aircraft are hangared to melt snow or frost, any melted snow or ice may freeze again if the aircraft is subsequently moved into subzero temperatures.

FROST REMOVAL

Frost deposits can be removed by placing the aircraft in a warm hangar or by using a frost remover or deicing fluid. These fluids normally contain ethylene glycol and isopropyl alcohol and can be applied either by spray or by hand. It should be applied within 2 hours of flight.
Deicing fluids may adversely affect windows or the exterior finish of the aircraft, only the type of fluid recommended by the aircraft manufacturer should be used.
Transport category aircraft are often deiced on the ramp or a dedicated deicing location on the airport. Deicing trucks are used to spray the deicing and/or antiicing fluid on aircraft surfaces. (Figure 17-7)

DEICING AND ANTI-ICING OF TRANSPORT TYPE AIRCRAFT
DEICING FLUID

The deicing fluid must be accepted according to its type for holdover times, aerodynamic performance, and material compatibility. The coloring of these fluids is also standardized. In general, glycol is colorless, Type-I fluids are orange, Type-II fluids are white/pale yellow, and Type-IV fluids are green. The color for Type-III fluid has not yet been determined.

HOLDOVER TIME (HOT)
Holdover Time (HOT) is the estimated time that deicing/anti-icing fluid prevents the formation of frost or ice and the accumulation of snow on the critical surfaces of an aircraft.

Some critical elements
andproceduresthat arecommonformost aircraftare:

Deicing/anti-icing fluids must not be sprayed directly on wiring harnessesand electrical components (e.g., receptacles, junction boxes), onto brakes, wheels, exhausts, or thrustreversers.

Deicing/anti-icing fluid shall not be directed into the orifices of pitotheads, static ports, or directly onto airstream direction detectors probes/angle of attack airflowsensors.

All reasonable precautions shall be taken to minimize fluid entry into engines, other intakes/ outlets, and control surfacecavities.

ICE AND SNOW REMOVAL

This type of deposit should be removed with a soft brush or squeegee. Use care to avoid damage to antennas, vents, stall warning devices, vortex generators, etc., that may be concealed by the snow

Light, dry snow in subzero temperatures should be blown off whenever possible; the use of hot air is not recommended, since this would melt the snow, which would then freeze and require further treatment.

EFFECT OF ENVIRONMENTAL CONDITIONS ON AIRCRAFT HANDLING AND OPERATION
Environmental conditions must be considered at all times when moving, maintaining, or operating aircraft. Extremely hot or extremely cold weather could produce conditions outside of the certified operating range. In this case, do not operate the equipment. More often, the operating conditions presented are within certified limits but require adaptation.

Aircraft performance losses due to extremely hot weather are well documented. Warm air is less dense that cold air which causes engine power and aerodynamic performance to degrade.

Keeping aircraft and any volatile materials out of extreme heat is recommended if possible.

In desert climates, protection from airborne particles (sand and dust) is also a top priority. Seals, fabrics and electrical equipment deteriorate faster
in hot, humid conditions.

Cold temperatures and operation in cold climates present a complete set of operating difficulties. While cold can be considered better for the materialsfrom
which aircraft are made, extremely cold temperature can reduce seal flexibilityand make brittle electrical wiring and other parts that are normallyrobust.

Avoid unnecessary contact with wires and cables in extremely cold conditions. Also remember that thermal shock is always to be avoided due to the stresses it puts on aircraft materials and parts.

The rapid cooling of a warm aircraft or rapid heating of a cold aircraft is potentially more damaging than the actual temperature to which the aircraft isexposed.

In cold operating environments, contained gas pressures decrease. Tire and strut pressures may need to be adjusted to move or fly the aircraft.
Accumulator and fire extinguisher agent pre-charge pressures will also be lower.
Fluid viscosities increase with a decrease in temperature. This can interfere with proper lubrication.

It can also slow the functioning of the hydraulic system. Engine nacelle pre-heaters can be used to warm the oil and engine accessories before starting. Note that it is primarily the oil that should be preheated.

Failure to heat a dry sump oil tank or the wet sump of a reciprocating engine does little to protect vital engine parts against oil starvation due to high viscosity upon start-up.
Hot air is the most common form of preheating. On aircraft with an APU, there may be an optional preheat function for the main engines using pneumatic bleed air from the APU. Ground-based permanent and portable heaters are also available.
Fuel drains must also be clear.

It is just as important to sump excess water out of the fuel before operation in the cold as it is in any other operating environment.
If there is a disruption of fuel flow during a cold weather start, check the fuel filters for frozen water that could be disrupting fuel flow.

Consistent frigid weather climate operation may require
the use of JP 4 if approved in turbine engines. It has better cold weather starting characteristics than regular jet fuel

Snow, ice, and frost on a propeller or airframe are common hindrances to safe operation in cold weather.

They must be completely removed before flight occurs and before start-up in the case of propeller icing.
A warm battery delivers its rated power but a cold battery may not deliver enough power to start an engine.

