SHA-SHIB GROUP OF INSTITUTIONS

Training Notes

Module 07- Maintenance Practices

SHA-SHIB GROUP

EMPOWERING KNOWLEDGE THROUGH VISION

FOREWORD

UNCONTROLLED COPY

- The information in this book is for study/ training purposes only and no revision service will be provided to the holder.
- While carrying out a procedure/ work on aircraft/ aircraft equipment you must always refer to the relevant Aircraft Maintenance Manual or Equipment Manufacturer's Handbook.
- For health and safety in the workplace you should follow the regulations/ Guidelines as specified by the Equipment Manufacturer, your company, National Safety Authorities and National Governments.

Knowledge Levels – Category A, B1, B2, B3 and C Aircraft Maintenance Licence

Basic knowledge for categories A, B1, B2 and B3 are indicated by the allocation of knowledge levels indicators (1, 2 or 3) against each application subject. Category C applicants must meet either the category B1 or the category B2 basic knowledge levels.

The knowledge level indicators are defined as follows:

LEVEL 1

- A familiarization with the principal elements of the subject.

Objectives: The applicant should be familiar with the basic elements of the subject.

- The applicant should be able to give a simple description of the whole subject, using common words and examples.
- The applicant should be able to use typical terms.

LEVEL 2

- A general knowledge of the theoretical and practical aspects of the subject.
- An ability to apply that knowledge.

Objectives: The applicant should be able to understand the theoretical fundamentals of the subject.

- The applicant should be able to give a general description of the subject using, as appropriate, typical examples.
- The applicant should be able to use mathematical formulae in conjunction with physical laws describing the subject.
- The applicant should be able to read and understand sketches, drawings and schematics describing the subject.
- The applicant should be able to apply his knowledge in a practical manner using detailed procedures.

LEVEL 3

- A detailed knowledge of the theoretical and practical aspects of the subject.
- A capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner.

Objectives: The applicant should know the theory of the subject and interrelationships with other subjects.

- The applicant should be able to give a detailed description of the subject using theoretical fundamentals and specific examples.
- The applicant should understand and be able to use mathematical formulae related to the subject.
- The applicant should be able to read, understand and prepare sketches, simple drawings and schematics describing the subject.
- The applicant should be able to apply his knowledge in a practical manner using manufacturer's instructions.
- The applicant should be able to interpret results from various sources and measurements and apply corrective action where appropriate.

-: DGCA MODULARISATION :-

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CAR – 66 ISSUE II R 2

(LICENSING OF AIRCRAFT MAINTENANCE ENGINEERS)

DIRECTORATE GENERAL OF CIVIL AVIATION

TECHNICAL CENTRE, OPP SAFDURJUNG AIRPORT, NEW DELHI

Modules	Subject	A or B1 Aero plane with		A or B1 Helicopter with		B2
		Turbine Engine (s)	Piston Engine (s)	Turbine Engine (s)	Piston Engine (s)	Avionics
1	Not Applicable					
2	Not Applicable					
3	ELECTRICAL FUNDAMENTALS	X	X	X	X	X
4	ELECTRONIC FUNDAMENTALS	X	X	X	X	X
5	DIGITAL TECHNIQUES ELECTRONIC INSTRUMENT SYSTEMS	X	X	X	X	X
6	MATERIALS AND HARDWARE	X	X	X	X	X
7A	MAINTENANCE PRACTICES	X	X	X	X	X
7B	MAINTENANCE PRACTICES					
8	BASIC AERODYNAMICS	X	X	X	X	X
9A	HUMAN FACTORS	X	X	X	X	X
9B	HUMAN FACTORS					
10	AVIATION LEGISLATION	X	X	X	X	X
11A	TURBINE AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS	X				
11B	PISTON AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS		X			
11C	PISTON AEROPLANE AERODYNAMICS, STRUCTURES AND SYSTEMS					
12	HELICOPTER AERODYNAMICS, STRUCTURES AND SYSTEMS			X	X	
13	AIRCRAFT AERODYNAMICS, STRUCTURES AND SYSTEMS					X
14	PROPULSION					X
15	GAS TURBINE ENGINE	X		X		
16	PISTON ENGINE		X		X	
17A	PROPELLER	X	X			
17B	PROPELLER					

MODULE 7A. MAINTENANCE PRACTICES		LEVEL	
		B1.1	B2
7.1	Safety Precautions-Aircraft and Workshop	3	3
	Aspects of safe working practices including precautions to take when working with electricity, gases especially oxygen, oils and chemicals. Also, instruction in the remedial action to be taken in the event of a fire or another accident with one or more of these hazards including knowledge on extinguishing agents.		
7.2	Workshop Practices	3	3
	Care of tools, control of tools, use of workshop materials; Dimensions, allowances and tolerances, standards of workmanship; Calibration of tools and equipment, calibration standards.		
7.3	Tools	3	3
	Common hand tool types; Common power tool types; Operation and use of precision measuring tools; Lubrication equipment and methods. Operation, function and use of electrical general test equipment;		
7.4	Avionic General Test Equipment	2	3
	Operation, function and use of avionic general test equipment		
7.5	Engineering Drawings, Diagrams and Standards	2	2
	Drawing types and diagrams, their symbols, dimensions, tolerances and projections;Identifying title block informationMicrofilm, microfiche and computerised presentations; Specification 100 of the Air Transport Association (ATA) of America;Aeronautical and other applicable standards includingISO, AN, MS, NAS and MIL;		
	Wiring diagrams and schematic diagrams.		
7.6	Fits and Clearances	2	1
	Drill sizes for bolt holes, classes of fits; Common system of fits and clearances; Schedule of fits and clearances for aircraft and engines; Limits for bow, twist and wear; Standard methods for checking shafts, bearings and other parts.		
7.7	Electrical Wiring Interconnection System (EWIS)	3	3

	Continuity, insulation and bonding techniques and testing; Use of crimp tools: hand and hydraulic operated; Testing of crimp joints; Connector pin removal and insertion; Co-axial cables: testing and installation precautions; Identification of wire types, their inspection criteria and damage tolerance. Wiring protection techniques: Cable looming and loom support, cable clamps, protective sleeving techniques including heat shrink wrapping, shielding. EWIS installations, inspection, repair, maintenance and cleanliness standards.	1	1
7.8	Riveting	2	-
	Riveted joints, rivet spacing and pitch; Tools used for riveting and dimpling; Inspection of riveted joints.		
7.9	Pipes and Hoses	2	-
	Bending and belling/flaring aircraft pipes; Inspection and testing of aircraft pipes and hoses; Installation and clamping of pipes.		
7.10	Springs	2	-
	Inspection and testing of springs.		
7.11	Bearings	2	-
	Testing, cleaning and inspection of bearings; Lubrication requirements of bearings; Defects in bearings and their causes.		
7.12	Transmissions	2	-
	Inspection of gears, backlash;		
	Inspection of belts and pulleys, chains and sprockets; Inspection of screw jacks, lever devices, push-pull rod systems.		
7.13	Control Cables	2	-
	Swaging of end fittings; Inspection and testing of control cables; Bowden cables; aircraft flexible control systems		
7.14	Material handling	2	-
	SheetMetal Marking out and calculation of bend allowance; Sheet metal working, including bending andforming; Inspection of sheet metalwork. Composite andnon-metallic Bonding practices; Environmental conditions Inspection methods		

`7.1 5	Welding, Brazing, Soldering and Bonding		
	(a) Soldering methods; inspection of soldered joints. (b) Welding and brazing methods; Inspection of welded and brazed joints; Bonding methods and inspection of bonded joints.	2 2	2 -
7.16	Aircraft Weight and Balance		
	(a) Centre of Gravity/Balance limits calculation: use of relevant documents; (b) Preparation of aircraft for weighing; Aircraft weighing;	2 2	2 -
7.17	Aircraft Handling and Storage	2	2
	Aircraft taxiing/towing and associated safety precautions; Aircraft jacking, chocking, securing and associated safety precautions; Aircraft storage methods; Refuelling/defuelling procedures; De- icing/anti-icing procedures; Electrical, hydraulic and pneumatic ground supplies. Effects of environmental conditions on aircraft handling and operation.		
7.18	Disassembly, Inspection, Repair and Assembly Techniques	3	3
	(a) Types of defects and visual inspection techniques. Corrosion removal, assessment and reprotection. (b)		
	General repair methods, Structural Repair Manual; Ageing, fatigue and corrosion control programmes; (c) Non destructive inspection techniques including, penetrant, radiographic, eddy current, ultrasonic and boroscope methods. (d) Disassembly and re-assembly techniques. (e) Trouble shooting techniques	2 2 2 2	- 1 2 2
7.19	Abnormal Events		
	(a) Inspections following lightning strikes and HIRF penetration. (b) Inspections following abnormal events such as heavy landings and flight through turbulence.	2 2	2 -
7.20	Maintenance Procedures		
	Maintenance planning; Modification procedures; Stores procedures; Certification/release procedures; Interface with aircraft operation; Maintenance Inspection/Quality Control/Quality Assurance; Additional maintenance procedures. Control of life limited components	2	2

Module 7A: Enabling Objectives and Certification Statement

Certification Statement

These Study Notes comply with the syllabus of DGCA, CAR – 66 (Appendix I) and the associated Knowledge Levels as specified.

REVISION LOG

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Safety Precautions

Safety with Electricity

The human body conducts electricity. Furthermore, electrical current, passing through the body, disrupts the nervous system and causes burns at the entry and exit points. The current, used in domestic 220-240 volt, 50Hz ac electricity, is particularly dangerous because it affects nerves in such a way that a person, holding a current-carrying conductor, is unable to release it. Table 2 shows some typical harmful values and effects of both ac and dc electricity supplies.
Harmful values of electricity

Voltage/Current	Possible Outcome
50V ac or 100V dc	**May give rise to dangerous shocks**
1 mA	Harmless tingle
1 – 12 mA	Painful, but can be released
12 – 20 mA	Very painful, cannot be released
20 – 50 mA	Paralysis of respiration
> 50 mA	**Heart stoppage**

Since water also conducts electricity, great care must be taken to avoid handling electrical equipment of all kinds when standing on a wet surface or when wearing wet shoes. The water provides a path to earth and heightens the possibility of electric shock. To ensure that equipment is safe, the minimum requirement is through the use of three-core cable (which includes an earth lead) and, possibly, a safety cut-out device (circuit breaker / fuse).

In conjunction, more often than not, with ignorance or carelessness, electrical hazards generally arise due to one or more of the following factors:
Inadequate or non-existentearthing

Worn or damaged wiring, insulation, plugs, sockets and otherinstallationsBad wiring systems and the misuse of goodsystemsIncorrect use offusesInadequate inspection and maintenance of power tools and equipment.

All electrical equipment must be regularly checked and tested for correct operation and electrical safety. To show that this has been done, a dated label should be attached, showing when the equipment was last tested and when the next inspection is due.
Any new item of equipment must have a test label attached. The presence of a test label does not, however, absolve the user from checking the equipment for any external signs of damage, such as a frayed power cord (or missing safety devices) before use.

In the event of a person witnessing another person receiving an electric shock,the basic actions, to be followed by the witness, are:

- Shout for help and ensure there is no danger of also becoming avictim
- Switchofftheelectricalcurrentorremovethevictimfromthesupplybymeansofinsulated material
- If the victim has ceased breathing, initiate resuscitation (artificialrespiration)

- Call for professional medicalhelp
- If the victim is suffering from burns, exclude air fromwounds
- Treat for shock by keeping the victim warm (cover with blanket to providewarmness)

Let's see how a common hand tool creates electrical hazard

Consider an electric drill that has an AC motor inside a metal housing. One wire connects the power terminal of motor and the other terminal connects to ground.
If there are only two wires in the cord and the power leads become shorted to the housing, the return current flows to ground through operator's body.
If the drill motor is wired with a three-wire cord, return current flows through earth wire connected in metal housing to ground.

[Note: In a three-cord plug connector, the earth connector pin is little longer & thicker than live and neutral pins, so while plugging the cord, the earth connector pin will touch first and while removing it will disconnect last, which is a safety design. And it is also thicker, so leakage current will come through larger area conductor first. Incase the live wire is frayed inside the equipment and touching the metal casing, the return current will go through the earth wire suddenly and the tripper or fuse will go off]
Do know the colour of each wires!

When working on an aircraft electrical system always ensure:
All unnecessary equipments switchedoff
The Fuse / Circuit breaker is "Pulled" and "tagged" on any circuit that is to be workedon.
Always consult the manual for any special safety precautions before commencingwork.
Make sure that the cables are in good condition (proper insulation and no damages) and routed & supported properly as per themanual

When working with any electrical equipment:
Never work with electrically operated equipment with wet hands or, feet in wetfloor
Never use electrical equipments in hazardous areas like fuel tanks unless the manual says so.
Check that the equipment has current serviceable labelfitted.

Safety with compressed gases and Oxygen

Compressed gases are frequently used in the maintenance and servicing of aircraft.

Compressed gas powers Pneumatic Rivet guns, Paint spray guns, drill motors, cleaning guns, etc.
Compressed Nitrogen is used to inflate tires and shock struts, while compressed oxygen- acetylene and compressed hydrogen-acetylene are used for welding.
The use of compressed gases requires a special set of safety measures.
Air hoses should be inspected frequently for breaks and worn spots. Unsafe hoseshould be replacedimmediately.
All connections should be kept in a "No leakcondition"
Air used for paint spraying should be filtered to remove oil andwater
Never play with compressed air like cleaning the hands or clothes. Pressure canforce debris into flesh leading to severeinjuries.
For this reason, the air dusting guns are equipped with a restrictor that reducesthe pressure at their discharge to 30 psi orless
Always wear eye protection while handling compressed gases. Forceful air touchingthe face can cause severeinjuries.
Too many accidents and incidents happened while inflating tires. Always usesafety cages recommended for inflatingtires.

Safety around the compressed cylinder

Oxygen and Nitrogen cylinders are mostly found in maintenance shops as thosegases are commonly used inaircraft. They are usually stored in steel containers around 2000 psi. and have brass valves screwed over them. If by any chance, they get knocked over and fell, and if thevalves got broken, the cylinder would propel like a rocket, which can be easily felt as extremely dangerous inshops.
So, always support the compressed cylinders over the walls bychains.
When the cylinder is not connected with any system, use protective caps to preventthe damage that may happen to the valves while fallingoff.

Additional care should be taken with oxygen cylinders as oxygen possess the risk of explosion and combustion. Never allow oxygen to come in contact with petroleum products such as oil, grease as oxygen causes these materials to ignite spontaneously andburn.

Safety while servicing oxygen system

While servicing an aircraft oxygen system in ramp, two persons are required. One man stationed at the control valves of servicing equipment in cart and other stationed where he can observe the pressure in aircraftsystem.
Aircraft should not be serviced with oxygen during fueling, defueling and other maintenance work which could provide a source ofignition.

Aircraft oxygen system should be serviced outside thehangerCare should be taken while handling liquid oxygen, since it causes severe "burns"or**"frostbite"** if it comes in contact with the skin because of its low temperature (-297deg F)

[Note: Liquid oxygen (LOX) is used in military aircrafts instead of gaseous oxygen as a small quantity of LOX can be converted to an enormous amount of gaseous oxygen, resulting in the use of very little storage space compared to that needed for high pressure gaseous oxygen cylinders. The difficulty in handling LOX and the expense of doing so, has restricted its use to military aircraftsonly]

Only cylinders marked **"Aviator's breathing oxygen"** may be used in aircraft breathing oxygen system.
[Note: *Aviator's breat*hing oxygen is for fighter jet pilots, which is a pure oxygen which contains maximum of 2ml of water per liter of gaseous oxygen, since flying at higher altitudes with very low temperature may cause the oxygen system lines to freeze and block the oxygen passage to pilots if the oxygen has more moisture]

Safety while charging a gas cylinder

Charge a gas cylinder slowly by slowly opening the valve of servicing equipment. Never charge to pressures greater than the maximumspecified.
Always keep blanks on connections when not inuseUse the right gas for the specified location. Never mixgases.

Safety while charging an oxygen cylinder

Keep the correct firefighting equipment in the chargingarea.
Display **"No Smoking"** signs.
If artificial lighting required, use flameproof torches or explosion prooflamps.
Ensure all equipment including the aircraft isearthed.
Don't use oil or grease while connecting the hose to a cylinder for charging, or for connecting fittings, regulators and gauges in the cylinder. It may cause explosions. Refer Manual safety instructions for using correct thread lubricants while connecting oxygen system components. To minimize the risk of fire, use only an approved MIL specification thread lubricant or tape like Teflon sealingtape.

High-Pressure Gas Replenishing

When replenishing tyres and hydraulic accumulators with high-pressure gas, care must be taken to ensure that only the required pressure enters the container. When full, a gas storage bottle can hold as much as 200 bar (3000 psi) whilst an aircraft tyre pressure may only require 7 bar (100psi).

To safely control the gas, two pressure regulating valves are used, one at the storage bottle end and one at the delivery end of the system. If one valve fails the other will prevent the receiving vessel from taking the full bottle pressure with the consequence of anexplosion.

The transfer of high-pressure gases from a large storage bottle to the aircraft component is often called decanting and must be done at a very slow rate. If the gas is decanted rapidly the temperature of the receiving component will increase in accordance with the gaslaws.

Again, using the same gas laws the temperature of the gas in the container will drop to ambient, and the pressure in that vessel will reduce. The component pressure will now be incorrect and require the decanting process to berepeated.
For added safety the gas bottle valve opening key should be left in the valve whilst decanting operations are completed. If problems occur then the high-pressure bottle can be quickly isolated before the situation becomesdangerous.

Passenger service unit (PSU)

Even though most of the aircraft are pressurised, emergency oxygen must be carried in the event that the pressurisation system fails. Smaller aircraft can carry oxygen in cylinders whilst the larger, civil aircraft have individual oxygen generator units. These units are stowed in the overhead cargo bins, above the passenger seats, and are known as the passenger service units or PSUs.

A PSU produces oxygen, by means of a chemical reaction, and is activated when its mask (which drops from the overhead bin in an emergency) is pulled by apassenger.

Note: When PSUs reach their life expiry and have to be returned to their manufacturer, it is vital that all precautions are followed to make the units 'safe' for transit. PSUs get very hot when working and have caused the destruction, due to fire, of an aircraft, which was carrying these units ascargo.

The main oxygen systems are serviced from trolleys or vehicles that carry a number of high-pressure bottles of oxygen, which can be at 140 bar (2000 psi) or more. Some trolleys may also have a bottle of nitrogen, to allow the replenishment of hydraulic accumulators and landing gears. The two types of bottles must be separated, in order to prevent the accidental mixing of thegases.

Gas Bottle Identification

High-pressure gas cylinders contain various types of gas, the most common used on commercial aircraft being nitrogen and oxygen. To ensure correct identification of these containers, they are colour coded and the name of the gas is stenciled on theside.

Fire safety

Personnel, engaged in the maintenance, overhaul and repair of aircraft, should be fully conversant with the precautions required to prevent outbreaks of any fire. They should be qualified in the operation of any fire protection equipment that is provided, and should know the action to be taken in the event of discovering afire.

Personnel should not wear foot wear with exposed iron or steel studs, nails or tips in hangars, fuelling and de-fuelling areas, and aircraft movement areas, and it is recommended that matches or other means of ignition should not becarried.

Always be aware of the possibility of fire and provide for exits when putting aircraft in hanger. The key to fire safety is the knowledge of what causes fire, how to prevent them and how to put themout.

What causes fire

Three conditions must be met for a fire to occur. There must be fuel, oxygen and enough heat to raise the temperature of the fuel to its ignition or kindlingpoint.

Chemically, fire is a reaction between Fuel and Oxygen. This reaction reduces fuel to its basic chemical elements and in the process produces tremendous amount ofheat.
If any of those three elements is removed then fire can beextinguished.

How to prevent them

In order to prevent a fire from happening, the source of fire should be identified.

Since aircraft fuel, paint and solvents are highly flammable, you must take every precaution to prevent fire where these materials arepresent.

Different type of fuel has different kindling temperatures. Eg; gasoline combines with oxygen at a relatively low temperature. On the other hand, materials such as wood must reach a considerably higher temperature before theyignite.

The concentration of available oxygen also affects a material'scombustibility.
A petroleum product such as oil or grease ignites at room temperature if it is blanketed with pureoxygen.
Steel alloy is normally not combustible, but it burns when it is heated red hot and a stream of pure oxygen is fed intoit.

The very nature of aircraft makes them highly susceptible to fire. They carry large amounts of highly flammable fuel, as well as oxygen under high pressure. Because of this, aviation technicians must take proper precautions to prevent fires in aircraft, and have the knowledge and tools to deal with fire when it happens.

Classes of fire

Fire protection begins with the knowledge of types of fires, what materials are involved, and which extinguishing materials work best for each type.

The National Fire Protection Association defines three classes of fires.

Class A – it involves Solid Combustible materials such as wood, paper or cloth.
In aircraft Control cabins, passenger compartments and baggage compartments, class A fires are likely to occur. Since the interior of the passenger compartmentandcockpit are readily accessible to crew, fire detection in these areas are generally accomplished by visual surveillance.

But during flight, baggage compartment is inaccessible to identify fire hazard. In such areas, monitoring is accomplished by electrically powered smoke / flame detector systems.

Class B – it involves Combustible liquids like petroleum products such as gasoline, oil, jet fuel, and many of the paint thinners and solvents used in aviation maintenance.
In aircrafts, this type of fire typically occurs in engine compartments or nacelles, and in compartment that house an APU (Auxiliary Power Unit).
Since these areas are operating at extreme temperatures, smoke / flame detectors cannot be normally used. So, to avoid false alarms, overheat detection systems are used.

Class C – it involves energized electrical equipments and wirings. These fires require special care, as danger with electricity is also involved.In aircraft, this type of fire usually happens in electrical and electronic control bays and areas behind electrical controlpanels.
Since the electrical fire usually starts with large amount of smoke, smoke detector systems are generally used formonitoring.

Class D – it is due to class A, B and C fire. Generally, a Flammable / Burning material like Magnesium. Class D fires are not commercially considered by NFPA as a basic type of fire, as it is due to combination of other classes offire.

Eg; Class D fire can happen when a flammable metal comes in contact with,electrical sparks from a broken wireorwith fuel and electrical sparks from a brokenwire.

A		Ordinary Combustibles	Wood, Paper, Cloth, Etc.
B		Flammable Liquids	Grease, Oil, Paint, Solvents
C		Live Electrical Equipment	Electrical Panel, Motor, Wiring, Etc.
D		Combustible Metal	Magnesium, Aluminum, Etc.
K		Commercial Cooking Equipment	Cooking Oils, Animal Fats, Vegetable Oils

Fire Extinguisher

Fire safety

The methods of extinguishing fires have led to the development of several types of extinguishants to cater for different types of fire. These methods include:

- Cooling thefuel
- Excluding theoxygen
- Separating the fuel from theoxygen

Extinguishants:

The materials, used as general 'domestic and commercial' extinguishants, which conform to the NFPA 10 – standard for Portable fire extinguishers differ from those used in aircraft Fire Protection systems. They are,Water (Water/Gas)
Aqueous Film-Forming Foam (AFFF)
Carbon Dioxide(CO_2)
DryPowder
Wetchemical
Halon (No longer in general use, limited to aircraft andmilitary)

Extinguishers:

A FIRE EXTINGUISHER is an active fire protection device used to extinguish or control small fires,ofteninemergencysituations.Itisnotintendedforuseonanout-of-controlfire,suchas one which has reached the ceiling, endangers the user (i.e., noescape route, smoke, explosion hazard,etc)

Applying the incorrect extinguishant to a fire can do more harm than good and may, actually, bedangerous.
It is, therefore, important that extinguishers are well marked for quick identification in an emergency.
It is also vital that all personnel are aware of the markings, which appear on extinguishers, so that the correct one is chosen to deal with a specificfire.

The extinguishing systems in general use are the fixed system and the portable system.
The term 'fixed' refers to a permanently installed system of extinguishant containers, distribution pipes and controls provided for the protection of power plants and, where applicable, auxiliary power units, landing gear wheel bays and baggage compartments.
A portable system refers to the several hand-operated fire extinguishers provided to combat any outbreaks of fire in flight crew Compartments and passenger cabins, and also in maintenance hangar areas.

Suitable extinguisher has to be held in place where aircraft systems are being serviced in line, like during oxygen systemservicing.

Construction of a fireextinguisher:

Stored-pressure

- The pressure is usually between 12 and 17 bar

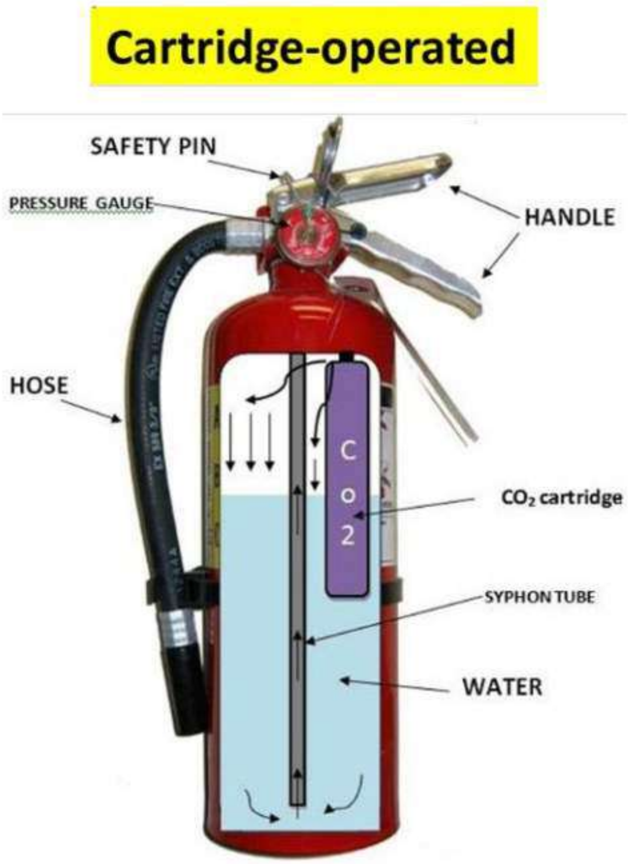
Water/gasExtinguisher:
Watercan be used only on class A fires (burning solids) such as aircraft cabin fires, where electricity is not involved. The extinguishant used is water mixed with antifreezematerial.
An anti-freezing agent is normally included to permit operation at temperatures as low as - 20°C.
Typical examples are the water/glycol extinguisher with 38% of inhibited ethylene glycol, and the 'wet-water' extinguisher with glycol, wetting agents to reduce surface tension, and inhibitors to impart anti-corrosivecharacteristics
Water has two effects on fire: it removes oxygen from fire and cools the material being burned.

How it is stored in cylinder: (Cartridge type)
The water is propelled from the extinguisher by a charge of CO_2. Once the extinguisher is activated, all the propellent is discharged and a new cartridge must be installed when the extinguisher isserviced.

Where can't use: (X)

Water could also cause liquid fires (Petroleum products) to spread and, obviously, using water on electrical equipment could have lethal results, so these extinguishers must NOT be used on Class B NOR on Class Cfires.
Water should, also, NOT be used on burning metal (Class D) fires, as the oxygen, in the water,willcausethefirestoburnmorefiercelyanditsusecouldleadtoviolentexplosions.

CO_2 Extinguisher:



Carbon dioxide (CO2) extinguisher named as **"universal fire extinguisher"** is used for Class A, B, and C fires. It extinguishes the fire by depriving it of oxygen. Since CO_2 is one and half times heavier than air, electrically non- conductive, and non-corrosive, it is effective on both class B and Cfires

Safety precautions:

Due to the fact that CO_2 gas tends to dissipate quickly, the extinguisher is provided with a horn device, which helps to concentrate the CO_2 at the site of thefire.
This horn must NOT be held with bare hands, as the intense cold of the released CO_2 will freeze the skin to the horn, resulting in severe injury (frostbite) to thehands.
A rubber, insulated coating is provided on the discharge tube and the CO_2 must be directed towards the fire by grasping and manipulating the insulatedtube.
How it is stored in cylinder: (Stored pressure type)

✓CO_2 is compressed and cooled and stored as a liquid in steelcontainers.

CO_2 fire extinguishers generally use the self-expelling method of operation. This means that the CO_2 has sufficient pressure at normal operating pressure to expelitself.
This pressure is held inside the container by some type of seal or frangible disk, which is broken or punctured by a firing mechanism, usually apin.
This means that once the seal or disk is broken, pressure in the container is released, and the fire extinguisher is spent, requiringreplacement.

How it extinguishes the fire:
When released into atmosphere, CO_2 expands and changes to a gas that cools to a temperature of about-110°F.
Because of the cooling effect, the water vapour in the air immediately condenses to form “Snow”, which causes the CO_2 to settle over the flames and smother them. Once the snow warms, it evaporates, leaving noresidue.
So, CO_2 extinguishes the fire by removing the contact of oxygen with fuel and the snow cools the fuel once settled in it andevaporates.
Where it is suitable to use:

Since it leaves no residue, it is most suited for engine intake and carburetorfire.
Where can’t use: (X)
Never use CO_2 on Class D fires. As with water extinguishers, the cooling effect of CO_2 on the hot metal can cause explosive expansion of themetal.
Extreme caution must be used when operating CO_2 fire extinguishers in closed or confined areas. Not only can the fire be deprived (removed) of oxygen, but so too can theoperator.

Dry Powder / Dry chemical Extinguisher: (ABC Powder)

Dry powder extinguishers, while effective on Class B fire, are the best for use on Class D fires. It is very effective against fires involving flammable liquids and free burning material such as wood, fabrics andpaper.
It does not have a quenching effect and thereby the dangers of distortion or explosionwhen used on hot surfaces, such as overheated wheel brakes, areminimised.
It also prevents a reflash that would re-ignite the fuel after it has beenextinguished.
It consists of a non-toxic powder (potassium bicarbonate) which is twice as effective as sodiumbicarbonate.
Not recommended for class C fire (electrical equipment), as the powder sprayed can enter into inaccessible places like nearby switch boards and other electrical components which makes the cleaning tough and the powder particles are capable of conducting high voltages (in excess of 1000 V) and, possibly, lesser voltages if they are used at distances of less than 1 metre from electricalfires.
Dry chemical extinguishers should not be used in flight crew compartments or passenger cabins where visibility would be seriously affected both during the discharge of powder and also as a result of its deposition on transparencies andinstruments.
How it is stored in cylinder: (Stored pressure type)

Dry powder is expelled from the container by compressed nitrogen

AFFF (Aqueous film forming foam)

Aqueous film forming foam (AFFF) is a highly efficient type of fire suppressantagent
AFFF foam fire extinguishers are highly effective on class A and class B fires (the foam agent helps to preventre-ignition).
Some foam extinguishers have been dielectrically tested to 35000 Volt (35kV) andcan be used on or near electrical appliances (Class Cfire)

Halons

Banned by U.S. Environmental Protection Agency (EPA) in 1994, as halogenated hydrocarbons (halons) causes the depletion of ozone layer.
Carbon tetrachloride (Halon104)
Methyl bromide (Halon1001)
Chlorobromomethane (Halon1011)
Dibromodifluoromethane (Halon1202)
Bromochlorodifluoromethane (B.C.F) (Halon1211)
Bromotrifluoromethane (B.T.M.) – Halon1301
BCF and BCM are commonly used in extinguishing fires in aircraft nowadays. They are available in fixed extinguishers in suitable locations in aircraft.
Some hydrocarbons combine with halogens to produce very effective fire-extinguishing agents that work by excluding oxygen from the fire source and by chemically interfering with the combustionprocess.
In aircraft, they are stored in bottles with nitrogen for pressurestorage

Methyl bromide (Halon 1001)

This chemical is very toxic & it is corrosive to aluminum alloys, magnesium, andzinc.
Commonly used in fixed systems, particularly for the protection of powerplants
Because of its toxicity, Methyl Bromide should not be used in confined spaces, flight crew compartments or passengercabins.
The effects of breathing the vapours may not be immediately apparent, but serious or even fatal after-effects may be sustained at a laterstage

Bromochlorodifluoromethane (B.C.F) - (Halon 1211)

This semi-toxic extinguishant is particularly effective against (B and C fires) electrical and flammable liquidfires.
It is used in power plant systems, and for the protection of auxiliary power units in some aircraft
It acts rapidly on fires by producing a heavy blanketing mist that eliminates oxygen from the fire source, with little or no deleterious effect on metallic, wooden, plastic or fabric materials.

Bromotrifluoromethane (B.T.M.) – Halon 1301

It is the most common fire extinguishing agent for aircraft interior fires (cabin fires). It is not harmful to humans in moderateconcentrations.
This semi-toxic extinguishant is used in fixed systems for the protection of both turbine and piston engine and

auxiliary powerunits.
It is also widely used in cargo compartment fire suppression systems of some types of aircraft and in lavatory fireextinguishing.

How to operate fire extinguisher

Identifying fire extinguishers

Where markings are applied to the extinguisher, they should be located on the front of the shell (if one is installed) above or below the extinguishernameplate.

Markings should be large enough and in a form that is easily seen and identifiable by the average person with average eyesight at a distance of at least 3 feet.
Where markings are applied to wall panels, and so forth, in the vicinity of extinguishers, they should be large enough and in a form that is easily seen and identifiable by the average person with average eyesight, at a distance of at least 25feet.
Safety around hazardous materials
Many large transport category aircraft contains potentially dangerous radioactive materials. For example, the balance weights on flight controls of many large aircraft contains depleted(expired) uranium238.

In aircraft cabin areas, radioactive tritium is used in luminescent devices such as exit signs.
Some optical instruments and electronic equipment contain radioactive thorium. In addition, many smoke detectors contain radioactive americium241.

All of these materials emit low level radiation and can be dangerous if handled or disposed of improperly.
As an aircraft maintenance technician working around these radiation sources, you must treat all radioactive materials with the respect they deserve.

Hazard communication program

The Occupational Safety and Health Administration (OSHA) developed a communication standard to make all personnel aware of shop materials that are considered hazardous or potentially hazardous, and train them in proper handling and disposal of these materials.

The one particular importance in the program is Material safety data sheet (MSDS) also called Safety data sheet (SDS)

OSHA regulations require an employer to have copies of relevant MSDS that are readily available to all shop personnel at all times. These data sheets allow for quick reference in case of a chemical spill orinjury.

In case of a chemical injury, a copy of MSDS of that particular chemical should be sent along to the emergency room to ensure proper medical attention.

What MSDS contains:

A material safety data sheet (MSDS or SDS) is a required document that contains information for the safe handling, use, storage and disposal of potentially hazardous chemicals.
Manufacturers and distributors of these substances must supply users with a safety data sheet for each different chemicalpurchased.

Previously, each country's regulating agency had some type of similar required documentation and procedures for disseminating information on chemical substances. The United Nations created a Globally Harmonized System of Classification and Labelling of Chemicals(GHS).
This standardizes worldwide the required documents that are to accompany and be kept on file for all potentially hazardouschemicals.
The goal is to ensure the safety of all personnel that are involved in manufacturing, distributing, transporting and using these materials in their day-to-day operations by providing standardizedinformation.

The GHS safety data sheet is a 16-section document that includes the following information:

- Identification
- Hazard(s)identification
- Composition/ information oningredients
- First-aidmeasures
- Fire-fightingmeasures
- Accidental ReleaseMeasures
- Handling and storage
- Exposure control/personalprotection
- Physical and chemicalproperties
- Stability and reactivity
- Toxicologicalinformation
- Ecologicalinformation
- Disposalconsiderations
- Transport information
- Regulatoryinformation
- Other information.

The GHS safety data sheets are accompanied by standard labelling pictograms or symbols which categorize substances and can be easily seen by a transporter or user of a particular substance. There are pictograms for physical hazards, health hazards and environmental hazards as well as transportation class identification pictograms.

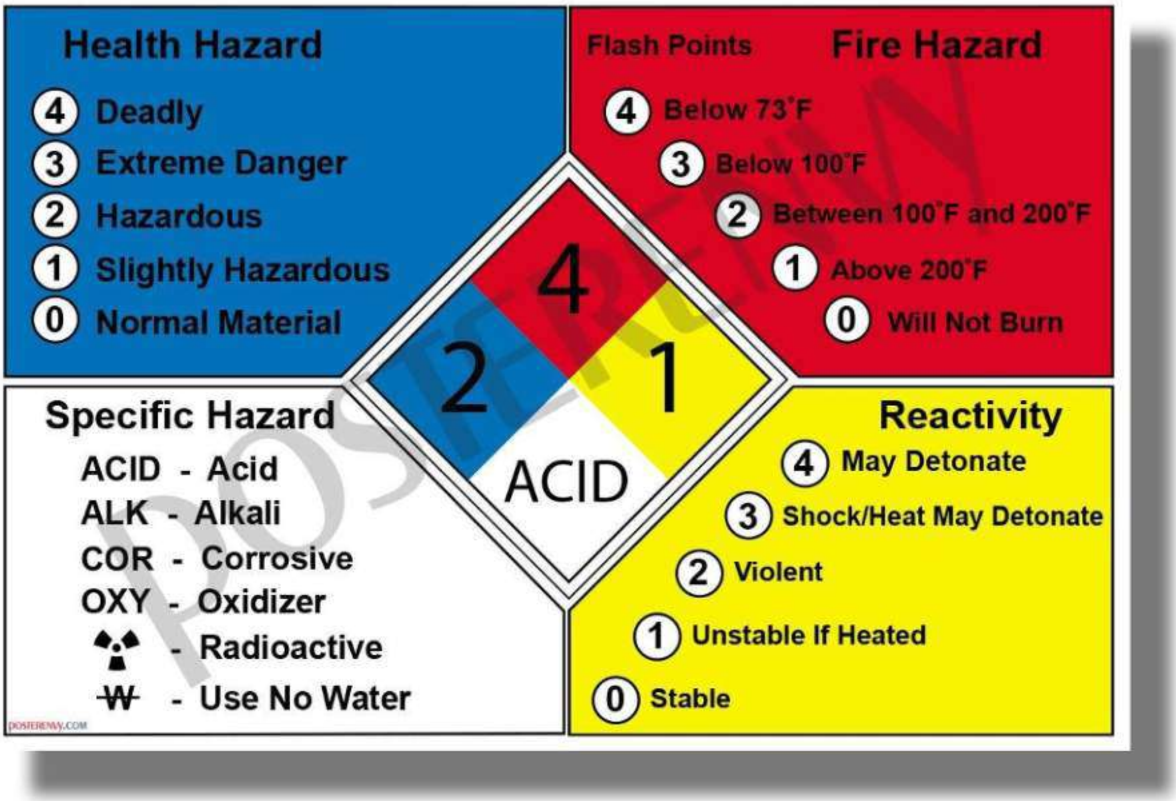
The most observable portion of the MSDS is the Risk Diamond
Many older national chemical safety organization SDS's may contain the pictogram label known as the risk diamond. This has been a staple of the Material Safety Data Sheet system utilized in the United States.

It is used by the emergency personnel to quickly and easily identify risks posed by hazardous materials.

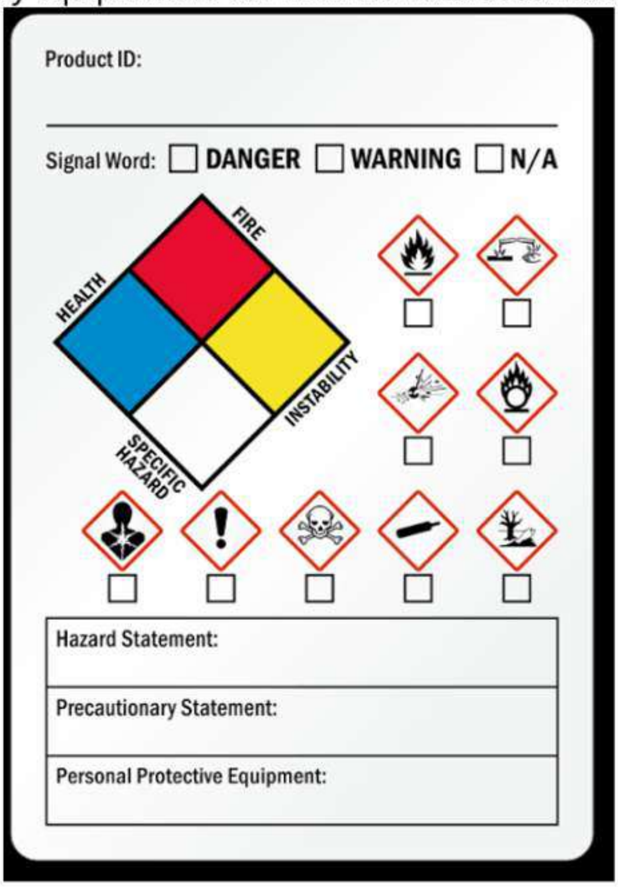
It is a four-colour segmented diamond that represents Flammability (Red), Reactivity (Yellow), Health (Blue), and special Hazard (White).

In the Flammability, Reactivity, and Health blocks, there should be a number from O to 4. Zero represents little or no hazard to the user; 4 means that the material is very hazardous.

The special hazard segment contains a word or abbreviation to represent the special hazard. Some examples are: RAD for radiation, ALK for alkali materials, ACID for acidic materials, and CARC for carcinogenic materials.



These forms and labels are a simple and quick way to determine the risk and if used properly with the tags, will indicate what personal safety equipment to use with the hazardous materials.



WORKSHOPPRACTICES

CARE OF TOOLS

The user of any tool has the responsibility to ensure the tool is in good working condition. The user of any tool has the responsibility to ensure the tool is in good working condition.

Tools must be kept clean. A light coating of oil wiped on the tool after use helps prevent corrosion of steel tools. Tools with moving parts should be kept clean
and lubricated if necessary to perform as designed.

CONTROL OF TOOLS

A misplaced tool can have
catastrophic effects resulting in significant expense and the possible loss of life.

Each engineer is responsible for the control of his or her own tools and any special tools borrowed from the company to perform a job.

A shadow board type concept
for storage of pliers, screw drivers, ratchets, hammers and other tools have the same effect.

The tools are frequently labeled with an identification number or have a bar code label attached directly to the tool for identification.No matter where tools are being used, it is the
responsibility of each technician to keep track of ALL of the tools used during a particular task.

USE OF WORKSHOP MATERIALS

Toxic materials may cause health risks which can becontrolled by controlling the handling and storage of this type of substance.
Still other materials are easily wasted or stolen unlesscontrolled through disciplined administration. Abrasivepapers, solder and brazing materials, wire wool, tirepowder, oil spill powder and so on, all require control of issue and use, though they may not, normally, require
stringent safety precautions.

Some materials areflammable and must, therefore, be stored outdoors or in
specially designed cabinets.These include oils, greases, some adhesives, sealing and glazing compounds in addition to many paints, enamels and epoxy surface finishes.
Another area of hazardous workshop materials is that of gases stored in high pressure containers such as nitrogen and oxygen.

TOOL CALIBRATION

Requirements within the relevant airworthiness codes of one's national aviation authority and EASA as well as a company's air operation certificate prescribe that, where necessary, tools, equipment and test equipment are all
calibrated to acceptable standards

The key factor is the need to establish confidence in the accuracy of the equipment when it is required for use. The required calibration frequency for any particular piece of test equipment is that which is considered sufficient to ensure it is in condition to perform its intended use.
Calibration takes place per the standard specified by the equipment manufacturer/design organization and/or the appropriate National/International Standards
A written record is kept for all tools that require calibration, detailing when last done, when next due, and the requirements of the calibration. A sticker is attached to the tool detailing the due date of the next

calibration. This should always be checked before use, and no tool should be used if it out of calibration. Calibration records or certificates should contain the following information:

Identification ofequipment
Standardused
Resultsobtained
Uncertainty ofmeasurement
Assigned calibrationinterval
Limits of permissibleerror
The authority under which the releasedocument wasissued
Any limitation in the use of theequipment
Date on which each calibration wasconducted

DIMENSIONS, ALLOWANCES, TOLERANCES
A dimension is a measurable extent of some kind, such as length, width, or height. Aircraft components including hardware have dimensions that physically
describe the item from a size prospective.

The basic size is the theoretical size from which limits of size are derived by applying allowances and tolerances.
The actual size of a part is the measured size. A tolerance is the total amount by which a given dimension is alloyed to vary.

Most tolerances are given as bilateral tolerances, meaning that the tolerance can be added to or subtracted from the basic size.

Tolerance can be used when examining the dimension of a single part or it can be used when comparing the dimensional relationship between two parts, which is known as fit.
An allowance is the minimum clearance space intended between two parts. The intentional difference between the maximum material dimensional limits of mating parts creates the allowance.

STANDARDS OF WORKMANSHIP
In aviation, the highest standards of workmanship are practiced. An error for any reason could result in the loss of human life. Therefore, it is the aspiration of all
engineers to meet or exceed the requirements of any maintenance function.

Maintenance instructions typically specify measurable values and tolerances for acceptable actions. Maintenance actions that do not achieve these values within tolerances cause the aircraft to remain unairworthy and it must not be released for service.

–Tools
Layout and measuring tools

Why accurate measurement is important in Maintenance?
Aviation manufacture and maintenance became an exact science rather than an art with the advent of mass production and the requirement for interchangeability of parts. This step increased the importance of accurate measurement.

In aviation maintenance there are many jobs that require precision measuring for close tolerance fits. Because of this you must be familiarized with several measuring devices.

Layout (Marking) and Measuring tools

"A wise and experienced advice – Measure twice before cutting once"

Layout and measuring devices are precision tools. They are carefully machined, accurately marked and, in many cases, are made up of delicate parts. When using these tools, be careful not to drop, bend, or scratch them.

it is very important to understand how to read, use, and care for these tools.

Rule / Engineer's Rule / Steel Rule /Scale

One of the most common measuring tools in a technician's toolbox is the six-inch steel rule, or scale, which is typically used for sheet metal layout and for taking measurements where extreme precision is notrequired.

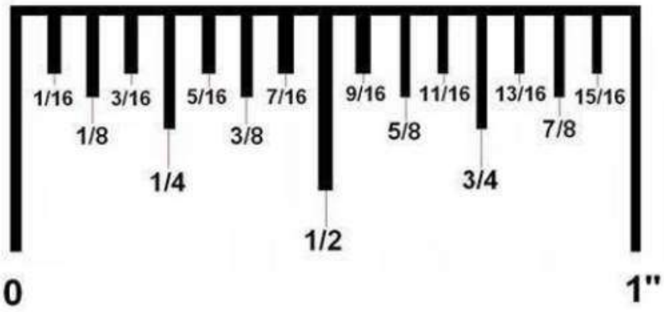
The better rules are made of flexible satin-finish stainless steel and are graduated in l/32- and 1/64-inch increments (common fractions) on one side, and 0.1- and 0.0 l-inch increments (decimals) on the other. Some rules are made of tempered carbonsteel.

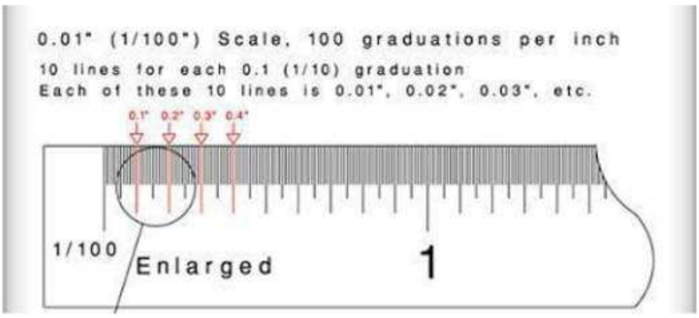
Metric rules are also available graduated in centimetres andmillimetres.

The flexible steel rule will bend, but it should not be bent intentionally as it may be broken rathereasily.

Rules are manufactured in two basic styles – those divided or marked in common fractions and those divided or marked in decimals or divisions of one one-hundredth (1/100) of an inch. A rule may be used either as a measuring tool or as astraightedge.

When making a measurement with a steel rule, do not use the end of the rule as end may have some damages. Rather, for greater accuracy, measure the distance between two marks away from theend.





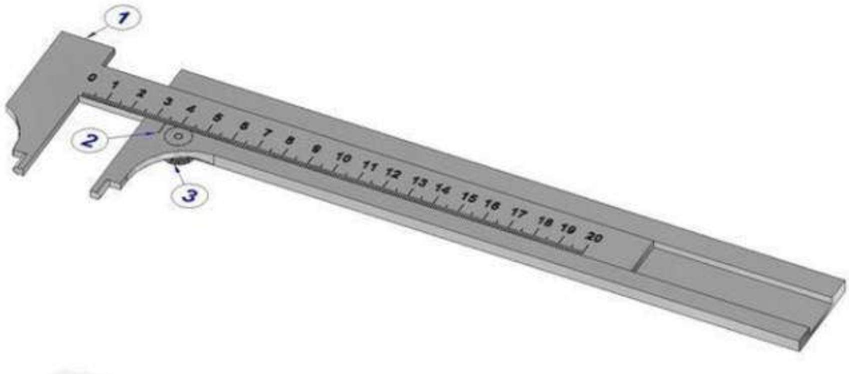
Other types of Rule:

Hook rule & Narrow hookrule

A hook rule has a hook attached to one end, which makes it easy to take measurements from an inside edge when it is not convenient to see the end of the rule. Hook rules are made in many sizes. A narrow hook rule is made for measuring in holes as small as 3/8in. in diameter. A hook rule may also be used for measuring outsidedimensions

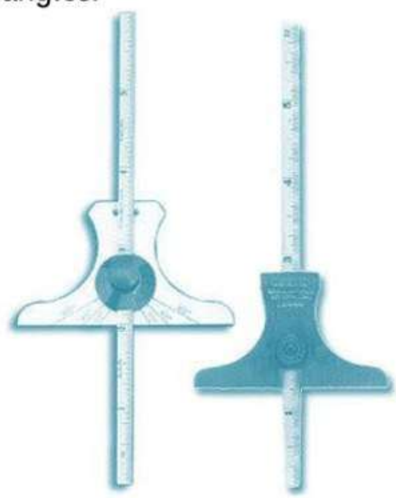
Slide caliperrule

A slide caliper rule is made with a narrow rule that slides inside a groove in the side of a wider rule. It may be used to make internal and external measurements. It is provided with a screw that will lock the slide in place as required. The narrow nibs
at the end of the jaws will enter a hole as small as 1/8in. in diameter.