Often, removal of the battery and storing it in a warm location until it can be reinstalled for the next operation is a workable solution. With a preheated engine oil supply and a strong, warm battery, the procedure for starting an engine in cold weather is pretty much the same as under normal conditions. Once started however, propeller control changes and hydraulic functions should be
delayed until the oil has had time to warm.

Full engine power should also be delayed until oil temperature has warmed to levels near typical operating temperatures.

Finally, it is not unusual for tires or chocks to be frozen to the ground in cold weather. Preheated air from a portable cart can loosen this connection without damaging the tires or struts

Chocking of Aircraft

When aircraft are parked, it is normal to place a chock ahead and behind at least one wheel set. The parking brakes are usually left in the 'off' position once chocks are in position, to allow the heat, generated by the brakes, to dissipate evenly.
At high wind speeds, it is normal to chock all the wheels and apply the brakes (if they have cooled). Some aircraft chocks can be chained together, to give a more
secure hold. During ground runs (and especially those involving high power), it is common sense to place chocks at the front of all main wheel sets, to reinforce the parking brake.

AIRCRAFT STORAGE

If an aircraft is de-activated for an extended time it will need to be protected against corrosion, deterioration and environmental conditions during its period of storage.

The following notes are based on the storage procedures applicable to BAe 146 aircraft that have been de-activated for periods in excess of 30 days and up to a maximum of 2 years.

It is not intended for the information given here to be complete, but merely to give the student examples of some of the activities performed. Specific details of an aircraft's storage procedures can be found in
A list of equipment and materials is normally given. This will, typically, include:
Hydraulic fluid and lubricating oils and greases
Specialised water-displacing fluids and corrosion-preventative compounds Aircraft covers and blanks
Plastic sheeting and adhesive tape.
Prior to the storage period certain tasks are completed. These may include
replacing the tyres with 'dummy' tyres (those not suitable for flight), or the raising of the pressures of the normal ones. The various tanks are either filled (water), drained (toilet), or part-filled (fuel). If the aircraft has propellers, they must be feathered, to prevent them rotating in the wind. (they may also be restrained by straps).

Generally there would be an initial procedure, this being repeated at specified intervals, as shown in Tables 1 (a) and 1 (b). If no repeat interval is given, then the item is only done initially.
Once the aircraft has been prepared, there are routine, weekly checks to keep it in good condition.

To allow the circulation of air around the inside of the aircraft, all the doors and curtains are fixed open, whilst all the external doors and panels are shut. The battery will be removed from the aircraft and kept in the battery bay.
More active checks might be done on the two-weekly checks.
These checks will probably involve re-installing the battery, running the engines for a period and functionally testing a number of the aircraft's systems that require the engines operating.

The flight controls might require cycling throughout their ranges and, if dummy tyres are not fitted, the aircraft must be moved slightly to prevent 'flat spots' forming on the tyres.

In addition, when power plants are stored separately, their fuel and oil systems must be inhibited and all their external mechanisms protected with grease or other suitable preservative.

They must be stored in a clean, warm, dry atmosphere with inspections at intervals to check for deterioration. Some engines are stored in an airtight bag, which has moisture-absorbent crystals (a desiccant) inside.

After the storage period all of the covers, blanks and preservative compounds will need to be removed. All of the systems will need to be restored to their original condition prior to aircraft use. A further set of procedures will be followed, similar to those previously discussed.

When the aircraft is to be returned to service, it is simply a case of initially removing all covers, blanks and tie-downs. Once access to the inside of the aircraft is obtained and the battery re-installed, all of the systems must be checked and tested.

All the tanks must be replenished to their correct levels and all pressure vessels will require their gases charging to their normal operating pressures. If the cabin furnishings, such as seats, carpets and galleys have been removed, they are to be inspected and, when serviceable, re-installed in the cabin.

As already stated, the foregoing summaries are only examples of the form that a basic aircraft storage procedure might take. If the aircraft is smaller or larger and more complex it will require a different form of inspection and routinechecking.

AIRCRAFT FUELLING PROCEDURES

The use of the term 'fuelling' can include both refuelling and defuelling procedures and these notes contain examples of the essential points to be considered when refuelling and defuelling aircraft.

There may, however, be some further, local instructions, regarding the responsibilities of the various personnel involved in fuelling procedures and these will always take precedence in conjunction with the relevant Maintenance Manual.

FuellingSafetyPrecautions

Particular care must be taken when fuelling aircraft, so that the operation may be accomplished in the safest possible manner.
Whenever possible, aircraft should be fuelled in the open, and not in a hangar (although this is, sometimes, necessary as part of a maintenance programme). This will minimise the fire risk from high concentrations of flammable vapours.