Rule depthgage

A rule depth gage consists of a steel head that has a slot to receive a narrow rule. The rule is held in position by a knurled nut. It is designed to measure the depth of small holes and slots. Further the steel head has angle markings for measuring angles.



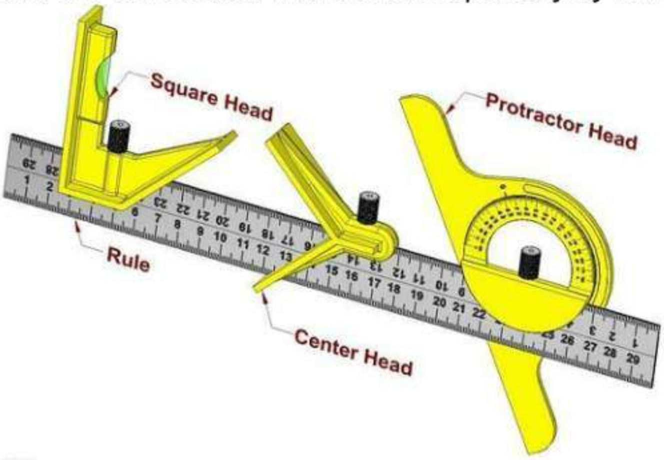
Combinationset

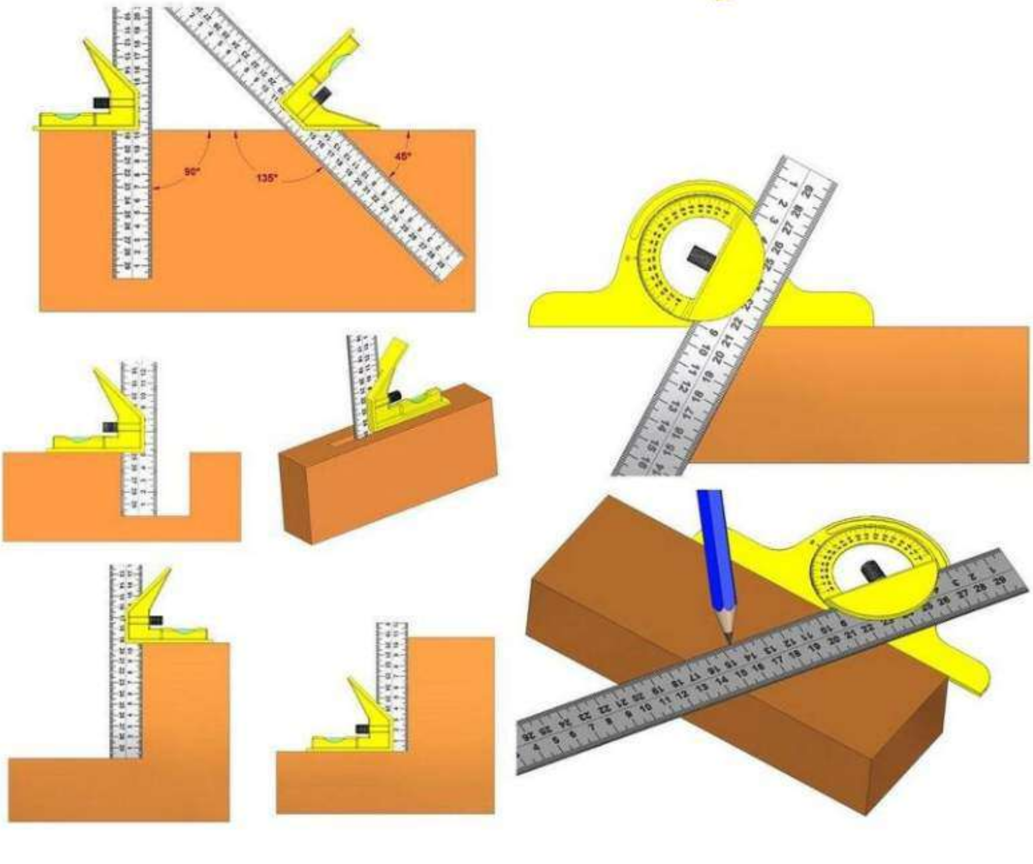
In addition to the flexible six-inch steel rule, most technicians have a combination set consists of a 12-inch steel rule with three heads held onto the rule byclamps.
One head is the stock head, which converts the rule into a square for marking 90° and 45° angles. The stock head also has a bubble level to check the squareness of a surface and also has ascriber.

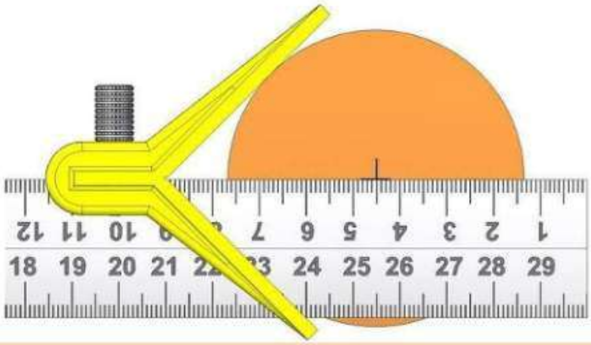
A protractor head can be attached to the rule, and it can be set to measure / mark any angle between the rule and the bottom of thehead.

The third head is the center head, in which one edge of the rule bisects the two arms of the head that are 90° apart. When the two arms are held against a circular object, the edge of the rule passes across the object's center, which helps to mark the object's center.

All three heads slide in the ruler and one can be used with the rule separately by removing the othertwo.

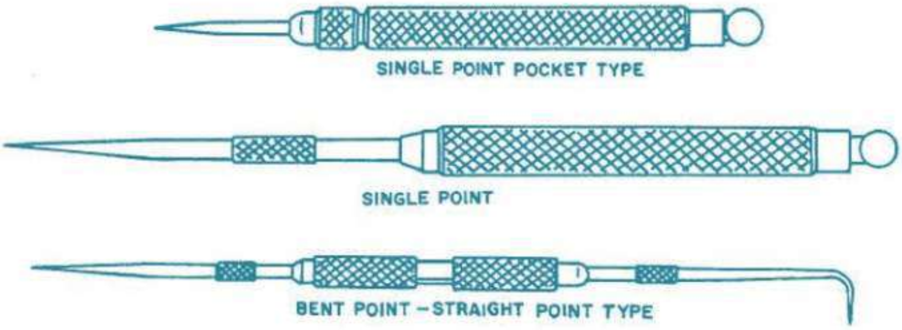


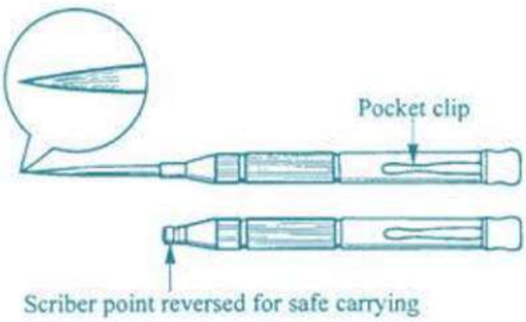




Scriber

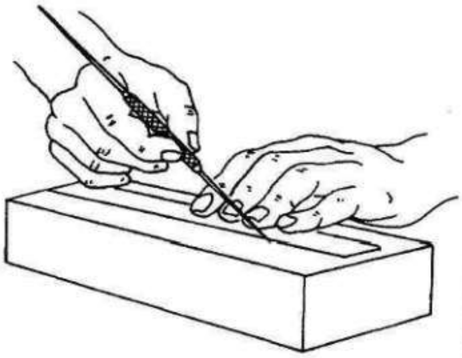
The scriber is designed to serve the aviation mechanic in the same way a pencil or pen serves a writer. In general, it is used to scribe or mark lines on metalsurfaces.
The scriber is made of tool steel, 4 to 12 inches long, and has two needle pointedends.
One end is bent at a 90° angle for reaching and marking throughholes.
In sheet metal fabrication, most work is done with soft metal so, a plain steel scriber is enough to scribe good. With rough and hard metals, a carbide tipped scriber would be good.
Some scribers have removable point, that can be reversed in the handle so it will not be dulled by contacting other tools while stored in toolbox.

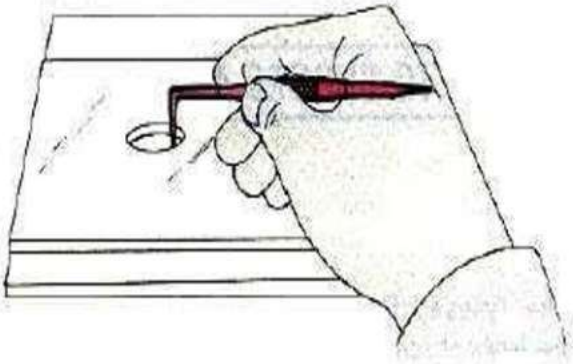




How to properly use a scriber:
Before using a scriber, always inspect the points forsharpness.
Be sure the straightedge is flat on the metal and in position forscribing.
Tilt the scriber slightly in the direction toward which it will be moved, holding it like a pencil.
Keep the scriber's point close to the guiding edge of thestraightedge.
The scribed line should be heavy enough to be visible, but no deeper than necessary to serve itspurpose.
The metal is usually sprayed with a thin coat of layout dye or zinc chromate primer, so that the mark made by the scriber will show upclearly.
Always give a little tolerance while scribing a metal area that are to be cut. Scribing the exact dimension to be cut, may leads to improper finishing aftercutting.
For ex: For cutting a sheet metal for 100 x 100 mm, scribe lines with tolerance of +1mm.

i.e. scribe for 101 x 101 mm, so that 1 mm tolerance can be filed for proper metal finishing and squareness.





How one shouldn't use a scriber:

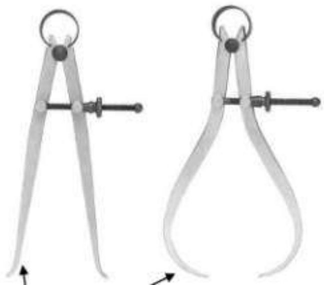
Scribe lines, that are to be cut. **Don't simply scribe lines in areas of sheet** metal that are not going to get cut. It may act as a scratch which affects thesurface.
Don't scribe the metal area that are to be bent. Scriber marking will slowly lead to breakage of metal in bent area. Bent lines should be marked with soft tippedmarker.
In the case of clad aluminum alloy, scriber will penetrate the protective coating of pure aluminum. A sharp-pointed soft lead pencil should be used in theseinstances.
When scribing a line, the scriber should be moved over the work only once. Scribing over the first line two or three times usually produces an unsatisfactory line or lines and is called shoddy workmanship.

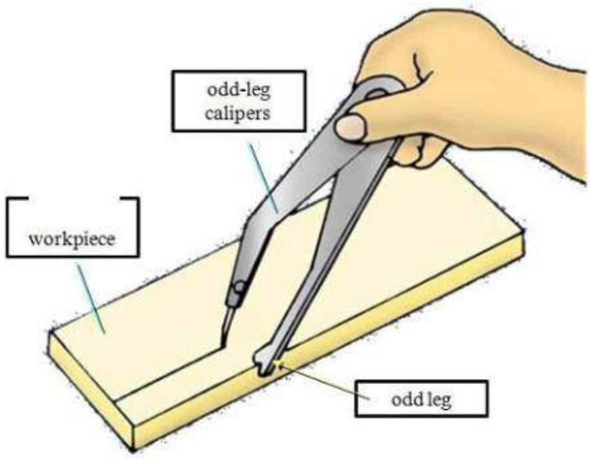
Dividers and Pencilcompasses

Dividers and pencil compasses have two legs joined at the top by a pivot. They are used to scribe circles and arcs on metals and for transferring measurements from the rule to thework.
The size of a Divider is the length of the legs from the pivot to thepoint.
Pencil compasses have one leg tapered to a needle point; the other leg has a pencil or pencil lead inserted. Dividers have both legs tapered to needlepoints.
Dividers are handy for spacing rivets in a row and for transferring distances when duplicatingparts.
How to properly use a Divider and Pencil compass:

The tendency for the legs to slip is avoided by inclining the compasses or dividers in the direction in which they are being rotated.
In working on metals, the dividers are used only to scribe arcs or circles that will later be removed bycutting.
All other arcs or circles are drawn with pencil compasses to avoid scratching the material.
Dividers should be used to transfer critical measurements because they are more accurate than a pencilcompass.
Calipers:

Calipers are used for measuring diameters and distances or for comparing distances and sizes. They are used along with a steel rule to measure the dimensions. The three common types of calipers are inside, outside, and hermaphrodite (odd leg) calipers.
Calipers resemble dividers except the ends of the legs are rounded rather than pointed, and the ends are bent so they are at right angles to the axis of the legs.





Outside calipers are used for measuring outside dimensions - for example, the diameter of a piece of round stock. It has legs pointedoutward.
Inside calipers have outward curved legs for measuring inside dimensions, such as diameters of holes, the distance between two surfaces, the width of slots. It has legs pointedinward.
A hermaphrodite caliper is generally used as a marking gauge in layout work. It should not be used for precisionmeasurement.
How to use Inside and Outside calipers:

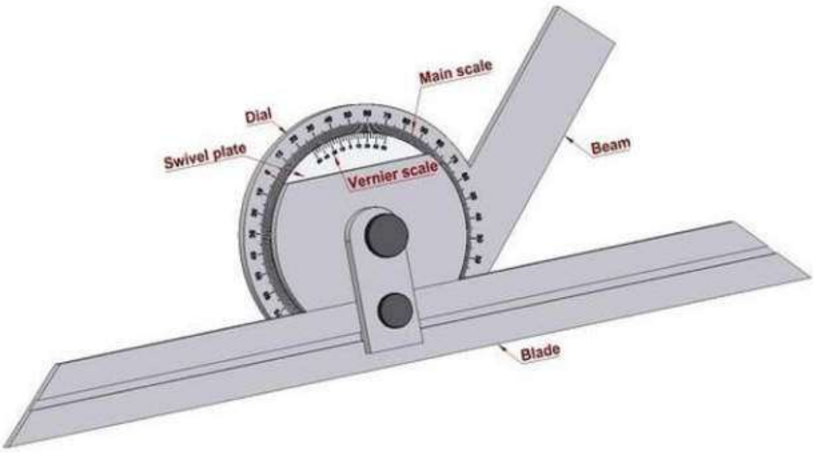
When using either type of calipers, you adjust the caliper until it fits snugly across the widest part of an object and then measure the distance the distance between the caliper leg points with a steelrule.How to use a hermaphrodite caliper:

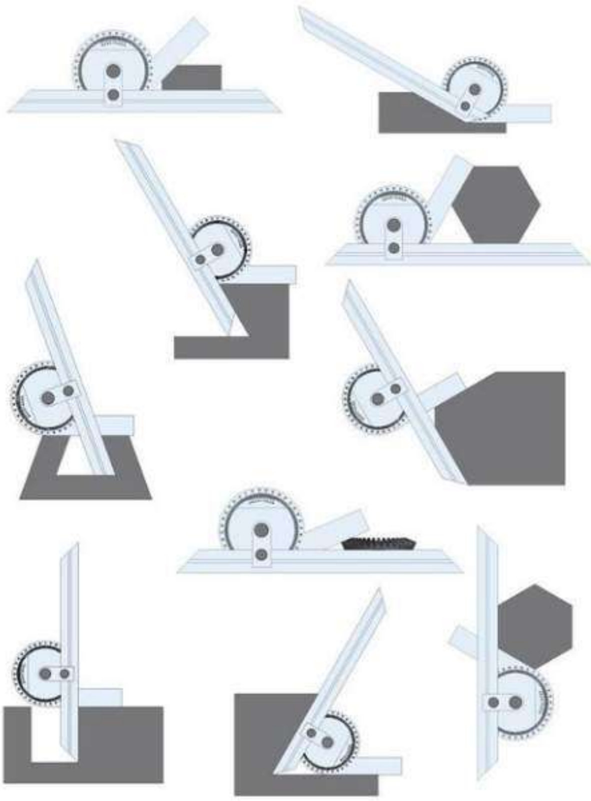
They are used to scribe marks at a specific distance from a radius edge ofwork.
One leg is sharp pointed – used for scribing.
Other leg curves to the inside – used for sliding along the radius edge of anywork.
Layout dye is applied on the material to be worked and then the caliper can be used to mark the requireddistance.

Bevel protractor:

A bevel protractor is a tool for measuring angles within one degree. It consists ·of a steel rule, a blade, and a protractor head. The protractor head has a revolving turret graduated to read from 0° to 180° and it reads to 5 minutes or1/20°.
How to read the scales in bevel protractor:

It has two scales. One graduated dial and a Vernierscale.
Graduated dial reads angles in degree and Vernier scale gives minutes of adegree.
The bevel protractor is used to measure or test angles to very closetolerance.





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Precision Measuring tools

During the operational life of an aircraft, its moving parts undergo dimensional changes. As a maintenance technician, you must have a working knowledge of the basic precision measuring devices, know how to use them properly and how to read them correctly. Finally, you must be able to compare the measurements you have taken from the instrument with the manufacturer's recommended service limits (check if the measurements are within the tolerance limits) to determine the continued airworthiness of thecomponent.

"How to easily read a precision measuring instrument like Vernier and micrometer?"

These instruments have two or three scales for accurate measurements. Rather than blindly reading all the scales and summing up the values for final readings, if one could understand the principle behind those scales then reading those instruments will hardly take seconds without any misunderstanding.

When we speak about measuring, the first thing that comes to our mind is ruler, right? Well, throughout our childhood, we call it as scale.
For an example, I took a shaft and measured its length with a ruler. The length is 10cm. Easy to read, right? Now I took another workpiece and measured its dimension. But am struck with measuring. Because, the value stands between 11cm and 12cm. what shall I do now? Can I guess the value?
These are my guessings.

It can be somewhere between 11.1 to 11.9cm (0.1 or 1/10 increments),right?
Or, it can be somewhere between 11.01 to 11.99cm (0.01 or 1/100increments).mm!
Or, it can be somewhere between 11.001 to 11.999 (0.001 or 1/1000 increments).
And it goes on (0.000000 who knows) Oops!
How can I guess?

Well, these increments define the accuracy of the value and while measuring a particular workpiece we have to find the accurate one.

"More numbers after the decimal, more the accuracy"

But how can I measure it. Can I simply guess through my eyes? No! Guessing is not for aviators.
For this purpose only, Micrometres and Vernier calipers were born.

Now you may think, - ok, how it is possible to make a scale with soooooooo many values between a particular range like 11cm to 12cm. don't you think the scale would be too long for a single range from 0 to 1 cm, if we want an accuracy of 0.001 increments?
For Eg; There will be 1000 graduations (lines or divisions in scales) between 11cm to 12cm,if we want an accuracy of 0.001. how its possible for someone to manufacture a scale with 1000 graduations, just for a single range of 1 cm, and how to even write those 1000 values in scale. it's impossible to even think,right?
Well. Thanks to the scientists who invented Micrometres and Vernier calipers.

Yes. With these instruments, its possible to measure such great accuracies up to 0.0001" (1/10,000 inch).
But the scale?
They are pretty brilliant because they devised a principle and used not just one, but two to three scales in a single instrument for greater accuracy.
Absolutely brilliant!
Let's see how it works.

I will start with Vernier caliperas it has two scales.

Certain things you have to keep in mind before using such Precision measuring instrument. Theyare:
What is Vernier caliper? Its parts, types and measuring capacity

What's the principle of Vernier? (It will tell us, how to use it and how precise it is?) How to measure with it? (Find the value of one division in main scale and vernierscale)
Maintenance of Vernier Instruments

What is Vernier caliper?

A Vernier caliper is a versatile precision measuring instrument used to measure both Inside and outside dimensions as well as depth measurements with an accuracy in the range of 1/1000 (0.001) inch or 1/50 (0.02) mm. The most widely used machinist calipers measure from 0 to 6 inches.

Measuring Capacity:
The measuring capacity of a vernier instrument is its graduated length minus the length of the vernier scale. While fully sliding the vernier scale over the bar scale, one can observe that the maximum measuring capacity is not the maximum range given. So, one should check for the measuring capacity before taking the instrument for measuring.

Parts:
For the measurement of internal dimensions, some instruments are provided with a pair of "knife-edge" jaws mounted immediately above the jaws used for external measurement.
Other instruments have the lower portion of the external measuring jaws rounded (called **"nibs"**), which can be used for internal measurements. The overall dimension of the nibs with the calliper closed, usually being some convenient figure (e.g. 0·3 in) which must be added to the indicatedreading.
The allowance to be made for the width of the nibs is usually indicated on the fixedjaw.

Some makes of callipers are marked with two spots, or "targets", one on the fixed jaw and one on the movable jaw, from which dividers or trammels may be set after the calliper has beenset.
The locking screw in the vernier scale is for locking the final measurement. The outer locking screw in the fine adjustment clipper should be locked after initial reading. Then, any fine adjustments required in closing the final value can be made with fine adjustmentscrew.
What's the principle of Vernier?

As you can see from the figure, the metric Vernier scale has 50 divisions. But if you see the length of main scale for the same 50 division length, there are only 49 divisions in main scale. So, the Vernier scale has one division more than the main scale for the same length.
The meaning isthat,

As we discussed earlier about measuring with ruler, to find the accurate value (more numbers after decimal), more scales are used. In case of Vernier caliper, one scale is main / bar scale and other is vernier scale. Main scale readings will be the main values as with a ruler (like 10 mm or 11 mm, etc.), and the vernier scale values will be the numbers after the decimal (like 10.10 mm or 11.20 mmetc.)

From the figure, each division in main scale is 1mm. [Take 0 to 10mm. the length is 10mm and there are 10 divisions in that 10mm. So, one division is 10/10 = 1mm in main scale]

Now, this 1 division is further divided into 50 divisions which cannot be put up in the same main scale (as we discussed earlier), so those 50 divisions are given in vernier scale. So, the value of one division in vernier scale in 1/50 =0.02mm.

[Note: once the value of one division in both scales has been found out, then measuring with avernier will be easy]

How to measure with it?

Before measuring using a vernier, one should do the followingsteps:

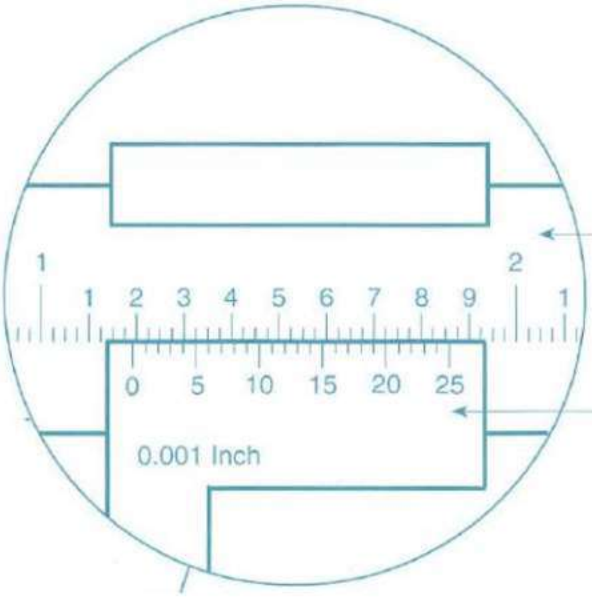
Clean the measuring faces thoroughly with a lint freecloth

And calibratethe instrument by closing the outside measurementjaw.

Calibration involves checking whether the **"0" of main scale is in line with the "0" of thimblescale.**

Or standard gage blocks can be used tocalibrate.

Find the value of 1 division in main scale and vernier scale.



Example:

As from the figure above, the range chosen is 1-2inches.

And it is divided into **tenths of an inch (1/10, 2/10……………10/10),** which is given as 1,2, 3… 9 between 1-2inches.

The tenths of an inch are further divided into 4 divisions of hundredth of an inch (0.025, 0.050, 0.075, 0.1). So, the value of one division is **0.1 / 4 =0.025".**

Now, this one division of 0.025" has 25 more divisions which are given in vernier scale. So, the value of 1 division in vernier scale is **0.025 / 25 =0.001"**

Read the inches, tenths, and hundredths of an inch on the main scale opposite the zero on the vernier scale. The zero is past the 1-inch mark, past the 1.1-inch mark, and past the third mark beyond this. This is a total of 1.175 inches(1+0.1+0.075).

Find the line on the vernier scale that exactly lines up with one of the marks on the main scale. The 20 line on the vernier scale lines up with one of the marks on the main scale, so we add 0.020 to the readingfound.
The final reading is 1.175 + 0.020 = 1.195inches

Maintenance of Vernier Instruments:

Indicated Dimension-The dimensions indicated by the instrument should be checked by means of slip gauges or precision blocks of known accuracy. On larger instruments, length bars should be used for the longer dimensions. Where a calliper is provided with knife edge jaws for internal measurement, the indicated measurement should be checked against a micrometer of known accuracy.

Straightness of Measuring Faces-The straightness of measuring faces should be checked by placing a knife-edge straightedge on each jaw in turn, holding the instrument before a source of diffused light. If the lighting is satisfactory, an error of as little as 0.0001 in should be readily visible.

Parallelism-The parallelism of the measuring faces may be checked by placing a precision parallel roller between the jaws of the instrument and gently closing them until contact is made, the movable jaw then being locked. Any error of parallelism of 0·0001 in. or more can be detected against a suitable source of diffusedlight.

An alternative method, or a method to be used when the error in parallelism appears excessive, is to check the variation of size between the measuring faces by means of slip gauges. It is recommended that, where an excessive error in parallelism is detected, the instrument should be returned to the manufacturer forrectification.

Nib Dimension- The jaws of the vernier calliper should be brought together and the nibs checked for general wear or flats by the use of a micrometer at two or three positions around thenibs.
[Note:Flats are most likely to occur in a plane parallel to the beam]
The original dimension across the nibs is usually indicated on the fixed jaw; if any "truing-up" of the nibs is carried out which results in a change in this dimension, the new dimension (which has to be allowed for when making internal measurements) should be etched on the fixed jaw and the original dimension should be cancelled by an etch mark.
Cleaning andLubrication:
The instrument should be kept thoroughly clean and the moving parts lightly lubricated with acid-free machineoil.
Graduation and scale marks should be cleaned with a suitable solvent and a soft brush; a pointed instrument or wire brush must never beused.
The instrument should never be polished, especially near graduation markings since, apart from the possible detriment arising from the abrasive action, bright reflections from the instrument may make readingdifficult.
Reflection has been eliminated on most modem vernier instruments by the application of a hard satin-chrome finish on thescales.
To ensure against jerkiness in the moving parts (which could seriously affect the "feel" of the instrument) those moving parts which the manufacturer stipulates may be removed periodically, dismantled, cleaned in a suitable solvent, dried, lubricated and reassembled. A check calibration should always be made afterreassembly.

Repair: In general, it is recommended that all repairs to vernier instruments should be undertaken by the instrument manufacturer. When instruments are returned after repair, it should be ensured that the new dimensions of the nibs and, in the case of height gauges, the measuring jaw (if altered), have been appropriately etched on theinstrument.

Storage. When not in use, vernier instruments should be kept in their appropriate cases and it is recommended that they should be stored in a warm cupboard. However, it is essential that the instruments should not be subjected to excessive heat otherwise/due to expansion, accuracy may be affected. Instruments should never be stored in the fully closed or lockedpositions.

Micrometercaliper

What is aMicrometer:
Outside micrometer calipers, are used for measuring outside dimensions like wear or out of round conditions, thickness of sheet metals,etc.
The inside diameter of a large hole is measured with an inside micrometer caliper. The diameter of a small hole is measured with a telescoping gage or a small-hole ball-gage. After these gages have been adjusted to the exact diameter of the hole, they are removed and measured with a micrometer caliper.
The depth of a groove in a machined part is measured with a depth micrometer. The end of the spindle is flush with the bar when the instrument reads zero, and as the thimble is turned outward, the spindle extends from thebar.
[Note:The regular micrometer, usually referred to in the shop as a mike, is used for measuringoutside dimensions]
Five principle parts of a Micrometer:
Frame, anvil, spindle, barrel, and thimble(sleeve).

Calibration:
Micrometer calipers are checked for accuracy by using gage blocks. A 0-to-1-inch micrometer is checked for its proper zero indication with the thimble screwed down against the anvil. For itsl
-inch indication, it is checked with a 1-inch gage block. A 1-to-2-inch micrometer uses a l-inch and a 2-inch gage block, and a 2-to-3-inch micrometer uses a 2-inch and a 3-inch gage block.
The spindle is closed to the block to create a pressed fit. A Pressed fit means that they come together with just enough force to meet each other squarely. A special spanner wrench (half- moon adjusting wrench) is then slipped into a hole in the micrometer sleeve and carefully rotated until the longitudinal line is in exact alignment with the zero mark on the thimble.
This calibration should be accomplished by a certified technician because temperature variation must be taken intoaccount.
[Note:Gage block - A precision ground block of hardened and polished steel used to check theaccuracy of micrometer calipers. Their dimensional accuracy is normally measured in millionthsof an inch]

Accuracy:
A standard micrometer caliper can be read directly to three decimal places; that is, to one thousandth of an inch,1/1000 (0.00 linch).
A vernier micrometer caliper can be read directly to one ten thousandth of an inch, 1/10,000 (0.0001inch).

Aircraft Application:
A micrometer caliper is used to measure a crankpin and a main bearing journal for an out-of- round condition. Make two measurements at right angles to each other; the difference between the two readings is the amount the shaft isout-of-round.

The Standard External micrometer
The jaws of the frame are suitably machined to receive the anvil (which is usually a press fit), and the barrel, which is frequently fitted into the frame with a fit which permits rotational adjustment by spanner or specialkey.
The barrel is engraved with a graduated scale equal in length to the measuring range of the instrument (usually 1 in. or 25 mm.), and is bored and internally screwed with a fine and accurate right-hand thread (Right hand thread runs in clockwisedirection).
This thread accommodates the spindle which is machined with a matching male thread. An integral sleeve on the spindle surrounds the barrel when the spindle is inserted and screwed into the assembly, and this is usually knurled

at the outer end to facilitate easy fingeroperation.
The inner end of the sleeve is bevelled to prevent barrel scale shadows, and the bevelled portion is graduated into equal divisions around itsperiphery.
Some micrometres may have a fixed barrel and a removable or adjustable anvil which might be located by a grub screw or a pin. Others may be equipped with a spindle locking device which, when used, ensures that the instrument remains set at any specific dimension or reading.
The spindle attachment containing a spring-loaded ratchet is a common fitment, and this produces pre-set "feel" to the operation of the instrument. Many micrometres are provided with tungsten or carbide tipped anvils and spindles to reduce wear on the measuringfaces.
The Internal micrometer:
Internal micrometres are designed for internal measurement only. There are two common categories; the end-measuring or "stick" type and the "three-point" measuring type. Both of these measure internal dimensions with the same systems of graduation as the standard micrometer.

End-measuring or "Stick" Micrometres.
These instruments are usually available in combination-set form, and consist of a measuring head (similar to the standard type barrel and sleeve), and sets· of extension rods which fit into the barrel to give various stages of measurement over the total range.
Common sets are provided with three, five or nine extension rods, and in most of these it is usual for an auxiliary handle to be included, which can be screwed into the side of the barrel to enable check measurements to be made at the extreme ends of deep bores,etc.

Three-point Micrometres.
This type of internal micrometer incorporates three measuring anvils which are co- axially mounted in a measuring head at 120° to each other. The feature of three-point contact ensures greater accuracy in the measurement of internaldimensions.
Generally, the larger type of micrometer head with 250 divisions, is embodied to enable the finer measurements to one ten-thousandth (0·0001) of an inch to be made, with the more convenient and simplest method of reading.
The sleeve and spindle operation are similar to that of standard types, but the longitudinal spindle movement is transferred to axial anvil movement and, in operation, the barrel axis of the instrument will coincide with that of the hole or bore being measured.

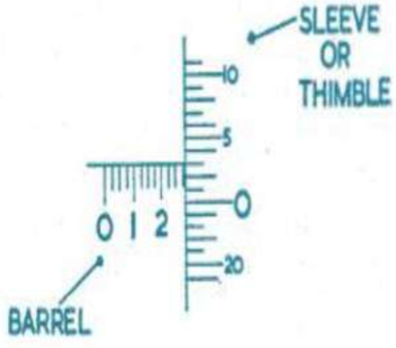
How to measure with it?

Example: A vernier micrometer with British system (1" Capacity)

First find the value of 1 division in all three scales (Main, thimble and Vernierscale)
As you can see from the figure, the 1" scale has divisions of one-tenths (1/10) in main scale. 0.1, 0.2……...0.9 which are given in the instruments as1,2,3…….9.
So,between0and0.1,therearefourdivisions.So,thevalueofonedivisioninmainscaleis
0.1/4 = 0.025" (One-fortieths of an inch).
This indicates that the main scale is graduated into Ones (1), tenths (0.10) and fortieths (0.025) of aninch.
Thimble scale has 25 divisions. If we rotate the thimble scale for one revolution, it will move 1 division (0.025") in main scale. It means, 0.025" has 25 divisions in thimble scale. So, the value of one division in thimble scale is, 0.025/25 =0.001".
This indicates that the thimble scale is graduated into one-thousandth (0.001) of an inch. Further this 0.001" is divided into two division in thimble scale. So, one small division in thimble scale is 0.0005"

This state the Principle of Micrometer. As with a screw, for one revolution, one thread will go inside the nut or one pitch will go inside the nut. With this micrometer, one revolution of thimble moves one division in main scale(0.025").

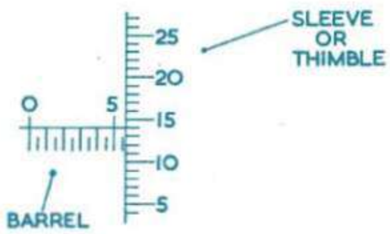
So, the pitch of this micrometer is 0.025". As for one revolution, one thread goes inside the nut and simultaneously one division moves in main scale, considering 4 divisions between 0 and 0.1" and for the entire 1" there will be 40 divisions. So, Threads per inch (TPI) of this micrometer is40.



TYPICAL BRITISH MICROMETER READING

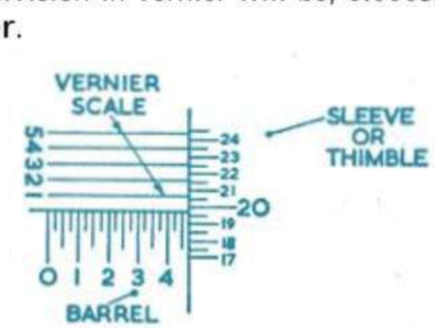
In metric (English system), one division in main scale is 0.5mm which is the pitch of English micrometer. It means, for one revolution of thimble, one division moves in main scale, which is0.5mm.

The barrel scale is graduated into twenty-five divisions of 1 mm, and usually every fifth division is numbered in multiples of five. The millimetre divisions are sub- divided into half-millimetres (0·5 mm.), and the thimble is graduated into fifty equal divisions. So the value of one division in thimble scale is, 0.5/50 = 0.01mm, which defines the accuracy of Englishmicrometer.



TYPICAL METRIC MICROMETER READING

[Continue from point 5+ This one division of thimble (0.001") is further divided into 5 more divisions by the vernier scale. So, the value of one division in vernier will be, **0.0005/5 = 0.0001" or 1/10,000 of an inch, which** tells the accuracy of thismicrometer.



TYPICAL MICROMETER VERNIER SCALE

Applying these steps defines the final value given in the above figure., whichis
Main scale = 0.4(one-tenths of an inch) + 0.050(one-fortieths of an inch) =0.450"
Thimble scale = 19.5 x 0.001(one-thousandths of an inch) =0.0195"
Vernier scale = 4 x 0.0001(one-ten thousandths of an inch) =0.0004"

Final reading = 0.450 + 0.0195 + 0.0004 =**0.4699”**

Thickness gauge:

Thickness gages, or feeler gages, are precision-ground steel leaves, used to measure the clearance, or space, between parts. The number stamped on the thickest leaf that will fit between the parts, is the separation between the parts in thousandths of an **inch(0.001”).**
Offset blades are available that are bent so they fit into tight locations where straight blades cannotgo.
A Go-No-Go gage has blades with different thickness. The tip of a blade has small thickness of 0.001” while the base of the blade has thickness of 0.003”. This helps in checking whether the tolerance limit of any given clearance of any part has reached or exceeded or not.

Small-Hole Gages and Telescoping Gages:

The diameter of a small hole may be measured by placing a ball-type small hole gage, in the hole and expanding it until its outside diameter is exactly the same size as the inside diameter of the hole.
Remove the gage from the hole, and measure its outside diameter with a micrometer caliper.
Small holes up to approximately 1/2 inch in diameter may be accurately measured with small-hole gages. The small hole gauge is also used to measure the fit between a shaft and its bushing.
The diameter of larger holes that cannot be measured with an inside micrometer may be measured with a T-shaped telescopinggage.
Select a gage having the right range and place it across the hole and release the locking handle. This releases the inside of the telescoping head, and a spring forces it against the walls of the hole. Hold the gage straight across the hole and lock the head by twisting thehandle.
Remove the gage and measure the length of the head with a micrometercaliper.

Dial Indicators:

Dial indicators are versatile tools that are especially useful in aviation maintenance for such measurements as end-play in shaft installations, gear backlash, bevel gear preload, and shaft out-of-round or runout. The basic dial indicator, is available with a variety of dials, hardware for mounting, and types of contactpoints.

General Purpose tools – Turning tools - Screwdrivers

What is a screwdriver?

The screwdriver can be classified by its shape, type of blade, and blade length. It is made for only one purpose, i.e., for loosening or tightening screws or screw headbolts.
The shank of some screwdrivers is square or have a hex-shaped holster where the blade enters the handle. These features allow you to turn the screwdriver with a wrench to provide additional leverage in torqueing or looseningscrews.

What if the wrong screwdriver is used?

The screwdriver’s handy shape and variety of sizes makes it tempting to use as a punch, a chisel, or a prybar.
If the screwdriver is the wrong size, it cuts and burrs the screw slot, making it worthless. The damage may be so severe that the use of screw extractor may berequired.
A screwdriver with the wrong size blade may slip and damage adjacent parts of the structure.

What it is made of?

The shank is made of steel, set into a wood and high-impact plastichandles.
The blades come with wide variety of shank and blade sizes. Standard screwdrivers are available with shanks from 1 ½ inches up to lengths of 10-12 inches. Special application screwdrivers are available with blades up to 20 incheslong.
The blade is shaped or flattened to fit recess in the head of screws orbolts.

Types:

Based on the Shape of blade tip or Screw head

Slotted head / Flat headScrewdriver:
This common screwdriver is used only where slotted head screws or fasteners are found on aircraft. An example of a fastener that requires the use of a common screwdriver is the cam-lock style fastener that is used to secure the cowling on some aircraft.
A Slot screwdriver must fill at least 75 percent of the screw slotswidth.

Recessed head Screwdrivers: (Cross-Slot or Cross-Pointscrewdriver)

The two types of recessed head screwdrivers used in aviation maintenance are the Phillips and the Reed & Prince.

PhillipsScrewdriver
The Phillips screw has a slightly larger center in the cross, and the screwdriver is blunt on the end that fits into a flat-bottomed hole. Phillips is Designed to 'Cam-Out' when the driver reaches maximum torque. This saves the screw from being over tightened or the head from being damaged or brokenoff.
The cross in a phillips screw head is cut with a double taper and the sides are not exactly parallel or90°.
It is made in several sizes. Each size is numbered and relates the diameter of the blade with the point number. For example, a No. 2 point has a ¼-in diametershank.

Reed & PrinceScrewdriver
The Reed & Prince recessed head has straight sides and forms a more perfect cross than phillipsscrewdriver.
The screwdriver used with this screw is pointed on theend.
There is also only one taper to the point of a Reed and Prince screwdriver and it has a smaller width thanphillips.

Note:The Phillips screwdriver is not interchangeable with the Reed & Prince. The use of the wrong type screwdriver results in mutilation of the screwdriver and the screw head. When turning a recessed head screw, use only the proper recessed head screwdriver of the correct size.

Tri-WingScrewdriver
Some airlines use screws with a special screw head produced by the Phillips screw company.
These screws have three slots instead of, the four slots found on the regular cross- point screw.
The screw head and bit are identified by their registered trade nameTRI-WING.
Posidriv:
A Posidriv bit resembles the Phillips bit in that it has a cross shape. However, there is a significant difference in the bottom of the recess that allows the bit to interlock with thescrewhead.

This design is produced by the Phillips Screw Company and provides a tighter and more positive connection between the screwdriver tip and the recess in the screw, thereby minimizing the chances of the screwdriver slipping out of the screwhead.

Torx:

The Torx screwdriver is used to remove and install torx-type screws which have a six- pointedslot.

The torx type screwdriver should not be used for an Allen type screw. Using the wrong type of screwdriver can damage both the screw and thescrewdriver.

Based on the Size and Shape of blade shank

Heavy-dutyScrewdriver:

A heavy-duty screwdriver is of average length but is made with a heavy blade and a squareshank.

The shape of the shank permits the use of a wrench to assist in tightening a screw. Heavy (thick) material is used so that the blade and shank will resist being twisted when a wrench isused.

Stubbyscrewdriver:

A stubby screwdriver helps to start screws, where space islimited.

Other types:

Offsetscrewdriver:

A double-ended offset screwdriver is used for turning screws in awkward places where there is not enough room to use a regularscrewdriver.

There are two types of offsets, one with two blades at right angles to each other and one with four blades oriented in 45°increments.

Reversible-bladescrewdriver:

It has a regular slotted blade on one end and a blade that fits a recessed screw head on the otherend.

This type of screwdrivers is useful for line technicians working away from their toolboxes.

The Interchangeable headscrewdriver:

It has a hollow magnetized shaft that holds ¼-inch hex bits. It comes in many types and sizes.

It also very useful for line technicians working away from theirtoolboxes.

Powered Screwdrivers:

Most airplanes have stressed inspection panels held on with many countersunk recessed- head screws. On each inspection, these screws must be removed and replaced. The time involved to complete this process makes this a major part of an inspection. To help decrease the time spent removing inspection panels, most shops are equipped with air or battery poweredscrewdrivers.

These tools accept a standard ¼-inch screwdriverbit.

Many of these screwdrivers allow you to adjust the amount of torque applied to a screw.

Once the preset torque value is reached, a chuck slips inside the screwdriver preventing the screw from beingover-torqued.

Yankee ratchet type screwdriver(Automatic):

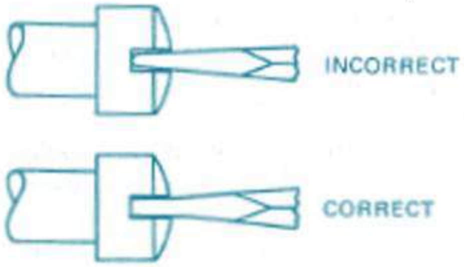
Yankee ratchet type screwdriver can be used when powered screwdrivers are not available.

This screwdriver accepts replaceable bits that are spun by working the handle in and out over its spiralshaft.

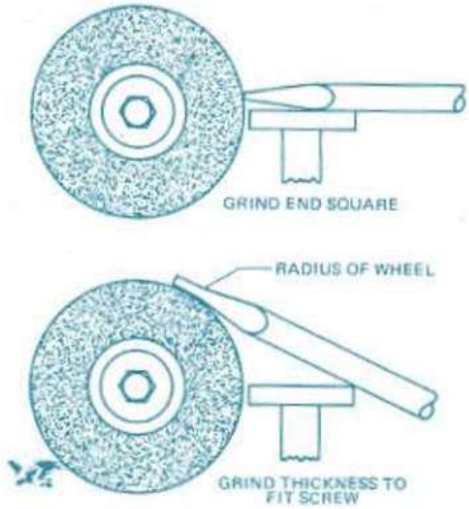
[https://m.youtube.com/watch?v=LvZPeRV49RA]

How should the blade of a worn screwdriver be ground?

A screwdriver blade should be ground so that the faces will be almost parallel with the sides of the screw slots.



The end of the blade should be made as thick as the slot in the screw will permit. A blade ground to a chisel point has a tendency to slip out of the screw slot and, also, to leave a ragged edge on theslot.
Excessive heat at the time of grinding, indicated by a blue colour appearing on the blade, will draw the temper of the steel and cause the blade to become soft. This will result in the end of the blade being bent out of shape when a heavy pressure is applied to tighten a screw.
When reconditioning a screwdriver blade, grind the end of the tip first to square it with the shank. Next, grind the blade to the thickness required by holding it on the grinding wheel, as shown in figure below. Usually, the radius of the grinding wheel will produce a satisfactory end on theblade.
Safety working with a screwdriver:
A screwdriver should not be used for chiselling orprying.



Do not use a screwdriver to check an electric circuit since an electric arc will burnthe tip and make ituseless.
In some cases, an electric arc may fuse the blade to the unit being checked, creating a short circuit.
When using a screwdriver on a small part, always hold the part in the vise or rest it on a workbench. Do not hold the part in the hand, as the screwdriver may slip and cause serious personalinjury.

General Purpose tools – Turning tools - Wrenches / Spanners

What is a wrench?

A wrench is a tool for turning nuts orbolts.

What it is made of?

One of the most widely used metals for making wrenches is chrome-vanadium steel. Wrenches forged of this metal are almost unbreakable, since this combination ofmetals is an extremely toughalloy.

After being forged, burrs are removed and then wrenches are plated with cadmium or hard chrome to protect them from therust.

The plating process improves the wrench's appearance and makes it easier toclean.

Parts:

Measurement of Wrenches:

Wrench sizes, no matter the style, coincide with the size of the bolthead.
The wrench size should be the same as the measurement of the inside of theend.
This measurement is also same as the hex head of the bolt from flat toflat.
This is true of both English (inches) and metric (mm)wrenches.

Wrench types:

Open-EndWrenches:

Open-end wrenches have an opening in each end that fits a bolt head ornut.
The openings of an open-end wrench are parallel to each other and are normally angled at 15° to the handle. This angle allows you to turn a nut even when the space for the handle is severelyrestricted.
Some open-end wrench of same size opening has one opening angled at 30 °s while the opposite opening at 60°. And some wrenches even have openings at an angle of 90°.

Box-end wrenches: (Closed-end wrench or RingSpanners)

Nuts that are exceptionally tight can spread the jaws on even the best open-end wrench. To break the torque on tight nuts, a box-end wrench isused.
Box-end wrenches have a six- or twelve-point opening, so they can be used in places having as little as 15-° swing. The openings attached to each end offset from the axis of the handle by about 15°.
They are called box-end wrench as the opening completely surround the nut or bolt head. Because of their enclosed design, box-end wrenches are less likely to slip, and are useful in closequarters.

Combinationwrench:

The disadvantage of a box-end wrench is the limitation of always having to lift and reposition the wrench in order to continue loosening afastener.
After a tight nut is broken loose, it can be completely backed off or unscrewed more quickly with an open-end than with a box-end wrench. In this case, a combination wrench can be used. It has a box-end on one end and an open-end wrench of the same size on theother.
This allows hard nuts to be broken loose with the box-end and then removed with the openend.
The box-end is typically angled 15° to the handle to allow clearance for your hands between the wrench and thework.
The open end of the wrench is offset by 15° to the axis of the handle to allow for a new grip on the nut for each 15° of handlemovement.

RatchetingWrench:

Ratcheting wrench can be swung back and forth to remove the nut or bolt.
Ratchetingopen-end:

A special design of open-end wrench allows nuts to be turned without removing thewrench.
One of the jaws of an open-end wrench is cut back just enough to engage one edge of anut.
While it has no ratcheting mechanism, the action it follows is ratcheting. [https://m.youtube.com/watch?v=qwFy8ICkX4U]

RatchetingBox-end:

This type of wrench consists of a box-end wrench set into a handle with a ratchetingmechanism.
Most ratcheting box-end wrenches are locked in one direction, thus to change the direction of movement, the wrench is turned over. [https://m.youtube.com/watch?v=1pXJzS198fM]

Flare Nutwrench:

As you know, aircraft fluid lines are connected to components with flare nuts. While these nuts are typically not tightly torqued, they are often situated in locations where the swinging of wrench handle is severelyrestricted.
In these cases, a special type of box-end wrench called Flare nut wrench isused.
A slot is cut into the box-end to allow the wrench to slip over a fluid line and then the hex of the nut is engaged each 15° of handlemovement.
Since a Flare nut wrench can engage a nut every 15° of handle movement, it is idle for use in confined areas.

Adjustablewrenches:

An adjustable wrench has a movable jaw, which makes it adjustable to various sizes of nuts.
A heavy type of adjustable wrench is the monkey Wrench. When using this type of tool, point the jaws in the direction of the force applied. This will prevent the jaws from springing apart, and the wrench will be less likely to slip off anut.
The movable jaw should be adjusted so that it is tight against a flat surface of the part to beturned.
It is not good practice to use a wrench as ahammer.