Fire appliances should be readily available during all fuelling operations. Carbon dioxide, or foam, extinguishers are recommended but, if there is a perceived increased fire risk, then fire-fighting vehicles should be standing by.
Within the specified danger area, around an aircraft being fuelled, no sources of ignition or sparks should be allowed and no electrical power should be switched on or off during the fuelling operation.
It is vital that the correct type and grade of fuel is used for the fuelling operation.
Use of a turbine fuel in a piston aircraft will certainly cause an engine malfunction,or failure, that could lead to loss of an aircraft. The correct type and grade of fuel isalways detailed in the Maintenance Manual and marked adjacent to the aircraft's fuelling point(s).
Care should also be exercised so as to avoid contamination of the fuel system with water or other contaminants. The fuel supply should be regularly checked for water contamination and a sample of fuel drained off after refuelling, so that a water check may be done.

It will sometimes be necessary to filter the fuel during over-wing refuelling, particularly in dusty climates.

Electrical bonding of the fuel system is vital during fuelling operations, as when fuel flows through the refuelling hose, static electricity may be generated.
This may lead to potential differences at adjacent metal parts and initiate a spark, fire or explosion.

To minimise this risk the following actions should be completed before fuellingoperations commence

The aircraft should be earthed
The refuelling tanker should be earthed
The nozzle of the fuel hose should be electrically bonded to the fuelling point.
Refuelling

When refuelling the AMM should always be consulted so that the positions and capacities of the fuel tanks and also the type of fuel, position of the refuelling point(s) and refuelling procedures are known. There are two general re-fuelling methods:

Gravity or over-wing refuelling: which is, essentially, the same method as used to refuel a motor car (automobile), with a similar type of refuelling hose being used. As the name suggests, the filler points are, generally, on the upper surface of the wing and the tank is open when refuelling is done
Pressure refuelling: in which the fuel may be pumped into the aircraft via a pressure refuelling coupling at very high rates. The refuelling pressures and the rates of fuel delivery may be quite different for individual aircraft types, so great care must be taken, to ensure no damage occurs to an aircraft through incorrect refuelling settings.
Checking Fuel Contents
This is normally done, using the aircraft fuel gauges, which may be calibrated in kilograms (kg), gallons (Imperial or US) or pounds (lb).
If a double check is required, then the contents may be determined, on the ground, by using ‘dip sticks’ (installed into the top of the tanks) or by ‘drip sticks’ (or magnetic ‘drop sticks’) which are installed in the bottom of some aircraft tanks.

The aircraft fuel gauges will normally be positioned on the flight deck, but they can, on some aircraft, be duplicated at a fuelling panel, adjacent to the pressure refuel coupling.
The Relative Density (RD) of fuel will vary with temperature and so the weight of a certain quantity of fuel will also vary.

When fuelling aircraft, it is essential that the technician is aware of the RD of thefuel, so that the necessary weight calculation may be done, if necessary.
Defuelling.
Occasionally, it is necessary to remove fuel from an aircraft, to facilitate fuel tank
maintenance, or because the aircraft is too heavily loaded for the next flight. Removing fuel from an aircraft can be accomplished by either the gravity or by the pressure defuelling method.

The gravity method entails draining the fuel into a suitably earthed container, and this is typical of light aircraft, which are normally 'gravity' refuelled. The fuel removed must be disposed of in the correct manner, with regard to local instructions and to theenvironment.

Aircraft that are normally pressure refuelled are normally equipped with a pressure defuelling facility. Pressure defuelling is achieved by utilising a small negative pressure (suction), which effectively draws the fuel out of the tank and returns it into the fuel tanker (bowser).
Current rules will normally only allow the fuel, removed from an aircraft, to be placed into a dedicated defueller vehicle and the fuel will not be permitted to be used in another aircraft. This ensures that any contamination such as water or debris will not be transferred to other aircraft.

GROUNDDE-ICING/ANTI-ICINGOFAIRCRAFT

Ice Types

There are three main types of ice/frost that can effect an aircraft's performance, Hoar Frost, Rime Ice and Glaze Ice. The temperature and weather conditions will determine the type of ice that forms, but all three types can have a detrimental effect.
The Dew Point is the temperature at which moist air becomes saturated and deposits dew if in contact with a colder surface or the ground. Above ground, condensation into water droplets takes place.

Hoar Frost is a deposit of ice crystals that form on an object when the dew point is below freezing point. High humidity will normally produce hoar frost, as these are similar to conditions that produce dew.

Hoar frost can form when theair
temperature is greater than 0°C, but the aircraft skin temperature is less than 0°C. This type of frost produces a very rough surface which leads to turbulent airflow. Rime Ice is a light coloured opaque rough deposit that has a porous quality. At ground level it forms in freezing fog from water droplets with very little spreading. It adds very little weight but it can disrupt the smooth flow of air over the wing, and block

pitot and staticvents.

Glaze Ice can be either transparent or opaque and can form into a glassy surface due to liquid water flowing over a surface before freezing. It is the most dangerous type of ice found on an aircraft and is dense, heavy and tough. It adheres firmly to a surface, is difficult to shake off, and if it does breakaway, it does so in large chunks.
During cold weather operations, it may be necessary to remove ice and snow from the aircraft, while it is on the ground, and to keep it clear long enough, toallow
the aircraft's systems to cope with snow or ice removal. This may not occur until the aircraft is flying.

On the ground, the aircraft must be cleared of all snow and ice from its wings, tail, control surfaces, engine inlets and other critical areas (refer to Fig. 4) before the aircraft can take-off

Ice formation on an aircraft on the ground may result from a number of causes: Direct precipitation from rain, snow and frost
Condensation freezing on external surfaces of integral tanks following prolonged flight at high altitude
After taxing through snow or slush, ice may accumulate on landing gear, forward facing surfaces and under-surfaces.
The formation of ice on aircraft structures can produce many adverse effects, and if allowed to remain may result in some or all of the following:
Decreased aerofoil lift Increased aerofoil drag Increased weight Decreased engine thrust
Freezing of moisture in control hinges
Freezing of micro-switches that affect systems such as the landing gear retraction
Ingestion of ice into the engine.

DISASSEMBLY,INSPECTION,REPAIRANDASSEMBLYTECHNIQUE

Types of defects and visual inspection techniques.
BASIC INSPECTION TECHNIQUES/ PRACTICES

Before starting an inspection, be certain all plates, access doors, fairings, and cowling have been opened or removed and the structure cleaned. When opening inspection plates and cowling and before cleaning the area, take note
of any oil or other evidence of fluid leakage.

PREPARATION

In order to conduct a thorough inspection, a great deal of paperwork and/or reference information must be accessed and studied before actually proceeding
to the aircraft to conduct the inspection.

The aircraft logbooks must be reviewed to provide background information and a maintenance history of the particular aircraft.

The appropriate checklist or checklists must be utilized to ensure that no items will be forgotten or overlooked during the inspection.

AIRCRAFT LOGS

"Aircraft logs," as used in this module series, is an inclusive term which applies to the aircraft logbook and all supplemental records concerned with the aircraft.
They may come in a variety of formats.

CHECKLISTS

Always use a checklist when performing an inspection. The checklist may be of your own design, one provided by the manufacturer of the equipment being inspected, or one obtained from some othersource.

An example checklist for a general inspection of an aircraft follows:

Fuselage andHull

Fabric and skin—for deterioration, distortion, other evidence of failure, and defective or insecure attachment offittings.
Systems and components—for proper installation, apparent defects, and satisfactory operation.
Envelope gas bags, ballast tanks, and related parts—forcondition.

Cabin andCockpit

Generally—for cleanliness and loose equipment that should besecured.
Seats and safety belts—for condition andsecurity.
Windows and windshields—for deterioration andbreakage.

Instruments—for condition, mounting, marking, and (where practicable) forproper operation.
Flight and engine controls—for proper installation andoperation.
Batteries—for proper installation andcharge.
All systems—for proper installation, general condition, apparent defects,and security ofattachment.
Engine andNacelle
Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of suchleaks.
Studs and nuts—for proper torquing and obviousdefects.
Internal engine—for cylinder compression and for metal particles or foreignmatter on screens and sump drain plugs. If cylinder compression isweak,
check for improper internal condition and improper internal tolerances.
Engine mount—for cracks, looseness of mounting, and looseness of engine tomount.
Flexible vibration dampeners—for condition anddeterioration.
Engine controls—for defects, proper travel, and proper safetying.
Lines, hoses, and clamps—for leaks, condition, andlooseness.
Exhaust stacks—for cracks, defects, and properattachment.
Accessories—for apparent defects in security ofmounting.
All systems—for proper installation, general condition defects, and secure attachment.
Cowling—for cracks anddefects.
Ground run-up and functional check—check all powerplant controls and systemsfor correct response, all instruments for proper operationand
indication.
Landing Gear
All units for condition and security ofattachment.
Shock absorbing devices for proper oleo fluidlevel.
Linkage, trusses, and members—for undueor excessive wear, fatigue, anddistortion.
Retracting and locking mechanism—forproper operation.

PUBLICATIONS

Aeronautical publications are the sources of information for guiding aviation engineers in the operation and maintenance of aircraft and related equipment.

MANUFACTURERS' SERVICE BULLETINS/ INSTRUCTIONS

Service bulletins or service instructions are two of severaltypes of publications issued by airframe, engine, and component manufacturers. The bulletins may include:
purpose for issuing thepublication,
name of the applicable airframe, engine, orcomponent,
detailedinstructions for service, adjustment, modification or inspection, and source of parts, if requiredand estimated number of man-hours required to accomplish thejob.

MAINTENANCE MANUAL

The manufacturer's aircraft maintenance manual contains complete instructions for maintenance of all systems and components installed in the aircraft. It contains information for the technician who normally works on components, assemblies, and systems while they are installed in the aircraft, but not for the overhaul mechanic.

TYPES OF DEFECTS

A defect is any event or condition which reduces the serviceability of the aircraft. There are nearly countless defects that could occur on an aircraft.

However,manufacturers typically specify the areas needed to be inspected and the type of defect expected to be found.

QThis does not relieve the technician of the responsibility to look for any sign of abnormality. A partial list of the types of defects encountered during a visual inspection follows.