Socket wrenches: (Socket +Handle)

Sockets are tools that typically have a square hole in one end that fits a square lug in drive handle, and another end with a six- or twelve-point opening with angular notches designed to fit different sizednuts.
The 6- and 12-point sockets are used for hexagon-head bolts and nuts, while the 4- and 8-point sockets are used for square-head bolts andnuts.
It can be used with different types of handles such as T, ratchet, screwdriver grip and speedhandle.
Socket sets are available in wide variety of drive sizes. In fact, for extremely large works, socket wrenches are available in square drive as large as 2½-inches.

How socket and drive/handle is attached perfectly without slipping?

Sockets have a lock-on feature in the form of a small hole on the side of the square hole into which a small spring-loaded ball in the driving attachment fits. When the socket is pushed on the drive attachment and the hole and ball are aligned, the ball is forced into the hole, thus preventing the socket from dropping off.

Types of sockets:

Standard sockets:

They are available in all popular drive sizes and with either four-, six-, eight- or twelve- point openings.
These sockets are also deep enough to fit over a bolt head or a nut if too much shank does notprotrude.
The six- and twelve-point sockets are used in aviation, whereas the four- and eight-point sockets are used to turn square head pipeplugs.

Deep sockets:

There are several applications where a bolt extends through a nut too far for a standard socket to grip thenut. In these cases, deep sockets are available to allow the socket to grip the nut and still allow room for the boltend.

Flexsockets:
When additional clearance is needed between the socket drive and the socket, a flex socket isused.
Flex socket have a pivot point between the drive handle end of the socket and the nut end.
These sockets are made with both six- and twelve-point openings and are available in the drive sizes most used in aviationmaintenance.

Crowsfootsockets:
Nuts are sometimes placed in locations on aircraft where neither a box-end, nor open- end wrench or standard socket wrench can beused.
The Crowsfoot wrench is designed to reach these nuts and is available with open, box, and flare-nutends.
Furthermore, they are available in several drive sizes including ¼ and 3/8inch.

Handles / Drives and adapters:
The chief advantage of using socket wrenches over any type of nut turning device is the wide variety of handles and adapters available.

Ratchet adapters:
Even if the socket drive does not have any ratcheting ability, several ratchet adapters are available to convert a socket wrench into a reversible ratchetingwrench.

Breakingbar:
When a nut is extremely hard to break loose, and more force is required than a ratchet handle is built to take, a socket is placed on a breaking bar and the required amount of force applied will decrease. When more force is required than can be applied with a breaker bar, use a socket and handle of the next largersize.
It is not recommended that you use a piece of pipe over the handle of a breaker bar to increase theleverage.

Speed handle:
Time is an expensive commodity in aviation maintenance, and therefore any tool that decreases the time required for an inspection or repair is typically used. One tool that can save a great deal of time is the speedhandle.
A speed handle resembles a bow type brace and has a socket or screwdriver bit snapped onto itsend.
Screws and nuts are turned much faster with a speed handle than they are with a conventional screwdriver or ratchet wrench.

Extensions:
Straight bar-type extensions are used to put sockets further away from the wrench handle. These extensions are made of forged steel alloys and are available in lengths from less than 2 inches up to 2 or 3 feetlong.

Universal Joints:
They have a square opening on one end that fits into a socket drive or extension and a male socket drive on the otherend.
Universal joint is used to tighten or loosen nuts and bolts that cannot be accessed with a straight extension.
They allow a socket and a drive to pivot independently of eachother.

Adapters:
Adapters are available to allow different size sockets and drives to fittogether.

Example: An adapter allows a ¼ inch drive socket to fit onto a 3/8 inch and ½ inch drive components.
When using an adapter to put a small socket on a large drive, use good judgement because the additional leverage obtained on the drive can break the adapter or the socket or might strip threads of afastener.

Other types of wrenches:

A lever-jaw wrench is a combination-gripping tool with adjustable jaws, which may be locked in place. It may be used as a wrench, clamp, pliers, orvise.

A check-nut wrenchis a thin, single ended or double-ended wrench used for turning check or jam nuts. The thinness of these nuts, often used in narrow spaces, requires the use of a thin wrench. These wrenches are not intended for hard use. The openings are offset at an angle of15°.

A tool-post wrenchis a combination box and open-end wrench. The open end is straight rather than offset. The square box end is designed to fit tool-post screws and setscrews on lathes and other machine tools. It is ruggedly designed to withstand wear and hard use.

A square box wrenchis a single-head closed-end wrench having a rather short handle. It is widely used for square-head setscrews on toolholders for the lathe and other machine tools. The square opening is made at an angle of 22 ½ ° forconvenience.

A T handle tap wrench(sometimes called a T-tap wrench) 'is used to hold and turn small taps up to about 1/2 in. It usually has two inserted jaws, which can be adjusted to fit the square end of the tap. The chuck when tightened holds the tap securely. This type of wrench is made in several sizes, each size having a capacity for several sizes of taps. This wrench may also be made with a long shank for tapping holes that are difficult to reach. It is also useful for turning small handreamers.

An adjustable tap wrenchis a straight type of wrench having a solid V-shaped opening in the center. A sliding member; or adjustable jaw, operated by one of the handles makes it possible to hold taps of various sizes. This type of wrench is made in many sizes to turn taps and reamers of allsizes.

A T-socket wrenchis made in the form of a T. The hole, or socket, in the end is made in a variety of shapes such as square, hexagonal, or octagonal. It is generally used on jobs where there is insufficient space to permit the use of an ordinary wrench. The handle may be removed from the hexagon-shaped head of the wrench to permit the use of another wrench to turn it when more pressure is required than can be applied with the handle.

An offset socket wrenchis made with the same variety of sockets as a T-socket wrench. It is designed to be used on nuts requiring great leverage or in place where a T-socket wrench cannot beused.

A pinhook spanner wrenchis designed to fit around the edge of large round nuts, which have holes in them to fit the pins of thewrench.

An adjustable-hook spanner wrenchis used on round nuts having notches or slots cut on their periphery to receive the hook at the end of the wrench. Being adjustable, it will fit many sizes of nuts. [Video link: vimeo.com/201898026]

An adjustable pin-face wrenchis designed with two arms, each having a pin in one end This tool is used to adjust nuts that are enclosed so that an ordinary wrench cannot be placed around them. A nut in this situation is made with holes around the face to accommodate the pins in the ends of the adjustable legs of thewrench.

A strap wrenchis used for turning cylindrical parts or pipes, removing bezels, or holding or revolving any job on which the surface finish must bepreserved.

A Stillson-type pipe wrenchis designed with adjustable jaws that are serrated, making it possible to grip round pipe and other cylindrical parts. The serrated edges tend to cut into the metal being gripped, so care should be used to protect plated or finished surfaces being turned with this kind ofwrench.

A hex key wrench, sometimes called an Allen wrench is made of hexagon-shaped stock to fit the holes in the head of setscrews or socket-head screws. They are available in many sizes.[https://m.youtube.com/watch?v=6TjprgTAENE]

How to remove a corroded fastener?

Impact tools

Impact tools are used when corrosion or rust on a fastener causes it to resist any loosening effort. A sharp blow from a hand-held impact driver utilizes mechanical advantage to give fastener a quick twist. They come in both hand and power types

What it contains?

It consists of a driver, an assortment of special six-point impact sockets, and bits for the screw sizes and types most often found on airplane.

How to use it?

Select the proper bit or socket and insert it onto thedriver.
Place the impact driver on the fastener and strike the driver with a sharp hammerblow.
Some stubborn fasteners may need more than one blow before they can be turned with a conventionalwrench.
An impact driver has both forward and reverse setting. The reason for this is that it is sometimes necessary to slightly tighten a fastener in order to break itfree.
However, don't overtighten it, as it may damage thestructure.

Although not typically used on aircraft, except with extreme care on some heavy structures, an impact driver may be required. Struck with a mallet, the impact driver uses cam action to impart a high amount of torque in a sharp impact to break loose a stubborn fastener.
Hand-held impact drivers typically break loose most stubborn fasteners. However, some fasteners may require an air-driven impacttool.
Power impact wrenches apply force in a series of jerks or impacts. This means that an impact wrench set to a specific level of torque actually applies a much higher peak torque than the wrench is setfor.
These torque spikes or peaks cannot be used on any fastener whose torque iscritical.

Torquewrenches:

What is a Torque wrench?

Torque wrench is used to create tension in bolts. How?

As the nut and bolt are tightened, the two plates are clamped together. The thread angle in the bolt converts the force applied (torsion) into tension (or stretch) in the bolt shank. The amount of tension created in the bolt is critical.
The holding power of a threaded fastener is greatly increased when it is placed under an initial tensile load that is greater than the loads the fastener is subjected to. The strongest threaded joint is one in which the load applied to the fastener when it is installed is greater than the maximum load that will be applied to the joint in service.
When the fastener is being torqued, it is subjected to both torsional and tensile stresses. After the

installation is complete, the fastener is subjected only to the tensile stress.
This task is accomplished by tightening a bolt or nut to a predetermined torque, or preload, with a torquewrench.
When torqueing a self-locking nut (Prevailing torque nut) on a bolt, first determine the amount of torque needed to run the nut down on the bolt before it contacts the surface (this is called prevailing torque). The final torque on the nut must be the sum of the prevailing torque plus the desired torque.

How to torque the bolt with the right and accurate torque value?

Aircraft and engine manufacturers have determined the maximum load that will be applied to each joint in aircraft and specify the proper torque for each fastener, which the bolt manufacturers indicate in the Aircraft bolt torque chart for various bolts of various sizes. This recommended torque is normally given for clean and dry threads. but if the threads are to be lubricated. the type and amount of lubricant will be specified.
A calibrated torque wrench is a precision tool consisting of a torque indicating handle and appropriate adapter or attachments. It measures the amount of turning or twisting force applied to a nut, bolt, or screw.

There are three ways the torque applied to a bolt may be measured and the airframe or powerplant manufacturer will specify the correct method to use to determine the torque.
Using a torquewrench:

Torque wrenches measure the amount of torque, or twisting force applied to the tool used to install the fastener. This method is widely used on airframe and many engine applications.
Measuring the amount the boltstretches:

The torque applied to certain highly- stressed engine bolts is determined by measuring the length of the bolt with a vernier micrometer caliper before the torque is applied, then tightening the nut until the bolt has stretched a specified amount.·
Turning the nut a specified amount after it reaches the bearingsurface:

This is a useful method in which the nut is turned until it contacts the bearing surface, then turned a specified number of degrees. This is usually specified by the flats of the nut. Turning a hex nut one flat is turning it 60°. The advantage of measuring torque by this method is that the final torque is not affected by the prevailing torque, nor by lubrication or lack of lubrication on the threads.

Theory behind torqueing with a torque wrench

Under controlled conditions, the amount of force required to turn a fastener is directly related to the tensile stress within thefastener.
The amount of torque, measured in inch-pounds or foot-pounds, is the product of the force required to turn the fastener multiplied by the distance between the center of the fastener and the point at which the force isapplied.
For example, a torque wrench has a length permanently established between the center of the drive hub and a pivot in thehandle.
The force is measured by the amount the beam deflects or by the tension set by a calibrated spring inside the wrench handle. Hooke's Law states that the amount a beam deflects (strain) is directly related to the force applied(stress).
Therefore, if the lever is exactly 12 inches long, and a force of 30 pounds is applied to the handle, a torque of 360 inch-pounds is produced on thefastener.
12 inches x 30 lbs = 360 inch-pounds

Types: [https://m.youtube.com/watch?v=NBxo1ftkn64]

Commonly used torque wrenches include the deflecting beam, dial indicating (torsion bar type), micrometer click-type (toggling type) and electronic setting type.

Deflecting-beam torquewrench:

The deflecting-beam torque wrench is one of the simplest. The square drive is on one end of the accurately ground beam with a handle mounted on a pivot at the otherend.

The pivot ensures that the force is always applied at a specificpoint.

A pointer attached to the end of a beam holds the drive square, and a scale is mounted near the handleend.

When force is applied to the handle, the beam bends and the pointer moves across the dial measuring the amount the beambends.

The amount of bend is directly proportional to the amount of torqueapplied.

Torsion bar torque wrench (dial indicating):

A bar accurately deflects in torsion as well as bending when a force isapplied.

The drive square of a torsion bar-type wrench is accurately ground and has a rack gear on one end. When the bar is twisted, the rack moves across a pinion gear in a dial indicator which shows the amount of bardeflection.

It comes in various units.

[https://m.youtube.com/watch?v=LcsvmBS8Zp4], [https://youtu.be/H7FfVqXe8sk]

Toggle-type torquewrench:

A toggle torque wrench is pre-set to the desired torque before it is put on afastener.

When this preset torque is reached, a sound is heard and the handle releases a few degrees.

The release indicates that the desired torque is reached. Once the release is reached all force should beremoved.

This wrench uses a calibrated compression spring to apply a force to the load lever. When the torque applied to the drive square reaches the pre-set value, the toggle forces the toggle slide bar back enough for the toggle to snapover.

What if extensions were added to torque wrench?

When an adapter is used to reach a particular fastener, the indication of torque on a torque wrench has to be modified to find the actual torque beingapplied.

Remember, when the length of a torque bar changes, the scale used on the torque wrench is no longeraccurate.

Example:A torque wrench has a length between the drive square and the handle pivot of 20 inches, and a five-inch extension. To find the torque applied to a fastener with an indication of 120 inch-pounds on the wrench, use the following formula.

Desired torque = Indicated torque $T_A / (L+A) = T_W / L$

$$T_A = \frac{T_W (L + A)}{L}$$

Where:

T_A = Actual (desired) torque

T_W = Apparent (indicated) torque

L = Length of torque wrench

A = Added length

When this formula is used and the torque wrench reads 120 inch-pounds, the amount of torque actually applied on the fastener is 150inch-pounds.

By shifting the variables, the same formula can be used to determine what a torque wrench will indicate for a given torque on a fastener.

i.e.,

$$T_W = \frac{T_A \times L}{(L + A)}$$

From the above formula, it is found that in order to apply 150 inch-pounds of torque on a fastener with a five-inch extension, the torque handle scale needs to read 120 inch-pounds.

Note:

When using the deflecting beam and dial indicating torque wrenches, the torque is read visually on a dial or scale mounted on the handle of thewrench.
Themicrometersettingtorquewrenchispresettothedesiredvalue.Whenthistorque is reached, the operator notices a sharp impulse or breakaway "click".

Safe working of torque wrench:

If a fastener is under torqued, it will result in wear of nuts and bolts and also there is a danger of the joint being subjected to unnecessary loads resulting in prematurefailure.

If a fastener is over torqued, the threads are over stressed and canfail.
Note:It is important to realize that, unless otherwise specified, all torque values givenare for clean dry threads.

When a self-locking nut is torqued, the nut should be run down on the threads until it nearly contacts the washer. The amount of torque required to run the nut downshould be measured and this value added to the amount of torque needed for the fastener. The torque needed to turn the nut down is called friction dragtorque.

The accuracy of a torque measurement is assured only when torque is applied witha smooth and evenmotion.
Note:Remember that impact-type wrenches should never be used on any fastenerwhose torque is critical.

When installing a castle nut, start alignment with the cotter pin hole at aminimum recommended torque, plus friction dragtorque.

A torque analyser is available in many shops so that wrenches can be calibrated by certifiedtechnicians.

Pounding tools – Hammers and Mallets

Pounding tools includes different types and weights of hammers and mallets, each with a very specific use. Since the misuse of pounding tools can result in damage to aircraft components and injury to personnel, it is important that you always use these tools properly.

Hammers

Hammers were one of man's earliest tools. The types of hammers used by machinists are limited, but they are available in many sizes. Machinist's hammers are classified as hard or soft hammers.

How they are sized?

The size of a hard hammer is specified by the weight of the head without thehandle.
Ball-peen hammer sizes range from 2 oz to 3lb.
Sizes of soft-faced hammers are specified by the diameter of the face and the length of the head and range from 5/8-in diameter to 3-in.diameter.

Faces are specified in degrees of hardness from super soft to extrahard.

Safely using a hammer

Wear appropriate eye and face protection before using a hammer or amallet.
Inspect the tool for damage that could affect safety. Make sure the handle is secure and in good condition beforeuse.
When striking a blow with a hammer, think of your forearm as an extension of the handle. In other words, swing the hammer by bending your elbow, not yourwrist.
Always strike the work squarely using the full face of ahammer.
To prevent marring the work, keep the face of a hammer or mallet smooth and free of dents.

What they are made of and where it is used?

A hard hammeris one that is made of carbon steel and forged to shape and size. It is heat- treated to make the striking faces hard. It has varioustypes.
Use: A hard hammer is used for striking punches, cold chisels, steel letters, and figures. It is also used for forging hot metal, riveting, bending, straightening, peening, stretching, and swaging
A soft hammer or malletmay have the entire head made of a soft metal such as hard rubber, rawhide, lead, babbitt, copper, orbrass.
Use: It is handy for shaping thin metal parts without causing creases or dents with abrupt corners. Always use a wooden mallet when pounding a wood chisel or a gouge. Also used for seating a workpiece in a machine vise or tapping finished work being set up for a machining or layout operation.
Soft-faced hammershave only their striking surfaces made of hickory, plastic, rubber, or rawhide. The faces are either clamped or press fitted on the metalhammerhead.
Use: They are used in forming soft metals and striking surfaces that are easily damaged. Should not be used for striking punch heads, bolts, or nails.

Types of hard hammers:

Ball Peen hammer

The ball peen hammers ranges in one ounce to 2-3pounds.
One hammer face is always flat while the other end is formed into the shape of aball.
The flat hammer face is used for pounding, striking punches, but should not be used to drive a nail. A claw hammer is best suited for driving nails, as the curved face of a claw hammer is better shaped for nail drivingcontrol.
The ball end of the hammer is typically used to peen over rivets in commercial sheet metal work. However, this is not the method used for securing rivets in aircraft sheet metal work.
Note:Peening, or swaging, is the stretching or spreading of metal by hammering. Examples ofpeening include flattening the end of a rivet, spreading babbitt metal to fit tightly in a bearing,and straightening a bar by stretching its short side.

Straight peen and Cross peenhammer

Commercial sheet metal and automotive body work often requires metal to be bent by hammering. This is accomplished by using either a cross peen or straight peenhammer.
Unlike the ball peen hammer, the cross and straight peen hammers have a wedge-type end (peen end) that is used to either crease metal (hit along the line drawn to bend) to start a bend, or to straighten out a rollededge.
On a straight peen hammer, the wedge is parallel to the handle, which is used for stretching and drawing out metal when forging. Use a straight peen hammer to stretch a piece of stock in the direction of itslength.
On a cross peen, it is at right angles to the handle, is used for riveting, stretching, and drawing metal. Use a Cross

peen hammer to stretch a piece of stock in the direction of itswidth.

Claw hammer

A claw hammer is slightly crowned on the face for nail driving control and has a set of claws opposite theface.
The head of the claw hammer is typically hardened, making it more brittle and susceptible to chipping (breakaway).
Therefore, a claw hammer should not be used on hardened steelparts.
Types: Curved claw – for pulling nails

Straight claw – for splitting wood as well as pulling nails.

Sledge hammer

Sledge hammers have two flat faces and are sized according to the weight ofthe head without the handle, and are wielded with twohands.
They are typically used whenever a lot of heavy pounding force is needed, suchas when driving stakes and are rarely used in aviationmaintenance.

Bodyhammer

Body or planishing hammers have large smooth faces and are lightweight.
These hammers are specifically used to remove small dents and to smooth orstretch sheetmetal.
Other types of body hammers include riveting, setting and stretchinghammers.

Mallets

There are two types – Soft faced & Hard plastictipped.
The forming and shaping of a soft aluminium alloy are accomplished with soft-faced mallets which, in early aviation, consisted of a rawhide roll held in aclamp.
However, when modern synthetic materials were developed, plastic andrubber mallets virtually replaced those made ofrawhide.
Hard plastic tip mallets, on the other hand, have two faces that are often replaceable. One face is made of a resilient rubber like material, while the otheris made of a hardplastic.
Note:Some of the faces are domed to better stretch the metal; some are flat to do some of theinitial smoothing.

Why should a hammer handle be gripped near the end?
A hammer handle should be gripped near the end so that full leverage maybe obtained when swinging thehammer.
A solid blow is difficult to deliver when the handle is gripped too close to the head of the hammer. The amount of force with which the hammer strikes depends, in part, on the length of the handle and the weight of thehead.
To get the most advantage of the handle's length it should be held as far from the head aspossible.

Pounding tools – Punches

Although punches are not pounding tools, they do allow the force from a hammer blow to be concentrated in the immediate area of punch tip. Eye and face protection are compulsory.

What is a punch?

Drilling requires some physical indentation on the surface in order to keep the drill from wandering when

first starting. This is done by various punches.
Punches are used to locate centers for drawing circles, to start holes for drilling, to punch holes in sheet metal, to transfer location of holes in patterns, and to remove damaged rivets, pins or bolts.

What it is made of?

Although most punches are made of hardened and tempered tool steel for greater strength and longer wear, it is sometimes necessary to use punches made of a soft metal such as brass to prevent damage to parts being assembled or disassembled.

Types

Solid or hollow punches are the two types generally used. Solid punches are classified according to the shape of their points.
Prick punch or Dotpunch:
A prick punch has a sharp point and is used to mark the exact location for drilling a hole in a piece of sheet metal. They cannot be used to drive a pin or rivet from ahole.
A prick punch is made of hardened tool steel and ground to a slender point having a 30° to 60° includedangle.
Prick punches are used to place reference marks on metal. This punch is often used to transfer dimensions from a paper pattern directly on themetal.
To do this, first place the paper pattern directly on the metal. Then go over the outline of the pattern with the prick punch, tapping it lightly with a small hammer and making slight indentations on the metal at the major points on thedrawing.
These indentations can then be used as reference marks for cutting themetal.
A prick punch should never be struck a heavy blow with a hammer because it may bend the punch or cause excessive damage to the material beingworked.
A lightly made prick-punch mark can be moved to correct an error by tilting the punch and striking it with a lightweighthammer.
Once marking is done with a prick punch, a slight enlargement which may be required can be done by centerpunch.

Center punch
Large indentations in metal, which are necessary to start a twist drill, are made with a centerpunch.
It should never be struck with enough force to dimple the material around the indentation or to cause the metal to protrude through the other side of thesheet.
A center punch has a heavier body than a prick punch and is ground to a blunt point with an angle of about 60° or 90° to provide an indentation that is approximately the cutting angle of adrill.
The point of the center punch is placed in the indentation formed by the prick punch, and the punch is hit with a hammer to create a depression to hold the drill as it begins to cut. They cannot be used to drive a pin or rivet from ahole.
Two types:Solid steel punch & Automatic center punch.

Solid steel punch can be struck by a hammer to marking, while the automatic center punch is based on a spring-loaded trip mechanism in itshandle.
When the handle is pushed in the prick punch mark, and when the proper force is reached, a trip mechanism releases and the point is struck with a sharp blow from within thehandle.
The amount of impact force applied can be controlled by rotating the handle, which compresses the springinside.
When a lot of sheet metal work is anticipated, an automatic center punch becomes extremelyuseful.

Drive or startingpunch:

The drive punch, which is often called a tapered punch, is used for driving out damaged rivets, pins, and bolts that sometimes bind inholes.
The drive punch is therefore made with a flat face instead of apoint.
They also drive pins through the holes by hammerblow.

Pin or driftPunch:

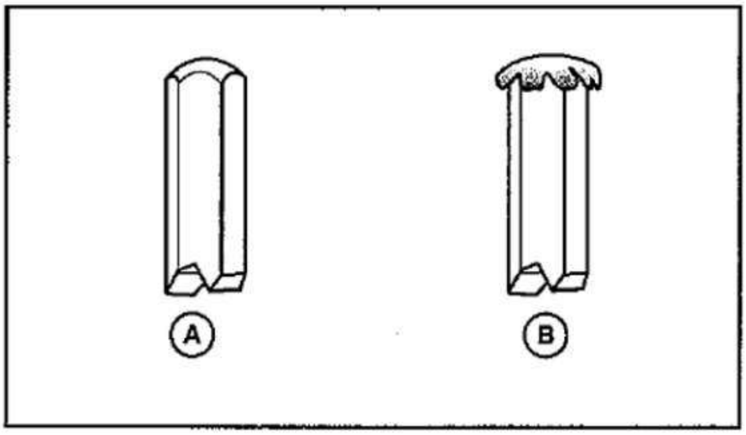
Pin punches, often called drift punches, are similar to drive punches and are used for the same purposes. The difference between the two is that the sides of a drive punch taper all the way to the face while the pin punch has a straightshank.
In general practice, a pin or bolt which is to be driven out is usually started and driven with a drive punch until the sides of the punch touch the side of thehole.
A Roll pin punch is then used to drive the pin or bolt the rest of the way out of thehole.
Pin punches are sized by the diameter of the face, in thirty-seconds of an inch (1/32-in), ranges from 1/16 to3/8-in.
They are commonly use to remove rivets. To do this, begin by drilling the rivet head. Once it is drilled enough, it can be removed with a chisel, or by snapping the rivet head off by inserting a pin punch and pryingsideways.
Once the rivet head is removed, then by using a proper size pin punch, the rivet shank can be removed, leaving the original size rivethole.
When removing rivets, thin sheet metals must be properly backed to prevent bending when the rivet shank is drivenout.
Note:Never use a prick punch or center punch to remove objects from holes because the pointof the punch will spread the object and cause it to bind even more.
A drift or alignment punch similar to a drive punch is used to align parts forassembly.
Drift punches are especially useful when installing wings or other large components on an airplane.
The wing is put in place, and a drift punch is used to align the holes in the wing spars and the fuselage before the bolts are put inplace.
They are sized by the diameter of the face which is usually 1/8-in to1/4-in.

TransferPunch:

The transfer punch is usually about 4 inches long. It has a point that tapers, and then turns straight for a short distance in order to fit a drill locating hole in atemplate.
The tip has a point similar to that of a prick punch. As its name implies, the transfer punch is used to transfer the exact location of drilled holes through the template or pattern or an old material to be replaced, to a new material.
Transfer punches are used to locate rivet holes when making a new aircraft skin using the old skin as apattern.
The skins are placed together, and a transfer punch whose outside diameter is the same as the diameter of the rivet hole is placed in the hole in the old skin. The punch is tapped with a lightweight hammer and the sharp point in the center of the flat end of the punch makes a small indentation in the new skin. This indentation is used as a location for a centerpunch.
Transfer punches are made as both solid steel and automaticpunches.

Safely using a Punch

After continuously hammering on a punch shank, the shank end typically deforms to the shape of amushroom. This shape has to be removed and the punch should regain its original crowned shape using a benchgrinder. When a punch has to be hit harder, then a punch holder will minimize the chance of self-injury.



7. (A) — The end of a punch must have a crowned shape in order to minimize the chance of splitting or chipping. (B) — This illustrates what the end of a punch typically looks like after continuous use.

Holding devices & tools

Holding tools are some of the most widely varied tools in aircraft maintenance shops. They range from vises installed on work benches to the various types of pliers in technicians' toolboxes, and some special fasteners for holding. The proper use of holding tools help ensure a professional looking job. However, care must be taken to use the proper tool for the proper job

Clamps and Vises

The type of operation being performed (Measuring or Machining or assisting to hold) and the type of metal being used, determine what type of the holding device is needed.
Clamps and vises hold materials in place when it is not possible to handle a tool and the workpiece at the same time.

Clamps

A clamp is a fastening device with movable jaws that has opposing, often adjustable, sides or parts. An essential fastening device, it holds objects tightly together to prevent movement orseparation.
Clamps can be either temporary orpermanent.
Temporary clamps, such as the carriage clamp (commonly called the C-clamp), are used to position components while fixing themtogether.

C-Clamp:

The C-clamp is shaped like a large C and has three main parts: threaded screw, jaw, and swivelhead.
The swivel plate or flat end of the screw prevents the end from turning directly against the material beingclamped.
C-clamp size is measured by the dimension of the largest object the frame can accommodate with the screw fully extended. The distance from the center line of the screw to the inside edge of the frame or the depth of throat is also an important consideration when using thisclamp.
C-clamps vary in size from one inchupward.
C-clamps can leave marks on aluminum, so, protect the aircraft covering with masking tape at the places where the

C-clamp isused.

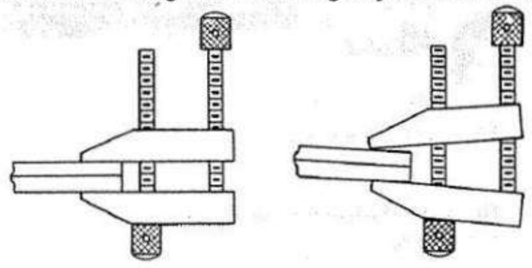
Toolmakers'clamp:

A toolmakers' clamp consists of two flat steel jaws, which may be adjusted to fit a piece of work by means of a screw passing through the center of eachjaw.

Another screw in the end of one jaw is used to exert pressure on the other jaw. This pressure tightens the opposite ends of thejaws.

It is used by toolmakers for holding small parts both at the bench and at machines. This tool is also known as a parallelclamp.

Care must be taken to keep the jaws in a parallel position. Otherwise the clamp screws may seem to be tight but will not be holding the work tightly because they are just being tightened one against the other.



2. Right and wrong way to use toolmakers' parallel clamps.

Vises:

Vises are another clamping device that hold the workpiece in place and allow work to be done on it with tools such as saws anddrills.

The vise consists of two fixed or adjustable jaws that are opened or closed by a screw or a lever.

The size of a vise is measured by both the jaw width and the capacity of the vise when the jaws are fullyopen.

Vises also depend on a screw to apply pressure, and their textured jawsenhance
gripping ability beyond that of a clamp.

Machinist's vise:

The machinist's vise has flat jaws and usually a swivel base. Machine vises are mounted on drill presses, grinding machines and milling machines.

Utility Benchvise:

Utility bench vise has scored, removable jaws and an anvil-faced back jaw. This vise holds heavier material than the machinist's vise and also grips pipe or rod firmly. The back jaw can be used as an anvil if the work being done islight.

To avoid marring metal in the vise jaws, add some type of padding, such as a ready- made rubber jaw pad, soft aluminium or brass or copper jawcaps.

Note:Tightening the vise by hammering on the handle is poor practice. When it is necessary to hammer a piece of work held in a vise, it is best to support the work by placing a block of wood or metal under it to prevent the work from being driven down through the jaws of the vise

Toolmakers' hand vise:

A toolmakers' hand vise is a small steel vise with two interchangeable blocks. The choice of block to be used depends on the size of the article to be held by thevise.

It is used by toolmakers at the bench for small machining operations such as drilling or tapping.

Drill-Pressvise:

Drill-press vises have a flat bottom with slots that allow them to be bolted to the table of a drill press.

V-blocks withclamps:

V-blocks with clamps, either singly or in pairs are used to hold cylindrical work securely during the laying out of measurements or for machine operations.

Pliers

Pliers are made in many styles and are used to perform as many different operations They are used for holding and gripping small articles in situations where it may be inconvenient or unsafe to use hands.

Combination / Slip-Jointpliers:

These pliers come in lengths from approximately 4-in to more than 9-in. The 6-in is the commonly usedtype.

Slip-joint pliers gets their name from the double hole used at the pivot. This double hole increases the range of material that can begripped.

These are the standard pliers with serrated jaws for gripping round objects and flatjaws for holding flat materials.

Most of these pliers have a short wire-cutting blade between the jaws near thepivot.

Don't use a slip-joint plier to turn a nut as they will invariably round off the nut corners. This is especially true of tubing nuts which are made of soft aluminium orbrass.

Interlocking-joint pliers / Water pumppliers:

Commonly called water pump pliers because they are often used to tighten the packing gland nut around a water pumpshaft.

These handy pliers are also called adjustable-joint / Tongue and groovepliers.

They have long handles for applying force to the jaws and torque to the object being turned.

They are available with a slip-joint adjustment, or with a tongue-and groove type of adjustment that cannot slip.

These pliers are available in lengths from 4½ inches (with parallel jaws that open to 1/2 inch), to 16 inches (with jaws that open to more than 4inches).

Vise-Grippliers:

These patented locking pliers have a knurled knob in the handle that adjusts the opening of the jaws.

When the handles are squeezed together, a compound-lever action multiplies the effort and applies a tremendous force to the jaws, and an over-center feature / toggle action holds them tightly locked on the object between the jaws, when the handles are released.

A trigger in the handle of the movable jaw may be squeezed to release the jaws from theobject.

These pliers are available in lengths from 4 to 10 inches with a wide variety of jaw configurations to hold pipe, cut wire, pinch off hoses,etc.

Special forms of vise-grip pliers are made with sheet metal bending jaws, while others are made with jaws that serve as welding clamps orC-Clamps.

Needle-Nose / long nosepliers:

Needle nose pliers have half round jaws of varyinglengths.

Thereareanumberoftypesofneedle-nosepliersusedtoholdwiresorsmallobjects and to make loops or bends in electrical wires.

Some have straight jaws and others are bent to reach into obstructedareas.

These pliers are available in lengths from 4½ to more than 10 inches, and may have wire cutters and insulated handles for use with electricalequipment.

Round-NosePliers:

Round-nose pliers are used to crimpmetal.
They are not made for heavy work because too much pressure will spring the jaws, which are often wrapped to prevent scarring themetal.

Safety-wiring tools: Need for safetywiring

Vibration is a characteristic of aircraft that requires all threaded fasteners to have some method of preventing them from becoming loose inoperation.

One of the most widely used methods is safetywire.

Stainless steel, Galvanized steel, or brass wire is attached to the fastener, twisted and anchored to the structure or to anotherfastener.
This wire pulls on the fastener in the direction of tightening so that vibration cannot loosenit.

Duckbillpliers:

These long-handled flat-jaw pliers resembles a "duck's bill" have been used since the beginning of aviation maintenance to twist and help remove safetywire.
The wide serrated jaws hold the wire firmly as it is beingtwisted.

Diagonal Cuttingpliers:

Used exclusively for cutting and stripping electrical wire, Diagonal cutters, or "dikes" are used to cut safety wire and cotter pins. The name of these pliers is derived from the shape of the jaws that have an angled cuttingedge.
The angled cutting edge makes diagonals unsuited for cutting rivets to length, but there are special rivet cutters which look much like diagonal cutters, except the jaws are ground flat on one side to cut the end of the rivet shank so it is smooth rather than angled.
Diagonals are not recommended for cutting the pigtails on electronic components such as transistors, because they cut with a pinching action that can damage the sensitive elements. Cutters for these components have overlapping jaws that cut with a shearing action.
Diagonals should never be used to cut steel wire or rods or in place of snips to cut or notch sheet metal. Such use will destroy the cutting edge and damage the tool'sjoint.

Safety Wire TwistingTools:

Duckbill pliers are capable of twisting safety wire for many applications, but modern turbine engine technology requires so much safety wiring that must be done efficiently and uniformly, special reversible safety wire twisting tools arenecessary.
This tool grips the wire securely, and the jaws lock on the wire. When the knob in the handle is pulled out, the tool twists the safety wire with a uniformtwist.
When the twisting is completed and the wire is secured, the ends of the wire are cut off with the built-in cutters, and a **"Pig tail"** or curl is put on the end of thewire.
This tool can be used to give the wire a right-hand or a left-handtwist.

Fasteners – Special assembly tools

There are many devices used by technicians to assist them when fabricating sheet metal aircraft components and structures. Some of the most important tool are those used to verify that parts remain in proper alignment during the assembly process. The most common holding tools for such operations are Cleco fasteners and Wingnutfasteners.

Need for pilot drill:

To provide the closest tolerance fit for rivets, it is standard practice in many operations to drill all of the rivet holes in the individual parts with a pilotdrill.
The pilot drill is typically smaller than the nominal size of the rivetshank.
Eventually, when the parts are mated together, another drill is passed through the pilot holes to open them up to the proper dimensions of the rivetshank.

To help prevent the parts from shifting during the final drilling and assembly process, it is common to use clamping fasteners to hold the parts together until the rivets are installed.

Cleco Fasteners:

It consists of a steel body, a spring-loaded plunger, two step-cut locking jaws and a spreader bar.
To install or remove a Cleco requires the use of a specially designed pair ofpliers.
With these pliers, the fastener body is held while the pressure is applied to the spring- loaded plunger on the top of theCleco.
The locking jaws comes together, reducing in diameter and can be inserted into the rivet hole.
When the plier is removed, the jaws spread apart andlocks.

Wing Nutfasteners:

Wing nut fasteners are used prior to final assembly of aircraft parts that need to be held extra tight before riveting isstarted.

For example:Sheet metal parts under tension around a bend tend to spring apart and may need more pressure to hold the metal together than a Cleco canprovide.

Cutting tools – Chipping by Chisels

One of the earliest methods of shaping a piece of wood, stone, or metal was to chip away the unwanted material with a hammer and chisel. This practice is still common today for jobs done at the workbench and when it is not practical to do the work on a machine. In this section we shall be concerned with the chipping of metal.

What is a chisel?

A chisel is a tool made from hexagon or octagon shaped tool steel, commonly called chisel-steel, of a size convenient for handling.
One end is shaped for the cutting operation, used for cutting and chipping any metal softer than the chisel itself and the other end is left blunt to receive the blows from a hammer.
It can be used in restricted areas and for such work as shearing rivets, or splitting seized or damaged nuts frombolts.
Chisels are usually forged to the required shape, then annealed, hardened, and, tempered. Finally, a cutting edge isground.
Need for heat treating the chisels:
Annealing relieves the internal strains of the metal, which develop during the forging operation and thus makes a chisel tough andstrong.
The hardening of the metal makes it possible for a chisel to maintain a sharp cutting edge.
Tempering reduces the brittleness of the metal so that the cutting edge of the chisel is less liable to befractured.
All these processes annealing, hardening, and tempering-are known as heattreatments.

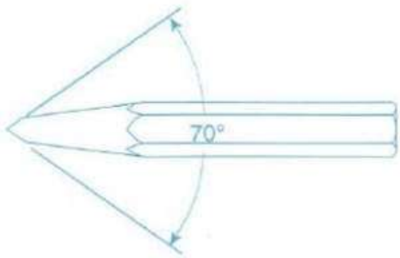
Note:Only the cutting end is hardened, and usually for a distance of 1 in. from the end. It isbetter for the opposite end to remain relatively soft, to avoid its being chipped by the blows ofthe hammer.

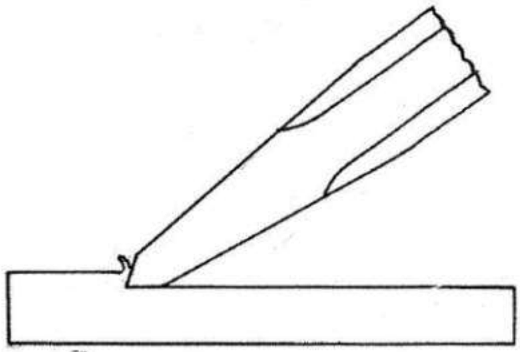
Types:

Flat coldchisel:

A flat cold chisel is the most common type of chisel, made from square or octagonal stock. It is used to chip flat surfaces and to cut thin sheetmetal.

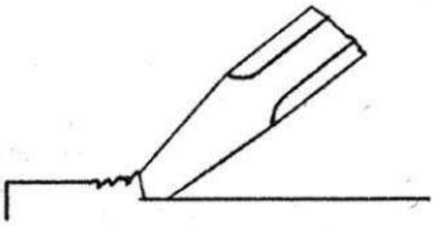
It is called a cold chisel because it is used to cut metals that have not been heated in a furnace.
The size of a flat cold chisel is determined by the width of the cuttingedge.
The cutting edge of a flat chisel is forged so it is slightly wider than the shank and it is ground to an angle of 70°. This angle allows the chisel to cut or shearmetal.
The correct cutting angle depends upon the hardness of the material to be cut. An angle of 70° is suitable for iron andsteel.



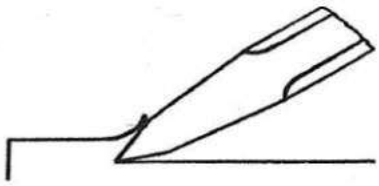


. Chisel held at correct angle.

Forsoftmetals,theangleshouldbeless.Theuseofachiselwithacuttingangleof90° or larger will tend to remove stock by pushing it off instead of cutting it off.



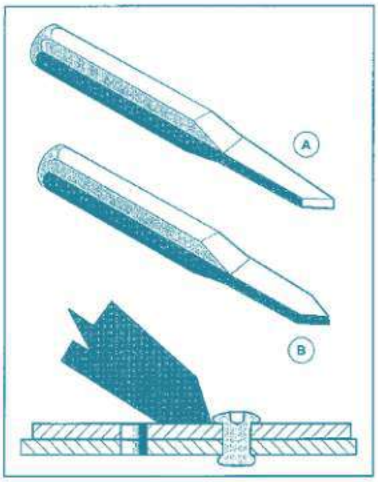
Cutting-edge angle is too large.



Cutting-edge angle can be smaller for soft metals than for iron and steel.

To use a flat chisel, the cutting edge is held flat against the material, and the depth of the cut is controlled by varying the angle between the chisel and thework.
The cutting edge is ground slightly convex, so that the greatest stress from a hammer blow is directed into the center of the chisel, at the point the cut is beingmade.
Thus, lesser stresses are transmitted to the weaker corners of the cuttingedge.

Cape / Crosscutchisel:
The cape chisel is a special cold chisel, forged from the same type of steel as the flat chisel and has the same cutting angle. However, a cape chisel's cutting edge is much narrower and has either a single or doublebevel.
This bevel makes the cape chisel ideal for chipping grooves, keyways andchannels.
Another common use for cape chisels is to knock the heads off rivets after they have been drilledthrough.
This type of chisel is preferred over the wider flat chisel because it is less likely to damage theskin.

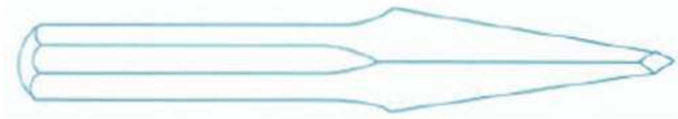


. Cape chisels come in either single-bevel (A), or double-bevel (B), and are typically used to knock off drilled-through rivet heads.

Diamond pointchisel:

A diamond-point chisel is forged into a sharp-cornered tapered square section and then ground to an acute angle. This forms a cutting edge that is similar in shape to a diamond.

These chisels are used to cut V-grooves and to chip sharp corners in square or rectangular grooves.

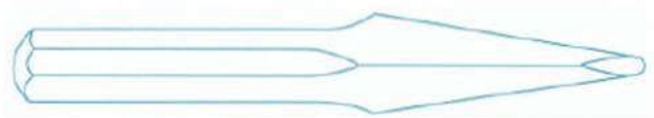


Roundnose / Half roundchisel:

Round-nose chisels look much like the diamond-point chisel except the cutting edge is ground to a circularpoint.

They are used for cutting radii in the bottom of grooves and to rough out small concave surfaces such as a filleted corner.

It is also used on drill-press work to cut a small groove in the sloping edge of a hole that is off center, for the purpose of drawing the drill back to place, concentric with the layout.



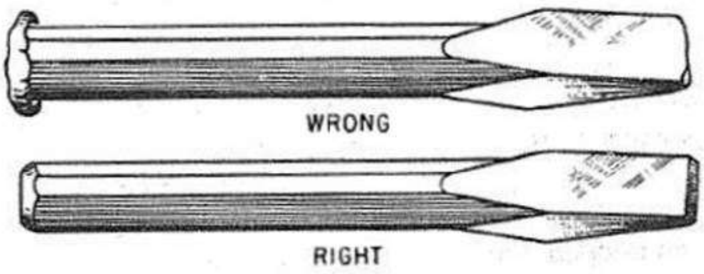
Chipping safely:

Always weargoggles.

Roll upsleeves.

Be sure chisel has no mushroomhead.

A mushroom head on a chisel is a head that has been hammered until the end spreads out to resemble a mushroom. A mushroom head should always be ground off and the cutting edge sharpened before using the chisel



). Keep chisels in good condition.

Hold the chiselcorrectly.
Hold the hammer at the end of thehandle.
Be sure the workpiece is securely held in thevise.
A guard may be placed to protect those who are near or passingby.

Cutting tools – Filing by files

Filing:

Filing is a method of removing small amounts of material from the surface of a piece of metal or other solid substance.
In some respects, the operation compares to smoothing a piece of wood with a chisel or plane. Just as there are many types of chisels and planes to suit many different operations with wood, so there are many types of files designed for specific types of work and for various kinds of metal.

What is a file? And how it differs from a chisel?

A file is a hardened-steel cutting tool having parallel rows of cutting edges, or teeth, on its surfaces, rather than a single cutting edge in chisel. It shapes a metal by cutting and abrasion, to get the final dimension of a part and to smooth asurface.
A file is pushed across a material by hand, and as it moves, the teeth acts like small chisels removing small chips ofmaterial.

Need for filing in aviation maintenance:

When aircraft sheet metal skins or other parts with close tolerances need to fit together, a file is often used to provide a finished edge orsurface.

Parts of a file:

The portion of the file on which the teeth are cut is called the face. Face is a long flat surface used as a primary cuttingsurface.
A file's edge is the long narrow surface that is perpendicular to theface.
The safe edge of a file is the one on which no teeth have been cut. This edge keeps one side of a piece of work safe while an adjacent surface is beingfiled
The tapered end that fits into the handle is called thetang.
The part of the file where the tang begins is the heel while point / tip is end of a file opposite theheel.
The length of a file is the distance from the point or tip to the heel and does not include the tang.

Note:Files normally taper in width from the heel to the tip. The exception is known as a bluntfile.

The teeth of the file do the cutting. These teeth are set at an angle across the face of the file.

Classification of files based on cut:

Files are classified based on the cut. Cut of a file refers to the number of teeth rows the file has.
A single-cut file has one row of parallel teeth, while a double-cut file has two rows of teeth, where one row of teeth crossing another row in a crisscrosspattern.
Crisscrossing produces a surface that has a very large number of little teeth that slant toward the tip of the file. Each little tooth looks like an end of a diamond point coldchisel.
The teeth of a single-cut file are cut at an angle between 65° and 85° and typically produce a smooth material finish. Therefore, most hand files are singlecut.
With a double-cut file, one set of teeth are set at an angle of about 40° -50°, which is called **"Overcut"** and the other between 70° and 80°, which is called **"Upcut".** This design of double cut is primarily used to remove large amounts ofmaterial.

Classification based on Grades of Coarseness of file:

Files are graded according to the tooth spacing (Pitch – Number of teeth per inch);a
coarse file has a small number of large teeth, and a smooth file has a large number of small
/ fine teeth.
The coarser the teeth, the more metal is removed on each stroke of thefile.
Cuts of file when going from the coarsest to finestare
Rough cut (20 teeth perinch)
Coarse cut (between rough- and bastard-cut – 25 teeth perinch)
Bastard cut (30 teeth perinch)
Second cut (40 teeth perinch)
Smooth cut (50 teeth per inch), and the smoothest isthe
Dead smooth cut (100 teeth perinch)
and the file may be either single cut or double cut. The Values given are approximate values to indicate the grade of file. The smaller the file, the finer the pitch.

3. The pitch of a 6-in. and a 16-in. second-cut file. (Nicholson File Co.)

Note:Both classes of files (single and double-cut) are made in similar grades or pitch, such asdead-smooth, smooth, second-cut, bastard, coarse, rough. The degree of roughness on smallfiles is indicated by numbers from 00 to 6, with 00 being the roughest.

Classification of files based on shape:

Millfile:

The mill file, which is single-cut, is used mostly in smooth and second-cut grades. It derives its name from the fact that it was first used for filingsaws.
These are usually tapered slightly in thickness and in width, for about one-third of their length.

It is also used for work on a lathe, for draw filing, and for finishing various compositions of brass and bronze (softmetals).
This type of file produces a finefinish.

Flat file:
Most flat files are double-cut on both sides and single cut on both edges and are preferred in bastard and second-cut grades. They are used by machinists, machinery builders, ship and engine builders, repairmen, and toolmakers, when a fast-cutting is needed.
Thesefilesareslightlytaperedtowardthepointinbothwidthandthicknessandhave
rectangular cross section.
This type of file produces a comparatively roughfinish.

Hand file:
A hand file has a rectangular cross-section, its sides are parallel, and it tapers in thickness.
One of the edges is safe; that is, there are no teeth cut onit.
Hand files are used for finishing flatsurfaces.

Pillarfile:
The pillar file is similar to the flat file, except that it is narrower; one or both edges are safe edges. Its sides are parallel and has taperedthickness.
The pillar file is used for filing slots and keyways and for filing againstshoulders.

Squarefile:
The square file has a cross section that is square and has double-cut teeth on all four sides. These files may be tapered orblunt.
It is used for filing small square or rectangular holes / slots and key seats, for finishing the bottoms of narrow slots, and soforth.
Roundfile:
The round file has a circular cross section. It is generally tapered in its length or blunt, and single or doublecut.
The small sizes are often called rattailfiles.
It is used for enlarging round holes, for rounding irregular holes, and for finishingfillets.

Half-roundfile:
A half-round file has a flat side and a rounded side. Their shape permits them to be used where other files would beunsatisfactory.
It tapers in both width andthickness.
Half-round files are used to file the inside of large radius curves and concavesurfaces.

Triangular or three-squarefile:
It has three tapered cutting sides of double cut in a triangular cross section with angles of60°.
Single cut on the edges is used for filing the gullet between sawteeth.
Double cut may be used for filing acute internal angles (angles less than 90°), clearing out corners in grooves and keyways, and filing taps and cutters and to restore damaged threads.