Metal Parts Defects:

Cleanliness and external evidence of damage

Leaks and discharge

Overheating

Fluid ingress

Obstruction of drainage or vent holes or overflow pipe orifices

Correct seating of panels and fairings and serviceability offasteners

Distortion, dents, scores, andchafing

Pulled or missing fasteners, rivets, bolts orscrews

Evidence of cracks orwear

Separation of adhesivebonding

Failures of welds or spotwelds

Deterioration of protective treatment andcorrosion

Security of attachments, fasteners, connections, locking and bonding.

Rubber, Fabric, Glass Fiber and Plastic Part Defects:

Cleanliness

Cracks, cuts, chafing, kinking, twisting, crushing, contraction - sufficient freelength

Deterioration, crazing, loss offlexibility

Overheating

Fluid soakage

Security of attachment, correct connections and locking.

ControlSystemComponentsDefects:

Correctalignment

Free movement, distortion, evidence ofbowing

Scores, chafing, fraying,kinking

Evidence of wear,flattening

Cracks, loose rivets, deterioration of protective treatment andcorrosion

Electrical bonding correctly positioned, undamaged and secure

Attachments, end connections and lockingsecure.

ElectricalComponentDefects:

Cleanliness, obviousdamage

Evidence ofoverheating

Corrosion and security of attachments and connections

Cleanliness, scoring and worn brushes, adequate spring tension after removal of protective covers

Overheating and fluidingress

Cleanliness, burning and pitting ofcontacts
Evidence of overheating and security of contacts after removal of protectivecovers.

VISUAL INSPECTION TECHNIQUES

When performing a visual inspection, use a checklist, flashlight, magnifying glass, gauge, mirror or other device that will aid in determining if a defect exists. In the next section, an example list of defects is presented, followed by frequently inspected parts of the aircraft that have their own particular set of visual inspection criterion.

COMMON VISUALLY INSPECTED AREAS EXTERNAL DAMAGE

The most common reasons for damage to the outside of the airframe is by being struck by ground equipment or severe hail in flight. During ground servicing many
vehicles need to be maneuvered close to the airframe and some have to be in light contact with it to work properly.
Contact with the airframe by any of these vehicles can cause dents or puncturing of the pressure hull, resulting in a time-consuming repair.

INLETS AND EXHAUSTS

Any inlet or exhaust can be a potential nest site for wildlife. The damage done by these birds, rodents and insects can be very expensive to rectify.Other items hat have been known to block access holes include branches, leaves and polythene bags. A careful check of all inlets and exhausts, during inspections, must be made, to ensure that there is nothing blocking them. A blocked duct can result in the overheating of equipment, or major damage to the internal working parts of theengine.

LIQUID SYSTEMS

Liquid systems usually have gauges to ascertain the quantity in that particular system. A physical quantity check is often done in addition to using the gauges, as the gauges are not always reliable. These systems usually include oil tanks for the engine, APU and Integrated Drive Generators (IDG), and also the hydraulics, fuel and potable water tanks.

External leaks of oil and fuel systems are normally easy to locate.
The rectification of an external leak is usually achieved by simply replacing the component, seal or pipe work at fault, and completing any tests required by the aircraft maintenance manual. If the leak is internal, then a much more thorough inspection of the component must be made, as the problem is more difficult to find.

If the fluid leaks onto the flight deck it will give off a distinctive odor in the enclosed space.
As the containers are replaced when low, it is more likely that the pipe work will be the likely cause of the leak.

GASEOUS SYSTEMS

These include gases such as oxygen, nitrogen and air. Usually a built in gauge can be checked for an indication of correct volume or pressure. A leak from an oxygen system is extremely dangerous due to the chances of an explosion if it comes into contact with oil or grease. Once the leak has been cured, the system can be recharged and leak tested.
Accumulators assist the hydraulic system as an emergency backup, which only works correctly if it is

charged to the correct pressure. Nitrogen, used in hydraulic accumulators, can leak into the liquid part of the hydraulic.

LANDING GEAR

Proper landing gear strut servicing is typically inspected visually by observing the linear amount of inner strut cylinder that is exposed.

A 6 inch rule may be needed. To determine if the aircraft tires are properly serviced, a pressure gauge is required.

The physical condition of the tread and sidewalls can be checked visually. Cuts, blisters, and creep are easily seen.

Creep is the slipping of the tire's position on the wheel. It is particularly important when inner tubes are used so that the valve stem of the tube does not shear.

SYSTEM INDICATORS AND GAUGES

Various systems have checkable indicators/gauges used during visual inspection to gain some idea of system condition. Gauges and warning devices are located around the aircraft to be visually inspected. Fire extinguishing agent, oxygen, and hydraulic accumulator pressure gauges are among these.

PROBES

Pitot tubes, angle of attack indicators, and other probes are inspected for obstruction and condition. Since these typically incorporate a heating mechanism, they should be checked for signs of over heating.