Knifefile:
The knife file is made knife shaped, the included angle of the sharp edge being approximately10°.
This file tapers to the point in width and thickness, and is double-cut on both flat sides, and single-cut on bothedges.

It is used for finishing the sharp corners of many kinds of slots and grooves and used by tool and die makers on work with acuteangles.
The grade preferred is bastard, in lengths of from 6 to 12in.

Woodrasp:

The wood rasp has individual teeth cut into its surfaces like a round point chisel, rather than rows ofteeth.
They are half-round and tapered, and are used to remove wood where a saw or plane is notpractical.
The surface they leave is quite rough and needs smoothening with a file orsandpaper.

Vixen file (curved toothfile):

They have curved teeth and used to produce a smooth finish with rapid filing on soft metals and wood. They slice off very small amounts of material from the surface over which they aremoved.
They do not taper in either thickness or width and are often used in special file holder that arches to allow for more concentrated cuttingpressure.
Their most common use is in automotive bodyrepair.

Lead floatfiles:

Especially designed for use in much softer metals like lead. They have single-cutteeth.
Their teeth spaced wider apart. This is to provide added resistance to clogging as lead is much softer thanaluminium.

Wardingfile:

Rectangular in section and tapers to narrow point in width, this file is used for narrow space filing where other files cannot be used.
It is used mostly by locksmiths for filing notches in keys and locks. It is made double- cut.

Swiss patternfiles:

Swiss pattern files are similar to ordinary files but are made to more exacting measurements.
The points of Swiss pattern files are smaller, and the tapered files have longertaper.
They are also made in much finercuts.
They are primarily finishing tools, used for removing burrs left over from previous finishing operations; truing up narrow grooves, notches, and keyways; rounding out slots and cleaning out corners; smoothing small parts; doing the final finishing on all sorts of delicate and intricatepieces.
The grades vary from 00, the coarsest, to 6, thefinest.

Crossing files / Swiss pattern crossingfiles:

The Swiss pattern crossing file has a double circular section, one side having the same radius as the half-round file and the other side having a flatter curve, or largerradius.
It tapers to the point in both width and thickness and is double-cut on bothsides.
These files are available in all grades from 00 to6.

Needlefiles:

Needle files are members of the Swiss pattern family. They usually come in sets of assorted shapes (allshapes).
This type of file is used by tool and die makers, and also by watch- andclockmakers.
One end of the file is knurled so that a separate handle is notneeded.

Methods of filing:

Cross-filing:

Before attempting to use a file, place a handle on the tang of the file. This is essential for proper guiding and safeuse.

In moving the file endwise across the work by about 45° (commonly known as cross- filing), grasp the handle so that its end fits into and against the fleshy part of the palm with the thumb lying along the top of the handle in a lengthwisedirection.

With the other hand, grasp the end of the file between the thumb and first twofingers.

To prevent undue wear of the file, relieve the pressure during the returnstroke.

Draw-filing:

A file is sometimes used by grasping it at each end, crosswise to the work, then moving it lengthwise with thework.

When done properly, work may be finished somewhat finer than when cross-filing with the samefile.

In draw-filing, the teeth of the file produce a shearing effect. To accomplish this shearing effect, the angle at which the file is held with respect to its line of movement varies with different files, depending on the angle at which the teeth arecut.

Pressure should be relieved during the backstroke for a single cutfile.

Since draw filing is for finishing purposes, always use a smooth or dead smoothfile.

Roundingcorners:

The method used in filing a rounded surface depends upon its width and the radius of the roundedsurface.

If the surface is narrow or only a portion of a surface is to be rounded, start the forward stroke of the file with the point of the file inclined downward at approximately a 45° angle.

Using a rocking chair motion, finish the stroke with the heel of the file near the curved surface. This method allows use of the full length of thefile.

Removing burred or silverededges:

Practically every cutting operation on sheet metal produces burrs orslivers.

These must be removed to avoid personal injury and to prevent scratching and marring of parts to beassembled.

Burrs and slivers will prevent parts from fitting properly and should always be removed from thework.

A smooth-cut file will remove these burrs easily and finish the surfaceperfectly.

Lathefiling:

Lathe filing requires that the file be held against the work revolving in the lathe. The file should not be held rigid or stationary but should be stroked constantly with a slight gliding or lateral motion along thework.

A standard mill file may be used for this operation, but the long angle lathefile provides a much cleaner shearing and self-clearing action.

Care of files:

Choose the right file for the material and work to beperformed.

Keep all files racked and separated so they do not, wear against eachother.

Keep the files in a dry place-rust will corrode the teeth points, dulling thefile.

Keep files clean. Tap the end of the file against the bench after every few strokes, to loosen and clear the filings.

Use the file card /wire brush to keep files clean; a dirty file is a dullfile.

Draw the brush across the file so that the bristles pass down the gullet between the teeth

A dirty file can also contaminate different metals when the same file is used on multiple metalsurfaces.

Never use a file without a handle. This is a safety rule. Make sure that the handle is firmly attached to thefile.

How to avoid pinning a file?

When filing soft metals, narrow surfaces, or corners, small particles of the material being filed tend to become clogged in the gullets between the teeth of the file. This is called pinning afile.
Pinning reduces the efficiency of the file and causes scratches on the surface of the work.
The main cause of pinning is the application of too much pressure on the file, especially when using smooth files. And also giving downward pressure in return stroke bends the angled teeth and causes the chips / burrs to get struck in the gullets.
It is helpful when using a new file to allow the rough edges and burrs to become worn slightly before taking heavy cuts. Rubbing chalk on a file will also help prevent pinning.

Why the downward pressure should be released during return stroke?
The downward pressure should be released during the return stroke in order to avoid dulling the file by wearing away the back of the teeth. This would destroy the cutting edges as said before, it results inpinning.
This procedure does not hold true in the filing of soft metals such as lead or aluminum. The file should be drawn back along those metals on the return stroke; this helps clean theteeth.
What should be the position of the body when filing?

It is important to have the body in the correct position because the muscles must movefreely.
The left foot should point forward and the right foot brought up close enough to the left to give the necessarybalance.
When filing, the body should lean forward on the beginning of the forward stroke and then return to the original position at the finish of thestroke.
The file must be held straight, or the surface will not beflat.
The strokes should not be too fast because this will ruin the file and the work. Enough pressure should be applied to make the file cutevenly.

Why are files made with convex surfaces?

Files are generally made with convex surfaces; that is, they are thicker in the middle than at theends.
This is done to prevent all the teeth from cutting at the same time because that would require too much pressure on a file and make it hard tocontrol.
A flat surface could not be obtained if the face of the file were straight because there is a tendency to rock the file.
The convex surface helps to overcome the results ofrocking.
The convexity of files also serves another purpose.

The pressure applied to a file to make it bite into the work also bends the file a little, and if the file in its natural state were perfectly flat, it would be concave during the cuttingoperation.
This would prevent the production of a flat surface because the file would cut away more at the edges of the work than in the center and thus leave a convexsurface.

Cutting tools – Shear cutters

Shears (for sheet metals)

As their name implies, shears cut metal by shearing it between two sharp blades in much the same way scissors cut across paper. Aviation maintenance shops normally have squaring shears to cut across large sheets of metal and several forms of smaller shears for cutting metal by hand.

Hand shears

Tin snips (Tinner's snip) or Straightsnips:

Tin snips / Straight snips, are a common cutting tool used for cutting thin sheets of metal, plastic, fiber, and so forth. They are used not only by tinsmiths, but by all bench workers as a utilitytool.

They have straight blades with cutting edges sharpened to an 85°angle.

Available in sizes ranging from 6 to 14 inches, they cut aluminum up to 1/16 of an inch.

Tin snips have relatively short blades, similar to those of a pair of scissors, and long handles to provide the neededleverage.

They are used for cutting straight lines when the distance is not great enough to use a squaring shear and for cutting the outside of a curve. The Aviation snips are used for cutting the inside of curves or radii orarcs.

Snips should never be used to cut heavy sheetmetal.

Aviation snips / Compound shears / Dutchmanshears:

Aviation snips are used to cut holes, curved parts, round patches, and doublers(a piece of metal placed under a part to make it stiffer) in sheetmetal.

Aviation snips have colored handles to identify the direction of the cuts:Yellow aviation snips cutstraight Green aviation snips curve right and Red aviation snips curve left.

Aviation snips are designed especially for cutting heat treated aluminum alloy and stainless steel. They are also adaptable for enlarging smallholes.

The blades have serrated cutting edge (small teeth on the cutting edges) that holds the metal that is being cut, and are shaped for cutting very small circles and irregular outlines.

The handles are the compound leverage type, making it possible to cut material as thick as 0.051 inch.

Note: Unlike the hacksaw, snips do not remove any material when the cut is made, but minutefractures often occur along the cut. Therefore, cuts should be made about 1/32 inch from thelayout line and finished by hand filing down to the line, to prevent stress risers.

Squaring shear (for straight cuts) What is a squaring shear?

The squaring shear provides the airframe technician with a convenient means of cutting and squaring sheet metal. Available as a manual (foot-treadle-operated), hydraulic, or pneumatic model, this shear consists of a stationary lower blade attached to a bed and a movable upper blade attached to a crosshead.

Note: Squaring - Cutting the adjacent edges perpendicular to each other.

Capacity:

A typical Foot-treadle-operated shear will accept a full 4-foot-wide (48-inch-wide) sheet and are able to make a straight cut across aluminium alloy sheets up to a 14-gauge (0.051-inch thick approx) and mild steel of 22-gage or thinner, but capacity varies widely depending on manufacturer.

Power-operated shears that use a small electric motor to store a large amount of energy in a heavy flywheel can cut much thicker sheets.

Parts and its working:

Two squaring fences/guide edge on both sides, consisting of thick strips of metal used for squaring metal sheets, are placed on the bed. One squaring fence is placed on the right side and one on the left to form a 90° angle with theblades.

Since the guide is adjustable, it is important to periodically check the alignment by making a sample cut, and checking the finished edge with a combination square. This is especially important to check before making cuts in widesheets.

The metal to be cut is placed on the bed, or table, of the shears and is squared by holding it against the

squaringfence.
An adjustable stop fence / gauge bar / backstop helps in setting the depth of the cut (distance from cutting edge to the stopfence).
A clamp for holding the metal tight against the table. It allows fingers to be kept away from the blade duringoperation.
When the metal is in place, stepping on a treadle or foot pedal, causes the clamp to drop down on the metal to hold it firmly as the blade shears across the material or when the energy stored in the flywheel forces the bladedown.
A scale graduated in fractions of an inch is scribed on the bed for ease inplacement.

How it works?

To make a cut with a foot shear, move the upper blade down by placing the foot on the treadle and pushing downward. Once the metal is cut and foot pressure removed, a spring raises the blade andtreadle.
Hydraulic or pneumatic models utilize remote foot pedals to ensure operatorsafety.

The squaring shear performs three distinctly different operations:
Cutting to aline.
Squaring.
Multiple cutting to a specificsize.
Cutting to aline.
When cutting to a line marked on the sheet, place the sheet on the bed of the shears in front of the cutting blade with the cutting line even with the cutting edge of thebed.
To cut the sheet with a foot shear, step on the treadle while holding the sheet securely in place.
Squaring.
Squaring requires several steps. First, one end of the sheet is squared with an edge (the squaring fence is usually used on theedge).
Then, the remaining edges are squared by holding one squared end of the sheet against the squaring fence and making the cut, one edge at a time, until all edges have beensquared.

Multiple cutting to a specificsize.
When several pieces must be cut to the same dimensions, use the backstop (adjustable stop fence), located on the back of the cutting edge on most squaringshears.
The supporting rods are graduated in fractions of an inch and the gauge bar may be set at any point on therods.
Set the gauge bar the desired distance from the cutting blade of the shears and push each piece to be cut against the gaugebar.
All the pieces can then be cut to the same dimensions without measuring and marking each one separately.

Throatless shear

Airframe technicians use the throatless shear to cut aluminum sheets up to 0.063 inches, considerably thicker than squaring shears are able to cut.
This shear takes its name from the fact that metal can be freely moved around the cutting blade during cutting because the shear lacks a "throat", down which metal must befed.
This feature allows great flexibility in what shapes can be cut because the metal can be turned to any angle for straight, curved, and irregular cuts. Also, a sheet of any length can becut.
A hand lever operates the cutting blade which is the top blade, the lower blade is fixed to thebase.

Scroll shear

Scroll shears are used to pierce a piece of sheet metal and cut irregular curves on the inside of the sheet

without having to cut through to theedge.
The upper blade is stationary while the lower blade is movable. The upper blade, which has a sharp point for piercing the metal, is fixed to the frame of the shears, and the lower blade is raised against the upper by the compound action of a hand-operated handle.
Best used to cut 10-gauge mild carbon sheet metal, or up to 12-gauge stainlesssteel.

Cutting tools – Saw

Saws cut metal by the chisel action of a large number of teeth. Most well-equipped aviation maintenance shops have a band saw for cutting metal, wood, and plastic. Technicians have hacksaws in their toolboxes for a wide variety of cutting operations.

Circular cutting saw

The circular cutting saw cuts with a toothed, steel disk that rotates at highspeed.
Handheld or table mounted and powered by compressed air / electricity, this powersaw cuts metal orwood.
To prevent the saw from grabbing the metal, keep a firm grip on the saw handle at all times. Check the blade carefully for cracks prior to installation because a cracked blade can fly apart during use, possibly causing seriousinjury.

Kett saw (Portable circular cutting saw)

The Kett saw is an electrically operated, portable circular cutting saw that uses blades of variousdiameters.
Since the head of this saw can be turned to any desired angle, it is useful for removing damaged sections on a stringer.
The advantages of a Kett sawinclude:
Can cut metal up to 3/16-inch in thickness.
No starting hole isrequired.
A cut can be started anywhere on a sheet ofmetal.
Can cut an inside or outsideradius.

Reciprocating saw

A reciprocating saw is an electrically powered tool, used for rough cutting of large damaged sections such as portions of spars andstringers.
This versatile reciprocating saw achieves cutting action through a push and pull (reciprocating) motion of theblade.
This saw can be used right side up or upside down, a feature that makes it handier than the circular saw for working in tight or awkwardspots.
A variety of blade types are available for reciprocating saws to cut from thin to thick metals of various sizes; blades with finer teeth are used for cutting throughmetal.
Thecuttingbladesusedtocutthroughmetalsareprimarilymadeofgoodqualitysteel
with different number of teeth per inch of blade.
For metal of thickness 0.250 inch or more, use a Coarse cutting blade. But if coarse blade is used on thin metals, the blade can hang up, dull rapidly orbreak.
The portable, air-powered reciprocating saw uses a standard hacksaw blade and can cut a 360° circle or a square or rectangularhole.

Safely using a Reciprocating saw:

Unsuited for fine precision work, this saw is more difficult to control than the pneumatic circular cuttingsaw.

Avoid applying too much downward pressure on the saw handle because the blade may break.
A reciprocating saw should be used in such a way that at least two teeth of the saw blade are cutting at alltimes.

Note: When using a reciprocating saw for metal cutting, make certain to use a blade with theproper number of teeth for the particular operation. In all cases, the manufacturer'sinformation regarding the correct blade to use and proper tool operation, should be consultedand followed.

Saber saw

Commonlyusedforsheetmetalrepairworks,thesetoolsareelectricallypoweredand similar in operation to reciprocating saw.
They are often used to cut holes in flat sheets of metals such as on wings or control surfaces, or for rough cutting the edges of sheet metalparts.
One advantage of saber saw is that its shoe plate can be tilted, allowing for bevel-edged cuts.
Like the reciprocating saw, saber saws can be adapted to cut materials other than metal by using different styles of cuttingblades.

Band saw

When sheet metal must be cut along curved lines, or when the metal is too thick to shear, a band saw can be used to cut the metal. One of the most versatile band saws found in the aircraft sheet metal shops is a **"Do-all"** vertical contour band saw.
This saw has a variable speed drive that allows the correct cutting speed to be adjusted for any metal.
In addition, the table can be tilted so bevels and tapers can be cut on thickmetals.
The band saw has a cutter, welder and grinderthat allow the saw to be used for cutting inside a piece of sheet material without cutting through to theedge.
Cutting a large inside hole with a band saw:

If a large opening or inside hole needs to be cut, a starting hole can bedrilled.
Then the saw blade is cut into two and the end placed through the startinghole.
The two ends of the blade are then clamped in the resistance welder that is built into the saw, and electric current flows through them, heating them enough to melt the ends, so the blade can be butt welded backtogether.
The current is shut off and the joint allowed to cool, and it is then groundsmooth.
The blade is reinstalled over the wheels, and it is ready to cut the inside of the thick metal, which cannot be done by other inside cutting shearsaws.

Hacksaw

A hacksaw is a hand-operated metal cutting tool that uses a narrow replaceable blade held under tension in a steelframe.
The common hacksaw has a blade, a frame, and ahandle.
The handle can be obtained in two styles: pistol grip andstraight.
Blades are made of high-grade tool steel or tungsten steel and are available in 10-inch and 12-inch lengths and from 14 to 32 teeth perinch.
The length of a blade is the distance from the center of the hole in one end of the blade to the center of the hole in the oppositeend.
There are two types, the all-hard blade and the flexible blade. In flexible blades, only the teeth are hardened and an all-hard blade is hardened allover.
Hacksaw blades have holes in both ends; they are mounted on pins attached to theframe.

Note:More the pitch (Teeth per inch), Fine the blade is. A coarse blade has less pitch. So, forthin metals, use a fine blade and for thick metals, use a coarse blade. Also, where free and fastcutting is important, use a coarse pitch blade and where smooth cut is important, use a finepitch blade.

Selection of the best blade for the job involves finding the right type and pitch. Choosing the right blade for right material based on type:
Choose the right blade for the right material. Some blades are very stiff for making straight cut and other are flexible for making slightly curved cuts withoutbreaking.
An all-hard blade is best for sawing brass, tool steel, cast iron, and heavy cross-section materials, where a straight or even cut is desired.
A flexible blade is often best for sawing hollow shapes and metals having a thin cross section.

Note:In the process of cutting such materials, there is a tendency for the blade to be twisted orpulled out of line. The flexible blade will yield under these conditions, whereas an all-hardblade will break.

Choosing the right blade based on pitch:

The pitch of a blade indicates the number of teeth perinch.
Pitches of 14, 18, 24, and 32 teeth per inch areavailable.
A blade with 14 teeth per inch is preferred when cutting machine steel, cold rolled steel, or structural steel.
A blade with 18 teeth per inch is preferred for solid stock aluminum, bearing metal, tool steel, and castiron.
Use a blade with 24 teeth per inch when cutting thick-walled tubing, pipe, brass, copper, channel, and angleiron.
Use the 32 teeth per inch blade for cutting thin-walled tubing and sheetmetal.

Set of a saw:

The set of a saw means the bending to one side or the other, of the teeth of asaw.
The standard practice is to bend the teeth alternately; that is, one tooth is turned to the right side, the next one to the left side, and soon.
The teeth are actually turned very little. Sometimes, in the case of fine-toothed saw blades, the teeth are set alternately in pairs. This is known as double-alternatesetting.
The teeth are set so that the slot made by the saw will be slightly wider than the thickness of theblade.
This prevents the blade from binding in the slot, which makes the cutting operation easier for the workman; also, because the friction between blade and work is reduced, the effective life of the blade isincreased.
The set of the teeth also permits the blade to be guided from left to right to simplify following a layoutline.

Positioning blade for Special conditions:

The blade may be set in four different positions, so that the teeth may face down, up, left, orright.
The clips in the ends of the frame may be turned to four different positions for thispurpose.

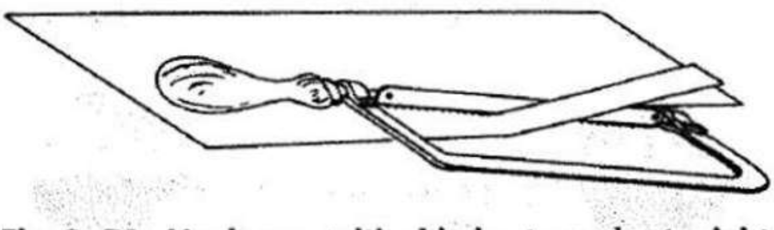
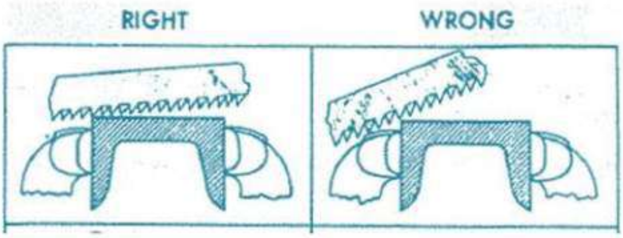


Fig. 3–70. Hacksaw with blade turned at right angles to frame.

Figure shows a blade turned to the right so that a long strip may be conveniently cut from a metalsheet.
In all cases, the blade should be drawn tight enough so that it will not bend. A flexible-back blade has a tendency to stretch because of the heat produced by friction. For this reason, it is necessary to increase the tension after the cutting has beenstarted.

How to place the work in vise and start the cut:

Avoid starting to saw on a corner. Corners have a tendency to strip teeth from theblade.
The work should be held securely and adjusted so that the cutting will take place close to the end of the visejaw.
This will prevent chattering or vibrating of the work, which is hard on the nerves of the workman and on the teeth of the sawblade.



How to saw thin materials:

Clamp thin stock between two pieces of wood or soft steel, and then saw through all three together. Thin stock that is not supported in this manner will bend under the pressure of thesaw.

Safely using a hacksaw:

Assemble the blade in the frame so the cutting edge of the teeth points away from the handle.
The teeth are designed to cut in one direction only. When cutting, pressure should be applied on the forward stroke and relaxed on the return stroke. When pressure is applied on the return stroke, the teeth will bend easily and hacksaw wearsfast.
Adjust tension of the blade in the frame to prevent the saw from buckling anddrifting.
Clamp the work in the vise in such a way that will provide as much bearing surface as possible and will engage the greatest number ofteeth.
A hacksaw blade should be chosen that will allow at least two teeth to be on the material at alltimes.
Indicate the starting point by nicking the surface with the edge of a file to break any sharp corner that might strip the teeth. This mark will also aid in starting the saw at the proper place.
Hold the saw at an angle that will keep at least two teeth in contact with the material at all times.
Start the cut with a light, steady, forward stroke just outside the cutting line. At the end of the stroke, relieve the pressure and draw the blade back. (The cut is made on the forward stroke.)
After the first few strokes, make each stroke as long as the hacksaw frame will allow. This will prevent the blade fromoverheating.
Apply just enough pressure on the forward stroke to cause each tooth to remove a small amount of metal. The strokes should be long and steady with a speed not more than 40 to 50 strokes perminute.
For hard materials, it is very effective to saw slowly and to use greater pressure than one would use for ordinary materials. Fast cutting on a hard metal will overheat and dull the blade.
After completing the cut, remove chips from the blade, loosen tension on the blade, and return the hacksaw to its properplace.

Cutting tools – Drilling

Drilling

Drilling is the operation of producing a hole in solid material by means of turning a cutting tool called a drill / drillbit.
Drill can be attached in a portable drill equipment and can be turned by hand or powered by electrics orpneumatics.
For heavy-duty and high precision, drills can be attached in shop mountedmachines.

Aviation maintenance technicians use drills and associate attachments almost more than any other tool when fabricating sheet metalcomponents.

Types of portable drill equipments

There are generally five types of portable drills used in aviation for holding and turning twist drills. These include the hand drill, the breast drill, the electric drill, the pneumatic drill and the cordless drill.

Non-Powered / Hand-operated drills:

The popular "egg beater" style hand drill is typically only used to drill holes ¼ inch and under.

The breast drill, on the other hand is designed to hold larger twist drills than the hand drill. Thus, holes over ¼ inch are typically drilled with a breastdrill.

Powered drills:

Pneumatic drill motors:

The availability of compressed air to operate rivet guns makes pneumatic, or air drill motors, a logical choice for aircraft structuralrepairs.

These drills are lightweight, have good speed control, do not overheat, and are available in a number of shapes that allows them to be used in differentlocations.

Note:Even though, electric drill motors are less costly than pneumatic, they possess the risk offire hazard and are relatively heavier than pneumatic drill motors. For these reasons, air drills,rather than electric drills, are generally more accepted for sheet metal work.

Cordless drills

Newer battery-powered drill motors, often called cordless drills, offer power and more freedom than electric and pneumatic drills. However, they should not be used near flammable materials.

Pistol grip air drillmotor:

The most popular air drill motor is the pistol grip model with a ¼ inchchuck.

The speed of these drills is controlled by the amount of pull on the trigger, but if it is necessary to limit the maximum speed, a regulator may be installed at the air hose, where it attaches to thedrill.

Most drill motors used for aircraft sheet metal work are rated at 3 000 rpm, but if drilling deep holes or drilling in hard materials, such as corrosion resistant steel or titanium, a drill motor with more torque and lower rpm should be selected to prevent damage to tools andmaterials.

Right angle and 45° drillmotors:

Right angle and 45° drill motors are used for positions that are not accessible with a pistol grip drillmotor.

Most right-angle drill motors use threaded drill bits that are available in several lengths.

If the chuck and the length of the twist drill prevent getting the drill motor in where it is needed, a right-angle drill motor equipped to use short-threaded twist drills can be used.

Heavy-duty right-angle drills are equipped with a chuck similar to the pistol grip drill motor.

Two-hole drillmotors:

Specialdrillmotorsthatdrilltwoholesatthesametimeareusedfortheinstallationof nutplates.

By drilling two holes at the same time, the distance between the holes is fixed and the holes line up perfectly with the holes in thenutplate.

Drill attachments:

When access to a place where drilling is difficult or impossible with a straight drill motor, various types of drill extensions and adapters areused.

Extension Drillbits:

There are applications in aircraft maintenance where it is necessary to reach through a part of the structure to drill a hole that is beyond the reach of an ordinary twistdrill.

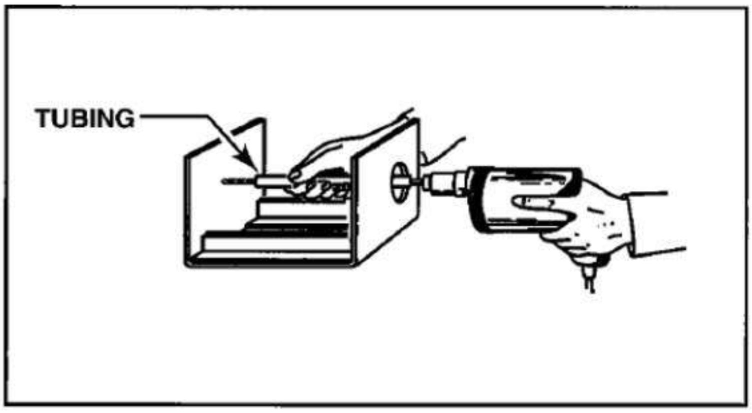
When this type of problem occurs, there are two types of extension drills available to use.

One is simply a long drill that must have a piece of aluminium tubing slipped over the shank to prevent it from whipping duringuse.

The other has a heavy shank with a small drill fixed into its end and needs no protective cover, as it is too rigid to whip

These drill bits, which come in 6 to 12-inch lengths, are high speed with spring- tempered shanks.

Extension drill bits are ground to a special notched point, which reduces end thrust toa minimum.



3. With thin shank extension drills, when pressure is applied during the drilling operation, the twist drill can bend and cause whipping. To prevent whipping, the twist drill is placed in a hollow tube to provide support for the drill.

When using extension drill bits always:

Select the shortest drill bit that will do the job. It is easier tocontrol.

Check the drill bit for straightness. A bent drill bit makes an oversized hole and maywhip, making it difficult tocontrol.

Keep the drill bit under control. Extension drills smaller than ¼-inch must be supportedby a drill guard made from a piece of tubing or spring to prevent whipping.

Straight extension:

A straight extension for a drill can be made from an ordinary piece of drillrod.

The drill bit is attached to the drill rod by shrink fitting, brazing, or silversoldering.

Drill Jigs:

Drill jigs are used to assist in drilling accurate holes in skins and structural subassemblies.
These are held in place by drilling one hole and anchoring the jig so it can be used as a template to drill numerous additionalholes.
The alignment of the jig makes it possible to obtain holes that are round, straight, and free fromcracks.
This is especially true when the metal is thick where holes drilled freehand have a tendency to be madecrooked.
Drill jigs are most commonly used during the assembly process while an aircraft is beingbuilt.
For example, drill jigs are very useful for installing anchor nuts or anything else that requires holes to be made with a high degree of repetitive dimensionalaccuracy.

Rivet removaltool:
A drill attachment used mostly during the disassembly of a damaged aircraft is a rivet removaltool.
A rivet removal tool is available with interchangeable twist drills that correspond to standard rivetsizes.
Drilling out rivets is made easier because the tool can be adjusted to cut only to the depth of the manufactured rivethead.

The procedure that follows after drilling the head, is same as for the freehand rivet removal technique. Once the head is drilled, simply tap or snap off the drilled head, and tap out the rivet shank with a hammer and a pinpunch.
Again, the material should be backed up with a bucking bar or other similar device to prevent damaging the base metal while the shank is drivenout.

Angled drill motor attachments:
Angleddrillmotorsareavailableintwostandardheadanglesof45°and90°.However,
for access into even tighter locations, angled rill motor attachments are also available.
A right-angled drill motor attachment is primarily used to open holes in close quarters where even an angled drill motor cannotwork.
The attachment is chucked into a straight pistol-typemotor.
The twist drill used on a right-angle attachment is installed in a collet, which can hold a standard twistdrill.
The twist drill is pressed into the collet and held in place by pressure exerted by the compressed wall of the collet when it is tightened in the attachment'sholder.

Snakeattachments:
A flexible snake attachment may be used in limited access areas where an angle drill motor or angle attachment cannot be used, as their handle will not permit a straight entry on the part beingdrilled.
The snake attachment basically performs the same function that a right-angle attachment does, except it can be snaked in, to drill a hole much farther away than can a right-angledrill.

One use for a snake attachment is for back-drilling through holes in original members, into new, undrilledskins.
Back-drilling is done to open holes in new skins through preexisting holes drilled in ribs, stringers, or spars, which were previously made during the original installation of sheet metalparts.

Note:A snake attachment with its right angle and threaded twist drill permits access through lightening holes to back-drill skin repairs.

Spring drillstops:
Although it is not uncommon to need a drill that is reasonably long, it is also important to be conscientious of the fact that a twist drill may be too long for a givenapplication.
In fact, it is often necessary to limit the amount that a twist drill can penetrate through a part to prevent damaging components on the other side of the drilledstructure.
A device that is often used to limit twist drill penetration is a spring drillstop.
These stops come in assorted sizes and are typically color coded to match the drillsize.

For example; Silver stops are used with No.40 drills; Copper stops are used with No.30 drills; Black stops are used with No.21drills.
These stops use a set screw to anchor the stop to the twist drill at any desiredposition.
In this fashion, the exposed length of the twist drill end can be adequately controlled to prevent the drill from penetrating too far through thestructure.

Shop mounted Machine – Drill Press

The drill press is a precision machine used for drilling holes that require a high degree of accuracy.
It serves as an accurate means of locating and maintaining the direction of a hole that is to be drilled and provides the operator with a feed lever that makes the task of feeding the drill into the workeasier.
The upright drill press is the most common of the variety of drill pressesavailable.

Safely using an Upright drill press

When using a drill press, the height of the drill press table is adjusted to accommodate the height of the part to bedrilled.
When the height of the part is greater than the distance between the drill and the table, the table is lowered. When the height of the part is less than the distance between the drill and the table, the table israised.
After the table is properly adjusted, the part is placed on the table and the drill is brought down to aid in positioning the metal so that the hole to be drilled is directly beneath the point of thedrill.
The part is then clamped to the drill press table to prevent it from slipping during the drillingoperation.
Parts not properly clamped may bind on the drill and start spinning, causing serious cuts on the operator's arms or body, or loss of fingers or hands. And never attempt to hold a part byhand.
The degree of accuracy that it is possible to attain when using the drill press depends to a certain extent on the condition of the spindle hole, sleeves, and drillshank.
Therefore, special care must be exercised to keep these parts clean and free from nicks, dents, andwarping.
Always be sure that the sleeve is securely pressed into the spindle hole. Never insert a broken drill in a sleeve or spindlehole.
Never leave the chuck key in the drill chuck. It may fly out during drilling operation, causing serious injury to operating personnel or nearbypersonnel.

Drill speed on a drill press:

The drill speed on a drill press is adjustable. Always select the optimum drill speed for the material to bedrilled. Technically, the speed of a drill bit means its speed at the circumference, in surface feet per minute(sfm). The recommended speed for drilling aluminum alloy is from 200 to 300 sfm, and for mild steel is 30 to 50sfm. In practice, this must be converted into rpm for each size drill. Machinist and mechanic handbooks include drill rpm charts or drill rpm may be computed by use of theformula:

Where:
CS = The recommended cutting speed in sfm.
D = The diameter of the drill bit in inches.
Example:At what rpm should a 1/8-inch drill turn, to drill aluminum at 300 sfm?
Answer: 9600 rpm.

One of the most critical aspects of drilling is the use of the correct drillspeed.
As a general rule, harder material should be drilled at a slower speed,whereas softer material is drilled at a higherspeed.
For examplewhen drilling a ¼-inch hole in a piece of aluminium, the proper drill speed is about 2500 rpm. However, when drilling this same size hole in stainless steel, a drill speed of around 500rpm is used so the drill does not overheat andburn.

Drill Speed/ chart	ALUMINUM	BRASS	TOOL STEEL	STAINLESS STEEL
HOLE SIZE (INCH)	DRILL SPEED (RPM)			
1/8	5000	2500	2000	1000
1/4	2500	1200	1000	500
1/2	1200	600	500	250
1	600	300	250	125

Types of Drills:
Commonly used drillsare

1. Twistdrills
2. Step drill.
3. Flatdrills,

4. Brad-Point drills (used for cutting Kevlar reinforced material (Composites), The cutting edges cut the fibers and produce a fuzz-freehole.
5. Oil-hole drills,and
6. Straight-fluteddrills.

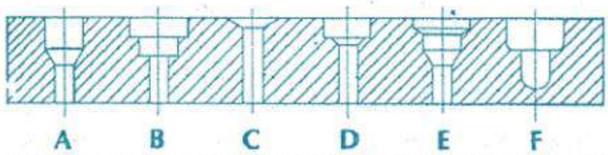
Twist drills made with straight or taper shanks are widely used for general purpose work. The flutes are made with different helix angles for special-purpose work such as drilling soft metals and deepholes.

A Step drill is a twist drill with two or more diameters for drilling holes in solid material or for finishing cast or pierced holes. It is more widely used in mass producing holes with two or more diameters that must be concentric, and for combining operations such as drilling and reaming, countersinking, chamfering, andcounterboring.

A flat drill is preferred for drilling brass because it will not dig in or feed itself into the material. Another reason for

Types of holes made with stepdrill

(A) drill, chamfer, and bore; (B) drill and multiple counterbore; (C) drill and countersink; (D) drill, counterbore, and chamfer; (E) drill multiple diameters; (F) radius drill and counterbore. (Cleveland Twist Drill Co.)



its use is that, whereas hard spots in steel will cause an ordinary drill to slide off center, flat drills are not affected in thismanner.

Also, flat drills make fine chips instead of longcoils.

An oil-hole drill is one which has holes through the body of the drill from the shank to the point. This permits oil to flow down to lubricate and cool the point of thedrill.

Oil-hole drills are generally used for deep-holedrilling.

A Straight fluted drill is used for drilling brass and soft and thin sheet materials. Having no rake angle like the helix-fluted drills, these drills do not grab or digin.

What they are made of?

High Speed Steel (HSS) drillbits

They come in short shank or standard length, sometimes called jobberslength.

HSS drill bits can withstand temperatures nearing the critical range of 1400 °F (dark cherry red) without losing theirhardness.

The industry standard for drilling metal (aluminum, steel, etc.), these drill bits stay sharperlonger.

Cobalt alloy Drillbits:

Cobalt alloy drill bits are designed for hard, tough metals like corrosion-resistant steel and titanium. It is important for the aircraft technician to note the difference between HSS andcobalt.

HSS drill bits wear out quickly when drilling titanium orstainless.

Cobalt drill bits are excellent for drilling titanium or stainless steel, but do not produce a quality hole in aluminumalloys.

Cobalt drill bits can be recognized by thicker webs and a taper at the end of the drill shank.

Twist Drill:

A twist drill, or drill bit, is a pointed tool that is rotated to cut holes inmaterial.

It is made of a cylindrical hardened steel bar having spiral flutes (grooves) running along the length of the body, and a conical point with cutting edges formed by the ends of theflutes.

This drill bit comes in a single-fluted, two-fluted, three-fluted, and four-flutedstyles.

Single-fluted and two-fluted drill bits (most commonly available) are used for originatingholes.

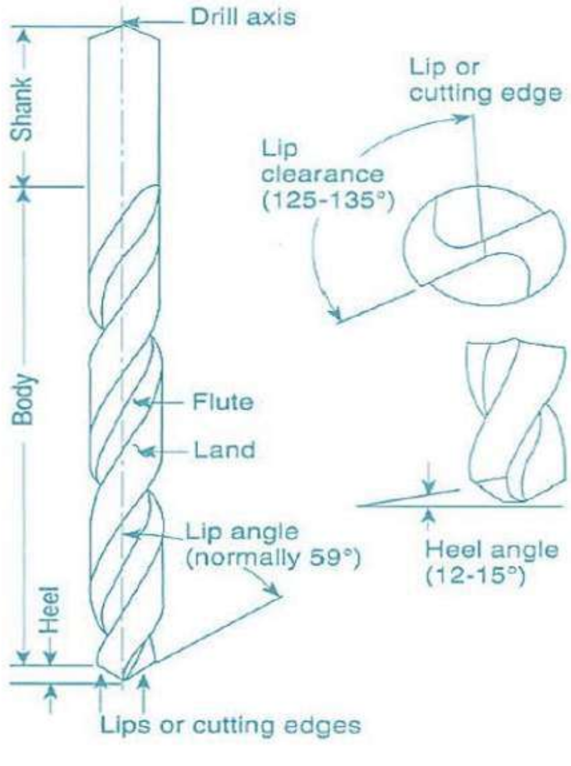
Three-fluted and four-fluted drill bits are used interchangeably to enlarge existing holes.

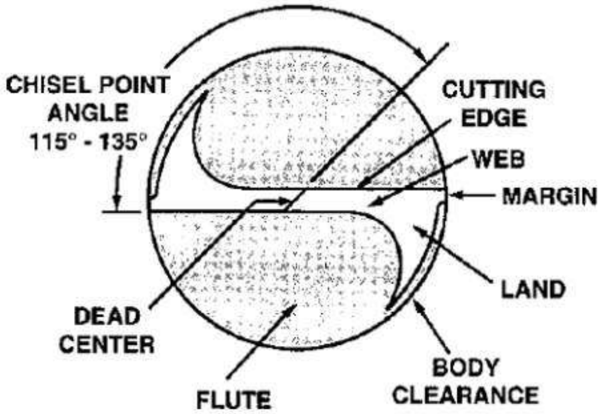
What it is made of?

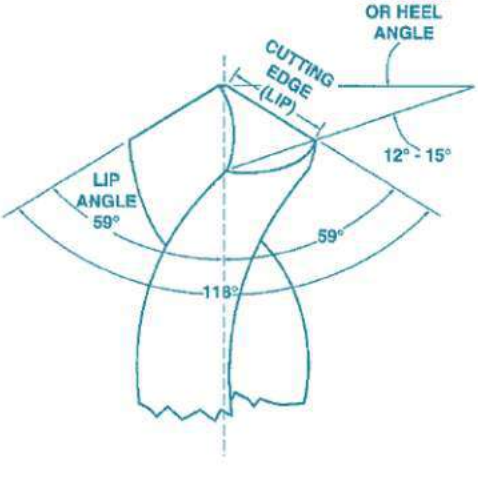
Twist drill bits are available in a wide choice of tooling materials and lengths with the variations targeting specificprojects.
ThestandardtwistdrillbitsusedfordrillingaluminumaremadefromHSSandhavea
135° split point.
Drill bits for titanium are made from cobalt vanadium for increased wearresistance.
Carbon steel twist drills are satisfactory for general work and are relatively inexpensive, but do not have nearly as long a life as highspeed drills and therefore have limiteduse.

Nomenclature of twist drill:

The principal parts of a twist drill are the shank, the body, and the heel (Point).





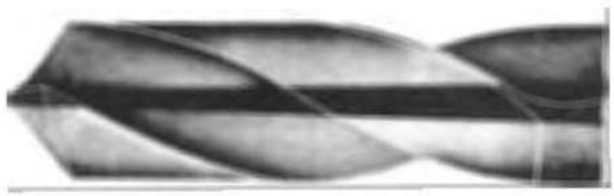


Shank

The drill shank is the end that fits into the chuck of a hand or powerdrill.
The two shank shapes most commonly used in hand drills are the straight shank and the square or bit stockshank.
The straight shank generally is used in hand, breast, and portable electric or pneumatic drills. They can be tightened into the chuck by means of a key orwrench.
The square shank is made to fit into a carpenter'sbrace.
Tapered shanks generally are used in machine shop drillpresses.
The tapered shank on a drill enables it to be quickly and accurately inserted into the spindle of a machine without using screws or clamps. The hole in the spindle and the tapered shank match each other. When the drill is thrust into the spindle, drill and spindle become wedged together. When drilling, the pressure of the work against the drill increases the wedge likeaction.

Body

The metal column forming the core of the drill is thebody.
The body of a twist drill has spiral flutes milled from the point to the shank. These flutes carry chips being cut by the cutting edge out of the hole, as well as carry lubricants to the material and cuttingedges.
The material between the flutes is called the land / Reamer land. They serve to provide a finished dimension to the hole.
The land near the cutting edge of the point and extends the entire length of the flute, that is the full drill diameter is called the margin. The margin ensures that the hole will be of accurate size.
Immediately behind the margin, the land is ground away slightly to provide bodyclearance.
The body clearance area lies just back of the margin; it is slightly smaller in diameter than the margin, to reduce the friction between the drill and the sides of thehole.
The web is the metal column, which runs the entire length of the drill between the flutes. It is the supporting section of the drill-the drill's backbone, infact.
The web gradually increases in thickness toward the shank. This thickening gives additional rigidity to thedrill.



1. Dark center section indicates the web of the drill. (Cleveland Twist Drill Co.)

A tang is found only on tapered-shank tools. It is designed to fit into a slot in the socket or spindle of a machine. Its principal use is to make it easy to remove the drill from thespindle socket with the aid of a drilldrift.

Heel / Point

The dead center / cut chisel edge is the sharp edge at the extreme tip end of the drill. Formed by the intersection of the cone-shaped surfaces of the point, the dead center should always be in the exact enter of the axis of thedrill.

It has no cutting effect; however, it exerts pressure and friction on the material while drilling, which results in increased heat generation. It can be reduced by Pointthinning.

The point of the drill should not be confused with the dead center. The point is the entire cone shaped surface at the cutting end of the drill. That's why it is also calledheel.

The cutting lip / edge of a drill is the part of the point that actually cuts away the material when a hole is drilled. It is ordinarily as sharp as the edge of a knife. There is a cutting lip for each flute of thedrill.

Note:On a typical metal drill, the cutting edges on the point perform the actual cutting. Thelands and the flutes remove the cut material and carry lubricant to the cutting edges.

Angles in a drill bit:

Rake / Helix angle – Angle of the flute in relation to the worksurface.

The rake angle also partially governs the tightness with which the chips curl and hence the amount of space they occupy. Other conditions being the same, a very large rake angle makes a tightly rolled chip, whereas a rather small rake angle makes a chip tend to curl into a more loosely rolledhelix.

Lip Clearance / Lip relief angle – is the relief given to the cutting edges that allow drill to enter into the workpiece without anyhindrance.

Cutting / Point angle – Angle between two lips in relation to the worksurface.

For most materials, cutting edges / Lips are ground at an angle of 59° on both sides from the central axis of the drill, which gives an included angle of 118° Chiselpoint.

A common drill used in aircraft sheet metal fabrication and repair is the 135° split point. Commonly called aircraft drills, these drills work best on aluminium alloy / Stainless steel material.

They provide a good starting point with very little burring around the exit hole. The 135° split point drill works very well for drilling out old rivet heads in repair or replacement work.

For drilling soft materials such as lead, wood and very soft aluminium, this angle is steepened to approximately 90°.

Hardmaterialssuchasstainlesssteelorheat-treatedsteelrequireaflatangleofabout 150°.

Furthermore,thepointisgroundwithaliporheelreliefanglerangingfrom12°to15°.

However, for very soft materials, this angle is usually increased to approximately 18° to 20°.

Grinding fixture:

The twist drill should be sharpened at the first sign of dullness. As an aviation maintenance technician, you should be able to properly grind a dull or improperly ground point to a new drillpoint.

For this, grinding fixtures that can quickly sharpen a drill point can beused.

The best way to ensure a properly sharpened point is to use a grinding fixture that grinds two cutting edges that are exactly the same length, and that meet in the exact center of the drill.

Typical procedures for sharpening drills are as follows:

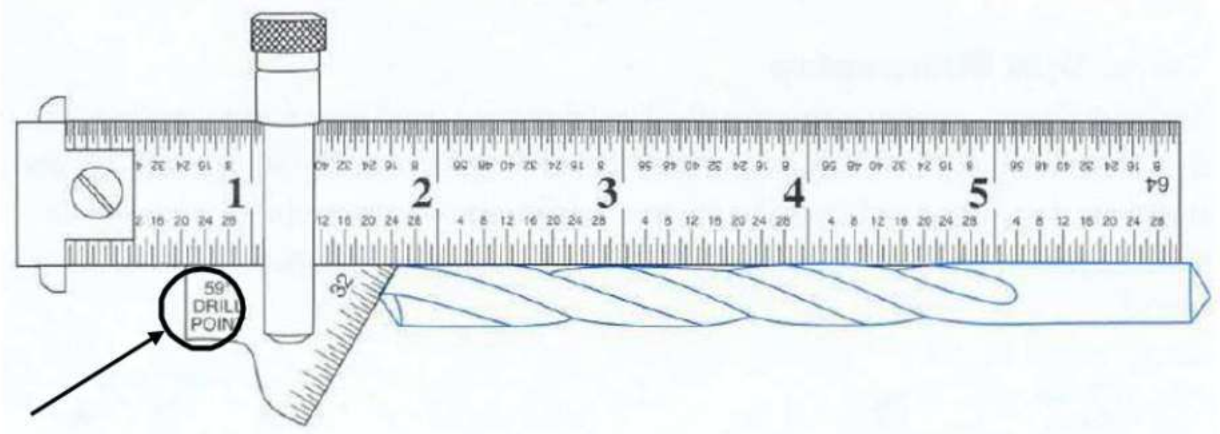
Adjust the grinder tool rest to a height for resting the back of the hand whilegrinding.

Hold the drill between the thumb and index finger of the right or left hand. Grasp the body of the drill near the shank with the otherhand.

Place the hand on the tool rest with the centerline of the drill making a 59° angle with the cutting face of the

grinding wheel. Lower the shank end of the drillslightly.
Slowly place the cutting edge of the drill against the grinding wheel. Gradually lower the shank of the drill as you twist the drill in a clockwise direction. Maintain pressure against the grinding surface only until you reach the heel of thedrill.
Check the results of grinding with a drill point gauge to determine whether or not the lips are the same length and at a 59°angle.

Note:Because the points of most drills used in routine aviation maintenance are ground to an included angle of 118°, or 59° either side of center, a handy drill point gage is available to determine that the angle is proper and the lips are of the same lengths.



How drill bits are sized:

The diameter of the drill is stamped on the shank of a drill. There are four methods to indicate the diameter of twist drills.
By Number,
By Fractions of aninch,
By Letters,and
By size in millimeters (for metric drills)
Numberdrillsrangeinsizefrom0.0135inchforthenumber80to0.2280inchforthe
number 1 drill, which are more accurate.

Fractional drills are available in sets from 1/64-inch (0.0156) to ½-inch(0.500).

Drill sizes larger than ½-inch are typically available individually and are not normally available insets.
Letter drill sizes are all larger than number sizes and range from A (0.2340) to the Z (0.4130), which also has exactmeasurements.

The only drill size available in two sets is the 0.2500-inch drill which is the letter E drill and the ¼-inch drill.
Metric drills are measured in millimeters and are available in sets with increments of either 0.5mm or0.1mm.
There are several commercially produced drill gauges available to measure the right size of a drill bit. Most drill gauges have holes in which you insert a drill in the appropriatehole.
Note:For fractional sized rivets, Numbered and letter drills are used to drill holes, rather thanfractional sized drills. Although the fractional drills come in 1/64-inch increments, in sizes less

than 1-inch in diameter, if a fractional drill is used, the clearances will either be too close, or tooextreme to permit proper hardware clearance.

For example:A No.30 drill has a diameter of 0.1285-inches whereas a -4 rivet has a diameter of 1/8 or 0.125-inches. Since the No.30 drill is 0.0035-inches larger, the rivet will easily fit into the hole without an excessive clearance.

Hole drilling techniques:
Precise location of drilled holes is sometimes required. When locating holes to close tolerances, accurately located punch marks need to bemade.
If a punch mark is too small, the chisel edge of the drill bit may bridge it and "walk off" the exact location before starting. If the punch mark is too heavy, it may deform the metal and/or result in a local strain hardening where the drill bit is to startcutting.
The best size for a punch mark is about the width of the chisel edge of the drill bit to be used. This holds the drill point in place whilestarting.