HANDLES, LATCHES, PANELS AND DOORS

Used frequently, handles and latches on aircraft will wear and eventually malfunction. Here, in addition to the way the device looks, it is important to operate a handle or latch during inspection. All panels on the aircraft must fit properly and securely as designed.

Follow manufacturer's instruction for wear and replace if needed. The loss of a door or panel during flight is a very serious condition.

OTHER INSPECTION ITEMS

The following are items that must also be inspected by the technician:

Moving Parts - All moving parts on anaircraft should have proper lubrication, security of attachment, proper safety wiring, proper operation and adjustment, proper installation, and correct travel. Visual inspection may identify binding, excessive wear, cracked fittings, loosehinges, defective bearings, corrosion, deformation, and improper sealing.

FluidLines-Allfluid lines and hosesare inspected for proper hose or rigid tubing material, proper fittings, correct fitting torque, leaks, tears, cracks, dents, kinks, chafing, proper bend radius, security, corrosion, deterioration, obstructions and foreign matter, and properinstallation.

Electrical wiring should also be inspected for proper type and gauge, security, chafing, burning, defective

insulation, loose or brokenterminals,
heat deterioration, corroded terminals, and proper installation.

Bolts are inspected for correct torque, elongation of bearing surfaces, deformation, sheardamage, tension damage, proper installation, proper size and type and corrosion.
Filters, screens, and fluids- forcleanliness, contamination,replacementtimes,propertypes, and properinstallation.

Powerplants - engine mount security, mount bolt torque, spark plug security, ignitionharness security, oil leaks, exhaust leaks, muffler cracks and wear, security of all engine accessories, engine case cracks, oil breather obstructions, firewall condition, and proper operation of mechanical controls.

Propellers - nicks, dent cracks, cleanliness, lubrication, gouges, proper blade angles, blade tracking, proper dimensions, governor leaks and operation and control linkages for proper tension and installation. Nicks on the leading edgeof
the blade are important items to inspect for: they produce stress concentrations that need to be removed immediately upon discovery in order to prevent the blade separating at the nick.

Ground runs - engine temperatures and pressures, static RPM, magneto drop, engine response to the changes of power, unusual engine noises, ignition switch operation, fuel shutoff/selector valves, idle speed and mixture settings, suction gauge,fuel
flow indicatoroperation.

LIFE LIMITEDITEMS

There are a number of parts and components on the aircraft that have a specific length of time in service (known as a 'life'). These items are required to be changed when their service life expires, regardless of their appearance and functioning status.
Some items have dates stamped on the outside of the unit on a placard which the technician uses in combination with maintenance records to identify and replace the units.

LOCATIONS OF CORROSION IN AIRCRAFT

Certain locations in aircraft are more prone to corrosion than others. The rate of deterioration varies widely with aircraft design, build, operational use and environment. External surfaces are open to inspection and are usually protected by paint. Magnesium and aluminium alloy surfaces are particularlysusceptible to corrosion along rivet lines, lap joints, fasteners, faying surfaces and where protective coatings have been damaged or neglected.

ExhaustAreas

Fairings, located in the path of the exhaust gases of gas turbine and piston engines, are subject to highly corrosive influences. This is particularly so where exhaust deposits may be trapped in fissures, crevices, seams or hinges. Such deposits are difficult to remove by ordinary cleaning methods.
During maintenance, the fairings in critical areas should be removed for cleaning and examination. All fairings, in other exhaust areas, should also be thoroughly cleaned and inspected. In some situations, a chemical barrier can be applied to critical areas, to facilitate easier removal of deposits at a later date, and to reduce the corrosive effects of these deposits.

EngineIntakesandCoolingAirVents

The protective finish, on engine frontal areas, is abraded by dust and eroded by rain. Heat-exchanger cores and cooling fins may also be vulnerable to corrosion. Special attention should be given, particularly in a corrosive environment, to obstructions and crevices in the path of cooling air. These must be treated, as soon as is practical.

LandingGear

Landing gear bays are exposed to flying debris, such as water and gravel, and require frequent cleaning and touching-up. Careful inspection should be made of crevices, ribs and lower-skin surfaces, where debris can lodge. Landing gear assemblies should be examined, paying particular attention to magnesium alloy wheels, paint-work, bearings, exposed switches and electrical equipment.

Frequent cleaning, water-dispersing treatment and re-lubrication will be required, whilst ensuring that bearings are not contaminated, either with the cleaning water or with the water-dispersing fluids, used when re-lubricating.

Bilge and Water Entrapment Areas

Although specifications call for drains wherever water is likely to collect, these drains can become blocked by debris, such as sealant or grease. Inspection of these drains must be frequent.

Any areas beneath galleys and toilet/wash-rooms must be very carefully inspected for corrosion, as these are usually the worst places in the whole airframe for severe corrosion. The protection in these areas must also be carefully inspected and renewed if necessary.

Recesses in Flaps and Hinges

Potential corrosion areas are found at flap and speed brake recesses, where water and dirt may collect and go unnoticed, because the moveable parts are normally in the 'closed' position. If these items are left 'open', when the aircraft is parked, they may collect salt, from the atmosphere, or debris, which may be blowing about on the airfield. Thorough inspection of the components and their associated stowage bays, is required at regularintervals.

The hinges, in these areas, are also vulnerable to dissimilar metal corrosion, between the steel pins and the aluminium tangs. Seizure can also occur, at the hinges of access doors and panels that are seldom used.

Magnesium Alloy Skins

These, give little trouble, providing the protective surface finishes are undamaged and well maintained. Following maintenance work, such as riveting and drilling, it is impossible to completely protect the skin to the original specification.
All magnesium alloy skin areas must be thoroughly and regularly inspected, with special emphasis on edge locations, fasteners and paint finishes.

Aluminium Alloy Skins

The most vulnerable skins are those which have been integrally machined, usually in main-plane structures. Due to the alloys and to the manufacturing processes used, they can be susceptible to intergranular and exfoliation corrosion.
Small bumps or raised areas under the paint sometimes indicate exfoliation of the actual metal. Treatment requires removal of all exfoliated metal followed by blending and restoration of the finish.

Spot-Welded Skins and Sandwich Constructions

Corrosive agents may become trapped between the metal layers of spot-welded skins and moisture, entering the seams, may set up electrolytic corrosion that

eventually corrodes the spot-welds, or causes the skin to bulge. Generally, spot-welding is not considered good practice on aircraft structures.

Cavities, gaps, punctures or damaged places in honeycomb sandwich panels should be sealed to exclude water or dirt. Water should not be permitted to accumulate in the structure adjacent to sandwich panels. Inspection of honeycomb sandwich panels and box structures is difficult and generally requires that the structure be dismantled.

Electrical Equipment

Sealing, venting and protective paint cannot wholly obviate the corrosion in battery compartments. Spray, from electrolyte, spreads to adjacent cavities and causes rapid attack on unprotected surfaces. Inspection should also be extended to all vent systems associated with battery bays.

Circuit-breakers, contacts and switches are extremely sensitive to the effects of corrosion and need close inspection.

ControlCables

Loss of protective coatings, on carbon steel control cables can, over a period of time, lead to mechanical problems and system failure. Corrosion-resistant cables, can also be affected by corrosive, marineenvironments.

Any corrosion found on the outside of a control cable should result in a thorough inspection of the internal strands and, if any damage is found, the cable should be rejected.

Cables should be carefully inspected, in the vicinity of bell-cranks, sheaves and in other places where the cables flex as there is more chance of corrosion getting inside the cables when the strands are moving around (or being moved by) these items.

CORROSIONREMOVAL,ASSESSMENTANDREPROTECTION

Due to the high cost of modern aircraft, operators are expecting them to last much longer than perhaps even the manufacturer anticipated. As a result, the manufacturers have taken more care in the design of the aircraft, to improve the corrosion-resistance of aircraft. This improvement includes the use of new materials and improved surface treatments and protective finishes. The use of preventative maintenance has also been emphasised more than previously.

Preventative maintenance, relative to corrosion control, should include the: Adequate and regular cleaning of the aircraft

Periodic lubrication (often after the cleaning) of moving parts
Regular and detailed inspection for corrosion and failure of protective treatments
Prompt treatment of corrosion and touch-up of damaged paint Keeping of drain holes clear
Draining of fuel cell sumps
Daily wiping down of most critical areas
Sealing of aircraft during foul weather and ventilation on sunny days Use of protective covers and blanks.
General treatments for corrosion removal include:
Cleaning and stripping of the protective coating in the corrodedarea Removal of as much of the corrosion products as possible Neutralisation of the remainingresidue
Checking if damage is within limits Restoration of protective surfacefilms
Application of temporary or permanent coatings or paint finishes.
Cleaning and Paint Removal
It is essential that the complete suspect area be cleaned of all grease, dirt or preservatives. This will aid in determining the extent of corrosive spread. The selection of cleaning materials will depend on the type of matter to be removed. Solvents such as trichloroethane (trade name ‘Genklene’) may be used for oil, grease or soft compounds, while heavy-duty removal of thick or dried compounds may need solvent/emulsion-type cleaners.

General-purpose, water-removable stripper is recommended for most paint stripping. Adequate ventilation should be provided and synthetic rubber surfaces such as tyres, fabrics and acrylics should be protected (remover will also soften sealants).

FerrousMetals

Atmospheric oxidation of iron or steel surfaces causes ferrous oxide (rust) to be deposited. Some metal oxides protect the underlying base metal, but rust promotes additional attack by attracting moisture and must beremoved.
Rust shows on bolt heads, nuts or any unprotected hardware.

Its presence is not immediately dangerous, but it will indicate a need for maintenance and will suggest possible further corrosive attack on more critical areas. The most practical means of controlling the corrosion of steel is the complete removal of corrosion products by mechanicalmeans.