The procedure that ensures accurate holes follows:
Measure and lay out the drill locations carefully and mark with crossedlines.
Use a sharp prick punch or spring-loaded center punch and magnifying glass to further mark theholes.
Seat a properly ground center punch (120°-135°) in the prick punch mark and, holding the center punch perpendicular to the surface, strike a firm square blow with ahammer.
Mark each hole with a small drill bit (1 /16-inch recommended) to check and adjust the location prior to pilot drilling (Startingdrill).
Pilot drill at eachmark.
For holes 3 /16-inch and larger, pilot drilling is recommended. Select a drill bit equal to the width of the chisel edge of the final drill bitsize.
Avoid using a pilot drill bit that is too large because it would cause the corners and cutting lips of the final drill bit to be dulled, burned, orchipped.
It also contributes to chattering and drill motorstalling.
Give a few turns by hand, by turning the chuck, to assist the drill motor / press in drilling exactly at the punch markedarea.
Enlarge each pilot drilled hole to finalsize.

Tools for drilling accurately:
Drill bushings
There are several types of tools available that aid in holding the drill perpendicular to the part. They consist of a hardened bushing anchored in a holder.
Drill bushing types:
Tube-hand-held in an existinghole
Commercial-twistlock
Commercial-threaded

Drill bushing holder types
There are four types of drill bushing holders:
Standard - fine for drilling flat stock or tubing/rod; uses insert-typebushings.
Egg cup - improvement on standard tripod base; allows drilling on both flat andcurved material; interchangeable bushings allowflexibility.
Plate - used primarily for interchangeable production components; usescommercial bushings and self-feedingdrills.
Arm - used when drilling critical structure; can be locked in position; usesinterchangeable commercialbushings.

Drill Lubrication:

Need for Lubrication

Normal drilling of sheet material does not require lubrication, but lubrication should be provided for all deeperdrilling.

Lubricants serve to assist in chip removal, which prolongs drill life and ensures a good finish and dimensional accuracy of the hole. It also preventsoverheating.

The use of a lubricant is always a good practice when drilling castings, forgings or heavy gauge stock.

A good lubricant should be thin enough to help in chip removal but thick enough to stick to thedrill.

As a general rule, if the drill is large or the material hard, use alubricant.

Lubricants used:

For aluminum, titanium and corrosion-resistant steel, cetyl alcohol-based lubricant is the mostsatisfactory.Cetyl alcohol is a nontoxic fatty alcohol chemical produced in liquid, paste and solid forms. Solid stick and block forms quickly liquefy at drillingtemperatures.

For steel, sulfurized mineral cutting oil is superior. Sulfur has an affinity for steel, which aids in holding the cutting oil inplace.

In the case of deep drilling, the drill should be withdrawn at intervals to relieve chip packing and to ensure the lubricant reaches thepoint.

Cutting tools – for Hole enlarging and threading

Drilling is done to provide means of joining things with bolts or rivets or screws and also for various other operations like Countersinking, reaming, counterboring, spot facing, tapping, and lapping which are done after drilling a hole to suit a purpose. We will be seeing this in detail.

Reaming:

What is reaming?

Reaming is the operation of finishing a drilled hole, by enlarging and smoothingit.

A finished hole has the specified diameter size, is perfectly round, the diameter is the same size from end to end, and it has a smoothly finishedsurface.

A drilled hole is seldom accurate enough in size or sufficiently smooth to be called a precision hole. When greater accuracy is required, the hole must be drilled undersize by a certain amount and finished byreaming.

Need for reaming

Drills cannot make holes with sufficient accuracy for certain applications. However, if a hole is drilled undersized and then reamed to a finished size, extremely accurate hole sizes can beobtained.

When preparing a hole for close-tolerance bolt, drill the hole about three to seven thousandths of an inch (0.003 to 0.007 inch) undersize, smaller than the outside diameter of thereamer.

A cut that removes more than 0.007-inch places too much load on the reamer and should not beattempted.

Be sure that the reamer is perfectly aligned with the hole and turn it steadily in its proper cutting direction to prevent itchattering.

Never turn the reamer backward after it has begun to cut as this will dull thereamer.

For example:If a structure is to be held together with both rivets and bolts, no relative motioncan exist between the bolt and its hole. For this reason, close tolerance bolts are used in holesthat require a light press fit to get the bolt into the hole.

Reamer:

Reamers are special cutting tools with sharp knife-edge blades or flutes, cut into their periphery. They are hardened to the point of being brittle and sharpened and must be handled carefully to avoid chippingthem.

Reamers are made of either carbon tool steel or highspeedsteel.

The cutting blades of a high-speed steel reamer lose their original keenness sooner than those of a carbon steel reamer; however, after the first super keenness is gone, they are stillserviceable.

The highspeed reamer usually lasts much longer than the carbon steeltype.

Properly using a reamer:

When a reamer is fed into a hole, it is turned in the direction that allows acut.

After the hole is reamed to proper size, the reamer must continue to turn in the cutting direction to remove it from the hole. When a reamer is turned without cutting, it is quicklydulled.

Types of reamers:

There are two basic types of hand reamers used by the aviation technician.

Solidreamer:

Only one size hole can be cut with a solid reamer. It comes in three varieties.

Straight flute taperedreamer

Spiral flute taperedreamer

Bottomingreamer

The spiral type has less tendency tochatter.

Both types are tapered for a short distance back of the end to aid instarting.

Bottoming reamers have no taper and are used to complete the reaming of blindholes.

The cylindrical parts of most straight reamers are not cutting edges, but merely grooves cut for the full length of the reamer body. These grooves provide a way for chips to escape and a channel for lubricant to reach the cutting edge. Reamer flutes are not designed to removechips like a drill. Actual cutting is done on the end of the reamer. The cutting edges are normally ground to a bevel of 45° ± 5°.

Expansionreamer:

Several different size holes can be reamed with an expansion reamer.

For general use, an expansion reamer is the mostpractical.

This type is furnished in standard sizes from ¼ inch to 1 inch, increasing in diameter by 1/32-inchincrements.

The adjustment on the end of the cutter is turned to increase the diameter of the cutters which can be measured with a vernier micrometercaliper.

Reamers, used for enlarging holes and finishing them smooth to a required size, are made in many styles. They can be straight or tapered, solid or expansive, and come with straight or helical flutes.

Piloted reamer, with the end reduced to provide accurate alignment.

Types of standard reamers used in drilling machines.

Fluted chuckingreamer:

A fluted chucking reamer is used to finish holes accurately andsmoothly.

This is a precision reamer designed to remove from 0.005 to 0.010 in. ofmaterial.
Each tooth is ground with a clearance angle back of the cutting edge for the full length of theland.
The ends of each tooth are chamfered slightly for endcutting.

Rosereamer:

A rose reamer is designed to cut on the ends of the teeth only. It has no clearance or cutting edges on theperiphery.
The flutes provide a means for chips to escape and for coolant to reach the end cutting edges.
This, reamer is considered a roughing reamer; it will remove a considerable amount of material but will not produce a smooth, accuratehole.

Shell reamer

A shell reamer, often called a hollow reamer, is actually a reamer without ashank.
A slightly tapered hole through the center permits the reamer to be held on a separate shank or arbor that has drivinglugs.

Taper-pin chuckingreamer:

A taper-pin chucking reamer is used to machine holes that are rather small in diameter but deep, such as parts to be held together by a taperpin.

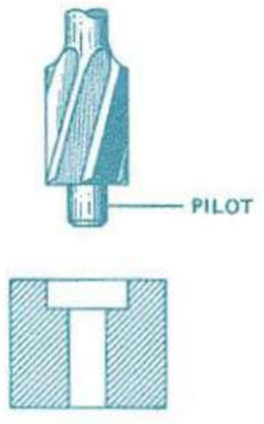
It has a taper of ¼-in. per foot. The short lead of the flutes produces a smooth, accurate hole for seating of the taperpin.

Jobber'sreamer:

A jobber's reamer is a taper-shank machine reamer having flutes about the same length as a hand reamer; it is used as a precision finishingreamer.

Counterboring:

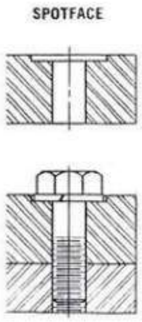
Counterboring is the operation of boring a second hole, larger in diameter than the first, but concentric withit.
When this operation is done on a drilling machine, a tool known as a counterbore isused.
The small diameter on the end of the tool, known as a pilot, keeps the counterbore concentric with the originalhole.
Pilots are interchangeable with others of different sizes to fit various sizes ofholes.

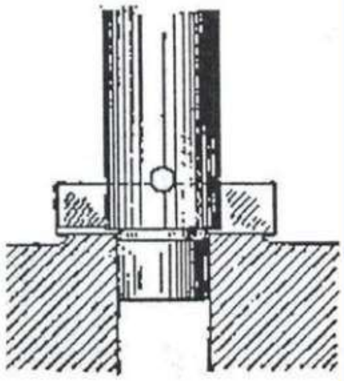


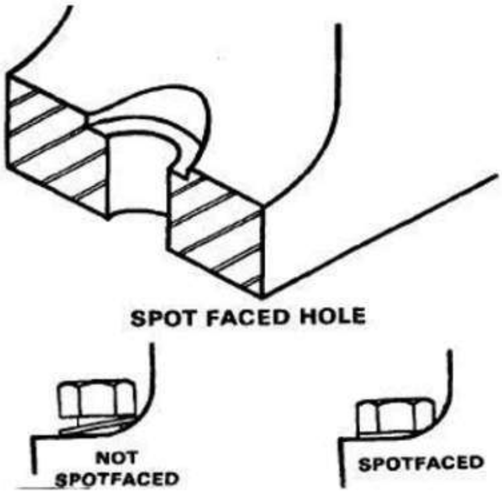
Counterbore and counterbored hole.

Spot-facing:

Spot-facing is the operation of machining a flat, circular surface around a hole to provide a seat for a bolt head, nut, or washer. It is usually performed on castings. A counterbore may be used for spot-facing. The surface machined should be square with the hole.



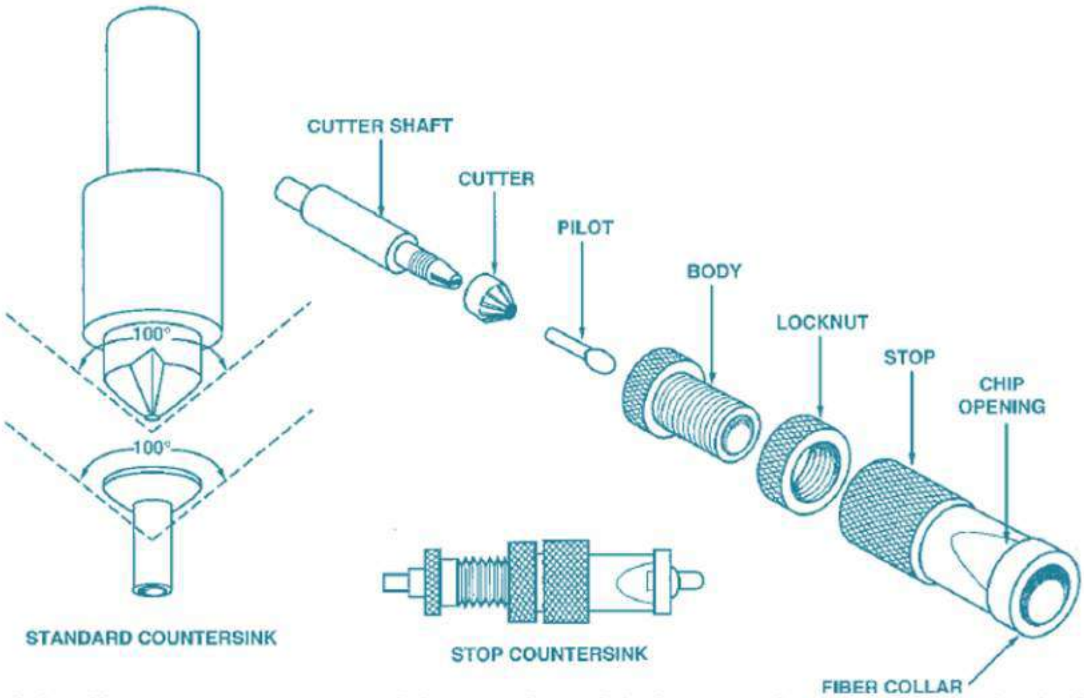




Countersinking

Flush rivets and structural screws are essential for a streamlined surface. Thick skins are countersunk (material removed to some extent to support flush rivet/screw) to produce a flush surface, and thin skins aredimpled.
Skins that are thinner than the head of the fastener are countersunk by beveling the edges of the holes (dimpling) so the fastener heads will be flush with theskin.
The heads of most flush fasteners used in aircraft have an included angle of100°.
The stop countersink has a countersink cutter that cuts a 100° bevel with an adjustable stop.

How a stop countersink works?



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 being installed.
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.

Cutters for Large Holes

The twist drills used by aviation maintenance technicians are seldom larger than one-half inch diameter. When it is necessary to cut larger holes in thin sheet metal or wood, a hole saw or fly cutter may be used.

Hole Saw

Hole saws are used to cut large-diameter holes in thin sheet metal orwood.

Different diameter saws can be installed on the arbor; these saws are available from 9/19 inch up to more than 4inches.

The arbor has a shank that fits into a drill press or a hand drill motor and the pilot drill have a short section of flutes with a longer smoothshank.

This allows the drill to cut the pilot hole, then when the saw reaches the material, the shank of the pilot drill is in the hole and therefore does not enlarge the hole, yet holds the saw centered.

Fly Cutters

Fly cutters are also used to cut large holes in thin sheet metal, but they are not limited to specific-sized holes as in a holesaw.

A cutting tool is mounted in the arm of the fly cutter and the arm is adjusted so the tip of the cutter is exactly the radius of the desired hole from the center of the pilotdrill.

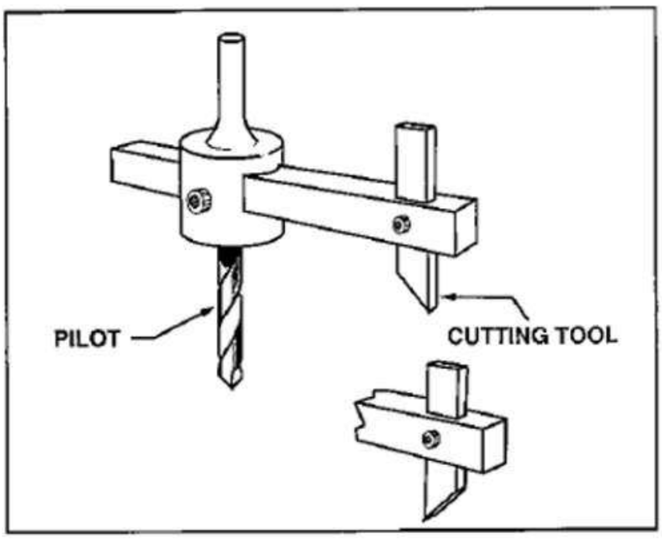
The shank of the fly cutter is chucked in a drill press, and the pilot drill cuts the guidehole.

The pilot drill has a long smooth shank so that it will not enlarge the guide hole when the metal is beingcut.

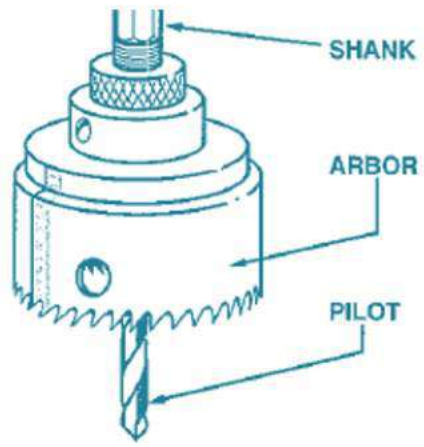
The drill press operated at a slow speed and the cutter is fed into the work very slowly and carefully in order to cut rather than grab the material.

WARNING:It is important when cutting holes in thin sheet metal that the metal be supported on a piece of scrap plywood and the metal and plywood firmly clamped to the drill press table. This prevents the metal from becoming a lethal spinning knife if the cutter should dig into it.

Threading Tapping by Taps



On a fly cutter, the cutting tool is reversible in its holder so that the edge of the hole being cut can have either a straight or beveled edge.



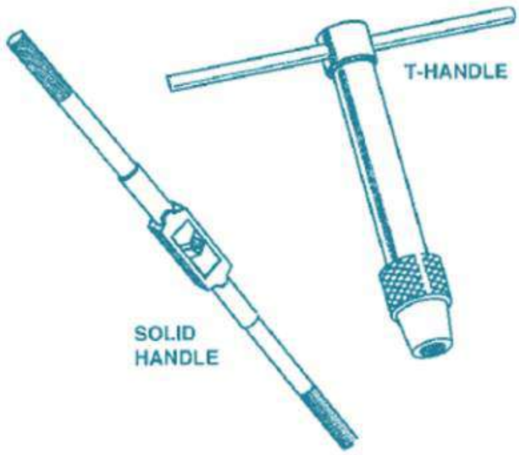
A tap is used to cut threads on the inside of a hole. Like drills, some are made of high carbon steel or high-speed steel, while others contain specialalloys.
Holes that are to be tapped (threaded) are first drilled to a specifiedsize.
There are a number of forms of threads used on bolts and screws, but the Unified and American Standard Thread form has been accepted as the standard for most aircraft hardware.
This thread form is available in both fine (UNF), and coarse (UNC)threads.

Types of Taps:

Hand taps are usually provided in sets of three taps for each diameter and thread series. Each set contains a taper tap, a plug tap, and a bottomingtap.
The taps in a set are identical in diameter and cross section; the only difference is the amount oftaper.
The taper tap is used to begin the tapping process, because it is tapered back for 6 to 7 threads.
This tap cuts a complete thread when it is cutting above the taper. It is the only tap needed when tapping holes that extend through thinsections.
The plug tap supplements the taper tap for tapping holes in thick stock, but tapers for only the first three to fivethreads.
The bottoming tap is not tapered. It is used to cut full threads to the bottom of a blindhole.

How to use a Tap:

Small taps are held with a T-handle tap wrench, while larger taps are typically held with a solid handle-tap wrench.
Both handles require two hands to turnthem.
A wrench is usually not used to turn a tap because pressure cannot be applied evenly to both sizes of tap, making it difficult to tap a straighthole.



Threads on fluid line fittings:

There is a special series of National Taper Pipe (NPT) threads used on fluid line fittings that screw into engine castings and instrumentcases.

The size of these fittings does not relate to their physical size, but is rather the size of the hole in a nominal iron pipe of the diametergiven.

For example: A 1/8-inch pipe thread actually has a root diameter of 0.3339, almost 3/8 inch.

The threads taper from 1/16-inch to 1 inch to ensure a leakproofseal.

An AMT will seldom find the need to cut tapered threads on the outside of a pipe or rod, but since a number of fittings for fluid lines have pipe threads on them, it may be necessary to cut internal threads for thesefittings.

Dies

A die is for cutting external threads on round stock, bolts andpipes.

A die is either round or hexagonal in shape with a round hole through the center that is lined with cuttingteeth.

Additional holes are provided so that the cut metal chips can fallout.

Types of dies:

Hexagonal Rethreading die

There are two basic types. The most common is the solid hexagonal rethreadingdie.

It is also called thread restorer, or threadchaser.

This type of die is screwed onto a damaged male thread with the appropriate size wrench.

The die straightens any flattened threads and removes a minimum amount ofmaterial.

Adjustable round Split die

The second type of die is the split diewhich is round and must be held in a die stock touse.

Most round dies have an adjusting screw that allows you to make small adjustments depending on the class of fitdesired.

For example:when the spring action of the die forces the sides together, a loose fitresult.

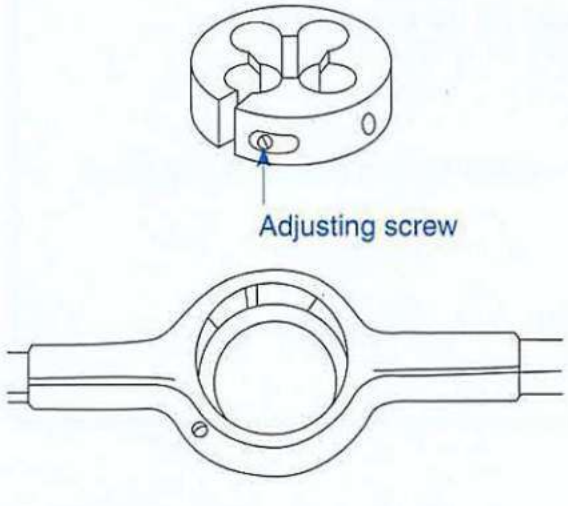


Figure 14-68. *Adjustable die and die stock*

However, when the die is spread apart with the adjusting screw, a tight fit is cut.
Note:The hexagonal die is typically used to rethread or clean existing threads and therefore itis turned with a wrench. The round split die, on the other hand, is used to cut new threads andmust be held in a diestock.
There are two basic ways of forming threads on a screw or bolt:

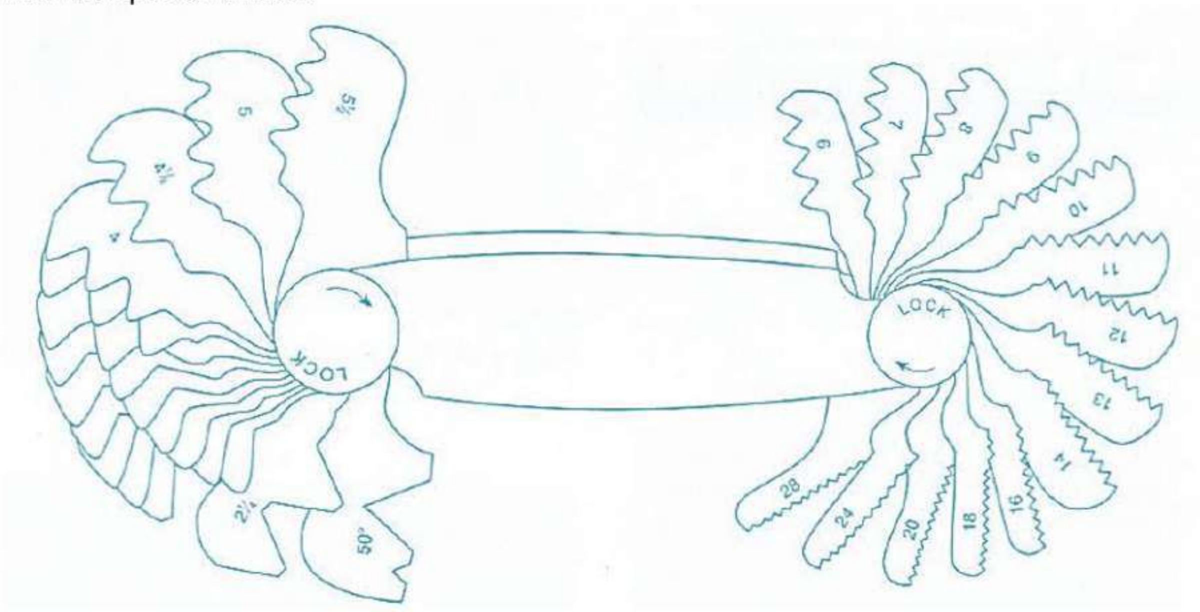
Rolling (By turning the Shank with a wrench) and

Cutting (By turning the die with a die stock).

Rolled threads are formed by squeezing the shank between rotating dies that displace the metal and force it into the threads of thedie.
Rolled threads are superior to cut threads because the cold-working of the metal produces a better grain structure in the threads as well as a burnished threadsurface.
Cut threads are formed with a die. The adjusting screw is screwed in to spread the split in the die in order to shallow the threads that are beingcut.
The die is put in the die stock, and the four set screws are tightened to hold the die in place.
The die is then placed over the end of the rod to be threaded, and turned to cut the threads.Thedepthofthethreadscanbeincreasedbyscrewingouttheadjustingscrew.

Screw PitchGage

It is difficult and time-consuming to count the threads on a bolt or nut to identify the thread type and size. For this reason, precision tool manufacturers provide screw pitch gages that have a series of blades, or leaves, in a steelcase. Each leaf has teeth corresponding to the threads with the number of threads per inch stamped onit.
To find the number of threads per inch on a bolt or nut, select the leaf whose teeth fit exactly into the threads and note the number stamped on theleaf.



Grinder:

DieGrinder

A die grinder is a handheld tool that turns a mounted cutoff wheel, rotary file, or sanding disk at highspeed. Usually powered by compressed air, electric die grinders are also used. Pneumatic die grinders run at 12 000 to 20 000 revolutions per minute (rpm) with the rotational speed controlled by the operator who uses a hand or foot-operated throttle to vary the volume of compressed air.

Available in straight, 45°, and 90° models, the die grinder is excellent for weld breaking, smoothing sharp edges, deburring, porting, and general high-speed polishing, grinding, and cutting.

Cut-Off Wheel

A cut-off wheel is a thin abrasive disc driven by a highspeed pneumatic die-grinder and used to cut out damage on aircraft skin and stringers. The wheels come in different thicknesses andsizes.

Wet and Dry grinder

Dry and/or wet grinders are found in airframe repairshops.

Grinders can be bench or pedestalmounted.

A dry grinder usually has a grinding wheel on each end of a shaft that runs through an electric motor or a pulley operated by abelt.

The wet grinder has a pump to supply a flow of water on a single grinding wheel. The water acts as a lubricant for faster grinding while it continuously cools the edge of the metal, reducing the heat produced by material being ground against thewheel.

It also washes away any bits of metal or abrasive removed during the grinding operation. The water returns to a tank and can bere-used.

Use of Grinders:

Grinders are used to sharpen knives, tools, and blades as well as grinding steel, metal objects, drill bits, andtools.

It can be used to dress mushroomed heads on chisels and points on chisels, screwdrivers, and drills, as well as for removing excess metal from work and smoothing metal surfaces.

Parts:

The bench grinder is generally equipped with one medium grit and one fine-grit abrasivewheel.

A grinding wheel is made of a bonded abrasive and provides an efficient way to cut, shape, and finishmetals.

Grinding wheels are removable and a polishing or buffing wheel can be substituted for the abrasivewheel.

Silicon carbide and aluminum oxide are the kinds of abrasives used in most grinding wheels.

Silicon carbide is the cutting agent for grinding hard, brittle material, such as cast iron. It is also used in grinding aluminum, brass, bronze, andcopper.

Aluminum oxide is the cutting agent for grinding steel and other metals of high tensile strength, as they don't wear out easily comparing to siliconcarbide.

Available in a wide variety of sizes and numerous shapes, grinding wheels are also used to sharpen knives, drill bits, and many other tools, or to clean and prepare surfaces for painting orplating.
The medium-grit wheel is usually used for rough grinding where a considerable quantity of material is to be removed or where a smooth finish isunimportant.
The fine-grit wheel is used for sharpening tools and grinding to close limits. It removes metal more slowly, gives the work a smooth finish, and does not generate enough heat to anneal the edges of cuttingtools.

Safely using a grinder:

Before using any type of grinder, ensure that the abrasive wheels are firmly held on the spindles by the flange nuts.
An abrasive wheel that comes off or becomes loose could seriously injure the operator in addition to ruining thegrinder.
A loose tool rest could cause the tool or piece of work to be "grabbed" by the abrasive wheel and cause the operator's hand to come in contact with the wheel, possibly resulting in severewounds.
Always wear goggles when using a grinder, even if eye shields are attached to the grinder. Goggles should fit firmly against the face and nose. This is the only way to protect the eyes from the fine pieces ofsteel.
Be sure to check the abrasive wheel for cracks before using the grinder. A cracked abrasive wheel is likely to fly apart when turning at highspeeds.
Never use a grinder unless it is equipped with wheel guards that are firmly inplace.

Sanders:

Disk sander

A heavy-duty disk sander is used to trim curved cuts in sheet metal, wood orplastic
after they have been rough-cut by a band saw.
With this tool, material can be milled right up to the scribedline.
Disk sanders have a powered abrasive-covered disk or belt and are used for smoothing or polishingsurfaces.
The sander unit uses abrasive paper of different grits to trim metalparts.
It is much quicker to use a disk sander than to file a part to the correctdimension.
The combination disk and belt sander have a vertical belt sander coupled with a disk sander and is often used in a metalshop.

Belt sander

The belt sander uses an endless abrasive belt driven by an electric motor to sand down metal parts much like the disk sanderunit.
The abrasive paper used on the belt comes in different degrees of grit orcoarseness.
The belt sander is available as a vertical or horizontal unit. The tension and tracking of the abrasive belt can be adjusted so the belt remains centered on itsrollers.

Deburring tool (removes burrs / chips):

Deburring a hole:

Once a hole is drilled in sheet metal, it is common to find that a sharp edge or burrs, is left around the circumference of ahole.
A drill several sizes larger than the drilled hole, or a standard countersink cutter, held in a file handle, makes a good tool for removing the burrs from the edges of theholes.
However, a common mistake made by inexperienced technicians is to remove too much material.

Remember, a deburring tool should be used to remove burrs and to smooth edges. If too much pressure is applied while deburring, it is possible that the hole will become undesirablycountersunk.

Deburring a sheet metal edge:

In addition to sharp edges around holes, when sheet metal is cut, the edge is also left sharp, and withburrs.

A hand deburring tool can be used for removing the burrs easily. To use this tool, just pull it along the edge of thesheet.

A file can also be used to remove the burrs from the edges of asheet.

Other special cutting tools

Rotary Punch press:

Used in the airframe repair shop to punch holes in metal parts, the rotary punch can cut radii in corners, make washers, and perform many other jobs where holes arerequired.

The machine is composed of two cylindrical turrets, one mounted over the other and supported by the frame, with both turrets synchronized to rotatetogether.

Index pins, which ensure correct alignment at all times, may be released from their locking position by rotating a lever on the right side of themachine.

This action withdraws the index pins from the tapered holes and allows an operator to turn the turrets to any size punchdesired.

How it works:

To operate the machine, select the desired punch by looking at the stamped size on the front of the dieholder.

Then place the metal to be worked between the die and punch by positioning the desired center of the hole over a raised teat on theturret.

Pulling the lever on the top side of the machine toward you actuates a pinion shaft, gear segment, toggle link and ram, forcing the punch through themetal.

When the lever is returned to its original position, the metal is released from thepunch.

Nibbler:

A nibbler is a tool used for rough cutting small to medium size holes in skins, radio chassis and instrumentpanels.

These tools may be electrically or pneumatically powered, but are also available in a nonpowered handversion.

Regardless of the operating power, each tool produces a similar stylecut.

Nibblers satisfactorily cut through sheets of metal with a maximum thickness of 1/16- inch.

How it works:

The main advantage of a nibbler, aside from its simplicity of operation, is the ability to use the tool for making detailed insidecuts.

To make a cut, the edge of the sheet metal is placed in a slot in the face of thetool.

By pulling a trigger, a cutting blade moves down to shear out a small rectangular section of the metal about 1/8-inch-deep by3/16-inch-wide.

As the metal is fed into the tool, the action repeats until the opening is made to the desiredsize.

One disadvantage of the nibbler is however, is that it tends to leave a rough edge requiring the use of a file to smooth the metal once the cut iscomplete.
Fort this reason, the initial cut should be made leaving excess material, permitting filing to be used to achieve the exact finisheddimension.

Notcher:

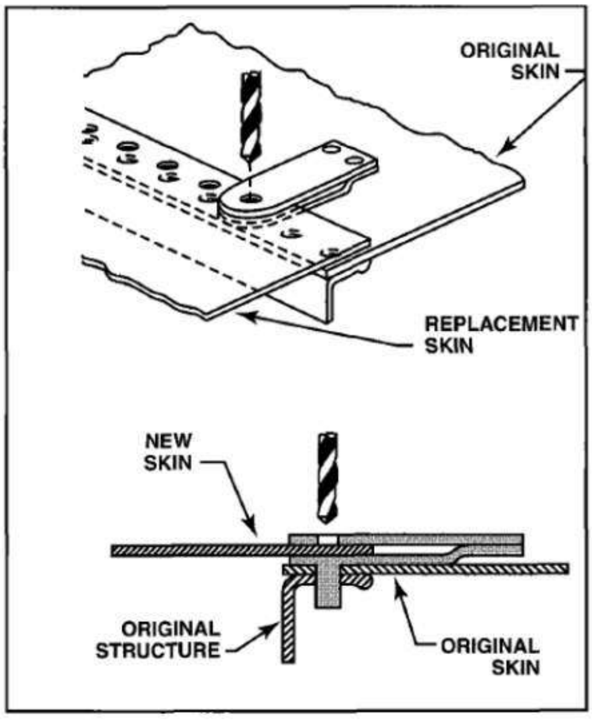
The notcher is used to cut out metal parts, with some machines capable of shearing, squaring, and trimmingmetal.
The notcher consists of a top and bottom die and most often cuts at a 90° angle, although some machines can cut metal into angles up to180°.
Notchers are available in manual and pneumatic models able to cut various thicknesses of mild steel and aluminum.
This is an excellent tool for quickly removing corners from sheet metalparts.

Hole finder:

Hole finders are used for locating rivet holes in undrilled skins where a pre-existing hole is hidden by the metalsheet.
For example: When an aircraft sheet metal structure is disassembled for a repair, damaged skins may be removed and replaced with new skins while some pre-drilled parts remain on theaircraft.
When a new skin is positioned, it may not be possible to see where the holes are located to drill to match the new skin to the pre-drilledparts.
Parts:

It consists of two metal straps that are brazed or riveted together at oneend.
At the opposite end, a pin or pilot extends out from one of the straps while the other strap either has a drill bushing or a center punch type plunger.
How to use:

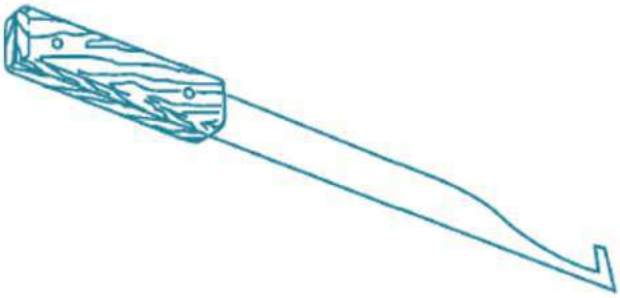
Separate the straps, and slide the one with the pilot in between the undrilled and drilledparts.



When the pilot drops into a rivet hole, the second strap with the drill bushing or center punch plunger will be in alignment with the center of thehole.
If a drill bushing is used, drill straight through the hole finder to make the new hole in theskin.
On the other hand, if a center punch plunger is used on the hole finder, tap the plunger lightly with a mallet to mark the center of thehole.
Once marked, remove the hole finder and drill the part in the normal fashion using the center punch mark as aguide.

Chip chasers:

It is sometimes impossible to disassemble skins after drilling a hole, and as a result, there are metal chips that can lodge between the skins that will prevent them from fitting tightly together when a rivet isinstalled.
A tool used to remove these metal chips is commonly called a chip chaser and can be purchased or made from a strip of feeler gauge stock.
To use it, just reach in between the skins with the chaser and rake the chips out from between the metal. Try to pull the parts back so that the chips or the tool does scratch the finish of themetal.



Lubricationequipments

Most shops have numerous grease guns, set up with particular greases and particular type of tip that attaches the respective fitting while using the greasegun.
It is critical that only the manufacturer specified grease be used in any lubrication operation.
Hand powered and pneumatic powered grease guns areused.
The powered guns simply attach to shop air. When the trigger is pulled, air pressure pushed the grease out of the gun and into the fitting andbearing.
Most shops that maintain transport category aircraft use pneumatic greaseguns.

Grease gun tip:

Some oil-lubricated parts are lubricated via a dispensing spout on an oil storage container.
These are often long, sometimes flexible delivery spouts designed for placing drops of oil exactly where required.
If the oil is in an aerosol type can under pressure, it may be dispensed simply by pressing the spray nozzle. Often a straw is inserted in the nozzle for pinpointing the direction of thespray.
Occasionally, application of oil to an aircraft part is with abrush.

Lubricant used in aircraft:

Grease is the required lubricant for many aircraft parts. From hinges to bearings to jackscrews, tracks, and doors, there are numerous locations on the aircraft that must receive regular servicing with grease.

Fittings in locations for lubricating:

Most of the locations are fitted with Zerk fittings. These fittings are mounted in the structure surrounding a particular bearing surface that needsgrease.

A tiny spring-loaded ball check valve inside the fitting allows easy servicing with a greasegun.
By seating the grease gun tip onto the head of the Zerk fitting, the ball is pushed back as grease is pumped past it onto the bearingsurface.
When the tip is removed the spring seats the ball protecting the bearing surfaces from contamination.

4. A typical zerk fitting and the grease gun adapter that fits on it.

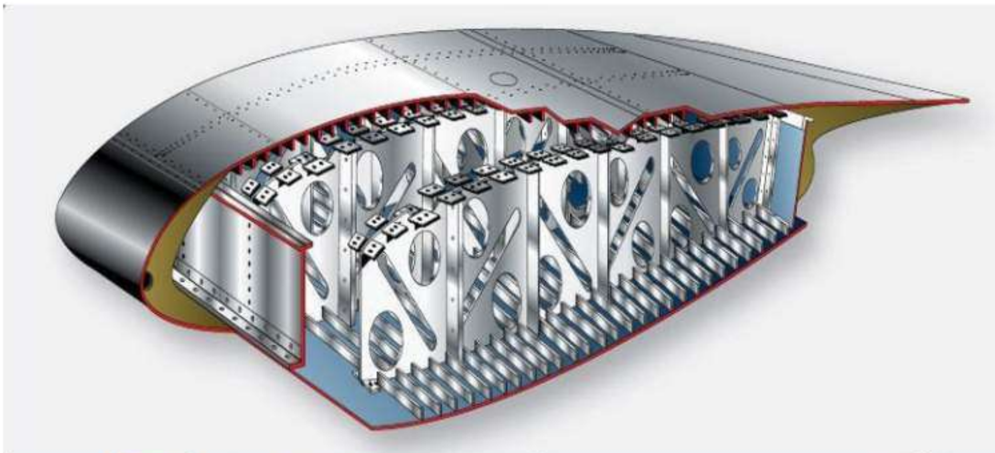
There are many variations of the Zerk grease fitting which include both protruding and flush fittings.
The type used in a particular location is chosen by the manufacturer based on clearances and accessibility. Note that it takes a different grease gun tip to grease through a flush mounted fitting than a regular protrudingfitting.

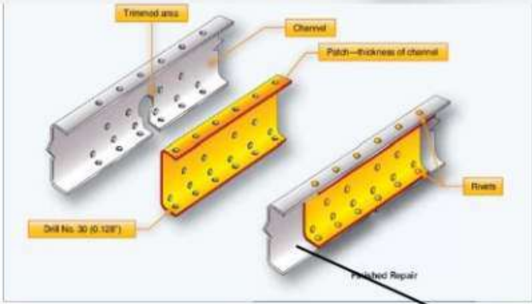
5. Flush mount grease fitting for a rod end bearing and grease gun tip.

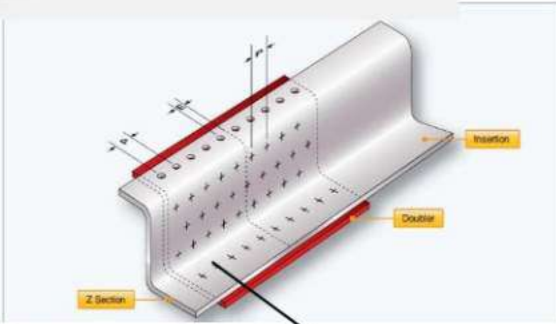
Bending and Forming machines

Need for Forming sheet metals

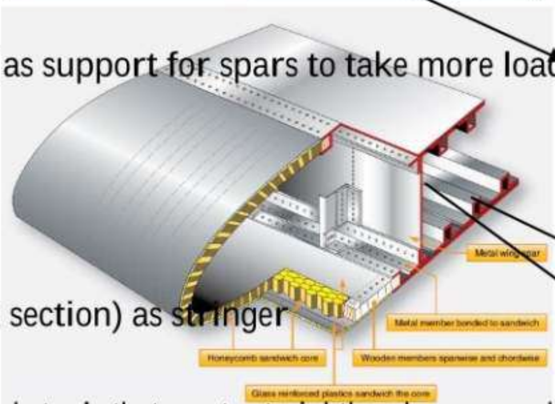
Sheet metal forming dates back to the days of the blacksmith who used a hammer and hot oven to mold metal into the desiredform.
Today's aircraft technician relies on a wide variety of powered and hand-operated tools to precisely bend and fold sheet metal to achieve the perfectshape.
Very few sheet metal skins are perfectly flat. In fact, nearly all require bends or curves that must be shaped in somemanner.
Construction of interchangeable structural and nonstructural parts is achieved by forming flat sheet stock to make channel (C), angle (L), zee (Z), and hat section members.
Examples of different sections used for aircraft wing structural construction







C section is used as support for spars to take more loads



Z section is used as string many aircrafts

Hat Section (Box section) as stringer

L section is used as support for spa take more loads

Forming tools include tools that create straightbend compoundcurves.

Note:Compound curves are made in large sheets of metal, such as fuselage and wing skins.

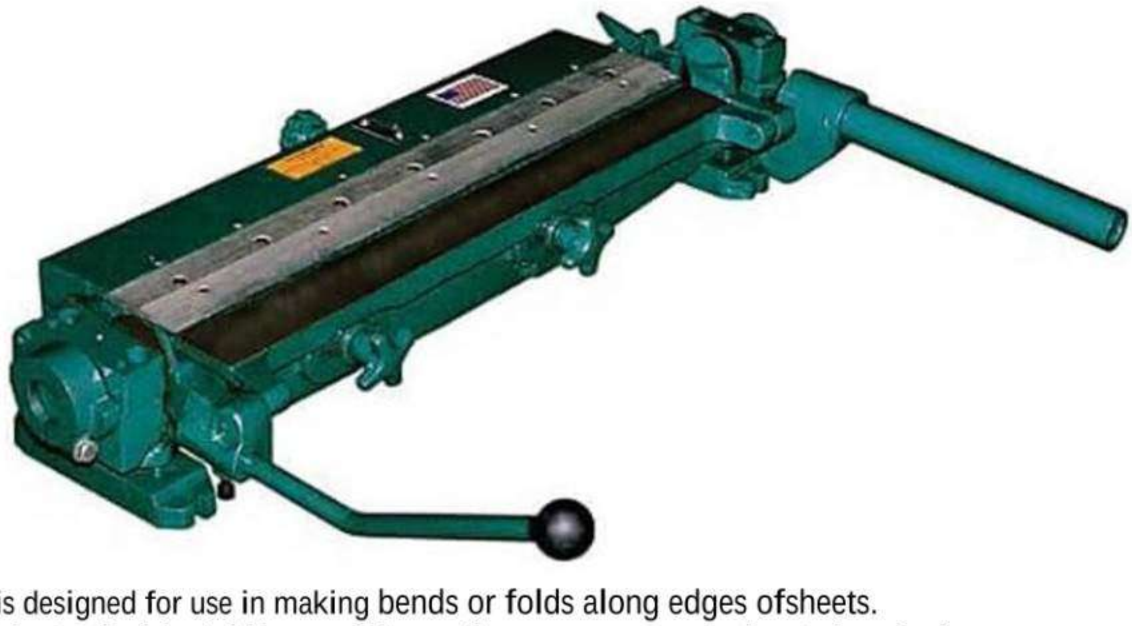
Importance of knowing the property of metal before forming

Tempered sheet stock is used in forming operations whenever possible in typical repairs.
Forming that is performed in the tempered condition, usually at room temperature, is known ascold-forming.
Cold forming eliminates heat treatment and the straightening and checking operations required to remove the warp and twist caused by the heat-treatingprocess.
Cold-formed sheet metal experiences a phenomenon known as spring back, which causes the worked piece to spring back slightly when the deforming force isremoved.
If the material shows signs of cracking during cold forming over small radii, the material should be formed in the annealedcondition.

Need for Annealing:

Annealing, the process of toughening steel by gradually heating and cooling it, removes the temper from metal, making it softer and easier toform.
Parts containing small radii or compound curvatures must be formed in the annealed condition.
After forming, the part is heat treated to a tempered condition before use on the aircraft.

Bar folding machine:[https://www.youtube.com/watch?v=RQPpM2_DShk]



The bar folder is designed for use in making bends or folds along edges ofsheets.
This machine is best suited for folding small hems, flanges, seams, and edges to be wired.
Most bar folders have a capacity for metal up to 22 gauge in thickness and 42 inches in length.
Before using the bar folder, several adjustments must be made for thickness of material, width of fold, sharpness of fold, and angle offold.

Setting thickness:

The adjustment for thickness of material is made by adjusting the screws at each end of the folder. As this adjustment is made, place a piece of metal of the desired thickness in the folder and raise the operating handle until the small roller rests on thecam.
Hold the folding blade in this position and adjust the setscrews until the metal is clamped securely and evenly the full length of the foldingblade.
After adjustment, test each end of the machine separately with a small piece ofmetal.

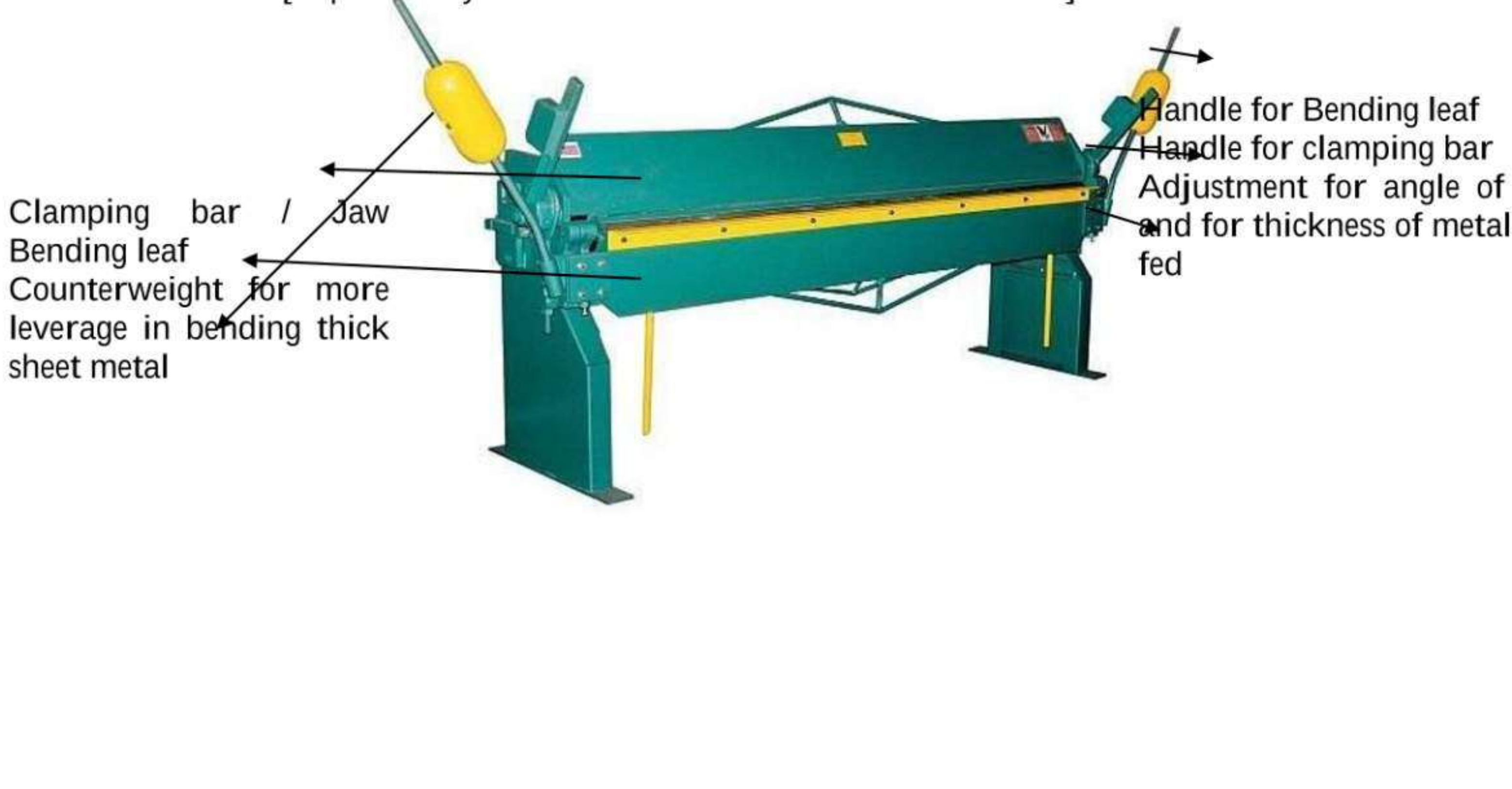
Setting desired angle of bend:

There are two positive stops on the folder, one for 45° folds or bends and the other for 90° folds orbends.
A collar is provided that can be adjusted to any degree of bend within the capacity of themachine.
For forming angles of 45° or 90°, the appropriate stop is moved into place. This allows the handle to be moved forward to the correctangle.
For forming other angles, the adjustable collar is used. This is accomplished by loosening the setscrew and setting the stop at the desiredangle.
After setting the stop, tighten the setscrew and complete thebend.

Making a fold:

To make the fold, adjust the machine correctly and then insert themetal.
The metal goes between the folding blade and thejaw.
Hold the metal firmly against the gauge and pull the operating handle toward thebody.
As the handle is brought forward, the jaw automatically raises and holds the metal until the desired fold ismade.
When the handle is returned to its original position, the jaw and blade return to their original positions and release themetal.

Cornice / leaf brake:[https://www.youtube.com/watch?v=siT2b83CLB4&t=886s]



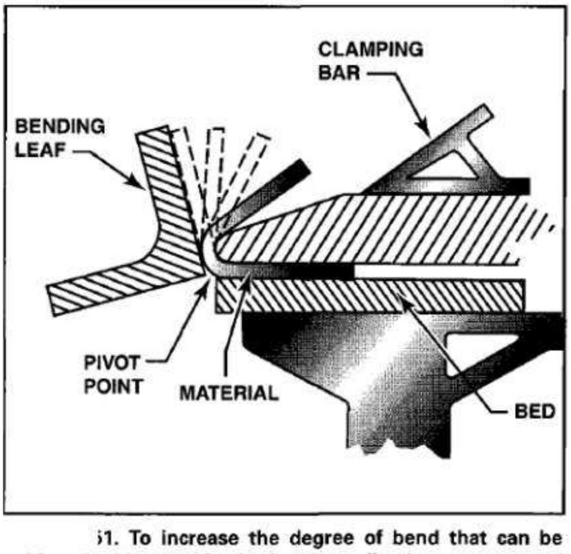
How a cornice brake differs from a Bar folding machine:

The cornice, or leaf brake is found in most aviation maintenance shops that do extensive sheet metal repair. These heavy shop tools are used to make straight bends across apiece of sheet metal.
A brake is similar to a bar folder because it is also used for turning or bending the edges of sheetmetal.
The cornice brake is more useful than the bar folder because its design allows the sheet metal to be folded or formed to pass through the jaws from front to rear without obstruction. i.e. it can accommodate a wide range of metalthickness.
In contrast, the bar folder can form a bend or edge only as wide as the depth of itsjaws.
Thus, any bend formed on a bar folder can also be made on the cornicebrake.
Bending capacity:

The bending capacity of a cornice brake is determined by the manufacturer. Standard capacities of this machine are from 12- to 22-gauge sheet metal, and bending lengths are from 3 to 12feet.
The bending capacity of the brake is determined by the bending edge thickness of the various bending leafbars.
How it works:

In making ordinary bends with the cornice brake, the sheet is placed on the bed with the sight line (mark indicating line of bend) directly under the edge of the clampingbar.
The clamping bar is then brought down to hold the sheet firmly in place. The stop at the right side of the brake is set for the proper angle or amount of bend and the bending leaf is raised until it strikes thestop.
If other bends are to be made, the clamping bar is lifted and the sheet is moved to the correct position forbending.
The bend radius appropriate for the thickness and temper of the metal can be chosen by using the appropriate radius block on the upper jaw of thebrake.
Radiusblock:

Thecornicebrakesnormallyhavearathersharpnosebar,aroundwhichbarsofany
desired milled radius may be placed.
The bend radius blocks may be moved back away from the edge of the bending leaf to accurately adjust the setback (the distance of the radius from the bendingleaf).
This is necessary to take into account the thickness of the metal so the metal will hold a tight contour around the radiusblocks.



;1. To increase the degree of bend that can be achieved with a cornice brake, the radius bars are tapered to allow the bending leaf to have a greater amount of travel.

Spring-back:

Most metals have a tendency to return to their normal shape--a characteristic knownas spring-back.

If the cornice brake is set for a 90° bend, the metal bent probably forms an angle of about 87° to 88°. Therefore, if a bend of 90° is desired, set the cornice brake to bend an angle of about 93° to allow forspring-back.

Box and Pan brake (Finger brake): [https://www.youtube.com/watch?v=xZBqX5Txtl8&t=497s]

Upper jaw with individual fingers rather than a solid jaw

(Helps in bending all four sides of a sheet without any obstruction)

The box and pan brake, often called the finger brake because it is equipped with a series of steel fingers of varying widths, lacks the solid upper jaw of the cornice brake, so all four sides of a box can be foldedup.

The box and pan brake can be used to do everything that the cornice brake can do, as well as several things the cornice brake cannotdo.

Shapes formed by finger brake:

The finger brake is used to form boxes, pans, and other similar shaped objects. If these shapes were formed on a cornice brake, part of the bend on one side of the box would have to be straightened in order to make the lastbend.

With a finger brake, simply remove the fingers that are in the way and use only the fingers required to make thebend.

The fingers are secured to the upper leaf by thumbscrews adjustable with Allen wrench.

All the fingers not removed for an operation must be securely seated and firmly tightened before the brake isused.

The radius of the nose on the clamping fingers is usually rather small and frequently requires nose radius shims to be custom made for the total length of thebend.

Press brake: [https://www.youtube.com/watch?v=-qRvS9VgR54] Need for pressbrake

The secret of economical mass production of airplanes lies in the ability of the designer's skill in specifying fabrication methods that require only skilled workers to setup machines, and then having workers of far less skill produce theparts.

The press brake needs only die installation and adjustment, and the stops properly set by a skilled worker; then any number of pieces can be formedwith relatively unskilled labor.

This tool is normally found in aircraftfactories.

Capacity:

Since most cornice brakes and box and pan brakes are limited to a maximum forming capacity of approximately

0.090-inch annealed aluminum, 0.063-inch 7075T6, or 0.063- inch stainless steel, operations that require the forming of thicker and more complex parts use a pressbrake.

How it bends a metal:

With press brake, a female die is fixed and a male die is driven by energy stored in a heavy flywheel by an electric motor or by hydraulicpressure.

The material is moved over the female die, (whose inside radius is the same as the outside radius of the finished bend), until it rests against the stop and the male die is lowered into it. Power press brakes can be set up with back stops (some are computer controlled) for high volumeproduction.

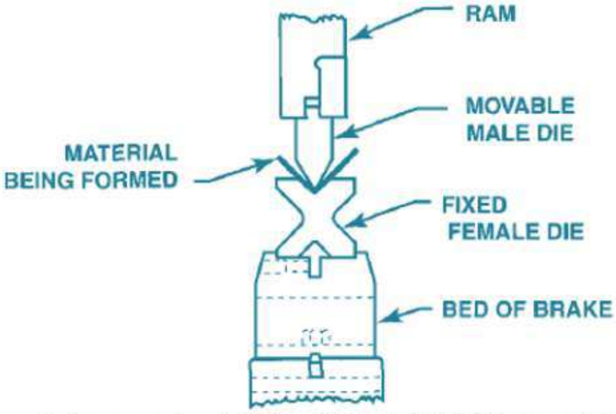
As the dies come together, they form an accurate bend that can be duplicated many times.

Type of bends:

Thenumberandtypeofdiesavailableforpressbrakesallowthemtobeusedtomake almost any kind of bend in sheet metal.

For example:Dies are available that bend the edges so wire can be installed to make hinges, or they can also be used to form lock-seams in thin sheet metal, or to form channels andboxes.

Narrow U-channels (especially with long legs) and hat channel stringers can be formed on the press brake by using special gooseneck or offset dies. Special urethane lower dies are useful for forming channels andstringers.



Slip Roll former:[https://www.youtube.com/watch?v=0JZ3fntDfBI] Need for slip rollformer

All of the machines discussed to this point are used to make rather sharp bends in sheet metal, but sometimes a gentle curve of large radius bendsin a part is needed to form a metal tube, or to form a skin for afuselage.

To make these curves, a slip roll former can beused.

Parts and its working:

It consists of right and left end housing with three solid rolls mounted inbetween.

Gears, which are operated by either a hand crank or a power drive, connect the two grippingrolls.

These rolls can be adjusted to the thickness of the metal by using the two adjusting screws located on the bottom of eachframe.

The front rolls serve as feeding, or gripping, rolls. The rear roll gives the proper curvature to thework.

Bend radius:

When the metal is started into the machine, the front rolls grip the metal and carry it to the rear roll, which curves it.

The desired radius of a bend is obtained by the rearroll.

There are no gauges that indicate settings for a specific diameter; therefore, trial and error settings must be used to obtain the desiredcurvature.

The bend radius of the part can be checked as the forming operation progresses by using a circle board or radiusgauge.

The gauge can be made by cutting a piece of material to the required finished radius and comparing it to the radius being formed by the rollingoperation.

Front and Rear roll:

The front and rear rolls are grooved to permit forming of objects that have wirededges.
Theupperfrontrollisequippedwithareleasethatpermitseasyremovalofthemetal
after it has been formed.

The lower front roll must be raised or lowered before inserting the sheet of metal. It acts as a gripping or clamping roll, to provide the right grip to themetal.

If the object has a folded edge, there must be enough clearance between the rolls to prevent flattening thefold.

If a metal requiring special care (such as aluminum) is being formed, the rolls must be clean and free ofimperfections.

How to operate:

The metal should be inserted between the rolls from the front of themachine.

Start the metal between the rolls by rotating the operating handle in a clockwise direction.

A starting edge is formed by holding the operating handle firmly with the right hand and raising the metal with the lefthand.

The bend of the starting edge is determined by the diameter of the part beingformed.

If the edge of the part is to be flat or nearly flat, a starting edge should not beformed.

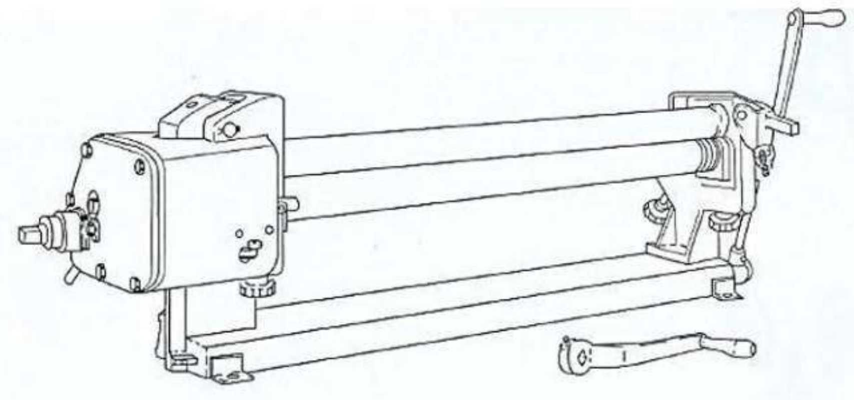
Ensure that fingers and loose clothing are clear of the rolls before the actual forming operation is started.

Rotate the operating handle until the metal is partially through the rolls and change the left hand from the front edge of the sheet to the upper edge of thesheet.

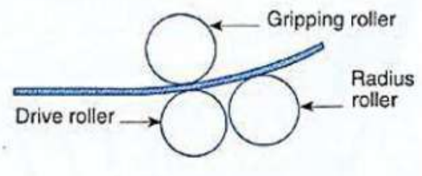
Then, roll the remainder of the sheet through the machine. If the desired curvature is not obtained, return the metal to its starting position by rotating the handle counterclockwise.

Raise or lower the rear roll and roll the metal through the rolls again. Repeat this procedure until the desired curvature is obtained, then release the upper roll and remove themetal.

Forming parts having tapered shapes and wired edge:



Slip roll former



Rollers in a slip roll former

If the part to be formed has a tapered shape, the rear roll should be set so that the rolls are closer together on one end than on the opposite end. The amount of adjustment must be determined byexperimentation.

If the job being formed has a wired edge, the distance between the upper and lower rolls and the distance between

the lower front roll and the rear roll should be slightly greater at the wired end than at the oppositeend.

Shrinking and Stretching tools – for Forming compound

Shrinking tools:

Shrinking dies repeatedly clamp down on the metal, then shiftinward.
This compresses the material between the dies, which actually slightly increases the thickness of themetal.
Strain hardening takes place during this process, so it is best to set the working pressure high enough to complete the shape ratherquickly.
CAUTION:Avoid striking a die on the radius itself when forming a curved flange. This damage the metal in the radius and decreases the angle of bend.

Stretching tools:

Stretching dies repeatedly clamp down on the surface and then shiftoutward.
This stretches the metal between the dies, which decreases the thickness in the stretchedarea.
Striking the same point too many times weakens and eventually cracks thepart.
It is advantageous to deburr or even polish the edges of a flange that must undergo even moderate stretching to avoid crackformation.
Forming flanges with existing holes causes the holes to distort and possibly crack or substantially weaken theflange.

Tools for Forming Compound Curves

Brakes and slip roll formers make straight bends across a piece of metal. For making compound curves in large sheets of metal, such as fuselage and wing skins aircraft factories use drop hammers or stretch presses. For small pieces hydropresses are used.
Stretch forming by Stretch Presses: [https://www.youtube.com/watch?v=SMXnAFD8EvQ], [https://www.youtube.com/watch?v=-b0h2qsCfKU]

Stretch presses are usually found in an aircraft factory. However, variations of this tool can be rented for use in small repairs or by aircraft homebuilders.
In the process of stretch forming, a sheet of metal is shaped by stretching it over a formed block to just beyond the elastic limit where permanent set takes place with a minimum amount ofspring-back.
To stretch the metal, the sheet is rigidly clamped at two opposite edges in fixedvises.
Then, the metal is stretched by moving a ram that carries the form block against the sheet with the pressure from the ram causing the material to stretch and wrap to the contour of the formblock.
When formed in this manner, the metal obtains a certain amount of strength and rigidity by being left in cold-workedcondition.
Once formed, the metal is then trimmed to the propersize.
Stretch forming is normally restricted to relatively large parts with large radii of curvature and shallow depth, such as contouredskin.
Uniform contoured parts produced at a faster speed give stretch forming an advantage over hand formed parts. Also, the condition of the material is more uniform than that obtained by handforming.
Drop hammer forming: [https://www.youtube.com/watch?v=ZocE8Y88bFc]

A process that has been used longer than the stretch press is drop hammerforming.
The drop hammer forming process produces shapes by the progressive deformation of sheet metal in matched dies under the repetitive blows of a gravity-drop hammer or a power-drophammer.
In this process, large matching metal female die (made of a lead and zinc alloy called Kirksite) and male die which is a matching punch (made of lead) areused.
By placing the sheet metal over the female die and dropping or slamming the male die onto the female die, the metal will be forged into the contouredshape.
This method of forming tends to make a uniform grain pattern in the metal, causing the strength of the material

toincrease.

Drop hammer forming is not a precision forming method and cannot provide tolerances as close as 0.03-inch to 0.06-inch. Nevertheless, the process is often used for sheet metal parts, such as aircraft components, that undergo frequent design changes, or for which there is a short run expectancy.

Configuration that can be formed by drop hammer forming:

The configurations most commonly formed by the process include shallow, smoothly contoured double-curvature parts, shallow beaded parts, and parts with irregular and comparatively deeprecesses.

Small quantities of cup-shaped and box shaped parts, curved sections, and contoured flanged parts are alsoformed.

Hydropress forming: [https://www.youtube.com/watch?v=1QPSCXEoJKQ]

A Hydropress uses water pressure to force a piece of sheet metal onto a male die which resembles the shape required toform.

Smaller components such as fuselage formers, wing ribs, and all types of compound curved brackets are formed in aHydropress.

How it works:

Blanks of the metal are cut and holes are drilled or punched for the locatingpins.

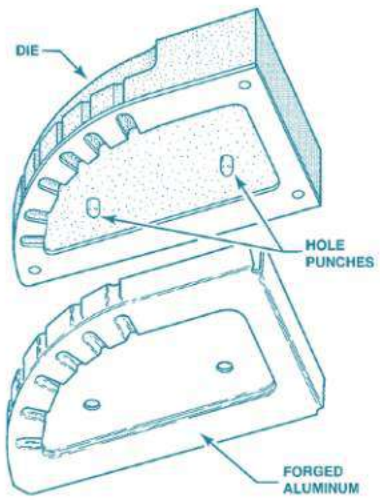
Locating pins prevent shifting of the blank when the pressure isapplied.

The blank is placed over the die which is mounted on the bed of thehydropress.

A rubber pad about four to six inches thick held in an open face heavy steel frame is forced down over the die with a force of several thousandtons.

The rubber pad forces the metal blank down around the male die withoutwrinkling.

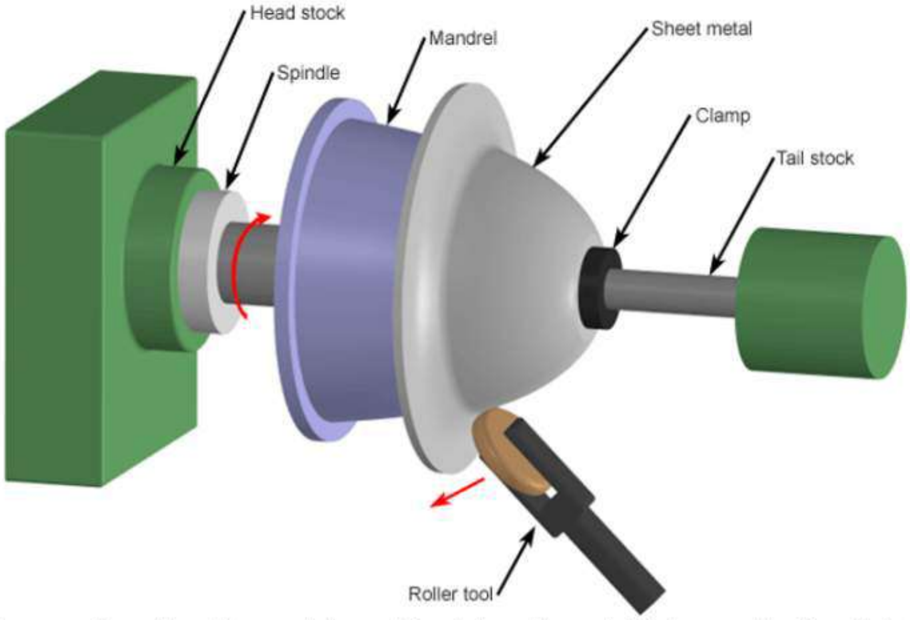
Note:Phenolic, masonite, kirksite, and some types of hard-setting moulding plastic have beenused successfully as form blocks to press sheet metal parts, such as ribs, spars, fans, etc.



Spin forming: [https://www.youtube.com/watch?v=43N44ICyuEU], [https://www.youtube.com/watch?v=wK_7tXGki1M]

In spin forming, a flat circle of metal is rotated at a very high speed to shape a seamless, hollow part using the combined forces of rotation andpressure.

For example: a flat circular blank such as an aluminum disk, is mounted in a lathe in conjunction with a form block / mandrel (usually made ofhardwood).



As the aircraft technician revolves the disc and form block together at high speeds, the disk is molded to the form block by applying pressure with a spinning stick ortool.

It provides an economical alternative to stamping, casting, and many other metal formingprocesses.

Propeller spinners are sometimes fabricated with thistechnique.

Aluminum soap, tallow, or ordinary soap can be used as alubricant.

The best adapted materials for spinning are the softer aluminum alloys, but other alloys can be used if the shape to be spun is not excessively deep or if the spinning is done in stages utilizing intermediate annealing to remove the effect of strain hardening that results from the spinningoperation.

Hot forming is used in some instances when spinning thicker and harderalloys.

Forming with an English wheel: [https://www.youtube.com/watch?v=XbPJZ6aorcA]

The English wheel is a sheet-metal tool that gained popularity during the 1990s, usedto create double curves in metal.

Aluminum sheets are formed by stretching them, which is initially done with a sandbag, resulting in a rough surface that must be smoothedout.

The smoothing is done by placing the stretched aluminum sheet over a smooth steel dolly and tapping it gently with a lightweight flat-face steelhammer.

A much more satisfactory and quicker method of smoothing the metal is by using an English wheel.

The English wheel is used for shaping low crowns on large panels and polishing or planishing (to smooth the surface of a metal by rolling or hammering it) parts that have been formed with power hammers or hammer and shotbag.

Parts:

An English wheel actually has two wheels, one above the other.

The upper wheel is a large cast-iron wheel with a highly polished and very slightly concavesurface.

A smaller, lower wheel is adjustable so it can be moved closer to or further from the upperwheel.

The lower wheel has a convex surface, and there are a number of wheels available with differing radii in order to vary the radius of the metal beingformed.
The metal being worked is moved back and forth between the two wheels to smooth and formit.

Working:

To use the English wheel, place a piece of sheet metal between the wheels (one above and one below themetal). Then, roll the wheels against one another under a pre-adjusted pressure setting. Steel or aluminum can be shaped by pushing the metal back and forth between thewheels.
Very little pressure is needed to shape the panel, which is stretched or raised to the desired shape. It is important to work slowly and gradually curve the metal into the desiredshape.
Monitor the curvature with frequent references to thetemplate.

CAUTION:Keep in mind that the English wheel is primarily a stretching machine, so it stretches and thins the metal before forming it into the desired shape. Thus, the operator must be careful not to over-stretch the metal.
Piccolo former: [https://www.youtube.com/watch?v=wzNaQMkcyiM]

From 1:32 to 1:37mins in video indicates how the jaws helps in stretching a metal[https://www.youtube.com/watch?v=01RnS6G6t30&t=409s]
The piccolo former is used for cold forming and rolling sheet metal and other profile sections(extrusions).
The position of the ram is adjustable in height by means of either a handwheel or a foot pedal that permits control of the working pressure.
Be sure to utilize the adjusting ring situated in the machine head to control the maximum workingpressure.
The forming tools are located in the moving ram and the lower toolholder.
Depending on the variety of forming tools included, the operator can perform such procedures as forming edges, bending profiles,removingwrinkles,spotshrinkingto
remove buckles and dents, or expanding dome sheet metal.
Available in either fiberglass (to prevent marring the surface) or steel (for working harder materials) faces, the tools are the quick-changetype.

Shrinkers and stretchers: [https://www.youtube.com/watch?v=6MmXcYLYvmU&t=284s] – video shows shrinking and stretching tools with jaws working similar to piccolo former.
Shrinking and stretching tools are used to form contours in parts by expanding or compressing metal to make it form a curvedsurface.
For example: When the edge of sheet metal is worked in a stretcher, the edge will expand, causing it to form an outsidecurve.
Conversely, a shrinker causes the metal to contract, which causes the metal to form an insidecurve.
Each tool is constructed in a similar fashion in that they both consist of two pairs of heavy jaws that are operated by a hand lever or footpedal.
In each tool, gripping jaws are opened and the edge of the material is placed between them.
How it works:

With a shrinker, pulling down on a lever or hydraulically operating the tool by a foot pedal causes the jaws to grip the metal and then move inward to compress a small portion of theedge.
With a stretcher, the opposite is true in that the jaws grip the metal and then spread apart.
By progressively working the metal over a certain distance along its edge, the metal will eventually begin to take on a contouredradius.
The jaws do not move enough to buckle or tear the metal, but just enough to compress or stretch itsomewhat.
The material is worked back and forth across the full width of the curve, shrinking or stretching it just a little with each movement of thejaws.
Dollies and stakes:

Sheet metal is often formed or finished (planished) over anvils, available in a variety of shapes and sizes, called dollies andstakes.
These are used for forming small, odd-shaped parts, or for putting on finishingtouches
for which a large machine may not be suited.
Dollies are meant to be held in the hand, whereas stakes are designed to be supported by a flat cast iron bench plate fastened to theworkbench.
Most stakes have machined, polished surfaces that have beenhardened.
Use of stakes to back up material when chiseling, or when using any similar cutting tool, defaces the surface of the stake and makes it useless for finishwork.

Harwood form blocks:

Hardwood form blocks can be constructed to duplicate practically any aircraft structural or nonstructuralpart.
The wooden block or form is shaped to the exact dimensions and contour of the part to beformed.

V-Blocks:

V-blocks made of hardwood are widely used in airframe metalwork for shrinking and stretching metal, particularly angles andflanges.
The size of the block depends on the work being done and on personalpreference.
Although any type of hardwood is suitable, maple and ash are recommended for best results when working with aluminumalloys.

Sandbags:

Need for sandbags:

Maintenance and repair shops do not normally use the production methods of forming compound-curvedparts.
When large skins are damaged, they are usually replaced with new skins available from the aircraft factory. These skins have pilot holes for therivets.
Small compound-curved parts of which only one or a few are required are formed with a soft-face mallet and asandbag.

What it contains:

A sandbag is generally used as a support during the bumpingprocess.
A serviceable bag can be made by sewing heavy canvas or soft leather to form a bag of the desired size, and filling it with sand which has been sifted through a fine mesh screen. This acts as amold.
Before filling canvas bags with sand, use a brush to coat the inside of the bag with softened paraffin or beeswax, which forms a sealing layer and prevents the sand from working through the pores of thecanvas.
Bags can also be filled with shot as an alternative tosand.

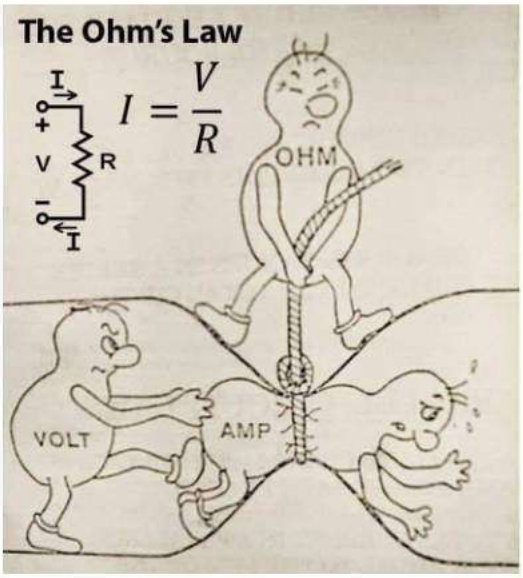
How to use:

To form a part, lay the sandbag on a work bench and make a depression in the bag that is roughly the shape of the piece beingformed.
Use the round-faced plastic mallet to work the metal down into the depression, beginning with the center and working out toward the edges in a spiralpattern.
This is strictly a trial and error method of forming, so, periodically check the amount of bend by comparing the bend with a template of the desiredshape.

Sheet metal hammers and mallets:

The sheet metal hammer and the mallet are metal fabrication hand tools used for bending and forming sheet metal without marring or indenting themetal.
The hammer head is usually made of high carbon, heat-treated steel, while the head of the mallet, which is usually larger than that of the hammer, is made of rubber, plastic, wood, orleather.
In combination with a sandbag, V-blocks, and dies, sheet metal body hammers and mallets are used to form annealedmetal.

Understanding the functional design and operation of electrical measuring instruments is very important, since they are used in repairing, maintaining, and troubleshooting electrical circuits.
The purpose of the meter is to measure quantities existing in a circuit. For this reason, when a meter is connected to a circuit, it must not change the characteristics of thatcircuit.
Meters are either self-excited or externallyexcited.
Those that are self-excited operate from a power source within themeter.
Externally excited meters get their power source from the circuit that they are connectedto.



The most common analog meters in use today are the voltmeter, ammeter, and ohmmeter. All of which operate on the principles ofelectromagnetism.

DC measuring equipments and its meters:

The principle behind the meter operation (Electromagnetism):

The fundamental principle behind the operation of the meter is the interaction between magnetic fields (Magnetic field of Permanent magnet and Magnetic field produced around the iron core due to change in electron motion through the wounded coil.

[Note:Electromagnetism – Change in magnetic field produces electric field and vise versa]

The greater the current through the coils of the rotating magnet, the stronger the magnetic field produced. A stronger field produces greater rotation of the coil, which deflects thepointer.

Principle of DC measurements - D’Arsonval meter movement

This basic DC type of meter movement, first employed by the French scientist, d'Arsonval, in making electrical measurement, is used in the ammeter, voltmeter, and ohmmeter.

The ammeter should be connected in series in a circuit since current breaks while flowing through a parallelconnection.

Since voltage changes from one equipment to another in a series, a voltmeter should be connected parallel in acircuit.

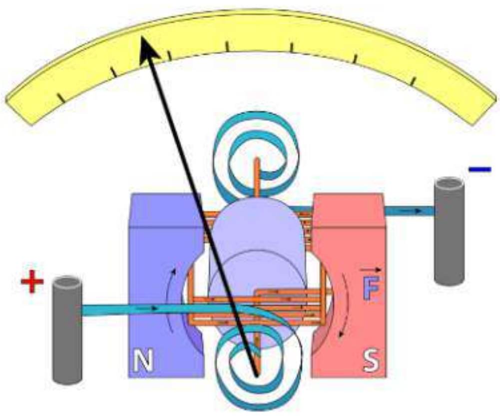
The ohmmeter differs from the ammeter and voltmeter in that it provides its own source (self-excited) of power and contains other auxiliarycircuits.

How it works:

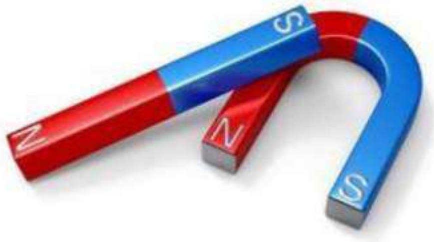
The most widely used meter movement is the D’Arsonval movement, whose pointer deflects an amount proportional to the current flowing through itsmoving coil.

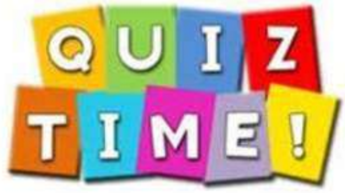
The current being measured flows through the coil and creates a magnetic field whose polarity is the same as that of the permanent magnet.

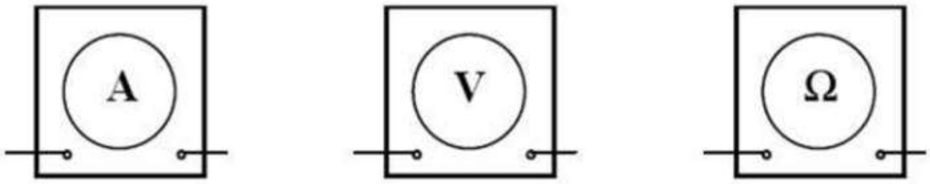
The two field thus oppose each other and cause the coil to rotate on its low friction bearings, which moves the pointeroverthescale,untiltheforceofacalibrated



hairspring exactly balances the force caused by the magnetic fields.







Ammeter Voltmeter Ohmmeter

Even though all these meters follows same principle (D'Arsonval meter movement), for direct current, how they measure different quantities (Amps, Volts and Ohm)

Mail me at jeevaramnivas@gmail.com, if you find the answer or if you can't find?

Meter ratings and terms:

Before using a basic meter, you need to understand some of the terms associated with it.

Full-Scale current / current sensitivity: The amount of current that must flow through the meter coil to cause a full-scale deflection. The amount of current required to do this varies with the scale the meter is setto.

Meter sensitivity: The Reciprocal value of the full-scale current and represents the total amount of resistance for each volt needed to produce a full-scalecurrent.

Multirange Ammeter:

The basic idea of a multirange ammeter is to make the meter usable over a wide range of voltages.
In order to accomplish this, each range must utilize a different shunt resistance. The example given here is that of a two-rangemeter.

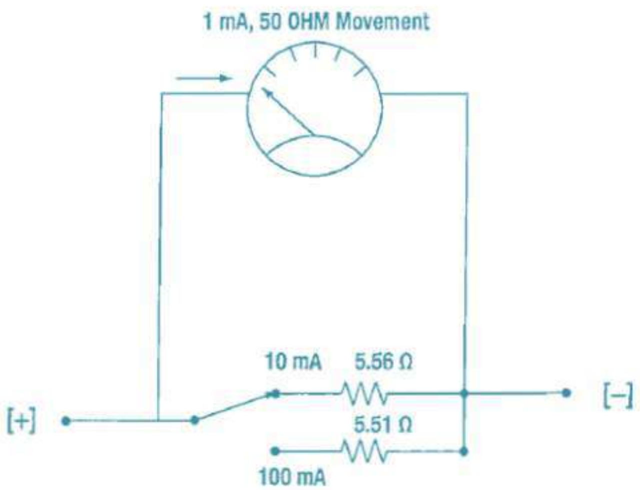


Figure shows the schematic of an ammeter with two selectable ranges. This example builds upon the previous 10mA range meter by adding a 100mArange.

With the switch selected to the 10-mA range, the meter will indicate 10-mA when the needle is deflected to full scale and will likewise indicate 100-mA at full scale when selected to 100-mA.

The value of the 100-mA shunt resistor is determined the same way the 10-mA shunt resistor was determined.

Quiz:For an input of 100-mA, if the meter movement can only carry 1 mA, the shunt should carry_____and its resistanceR_{SH}=__. Find! *if meter resistance = 50Ω+

Precautions

The precautions to observe when using an ammeter are summarized as follows:

Always connect an ammeter in series with the element through which the current flow is to be measured.

Never connect an ammeter across a source of voltage, such as a battery or generator. Remember that the resistance of an ammeter, particularly on the higher ranges, is extremely low and that any voltage, even a volt or so, can cause very high current to flow through the meter, causing damage toit.

Use a range large enough to keep the deflection less than full scale. Before measuring a current, form some idea of its magnitude. Then switch to a large enough scale or start with the highest range and work down until the appropriate scale is reached. The most accurate readings are obtained at approximately half-scale deflection. Many milliammeters have been ruined by attempts to measure amperes. Therefore, be sure to read the lettering either on the dial or on the switch positions and choose proper scale before connecting the meter in the circuit.

Observe proper polarity in connecting the meter in the circuit. Current must flow through the coil in a definite direction in order to move the indicator needle up scale. Current reversal because of incorrect connection in the circuit results in a reversed meter deflection and frequently causes bending of the meter needle. Avoid improper meter connections by observing the polarity markings on themeter.

D'Arsonval meter used for measuring voltage – (Voltmeter with Multiplier resistor)

A d'Arsonval meter can be used to measure voltage by connecting resistance in series with the meter movement. This limits the current flow to a value which results in full scaledeflection.

Voltmeter sensitivity is defined in terms of resistance per volt (Ω/V).

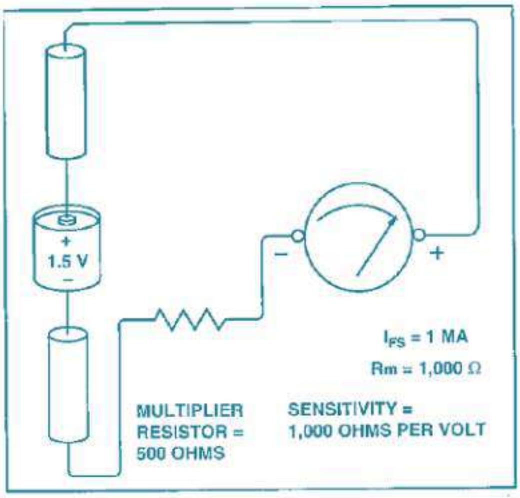
For example:If 1 mA meter with a resistance of 1000 Ω is used to measure the voltage acrossa V battery, how much additional resistance must be connected in series with the meter to limit the current to 1mA?

As per ohm's law, V=IR

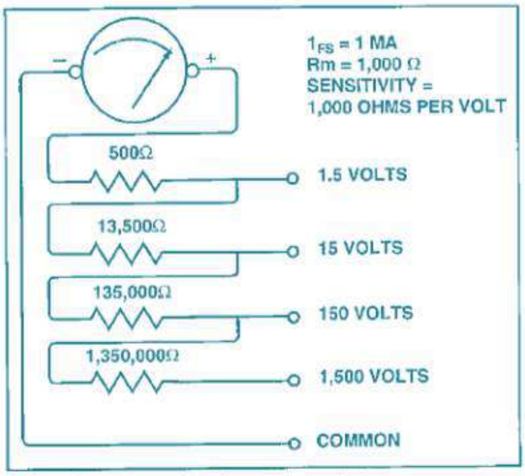
R=V/I R=1.5/0.01 ⟶ R=1500Ω ⟶

It means, 1.5 volt of charge flows at a rate of 0.01 amp, produces a resistance of 1500 Ω

So, a total of 1500 Ω is required to limit the current to 1 mA. Since the meter has a resistance of 1000 Ω already, only 500 Ω of additional resistance is required.
This additional resistance is provided by placing a 500 Ω resistor in series with the meter movement. That resistor is called a **Multiplier resistor or Multiplier** because it multiplies a meter's basic range.



Multi-range voltmeters use one-meter movement with several differentmultipliers.
These multipliers are usually arranged so the current for each succeeding higher range flows through the multipliers for all of the lowerranges.



Influence of the voltmeter in the circuit

When a voltmeter is connected across two points in a circuit, current will beshunted.
If the voltmeter has low resistance, it will draw off a significant amount of current. This will lower the effective resistance of the circuit and change the voltagereadings.

When taking a voltage measurement, use a high resistance voltmeter to prevent shunting of thecircuit.

D'Arsonval meter used for measuring Resistance – Ohmmeter (Series ohmmeter):

Ohmmeters measure the resistance of a component by measuring the amount of current that flows through the component from the known voltage of a self-contained battery.

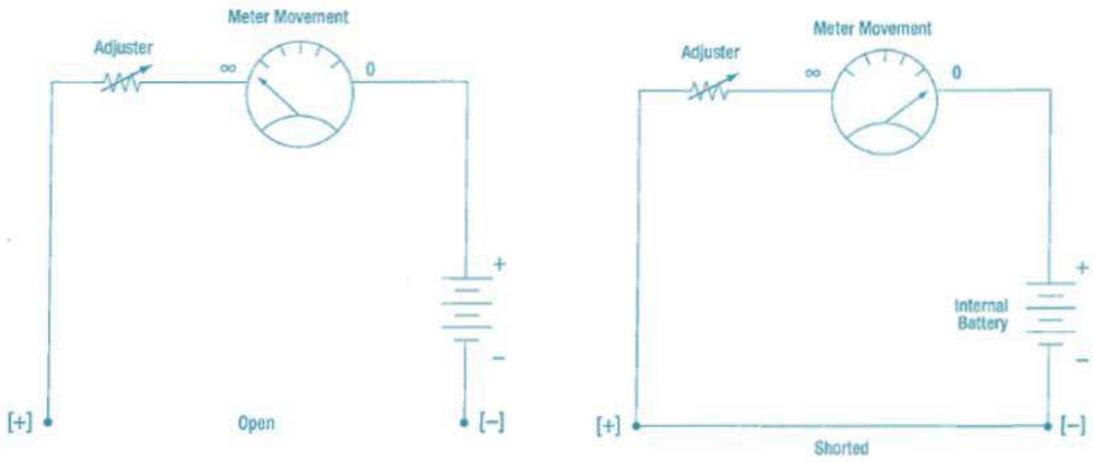
The series ohmmeter uses small flashlight or penlight batteries connected in series with a fixed resistor, an adjustable resistor and ameter.

If a meter uses 3.0 V battery and has a sensitivity of 1000 Ω/V, the total resistance required to produceafull-scaledeflectionequals3000Ω.*V=IR R=3 / 0[redacted]= 3000Ω+

Because the battery voltage changes with use, the variable resistor is used to "Zero" or standardize the meter before eachuse.

Before using the meter on any resistor, hold the test leads together to close the circuit and turn the zero-adjusting knob until the meter indicates an exact full-scale deflection to Zero.

When the leads are separated, the needle drops back to the opposite side of the scale which is **infinity** '∞'. This indicates that there is an infinite resistance between the test leads and no current isflowing.

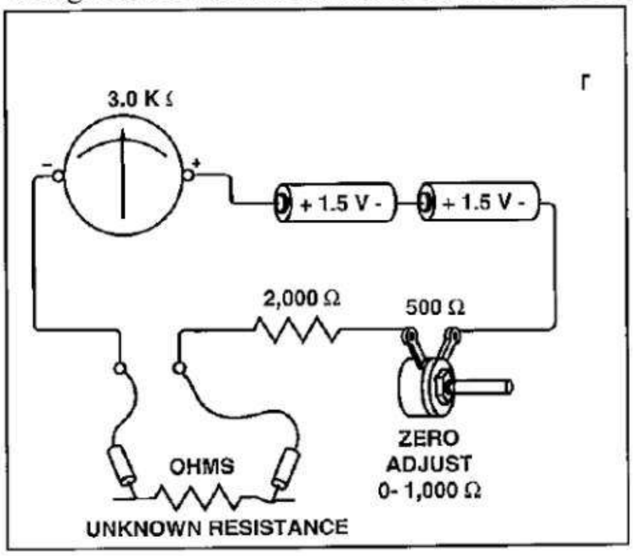


In the example given below, the meter has 500 Ω of meter resistance and uses a 2000 Ω of fixed resistor and 1000 Ω of variable resistor which can be varied between 0 Ω - 1000 Ω.

When the leads are shorted, current will flow through the circuit and the meter should indicate zero. For that, the variable resistor is set at 500 Ω, and so the total resistance in the circuit will be 3000 Ω which is the same as the sensitivity (Ω/V) of the meter. So, the meter will indicate0.

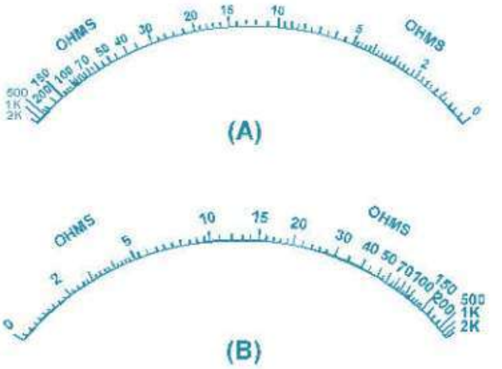
After the Zero adjustment, a unknow resistor is connected between theleads.

The indicator moved to the middle of the scale meaning that the unknown resistance dropped exactly the same voltage as the internal resistance of the meter. Therefore, the value of unknown resistance is 3000Ω.



The scale on a series ohmmeter is nonlinear, meaning that there is no uniform distance between thegraduations.

The numbers are widely separated at the low-range end and are close at the highend.



(A) SERIES OHMMETER (B) SHUNT OHMMETER

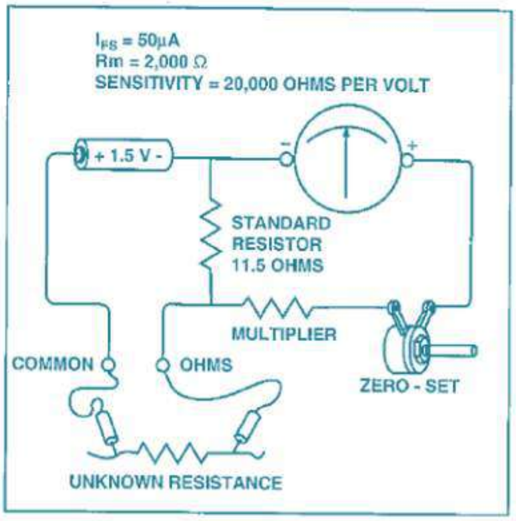
Potentiometer-type Ohmmeter:

The series type ohmmeter has a shortcoming in that resistances on the high end of the scale are crowded together on the meter face.

This problem is solved to some extent by the potentiometer type ohmmeter, as its meter face is not thatcrowded.

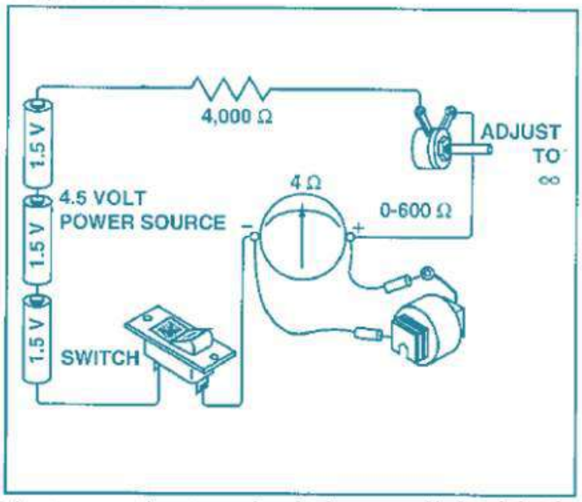
To accomplish this, a low resistance resistor is connected in series with the battery and the resistance to be measured. This sets up a voltage dividercircuit.

A voltage divider circuit turns a large voltage into smaller one and so the output voltage is a fraction of the input. Based on that the scale is calibrated and so it will be easy to read.



Shunt-type Ohmmeter:

It is sometimes necessary to measure very low resistances, such as that of a primary winding of a magnetocoil.
To do this, a shut type ohmmeter isused.
The shunt type ohmmeter uses a meter with a very low internal resistance connected in series with a switch, a fixed resistor, a variable resistor, and a powersource.

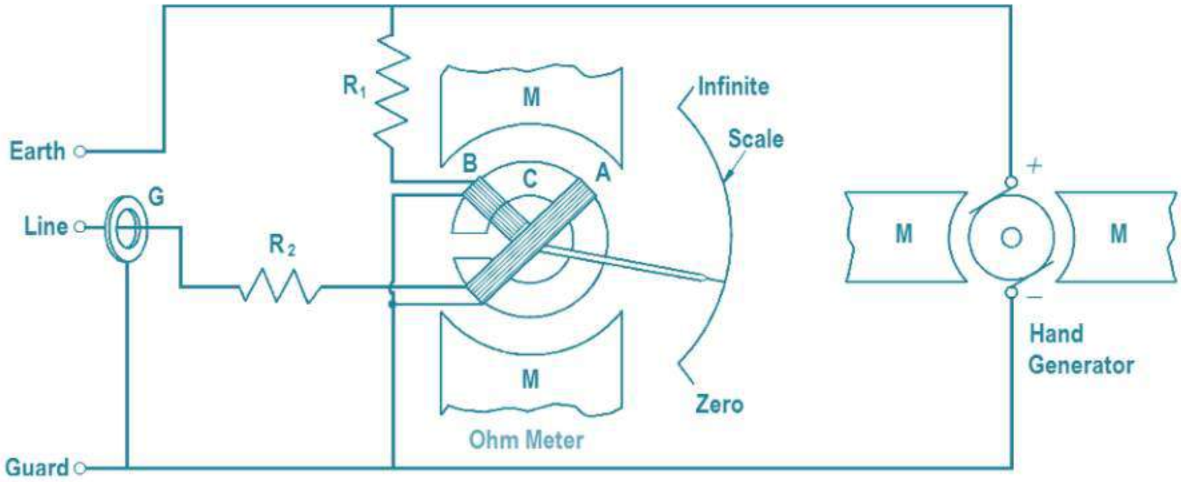


The unknown resistance is placed between the terminals in parallel with themeter movement. The smaller the resistance value being measured, the less current flows through themeter.
The value of fixed resistor is usually large compared to the resistance of the meter movement. This keep the current drawn from the battery practicallyconstant.
Thus, the value of unknown resistor determines how much current flows throughthe meter and how much through the unknown resistoritself.

Megger (Megohmmeter):

The megger, or megohmmeter, is a high range ohmmeter containing a hand-cranked generator, which allows the operator to produce a voltage of several hundredvolts.
It is used to measure insulation resistance and other high resistancevalues.
It is also used for ground, continuity, and short circuit testing of electrical power systems.
The chief advantage of the megger over an ohmmeter is its capacity to measure resistance with a high potential, or "breakdown" voltage. This type of testing ensures that insulation or a dielectric material will not short or leak under

potential electrical stress.



Parts and Working of the megger circuit:

Hand cranked generator:

A series ohmmeter can be used to measuring high resistance values and shunt ohmmeter can be used for measuring very low resistance values. For very high resistance in insulation and dielectric, a megger can beused.

So, for measuring high resistances, high voltage has to be supplied by the ohmmeter to the unknownresistance.

A hand generator as shown in figure is cranked to supply the necessary high voltage through the circuit. (Incase of other ohmmeters, as they measure very low or moderate resistances, they have inbuilt batteries to supply the necessaryvoltage).

Control coil(B) and Deflecting coil(A) in Core(C):

If the terminals are open circuited, no current flows in coil A, but the current flows in coil B which controls the movement of thepointer.

Coil B takes a position opposite the gap in the core (since the core cannot move and coil B can), and the pointer indicates infinity on thescale.

Note:The reader may get a doubt here, as if current flows through coil B, the circuit will be completed and pointer should move to zero, indicating that there is current in megger circuit and so zero resistance. Actually, the scale is written as infinity in the direction the pointer moves when current flows through coil B. The reason is asfollows:

When a resistance is connected between the terminals, current flows in coil A, tending to move the pointerclockwise.

At the same time, coil B tends to move the pointer counter clockwise. Therefore, the moving element, composed of both coils and the pointer, comes to rest at a position at which the two forces arebalanced.

This position depends upon the value of the external resistance, which controls the relative magnitude of current of coilA.

Note:There are no restraining springs on the movable member of the instrument portion (Coil core) of the megger. When the generator is not in operation, the pointer floats freely and may come to rest at any position on the scale.

Types of hand-driven meggers:

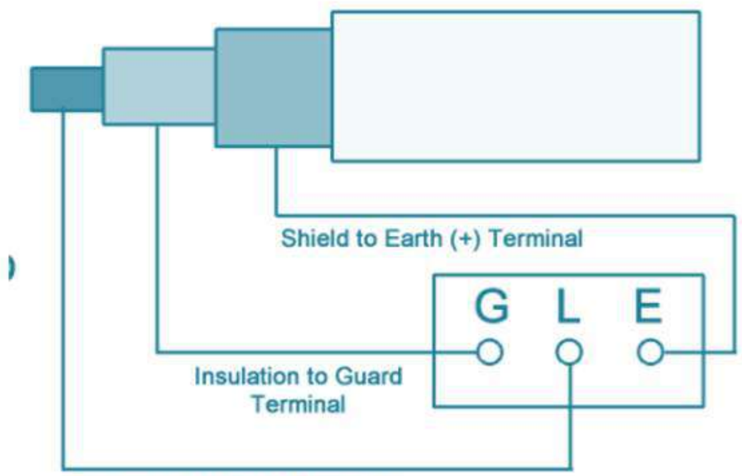
There are two types of hand-driven meggers: the variable type and the constant pressuretype.