Abrasive papers, power buffers, steel wool and wire brushes are all acceptable methods of removing rust on lightly stressed areas. Residual rust usually remains in pits and crevices. Some (dilute) phosphoric acid solutions may be used to neutralise oxidation and to convert active rust to phosphates, but they are not particularly effective on installed components.
Corrosion on high-stressed steel components may be dangerous and should be removed carefully with mild abrasive papers or fine buffing compounds. Care should be taken not to overheat parts during corrosion removal. Protective finishes should be re-applied immediately.

Aluminium and AluminiumAlloys

Corrosion attack, on aluminium surfaces, gives obvious indications, since the products are white and voluminous. Even in its early stages, aluminium corrosion is evident as general etching, pitting or roughness.
Aluminium alloys form a smooth surface oxidation, which provides a hard shell, that, in turn, may form a barrier to corrosive elements. This must not be confused with the more serious forms of corrosion.
General surface attack penetrates slowly, but is speeded up in the presence of dissolved salts. Considerable

attack can take place before serious loss of strength occurs. Three forms of attack, which are particularly serious, are:

Penetrating pit-type corrosion through the walls of tubing Stress corrosion cracking under sustained stress Intergranular attack ,characteristic of certain improperly heat treated alloys.

Treatment involves mechanical or chemical removal of as much of the corrosion products as possible and the inhibition of residual materials by chemical means. This, again, should be followed by restoration of permanent surface coatings.

Alclad

Warning: use only approved paint strippers in the vicinity ofredux bonded joints. Certain paint strippers will attack and degrade resins. Use adequate personal protective equipment when working with chemicals. Use only the approved fluids for removing corrosion products. Incorrect compounds will causeserious

Damage to metals.

Obviously great care must be taken, not to remove too much of the protective aluminium layer by mechanical methods, as the core alloy metal may be exposed, therefore, where heavy corrosion is found, on clad aluminium alloys, it must be removed by chemical methods wherever possible.

Corrosion-free areas must be masked off and the appropriate remover (usually a phosphoric acid-based fluid) applied, normally with the use of a stiff (nylon) bristled brush, to the corroded surface, until all corrosion products have been removed.

Copious amounts of clean water should, next, be used to flood the area
and remove all traces of the acid, then the surface should be dried thoroughly. Note: A method of checking that the protective aluminium coating remains intact is by the application of one drop of diluted caustic soda to the cleaned area. If thealclad has been removed, the aluminium alloy core will show as a black stain, whereas, if the cladding is intact, the caustic soda will cause a white stain.

The acid must be neutralised and the area thoroughly washed and dried before a protective coating (usually Alocrom 1200 or similar) is applied to the surface. Further surface protection may be given by a coat of suitable primer, followed by the approved top coat of paint.

Magnesium Alloys

The corrosion products are removed from magnesium alloys by the use of chromic/sulphuric acid solutions (not the phosphoric acid types), brushed well into the affected areas. Clean, cold water is employed to flush the solution away and the dried area can, again, be protected, by the use of Alocrom 1200 or a similar, approved, compound.

Acid Spillage

An acid spillage, on aircraft components, can cause severe damage. Acids will corrode most metals used in the construction of aircraft. They will also destroy wood and most other fabrics. Correct Health and Safety procedures must be followed when working with such spillages.
Aircraft batteries, of the lead/acid type, give off acidic fumes and battery bays

should be well ventilated, while surfaces in the area should be treated with anti- acid paint. Vigilance is required of everyone working in the vicinity of batteries,to detect (as early as possible) the signs of acid spillage. The correct procedure to be taken, in the event of an acid spillage, is as follows:
Mop up as much of the spilled acid, using wet rags or paper wipes. Try not to spread the acid
If possible, flood the area with large quantities of clean water, taking care that electrical equipment is suitably protected from the water
If flooding is not practical, neutralise the area with a 10% (by weight) solution of bicarbonate of soda (sodium bicarbonate) with water
Wash the area using this mixture and rinse with cold water
Test the area, using universal indicating paper (or litmus paper), to check if acid has been cleaned up
Dry the area completely and examine the area for signs of damaged paint or plated finish and signs of corrosion, especially where the paint may have been damaged.

Remove corrosion, repair the damage and restore the surface protection as appropriate.
Alkali Spillage
This is most likely to occur from the alternative Nickel-Cadmium (Ni-Cd) or Nickel-Iron (Ni-Fe) type of batteries, containing an electrolyte of Potassium Hydroxide (or Potassium Hydrate).
The compartments of these batteries should also be painted with anti-corrosive paint and adequate ventilation is as important as with the lead/acid type of batteries. Proper Health and Safety procedures are, again, imperative.
Removal of the alkali spillage, and subsequent protective treatment, follows the same basic steps as outlined in acid spillage, with the exception that the alkali is neutralised with a solution of 5% (by weight) of chromic acid crystals inwater.
Mercury Spillage

Warning: mercury (and its vapour) is extremely toxic. Instances of mercury poisoning must, by law, be reported to the health and safety executive. All safety precautions relating to the safe handling of mercury