The speed of the variable pressure megger is dependent on how fast the hand crank is turned.

The constant pressure megger uses a centrifugal governor, or slip clutch. The governor becomes effective only when the megger is operated at a speed above its slip speed, at which speed its voltage remainsconstant.

A simple use of Megger:

Sample connections for cable insulation resistance testing



When the hand generator is cranked, the current flows through the coil B and moves the pointer toinfinity.

Then the current flows through the coil A to the line which is connected to the conductor of a wire as shownabove.The insulation of the wire is connected to the earth terminal of megger, which completes the circuit. But the circuit will be completed only when the electrons flow through the conductor and through the insulation and back to megger'searth.

The megger is sending very high voltages to test the insulation resistance of thewire insulation, which will be very high. If the insulation resistance is very high and if it doesn't allow any electrons to pass through, then current from coil A through conductor will not flow and Pointer will still be at infinity showing that infinite resistance is there in wire insulation.

But if the wire insulation is week and if the resistance is lowered, then the high voltage electrons will flow through the circuit, to the earth. This completes the circuit and the pointer moves from infinity to a particular lower value as per the wire insulationresistance.

Why a DC meter cannot be used to measure AC

A DC meter, such as an ammeter, connected in an AC circuit will indicate zero, because the meter movements used in a d 'Arsonval type movement is restricted to direct current.

Since the field of a permanent magnet in the d'Arsonval type meter remains constant and in the same direction at all times, the moving coil follows the polarity ofthe current.

The coil attempts to move in one direction during half of the AC cycle and in the reverse direction during the other half when the currentreverses.

The current reverses direction too rapidly for the coil to follow, causing the coil to assume an averageposition.

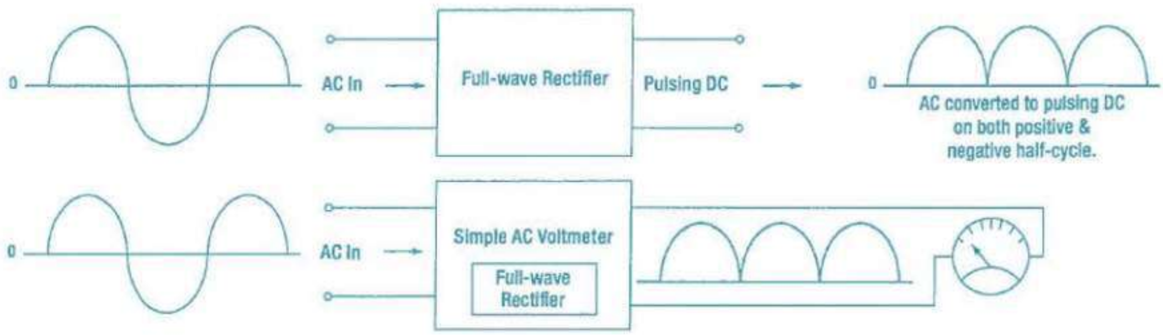
Since the current is equal and opposite during each half of the AC cycle, the direct current meter indicates zero, which is the averagevalue.

Thus, a meter with a permanent magnet cannot be used to measure alternating voltage and current.

D'Arsonval meter with a rectifier for Measuring AC

For AC measurements of current and voltage, additional circuitry isrequired.

The additional circuitry has a rectifier, which converts AC to DC. There are two basic types of rectifiers: One is the half-wave rectifier and the other is the full-waverectifier.



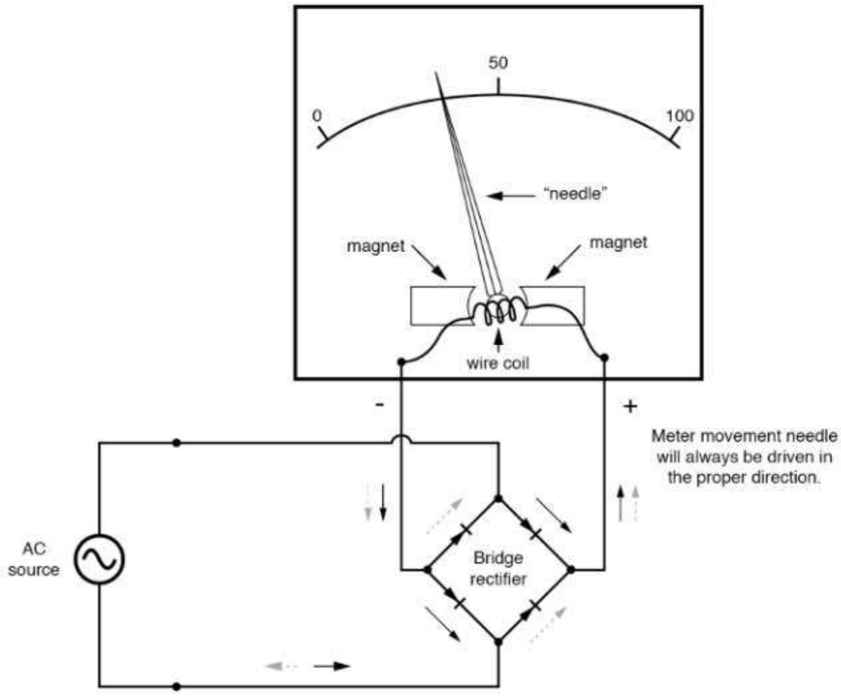
In this depiction, the full-wave rectifier precedes the metermovement.

The movement responds to the average value of the pulsating DC. The scale can then be calibrated to show anything the designerwants.

In most cases, it will be root mean square (RMS) or peakvalue.

Example of a D'Arsonval meter with a rectifier for Measuring AC (A multirangevoltmeter):

When the meter is set to AC, it connects with the inbuilt bridge rectifier, which is biased and so the input AC can flow in one direction only into the meter, for both +ve and -ve AC cycles.



Principle of AC measuring instruments – Electrodynamometer movement:

How it differs from a D'Arsonval meter movement?

The electrodynamometer can be used to measure alternating or direct voltage and current.

It operates on the same principles as the permanent magnet moving coil meter, except that the permanent magnet is replaced by an air core electromagnet(fixedcoils).

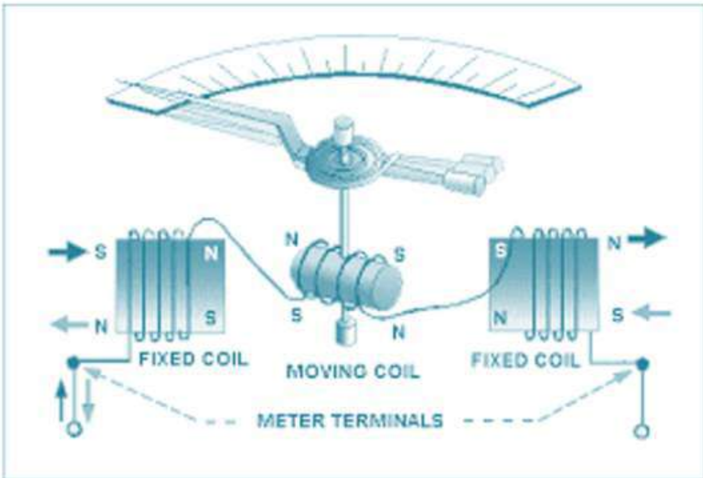
In a D'Arsonval meter, the field that repels the coil's field is given by permanent magnet, while the field of the electrodynamometer is developed by the current through the fixed coils and movablecoils.

Note:An air core electromagnet is nothing but a coil wounded without any iron (like asolenoid)or wounded around aninsulator.

How it works?

The fixed coils and movable coils are connected in series and wounded in such a way that when the current flows through them, the movable coil will getrepelled.

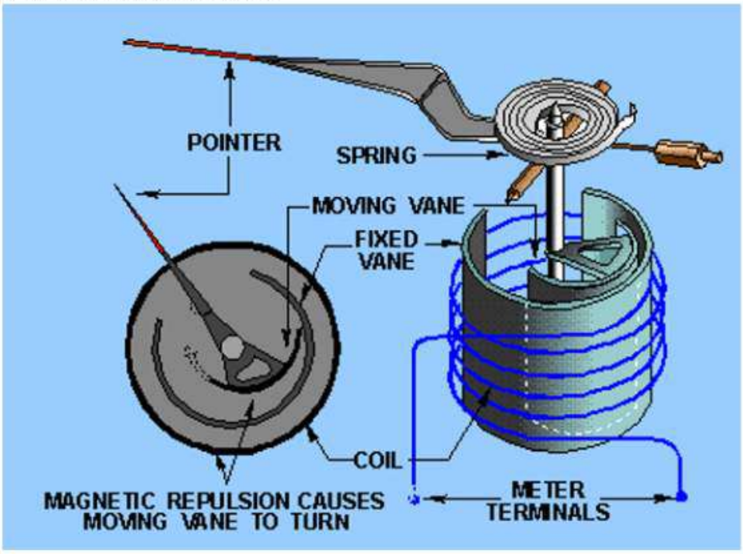
If the current reverses, the polarity also reverses, but between the movable coil and fixed coils, same polarity will exist which keep on repelling the coil in same direction and so pointer will move over scale in same direction for both cycles. See thefigure.



Note:However, for either voltmeter or ammeter applications, the electrodynamometer is tooexpensive to economically compete with the d 'Arsonval type movement.

Moving iron vane meter (Repulsion type):

The moving iron vane meter is another basic type of meter. It can be used to measure either AC orDC.
Unlike the d'Arsonval meter, which employs permanent magnets, it depends on induced magnetism for itsoperation. It utilizes the principle of repulsion between two concentric iron vanes, one fixed and one movable, placed inside a solenoid. A pointer is attached to the movablevane.



How it works?

When current flows through the coil, the two iron vanes become magnetized withnorth poles at their upper ends and south poles at their lower ends for one direction of current through thecoil.
Because like poles repel, the movable vane turns against the force exerted bythe springs.

How the tapered design of fixed vane helps in moving the movablecoil?

When no current flows through the coil, the movable vane is positioned so that it is opposite the larger portion of the tapered fixed vane, and the scale reading iszero.

The amount of magnetization of the vanes depends on the strength of the field, which, in turn, depends on the amount of current flowing through thecoil.
The force of repulsion is greater between the movable vane and larger portion of fixed vane, than at the smallerend. This is because the flux density is more near larger end due to more material than at smallerend.
Therefore, the movable vane moves toward the smaller end through an angle that is proportional to the magnitude of the coilcurrent.
The movement ceases when the force of repulsion is balanced by the restraining force of thespring.
Because the repulsion is always in the same direction (toward the smaller end of the fixed vane), regardless of the direction of current flow through the coil, the moving iron vane instrument operates on either DC or ACcircuits.

Damping:

Mechanical damping in this type of instrument can be obtained by the use of an aluminum vane attached to the shaft so that, as the shaft moves, the vane moves in a restricted airspace.
This slows the motion of pointer and ultimately reduces the oscillations of pointer over the scale.

Aluminium vane enclosed in air chamber, attaches with the pointer

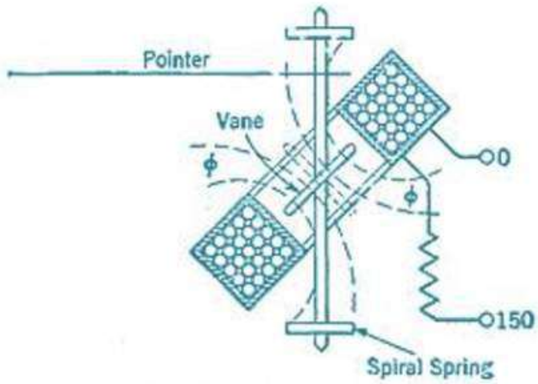
Moving iron vane meter for ammeter and voltmeter:

When the moving iron vane meter is used as an ammeter, the coil is wound with relatively few turns of large wire in order to carry the ratedcurrent.
Whenthemovingironvanemeterisusedasavoltmeter,thesolenoidiswoundwith
many turns of small wire.

Limitations:

Because the reluctance of the magnetic circuit is high, the moving iron vane meter requires much more power to produce full-scale deflection than is required by a d 'Arsonval meter of the same range. Therefore, the moving iron vane meter is seldom used in high resistance low powercircuits.

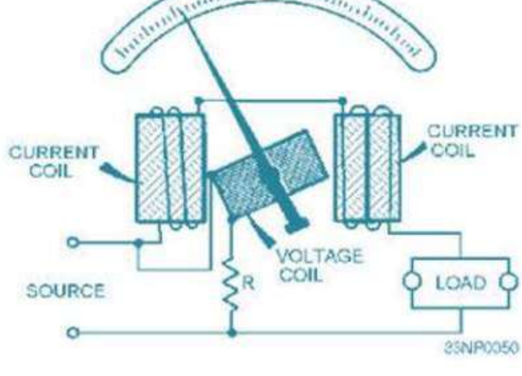
Inclined Coil iron vane meter (Attraction type):



The principle of the moving iron vane mechanism is applied to the inclined coil type of meter, which can be used to measure both AC andDC.
The inclined coil, iron vane meter has a coil mounted at an angle to the shaft. Attached obliquely to the shaft, and located inside the coil, are two soft ironvanes.
When no current flows through the coil, a control spring holds the pointer at zero, and the iron vanes lie in planes parallel to the plane of thecoil.
When current flows through the coil, the vanes tend to line up with magnetic lines passing through the center of the coil at right angles to the plane of thecoil.
Thus, the vanes rotate against the spring action to move the pointer over thescale.
The iron vanes tend to line up with the magnetic lines regardless of the direction of current flow through thecoil.
Therefore, the inclined coil, iron vane meter can be used to measure either alternating current or direct current. The aluminum disk and the drag magnets provides electromagneticdamping.
Like the moving iron vane meter, the inclined coil type requires a relatively large amount of current for full-scale deflection and is seldom used in high resistance low power circuits.
As in the moving iron vane instruments, the inclined coil instrument is wound with few turns of relatively large wire when used as an ammeter and with many turns of small wire when used as avoltmeter.

Wattmeter:

Electric power is measured by means of awattmeter.
Because electric power is the product of current and voltage, a wattmeter must have two elements, one for current and the other forvoltage.
For this reason, wattmeters are usually ofthe electrodynamometer type.



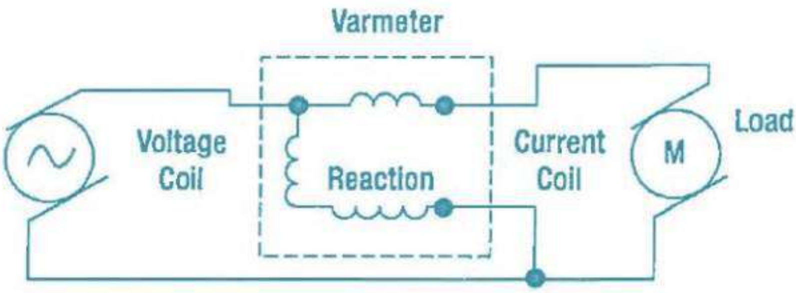
How it works?

Since the pointer has to measure Power, which is a product of V and I, the current reading 'I' can be taken from fixed coils (current coil) as they will be in series when the meter leads are connected to a source (see infigure).
And also, as the fixed coils has to measure current, they are made with small number of large turns, so the resistance will be very less and so source current can flow in the fixed coilfreely.
Voltage reading 'V', can be taken from the movable coil (voltage / potential coil) and for that reason it will be in parallel connection when the meter leads are connected to the source. And also, as movable coil has to measure voltage, they are made with large number of small turns and so there will lot of resistance in the coil, from which voltage drop can bemeasured.
So, the power value is shown by the pointer over the scale which is graduated for the product of V andI.
If the current in the line is reversed, the direction of current in both coils and the potential coil is reversed, the net result is that the pointer continues to read up scale. Therefore, this type of wattmeter can be used to measure either AC or DC power.

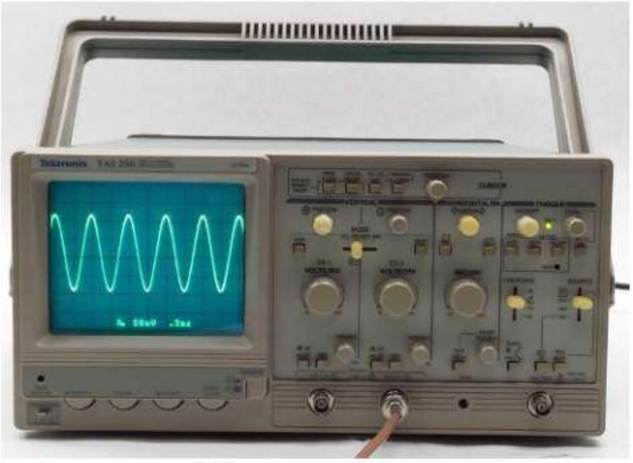
Varmeter:(VAR – Volts Amps Reactive)

Multiplying the volts by the amperes in an AC circuit gives the apparent power: the combination of the true power (which does the work) and the reactive power (which does no work and is returned to theline).
Reactive power is measured in units of vars (volt-amperes reactive) or kilovars (kilovolt- amperes reactive, abbreviatedkVAR).
When properly connected, wattmeters measure the reactive power. As such, they are called varmeters.
How it works:

As you can see from the figure, similar to a wattmeter, the voltage and current coils of varmeter will be connected (in parallel and series), when its leads are connected to a source.
There's another coil called reactive coil in the meter, which connects the return line of the circuit and it measures the reactive power based on the current that flows through it. And the pointer moves based on the current through all threecoils.



CRO (Cathode Ray Oscilloscope):

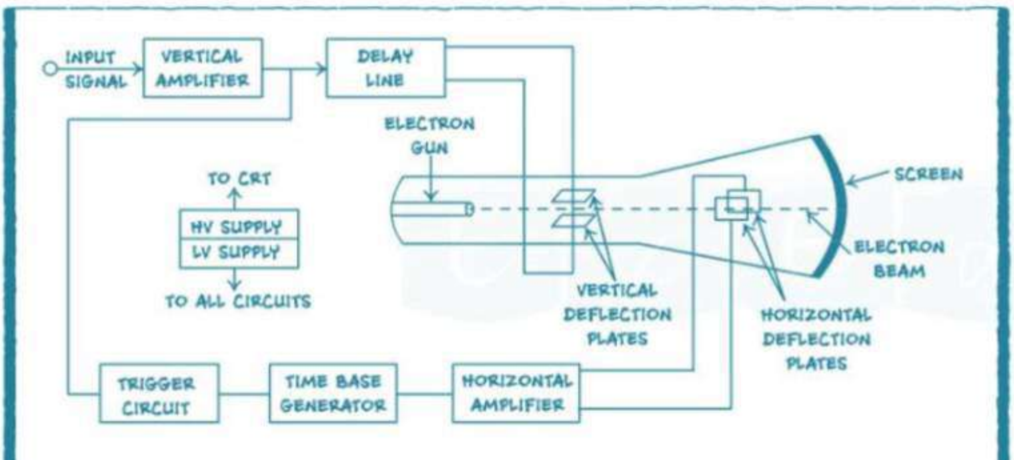


[Note:What we are going to learn about CROis, how this waveform (as seen in above picture) is created and how an operator uses thecontrols to plot the waveform perfectly over the screen (which is a graph) to find variousquantities like frequency, time duration, voltage, etc.]

What is CRO?

It gets its name from the use of CRT (Cathode ray tube) present inside the equipment. CRT has an electron gun, which produces a fine beam of electrons and when it hits a phosphorus coated screen, emitslight.
Deflection plates present inside the CRT gets the input signal and bend the electron beam which then draws the waveform on the screen. Waveform depends on the inputsignal.
The operator can use the controls of CRO to control the intensity and focus of beam and the time period, to plot the waveform perfectly on the screen, from which different quantities can befound.
So, with the help of a CRO, one can visualize the waveform of input signal and also measure its quantities, unlike other measuring instruments which we have seen so far can only measure the quantities like voltage, ampere,etc.

How it works:

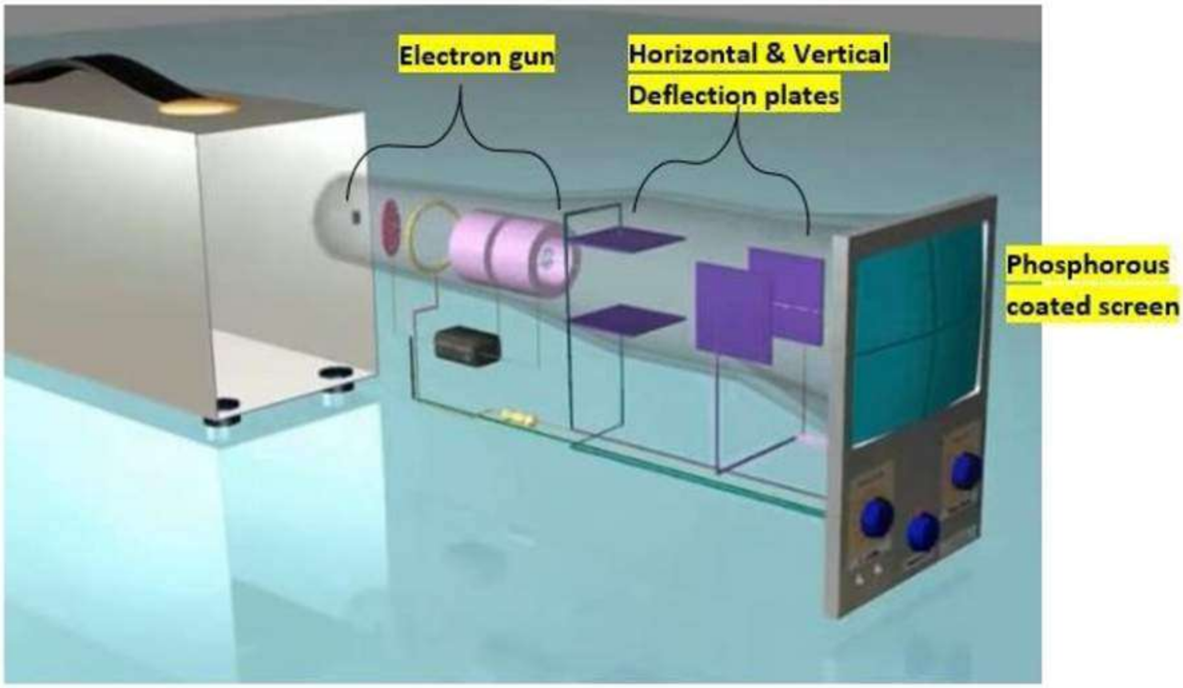


Block Diagram of General Purpose CRO

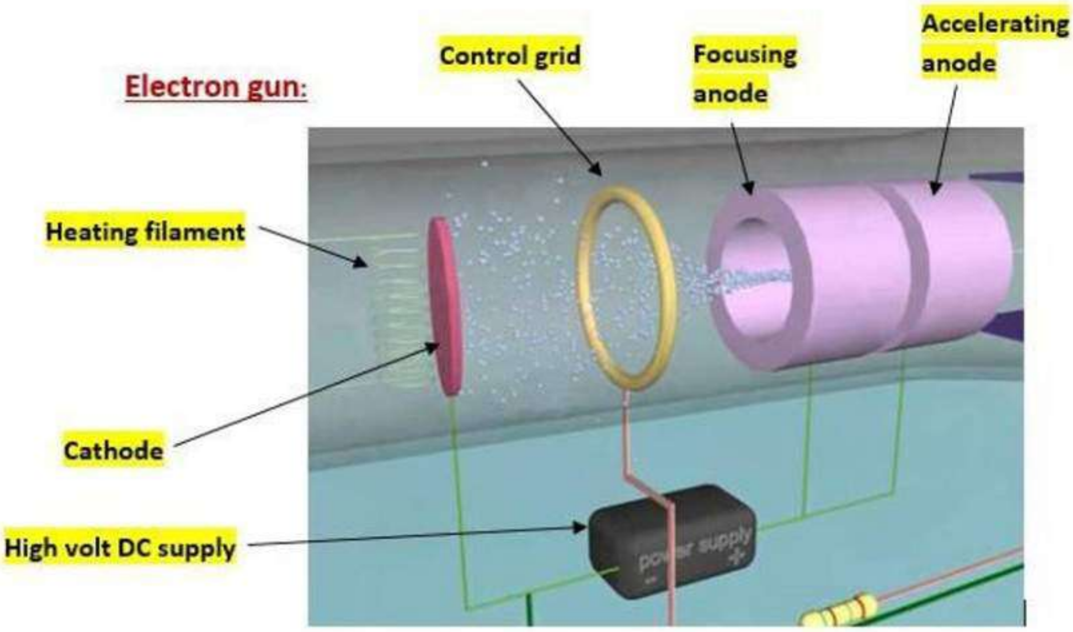
- Vertical Amplifier
- Delay Line
- Trigger Circuit
- Time Base Generator
- Horizontal Amplifier
- Cathode Ray Tube (CRT)

From the block diagram one can understand that there are so many components. So first we will see how a fine beam of electrons is produced byCRT.
CRT:

CRT has three majorparts
Electron gun – Produces a fine beam ofelectrons
Deflection plates – Deflects the electron beam based on the input signal, which in turn moves over the screen as awaveform.
Phosphorous coated screen – converts the electrical energy (electrons) into light energy



Electron gun:



As seen from figure, a high voltage DC supply is sent to cathode. Positive side is connected to focusing and acceleratinganodes.

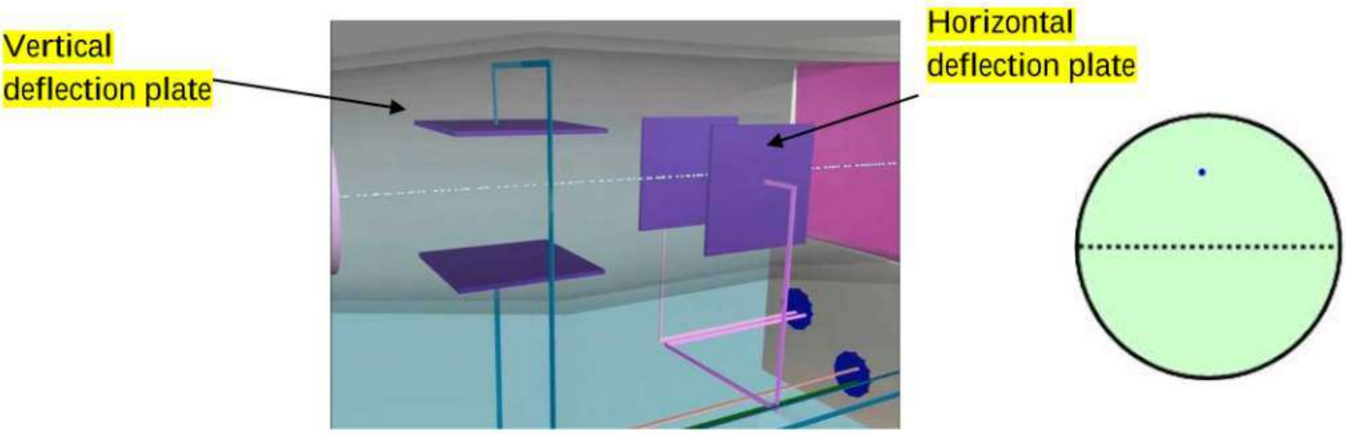
When the heating filament is heated, cathode releases electrons that came from the high voltage supply, by thermionic emission (heated more than its thermalenergy).

Since the emitted electrons are scattered (see figure), a negative voltage is given to control grid, which repels all the scattered electrons towards the center to form a finebeam.

The intensity (brightness), of beam is controlled by a switch which controls the voltage sent to control grid.
Example:For more brightness of waveform on screen, more electrons of thick beam required, so negative voltage to control grid can be reduced, and so repelling force around control grid reduces which allows more electrons of thick beam to passthrough.

Since the positive side of High voltage DC is connected to focusing and accelerating anode, the electrons will get attracted towards it and keep on moving as everything is enclosed in vacuum.
Accelerating anode controls the speed of electrons while focussing anode controls the focus of electrons on the screen. Focus switch helps to control the focus of beam onscreen.
Phosphorous screen:

When this beam of electrons hits the screen that is coated with phosphor, it is converted to lightenergy.
The surface of the screen is also an anode and will assist in accelerating the electronbeam.
It will be seen as a dot on screen, which indicates that the electron beam is focussedcorrectly.
For more brightness, the intensity switch can be adjusted, which adjusts the control grid, as explainedbefore.
Vertical and horizontal deflection plates:



Initially, a dot appears on the screen when the instrument isON.

The input signal is given to vertical deflectionplates.

Example:If AC signal is given to the vertical deflection plates, for +ve cycle, they deflect the electron beam vertically over the screen upwards as the electron beam gets attracted towards positive. During - ve cycle, the electron beam repels and gets deflected downwards. And that's how the screen shows +ve and -ve peaks of sinewave.

The vertical deflection plates deflect the beam only vertically. Butthere should be some gap (time duration) between +ve and -ve peaks. For that, the beam should be deflected horizontally also. Then only you will get a proper sine waveform for AC

In order to have this uniform time duration between two peaks, the input signal is sent to a trigger (see in blockdiagram).

Trigger and time base generator:

When the input signal reaches the trigger, it sends a signal to the time basegenerator.

The time base generator produces a constant velocity sawtooth waveform signal and supply it to the horizontal deflectionplates.

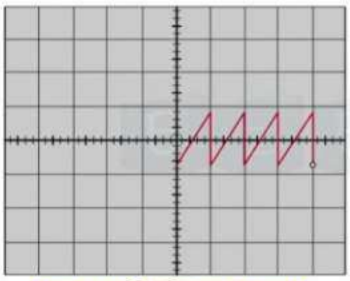
As seen in the graph given, a saw tooth waveform signal has constant Y-axis value (velocity) and Uniform X-axis value(Time).

Whenthissignalissuppliedtothehorizontaldeflectionplates,the +ve and -ve peaks produced by the vertical deflection will have a uniform time duration in-between.

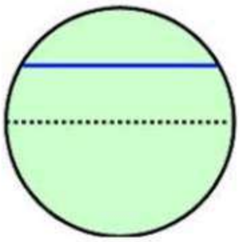
Thus, a sine wave is produced for an ACinput.

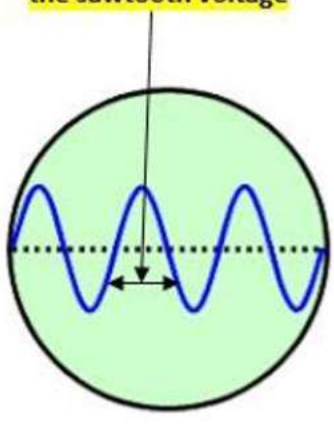
If a DC input is supplied, then vertical deflection plates will not deflect the electron beam as DC is unidirectional. So, the sawtooth voltage to horizontal deflection plates only moves the electron beam horizontally and so a straight line appears forDC.

The amplifiers strengthen the signal before reaching the plates and the delay line delays the input signal to vertical deflection plates so both horizontal and vertical deflection of beam will besynchronized.



Sawtooth waveform

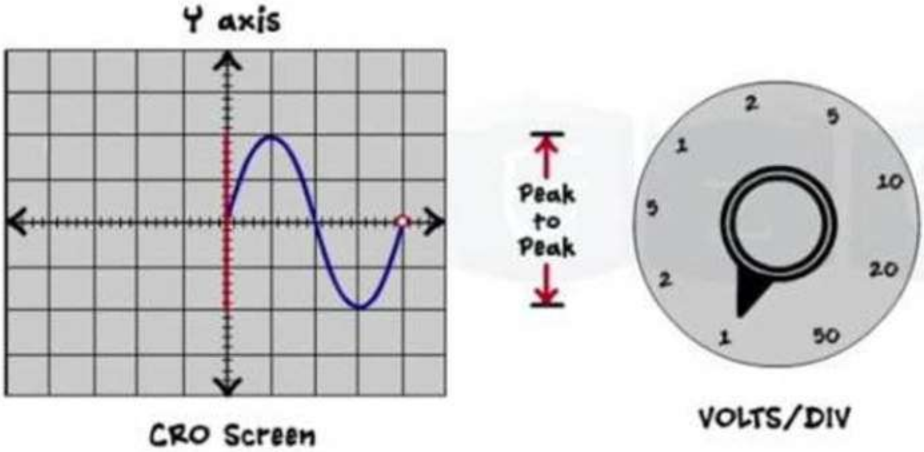




A trigger helps in this synchronization by send timely signal to time base generator for producing the saw tooth voltagesignal.

CRO:

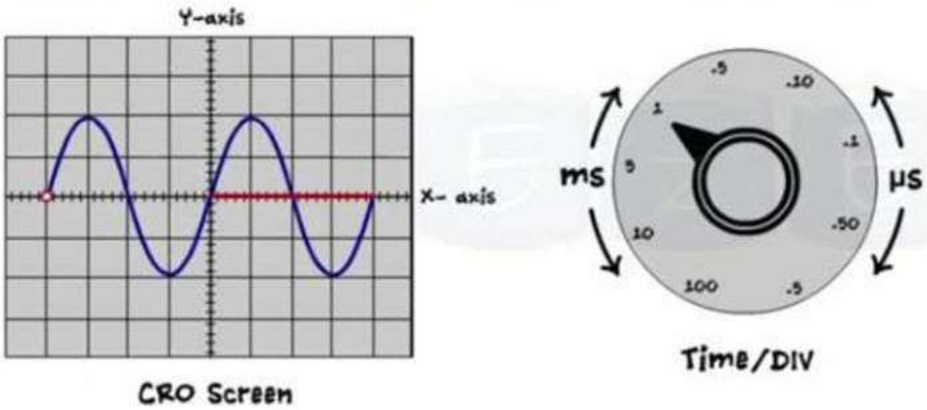
Measuring voltage of input signal:



- ✓ **Once the graph appears on the screen, use X- and Y- Position buttons to fix the graph correctly.**
- ✓ Then set the Value of Volt per each division to shrink the waveform correctly to place it within the screen.
- ✓ In given figure, volt/div is set as 1. so each division in Y axis is 1 volt.
- ✓ Peak to peak the voltage is calculated and so V = 4 Volts

CRO:

Measuring Time & Frequency of input signal:



- ✓ **Once the graph appears on the screen, use X- and Y- Position buttons to fix the graph correctly.**
- ✓ Then set the Value of time per each division to shrink the waveform correctly to place it within the screen.
- ✓ In given figure, time/div is set as 1ms. so each division in X axis is 1ms.
- ✓ For one complete cycle, time is calculated and so t = 4ms.

Frequency and Time Period are inverse to each other

$F = \frac{1}{T}$

$F = \frac{1}{4}$ $F = 250\ Hz$

– Avionics general testequipment

GTE (Ground test equipment) – ATE

Automatic test equipment (ATE) is dedicated ground test equipment that provides a variety of different functional checks on line-replaceable units (LRUs) or printed circuit boards(PCBs).
ATE usually incorporates computerized control with displays and printouts that indicate what further action (repair or adjustment) is necessary in order maintain the equipment.
Equipment may then require further detailed tests and measurements following initial diagnosis.
ATE tends to be dedicated to a particular type of avionic system; means for each avionic system, an ATE is developed. It is therefore expensive to develop, manufacture and maintain.
Because of this, ATE tends to be only used by original equipment manufacturers (OEMs) and licensedrepairers.
Systems have been developed to match the complexity of electrical and electronic systems to assist the avionics engineer in fault finding on aircraftsystems.
On-board diagnostics use a range of techniques that are built into and integrated with the aircraftsystems.
Such ODE are;

CMS (Centralized Maintenance system) with BITE (Built-in TestEquipment)
ACARS (Aircraft communication addressing and reportingsystem)
Note: LRU– The individual avionic systems and computers that can be removed from the aircraft for maintenance and repair. Unlike EWIS (Wiring systems)

ODE (On-board diagnostic equipment) – BITE:

In most aviation maintenance operations, electronic troubleshooting and repair of avionics Line Replacement Units (LRU's) and avionics systems are performed by the B-2 technician specially trained in suchmatters.
Use of Built In Test Equipment (BITE) may be the only exposure to avionics testing a B-1 engineer experiences.
Built in test equipment is a common feature on all modern aircraft.
As the name implies, built-in test equipment (BITE) is primarily a self-test feature built into aircraft electrical and electronic equipment as a meansof:
detecting and indicating specific equipmentfaults
monitoring equipmentperformance
detectingproblems
storing faultdata
isolate faultysensors/components.

The origins of BITE started with simple on/off displays on the front of line replaceable units (LRU) to assist the avionics engineer with troubleshooting; this display (typically a light- emitting diode, LED) would indicate the go/no-go status for a particular unit, either as a result of system test or in-flightfault.
If the LED indicates an LRU fault, the engineer either changes the LRU or check the interfaces (connections) with the unit. This simple technique is applied to individual LRUs, and will only indicate real-timefaults.
BITE techniques were developed alongside the increasing complexity of electrical and electronicequipment.
Features such as fault storage provide an indication of faults over many flights; this information is often provided in coded form and needs to be interpreted by theengineer.
Note (Just for understanding): BITE is similar to the security and cleaning system in our mobile / laptop which are inbuilt in it. While using such features, we can find the faulty apps and virus.BITE is usually designed as a signal flow type test. If the signal flow is interrupted or deviates outside accepted levels, warning alerts indicate a fault has occurred. The functions or capabilities of BITE include thefollowing:

real-time monitoring ofsystems
continuous displaypresentation
sampled recorderreadouts
module and/or subassembly failure isolation
verification of systemsstatus
go/no-goindications
quantitativedisplays

Flight Management System

FMS = Flight Management System
FMC = Flight Management Computer

"A flight management system (FMS) is a fundamental component of a modern airliner's avionics. An FMS is a specialized computer system that automates a wide variety of in-flight tasks, reducing the workload on the flight crew to the point that modern civilian aircraft no longer carry flight engineers or navigators. A primary function is in-flight management of the flight plan."

Flight Engineer

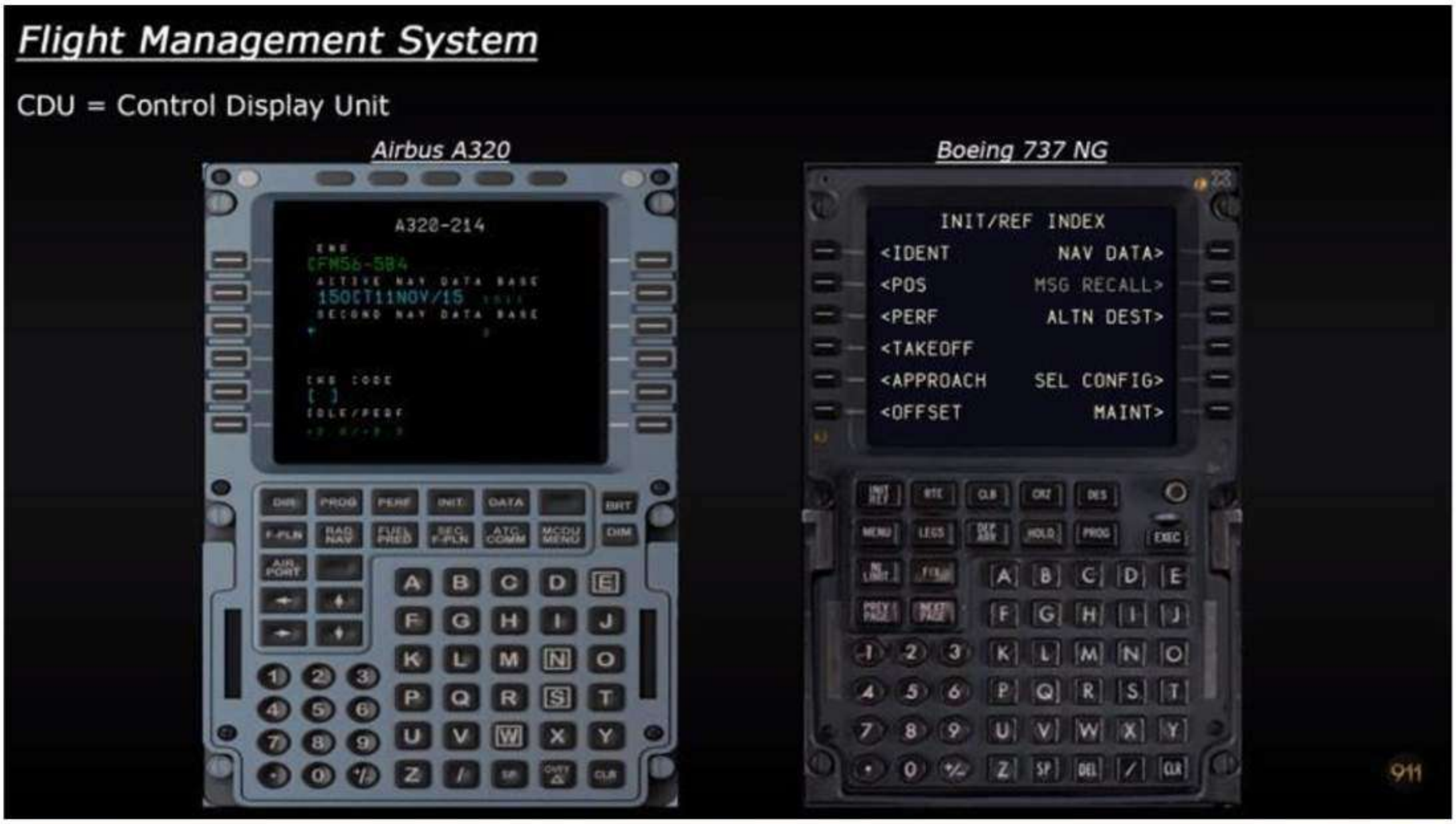
Responsible for Engine + Fuel Management, Electrical, Hydraulics and other systems.

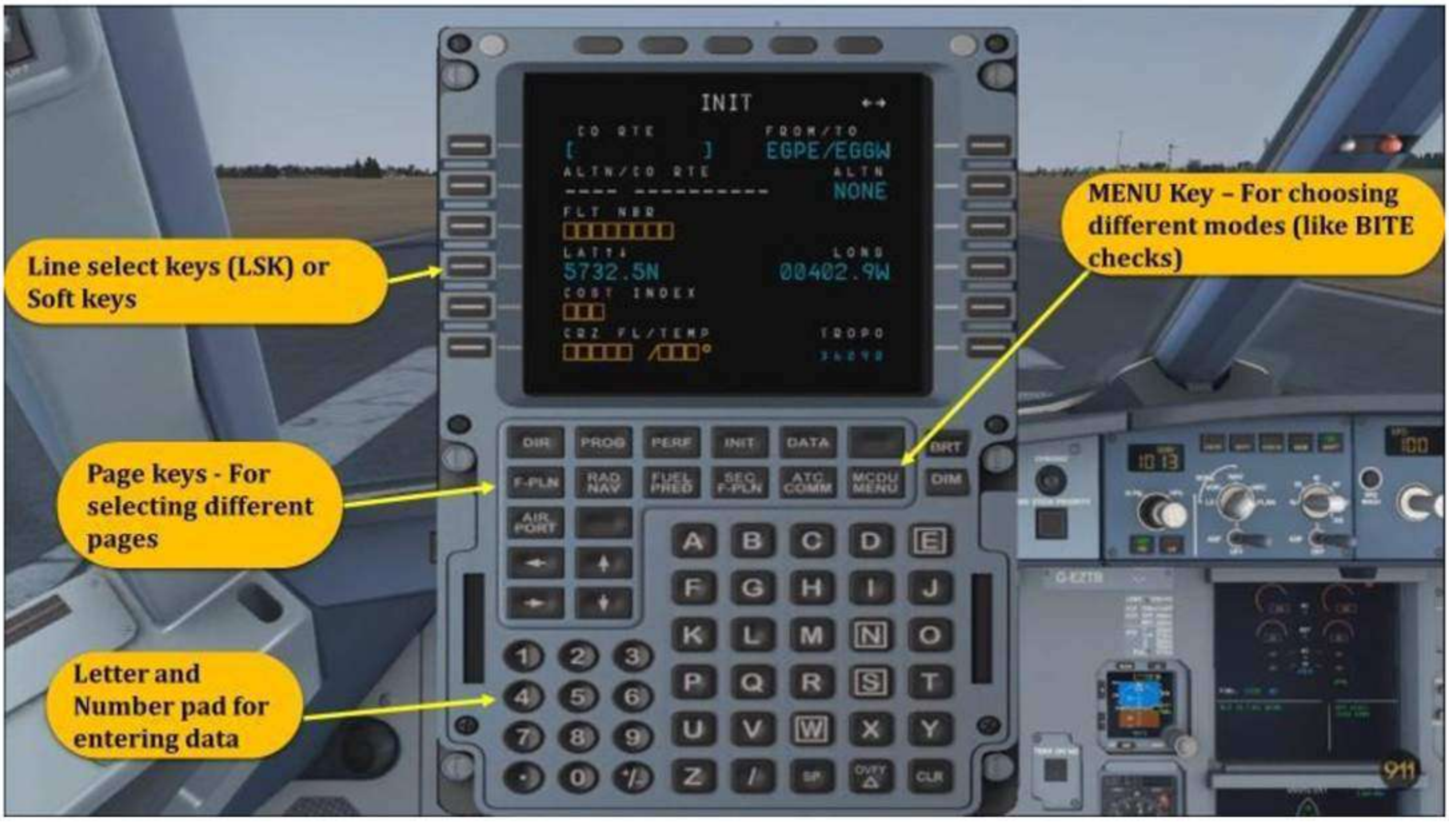
Navigator

Route Planning, Radio Navigation and Flight Timing.

These roles are fulfilled by a Flight Management System in modern aircraft.

911





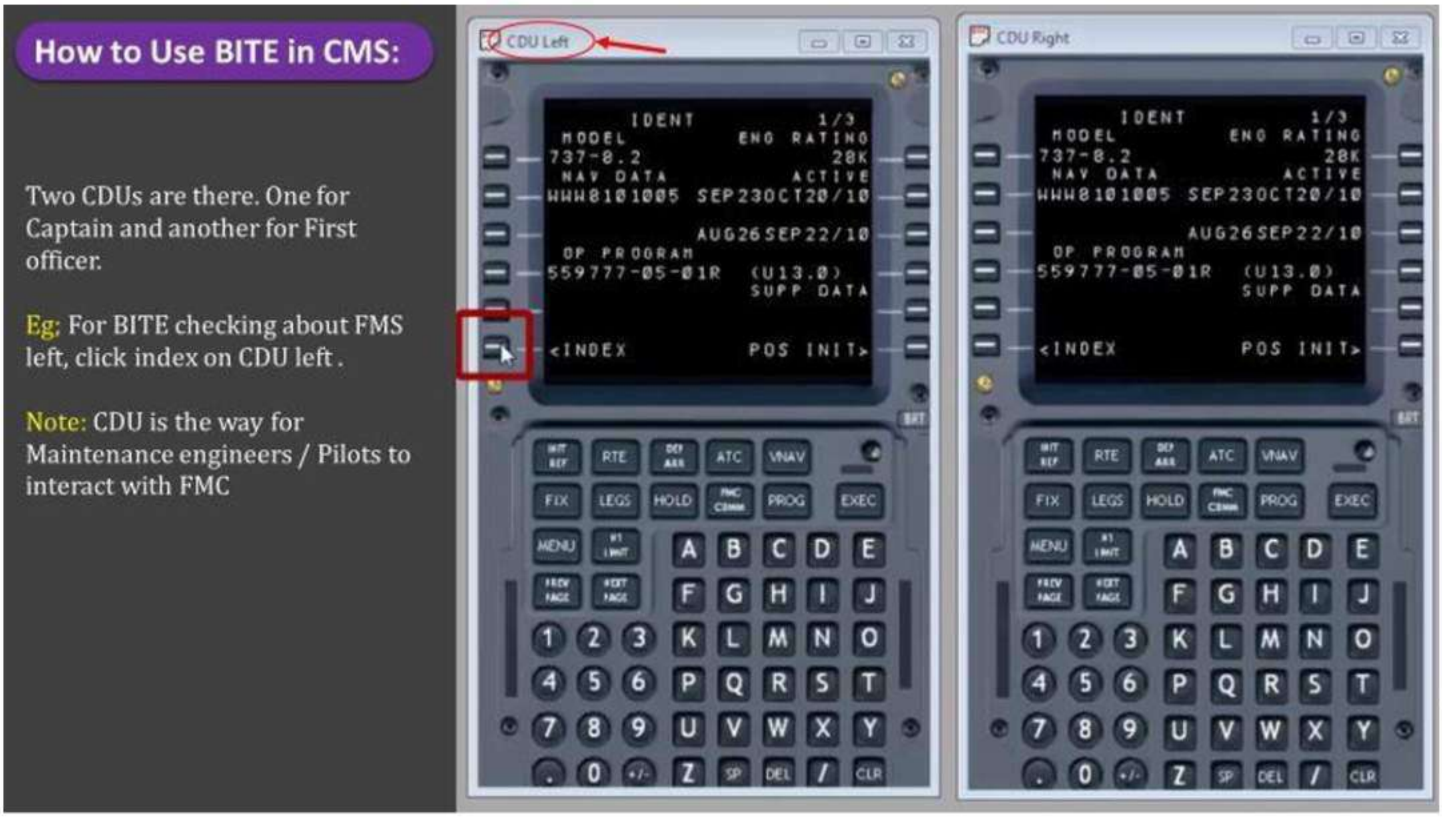
Centralized Maintenance system (CMS):
(Central maintenance computer + Control Display unit):

BITE technology has now been developed into centralized maintenance systems on modern aircraft.

The electronic centralized aircraft monitoring system in airbus (ECAM) or Engine indications and crew alerting system (EICAS) oversees a variety of aircraft systems and also collects data on a continuousbasis.
While ECAM automatically warns of malfunctions, the flight crew can also manually select and monitor individualsystems.
Failure messages recorded by the flight crew can be followed up by maintenance personnel by using the system test facilities on the maintenance panel in the flight compartment.
Printouts can be produced as permanent records for furtheranalysis.
Fault detection of electronic circuits is a continuous function. Once a fault is detected, an isolation sequence is initiated to pinpoint the problem and display it to the technician.
BITE displays are selected on the central maintenance computer Control Display Units (CDU's). These are typically located on the flight deck and in the avionicscompartment.
On the flight decks of many aircraft, a Flight Management System (FMS) incorporates the central maintenance computer system interface on the same CDU panel(s) used by the flightcrew.
The on-screen display of faults and corrective actions, can be printed or electronic downloaded to capture the BITE produceddata.
An automatic Aircraft Communications Addressing and Reporting System (ACARS) sends BITE maintenance data to the ground maintenance station while the aircraft isen-route.
Replacement parts can be readied for installation so that, when the plane arrives, maintenance personnel can begin the repairimmediately.
A quick turn-around keeps the aircraft flying as scheduled to produce anticipated revenue.
Note:CMC and FMS are used to send & receive information via datalink without requiring crew intervention. CMC collects the warning and failure information from all aircraft equipments.

How to Use BITE in CMS:

While in flight, a fault initiates a BITE recording of parameters that is later displayed to the technician when accessing the BITE on theground.
The maintenance function of BITE is accessible only when the aircraft is on the ground. The technician can select options for display on a Computer Display Unit(CDU).
To interrogate the Central Maintenance Computer (CMC) or conduct a BITE check of a system, the technician selects the BITE checks from the menu in the CDU. And then uses the soft keys fortesting.
There are large buttons next to the CDU display screen, each button is known as a Line Select Key (LSK) of softkeys.
As the technician enters the option by pressing the LSK adjacent to the listing, a new menu appears and provides additional options from which tochoose.
It is important for the technician to check if there are more page options available which can be determined by looking in the corner of thescreen.
A page 1 of 1 means the displayed page is as far as the options extend for that particular system.
Page 1 of 2 means the technician is viewing page 1 of 2 and page 2 contains additional options to selectfrom.
When a new test is selected, a complete check of circuitry and software occurs.This



8

check yields output data that is both recorded and displayed.

How to Use BITE in CMS:

Upon clicking any one system, for example FMCS, a page will open, having options FMCS LEFT and FMCS RIGHT.

Selecting FMCS LEFT will show testing options and data as shown in figure.

The "INFLT FAULT" means fault happened in systems while flying. BITE will record and store such faults during flying and can be viewed after landing, by clicking "INFLT FAULT".

How to Use BITE in CMS:

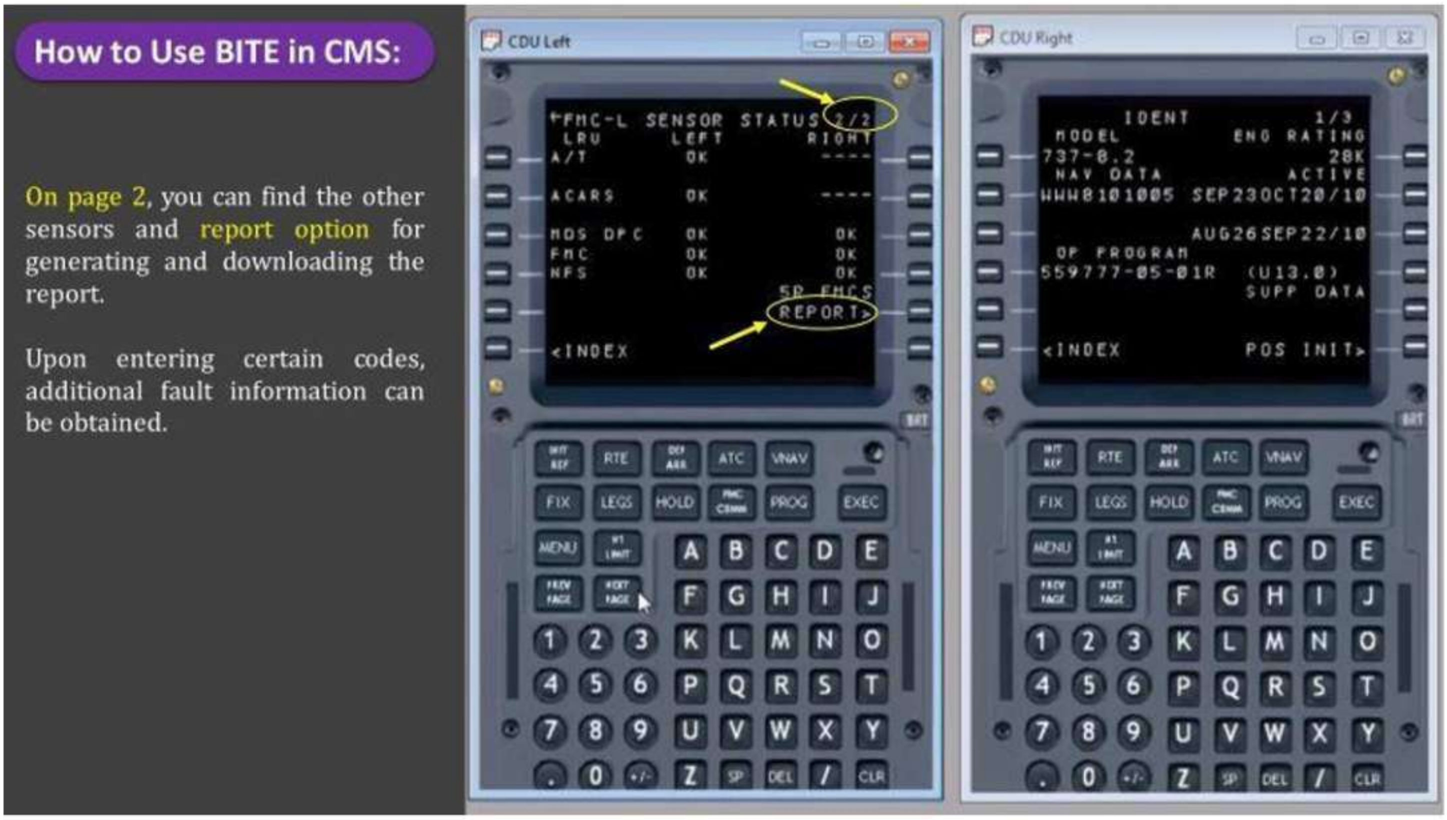
When the sensor option is clicked, you can find the status of all L-FMCS sensors, as shown in fig.

Ok indicates the system is working fine

Fail indicates the sensor is failed

---- indicates the particular sensor is not connected

TEST indicates the sensor is under test



ACARS:

Some aircraft are installed with a system called ACARS (Aircraft communication addressing and reportingsystem). This is a digital data link system transmitted in the VHF range (118 MHz to 136 MHz). ACARS provides a means by which aircraft operators can exchange maintenance and operational data directly without human intervention. ACARS uses an aircraft's unique identifier and the system has some features that are similar to those currently used for electronicmail.

Typical ACARS messages are used to convey routine information suchas:
fueldata • engineperformancedata • aircraft faultdata
passengerloads •departurereports • arrivalreports.

Avionic test equipment – Classification:

All troubleshooting and testing of aircraft electronic equipment is not performed by built in testequipment.
Trained technicians use a wide variety of avionics testing equipment to investigate, test and repair the aircraft's electronic units andsystems.
Avionics test equipment can be classified into two categories: shop test equipment and portable testequipment.
Extensive testing on a piece of equipment while installed may be inconvenient or expensive if the aircraft is held from service because ofit.
Replacement of the unit suspected of malfunction can be accomplished quickly and the unit can be sent to the avionics shop for extensive testing using shop testequipment.

However, a quick check of a unit with a portable test unit can answer critical questions concerning the serviceability of aunit.
Need for portable test equipment:

A modularized, remove and replace approach to avionics maintenance allows quick and easy resolution of many avionicsmalfunctions.

But replacing a piece of avionic equipment may not solve a reportedmalfunction.

Today, aircraft electronics are part of an integrated system connected via a data bus. The problem with a certain avionics unit may be present only when installed and integrated with the aircraft's otheravionics.

Portable avionic test equipment allows the technician to test the suspected unit while it isinstalled.

Classification by function:

Another way to classify avionics testing equipment is byfunction.

Two basic categories exist – generators andanalyzers.

A generator provides a known signal or stimulus which is then processed by the tested unit.

The second type of test equipment, an analyzer, is used to determine whether the output of the unit is within designtolerances.

Generators often have interaction with the unit being tested and release the test signal after conditions aremet.

These more sophisticated signal generators are known as testsets.

Analyzers can be shop-based or portable units. The common multimeter is one type of analyzer. The ability to measure voltage current and resistance is veryuseful.

Many modern digital multimeters include expanded capabilities to measure frequency, capacitance andtemperature.

Oscilloscopes are another commonly used analyzer. Frequency domain analyzers are also common.

Examples include spectrum analyzers, modulation meters and distortionmeters.

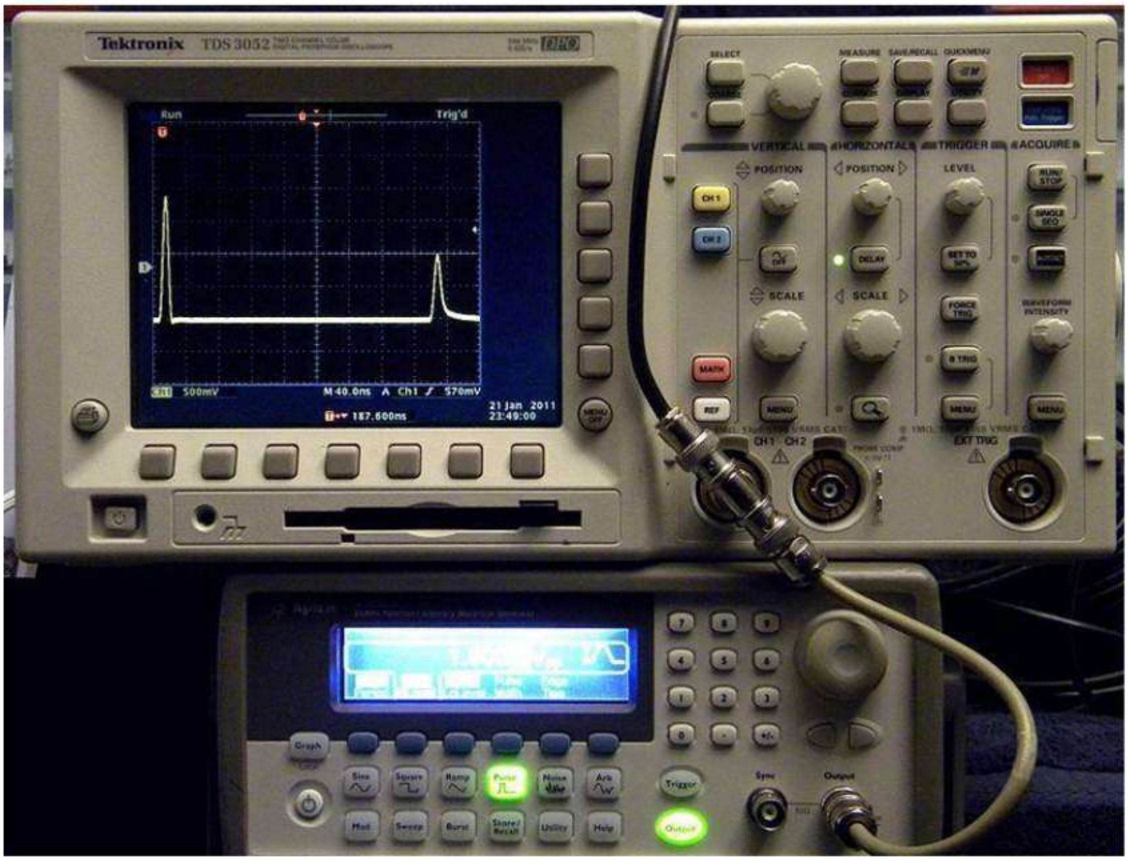
Many modern aircraft make use of computer-based analyzing. A connection is made to a portable laptop computer for processing and display of information. In some cases, an adapter unit allows access directly into the digital databus.

TDR (Time Domain Reflectometer):

A time-domain reflectometer (TDR) is an electronic instrument used to determine the characteristics of electrical lines by observing reflectedwaveforms.

It can be used to characterize and locate faults in metallic cables (for example, twisted pair wire or coaxialcable).

It can also be used to locate discontinuities in a connector, printed circuit board, or any other electricalpath.



A TDR measures reflections along a conductor. In order to measure those reflections, theTDRwilltransmitanincidentsignalontotheconductorandlistenforitsreflections.

If the conductor is of a uniform impedance and is properly terminated, then there will be no reflections and the remaining incident signal will be absorbed at the far-end by thetermination.

Instead,iftherearei mpedancevariationsduetoopen/short/faultycircuit,thensomeof the incident signal will be reflected back to the source from thatfault.

A TDR is similar in principle toradar.

The impedance of the fault/discontinuity can be determined from the amplitude of the reflected signal. The distance along the transmission line (exact location) where the open or short occurs can also be determined from the time that a pulse takes toreturn.

A TDR can also indicate if a cable is pinched orfrayed.

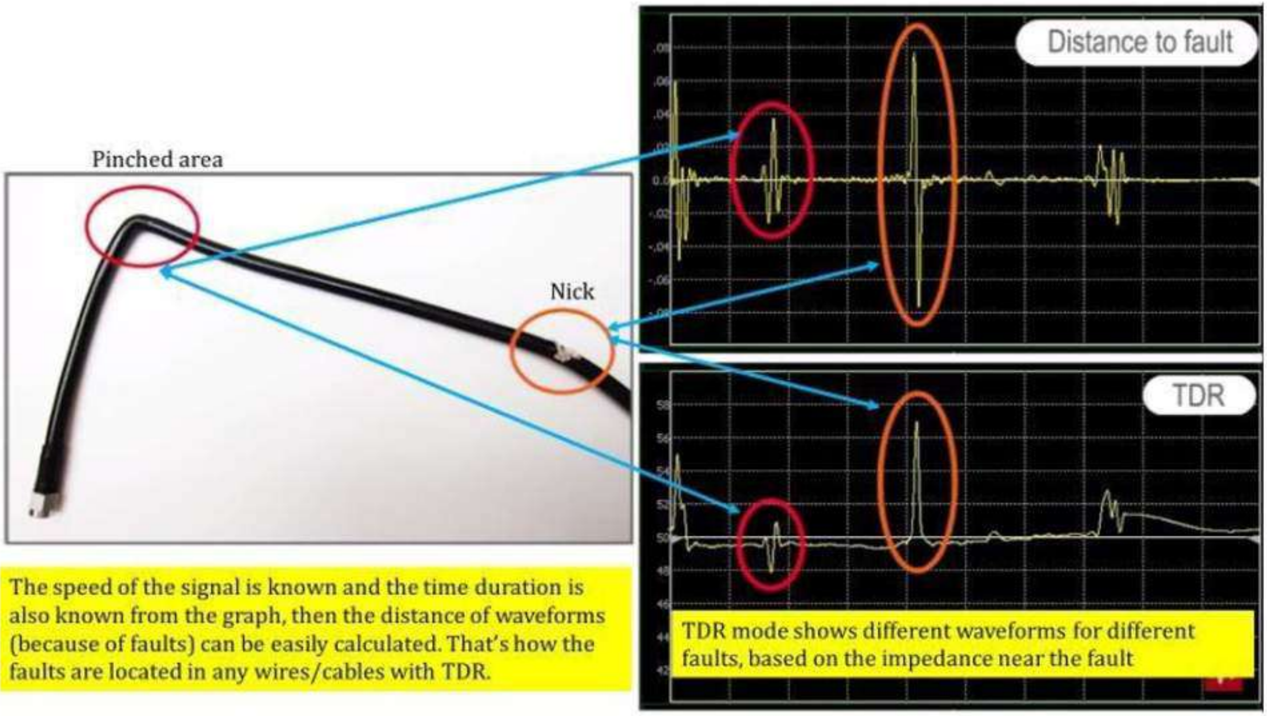
A pinch condition will appear on the graticule as a dip due to added impedance. A fray will cause the trace to driftup.

These two conditions are often found as a partial open or partial short and willappear on the graticule as minor dips or rises in the tracesignal.

Time domain reflectometry, specifically spread-spectrum time-domain reflectometry is used on aviation wiring for both preventive maintenance and faultlocation.

Spread spectrum time domain reflectometry has the advantage of precisely locating the fault location within thousands of miles of aviationwiring.

Additionally, this technology is worth considering for real time aviation monitoring,as spread spectrum reflectometry can be employed on livewires.



Pitot-Static test equipment:

The pitot-static system must be tested periodically to ensure instrumentation that uses pitot and static pressures as inputs provide accurate indications to the flightcrew.

Typical instrumentation on pitot-static test equipment includes an altimeter, vertical speed indicator, and airspeedindicators.

There are two types of diagnostic equipment used for testing the pitot-staticsystem based on their mode of operation.

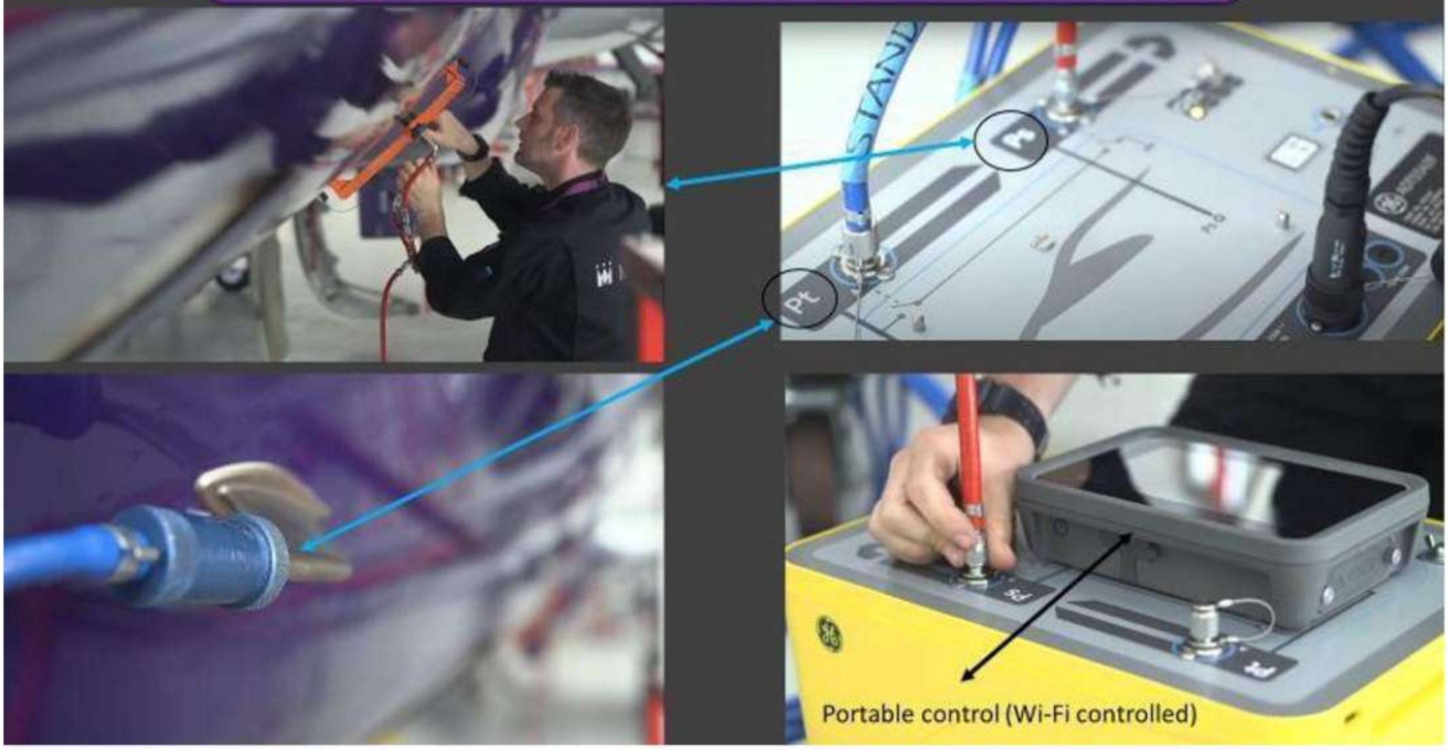
One type operates by the technician manually pumping a small hand pump to change the systempressure.
The second type operates on electrical power to change the systempressure.

Ifthesystemfailsduringtesting,doublecheckthatallportsareproperlysealedandthe aircraft is correctlyconfigured.
If the system fails the check again, review the entries in the aircraft logbook for thelast time an avionics component was maintained orreplaced.

A loose fittings around that component islikely.
Shouldthesystem stillnotpassthetest,anothertestunitcanbeusedtoensurethat there is not a problem with thetester.

If the system continues to fail, the technician must either replace a defective aircraft indicator or check all fittings in the pitot-static system until the malfunction iscorrected.
As always, record results with a logbookentry.

Connecting hoses from test equipment to pitot tube and static port:



1) Test equipment supplying air through hoses and changing the aircraft system pressure as seen in the below PFD.

2) Avionics Engineer sitting in the cockpit with a part of the test equipment which is portable (Wi-Fi controlled) for controlling the input of the test equipment and checking the output in aircraft PFD.

3) As seen in the left figure, the altimeter in PFD is showing 10000 ft for the supplied air pressure from test equipment which is set for 10,000 ft from the portable test equipment control, as seen in right figure. This states that the altimeter part of pitot-static system is working fine.

EngineeringDrawing

Draftsmen drafting aircraftdiagrams

In past, drawings were made on paper or Mylar film in pencil and reproduced as a paper print.

These were blueprints with white lines on a dark bluebackground.

Later these prints were made by a process that produced blue or brown lines on a white background.

Purpose of drawing:

Drawing is the draftsman'slanguage.

The purpose of an engineering drawing is to record and convey thedesigner's requirements.

The drawing must therefore, include sufficient information to enable production planning, manufacture, assembly, testing and inspection of the particular componentor assembly to be carried out.

So that there can be no misinterpretation of drawings, it is essential that both the person preparing the drawing and the person using the drawing should have a knowledge of the terms, symbols, abbreviations, and methods ofpresentation.

Types ofdrawing:

There are drawings for every purpose;

some describe the construction of a single part, others show how parts areassembled, and

some show the way the part is installed in theaircraft.

some drawings are used for troubleshooting, and others are referred towhen overhauling acomponent.

The most important working drawings are:

Detaildrawings

Assembly drawings,and

Installationdrawings

Other types of drawings include sectional drawings, exploded view drawings, block diagrams, logic flowcharts, electrical wiring diagrams, pictorial diagrams, and schematic diagrams.

Each of these drawing is designed to communicate a certain type of information.

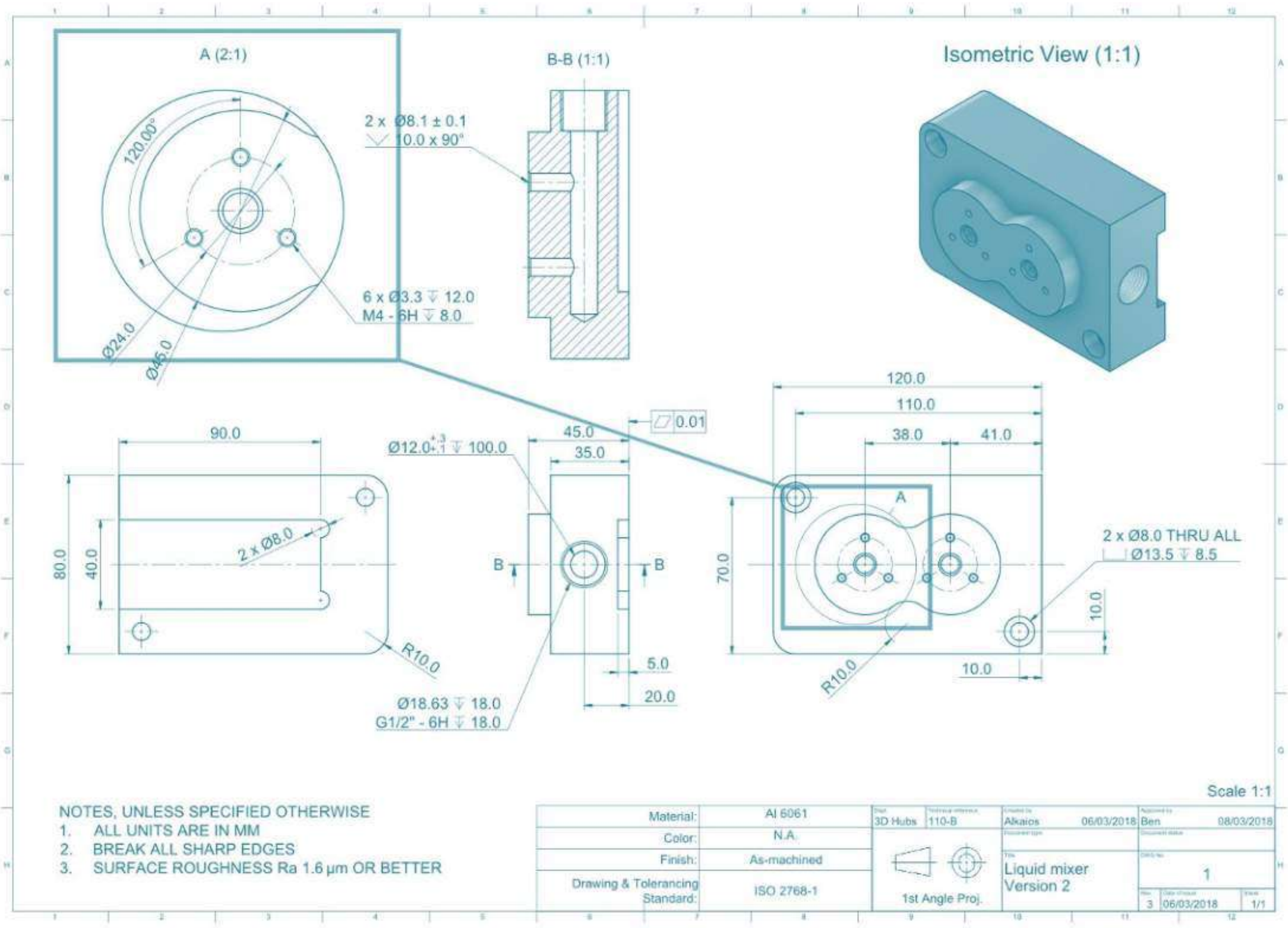
Detail drawing (Single part):

When an aircraft is designed, a detail drawing is made for everypart.

A detail drawing provides all the information required to construct a part, includingall dimensions, materials, and

type offinish.
When needed, an enlarged section or a drawing of another view is added to makethe drawing easier tounderstand.
Scaling:

When a detail drawing is made, it is carefully and accurately drawn to scale (Shrink or stretch) anddimensioned.
For e.g.; An aircraft with fuselage length of 50ft (1500cm) cannot be drawn with same dimensions in a sheet of very small length. So, for that, the dimension is scaled down appropriately to drawn perfectly in the small sheet. But the actual dimension should be marked on the drawing.
So, a 1500cm length can be drawn with a scale ratio of 1/10 (150cm) on the drawing sheet, but the actual dimension will be marked on the sheet.

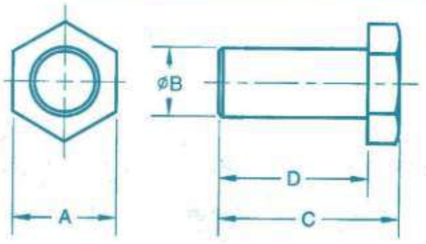


Detail drawing - (Tabular / Collective Single part):

Shows parts or assemblies of essentially similar shape, but of differentdimensions.

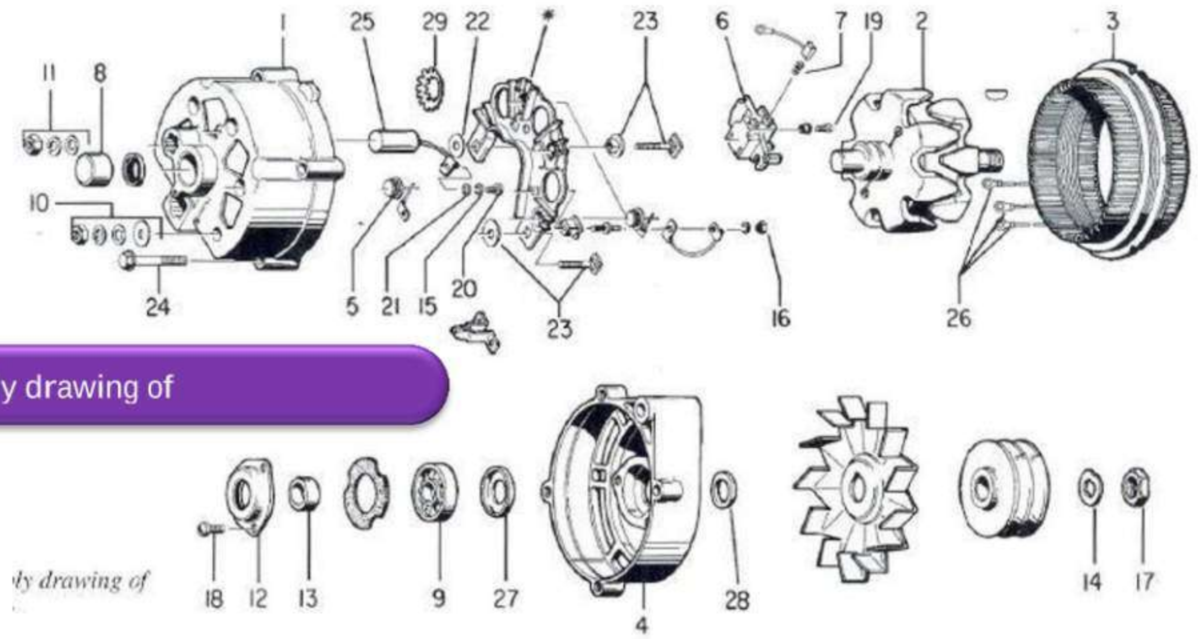
Tabular dimensions simplify drawings of family parts.

PART NO.	A	B	C	D
41–8706	.750	.500	1.312	.875
41–8707	1.125	.750	1.812	1.000
41–8708	1.500	1.000	2.062	1.125



Assembly drawing:

After individual parts are fabricated, they are assembled into various subassemblies with the aid of an assemblydrawing.
An assembly drawing depicts the relationship between two or moreparts.
These drawings indicate individual parts by their part number and specify the typeand number of fasteners needed to jointhem.
Because there are detail drawings for each component, no materials are specified and only those dimensions needed to assemble the parts areincluded.
By studying an assembly drawing and keeping it handy as the part is repaired, you can be sure that all parts are installed in their proper place. Using the appropriate parts list will assure that only the correct parts are



Assembly drawing of

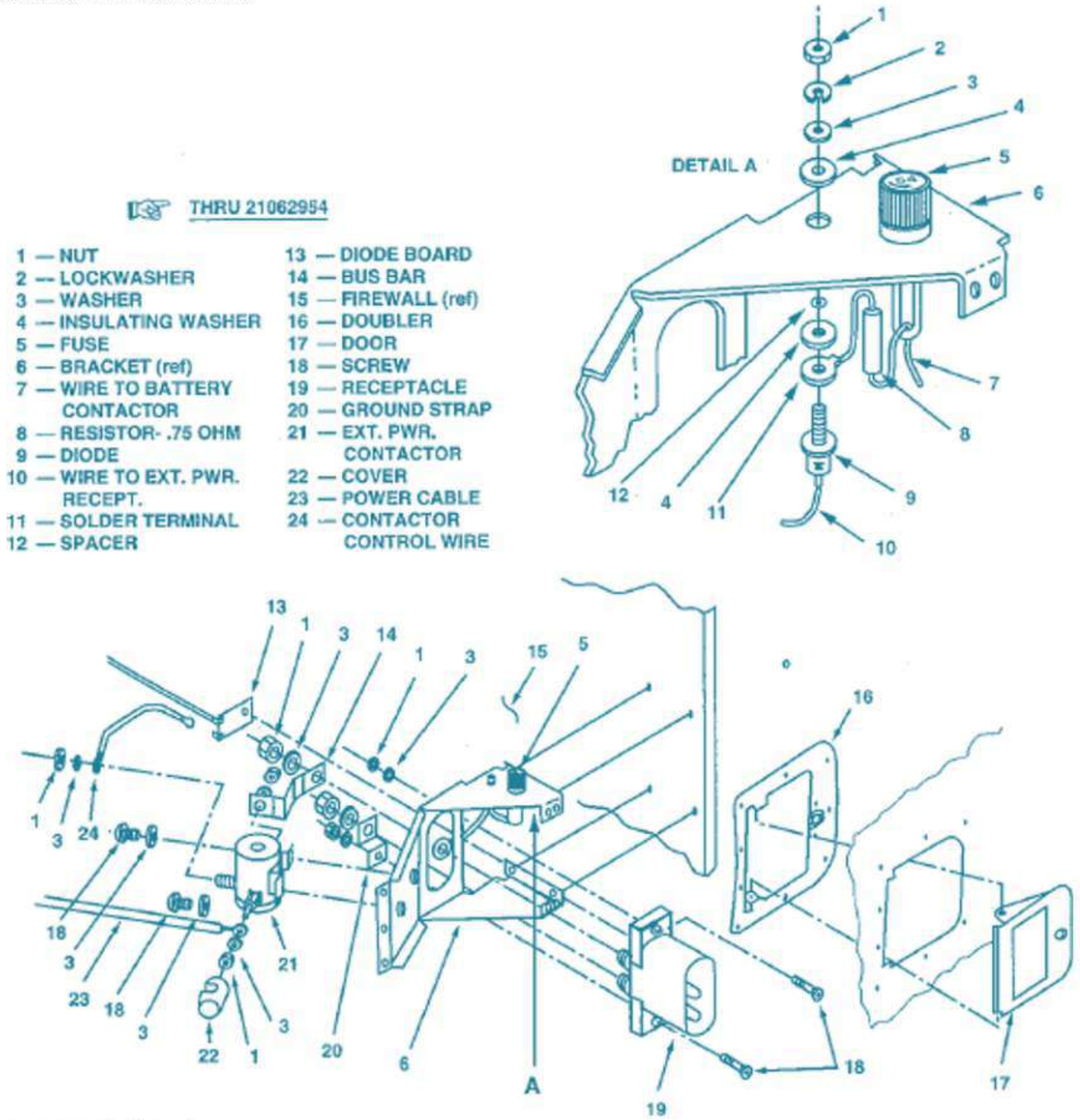
used.

Installation drawing:

An installation drawing is one which includes all necessary information for a part oran assembly in the final installed position in theaircraft.

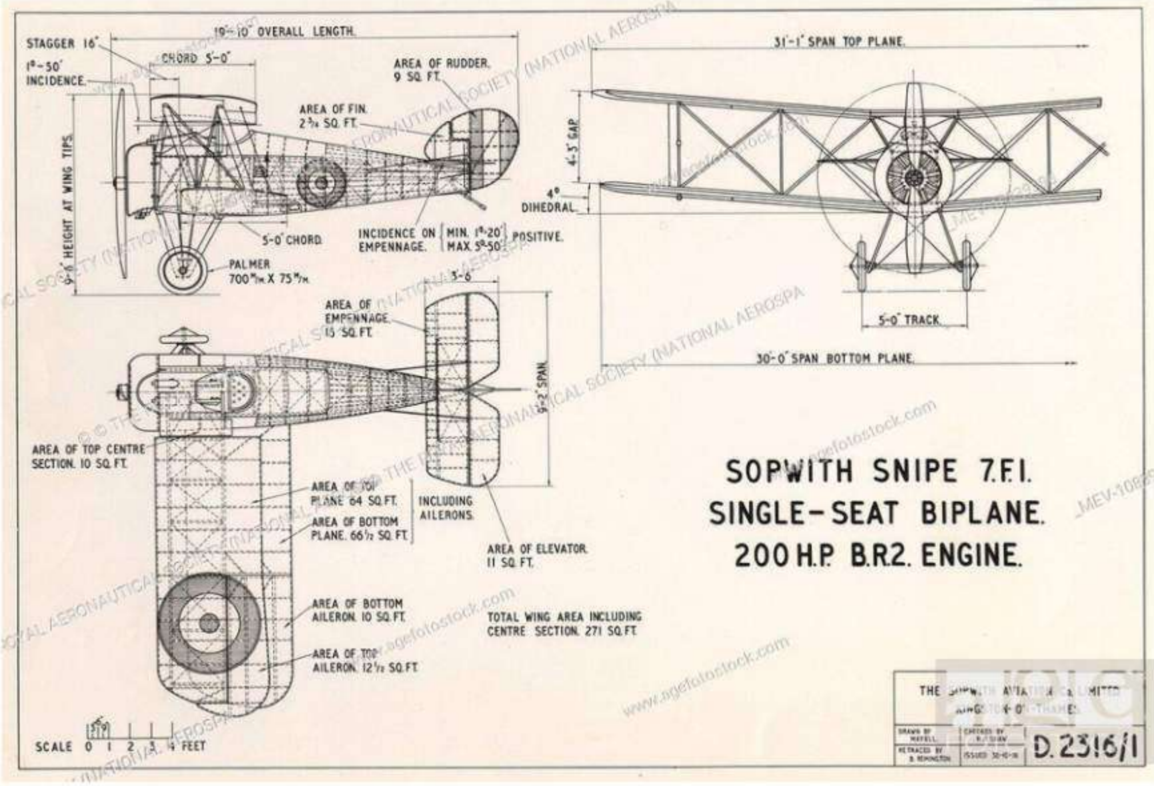
All subassemblies are brought together in an installationdiagram.

This type of drawing shows the general arrangement or position of parts with respectto an aircraft and provides the information needed to installthem.



General arrangement drawing:

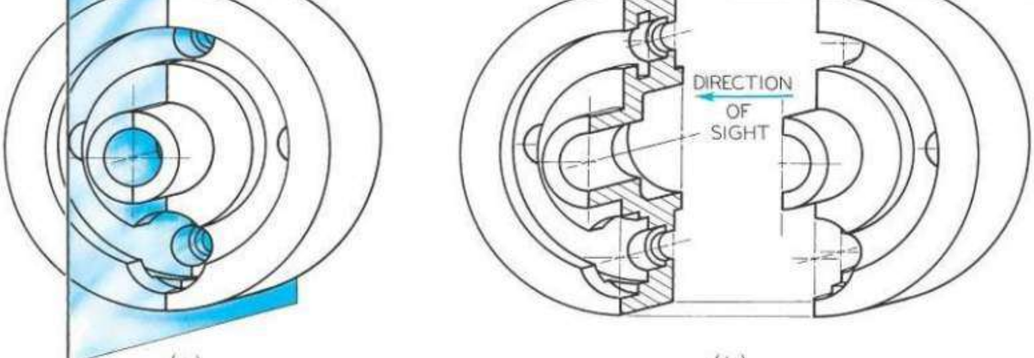
Produced for main assemblies such as fuselage, systems. They usually indicate profiles and overall dimensions and often internal details also.



Diagrams based onviews

Section view:

When it is necessary to show the internal construction or shape of a part, a sectional drawing is used. The part or parts cut away are shown by the use of section (crosshatching)lines.
To produce a sectional view, a cutting plane is imagined cutting through the part,as shown in fig.(a).
Picture the two halves of the object pulled apart, exposing the interior construction, as shown in fig.(b).
In this case, we will look toward the left half of the object in the sectionview.

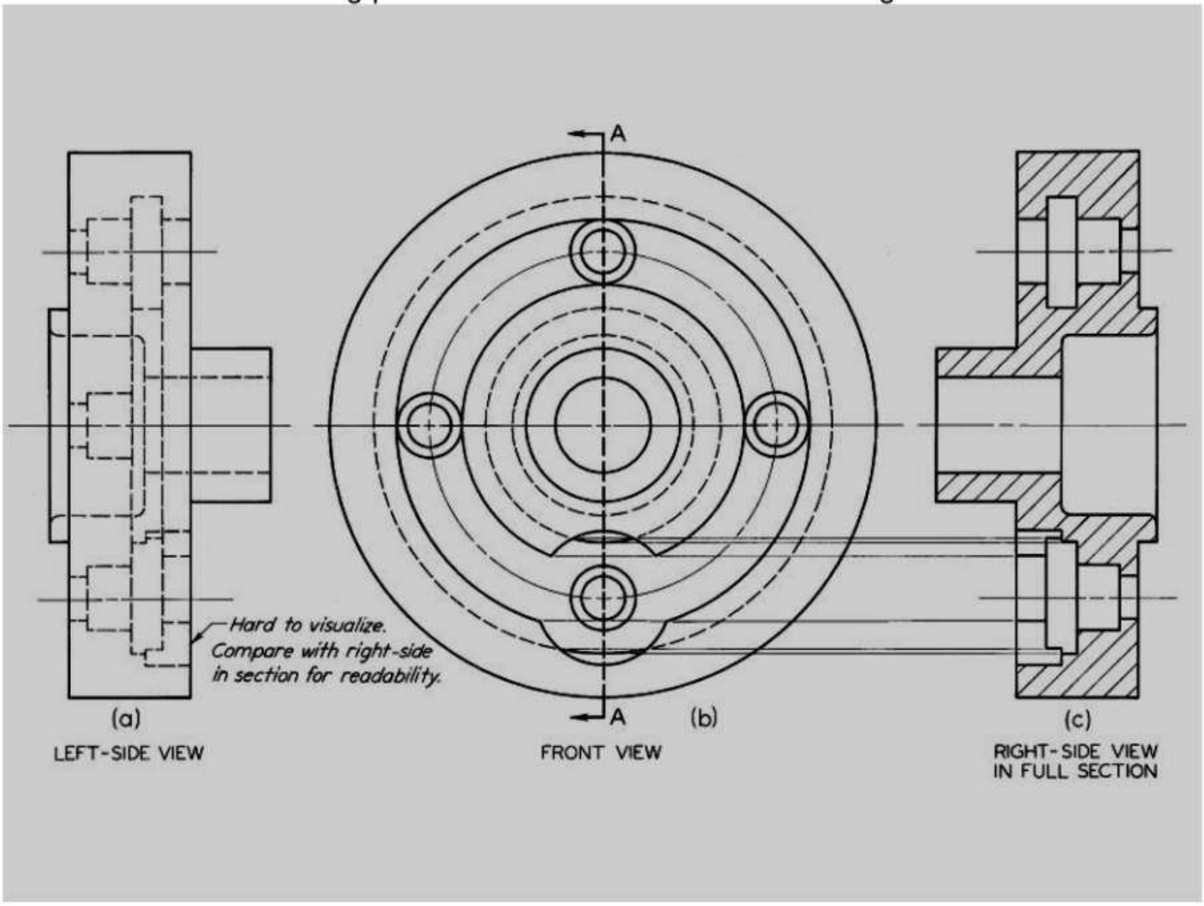


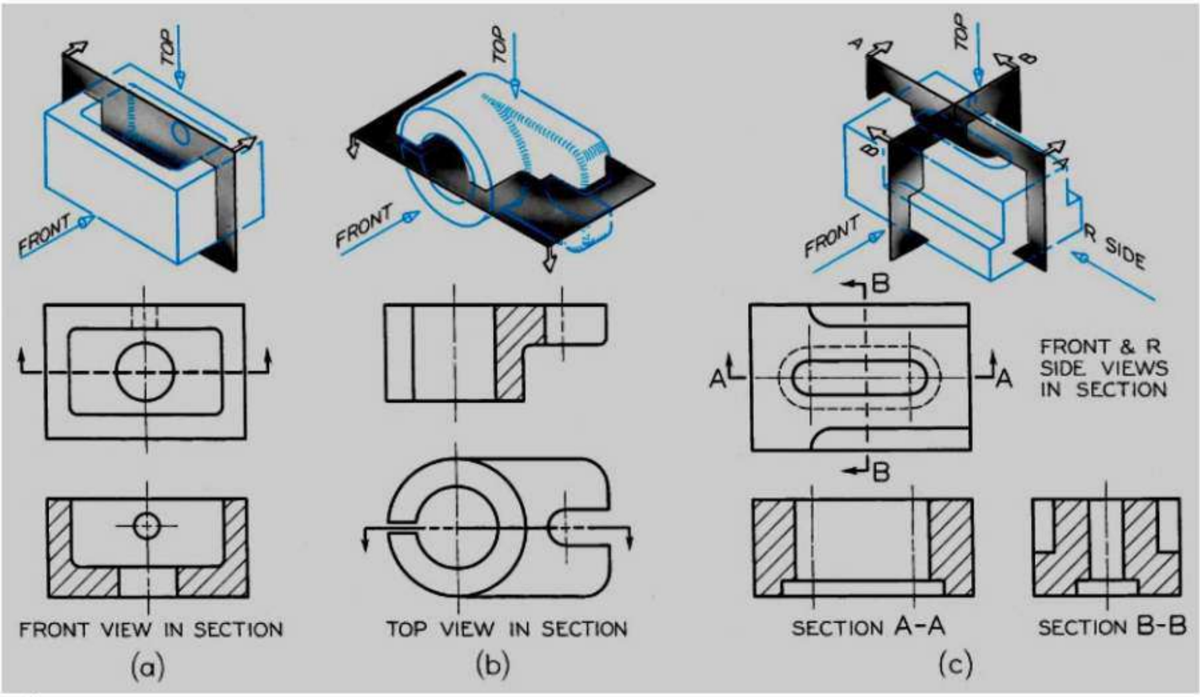
(a) (b)

Full section view:

The section produced by cutting through the entire object is called a full section. The cutting-plane line is

shown as a special pattern.
The arrows at the ends of the cutting plane line indicate the direction of sight for the section view.

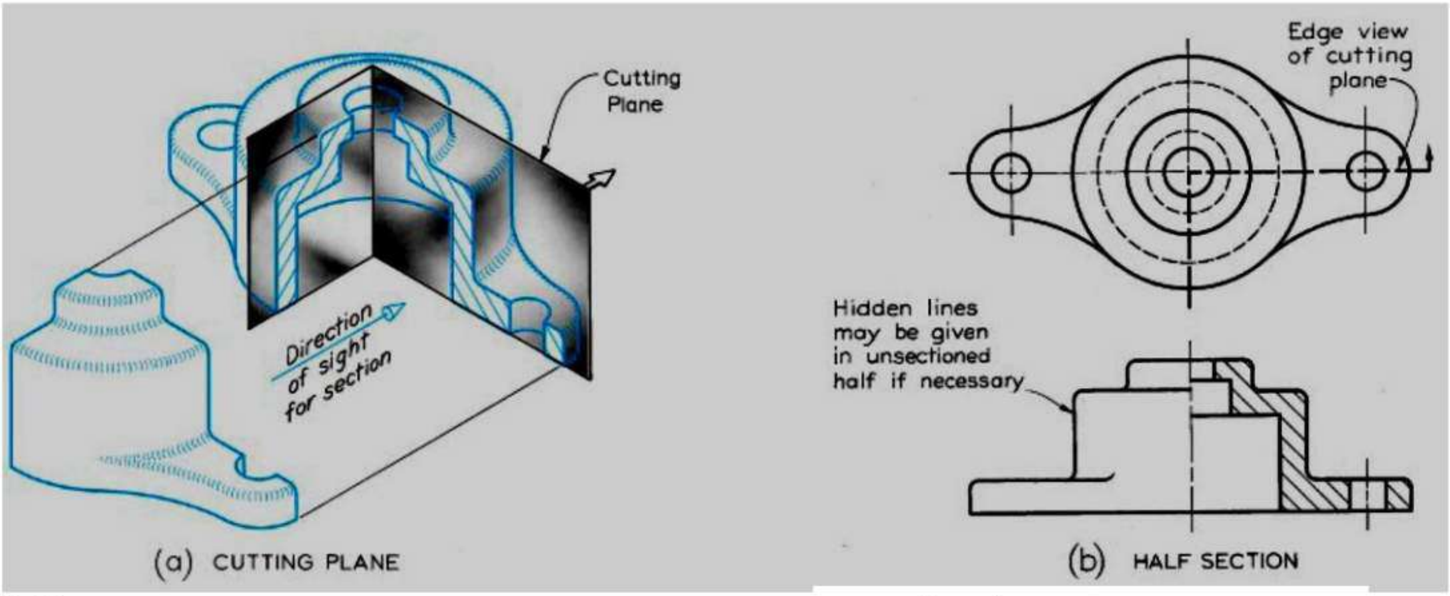




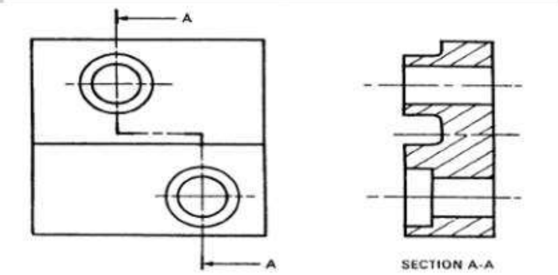
Half section view:

In a half section, the cutting plane extends only halfway across the object, leaving the other half of the object as an exteriorview.

Half sections are used to advantage with symmetrical objects to show both the interior and



exterior.

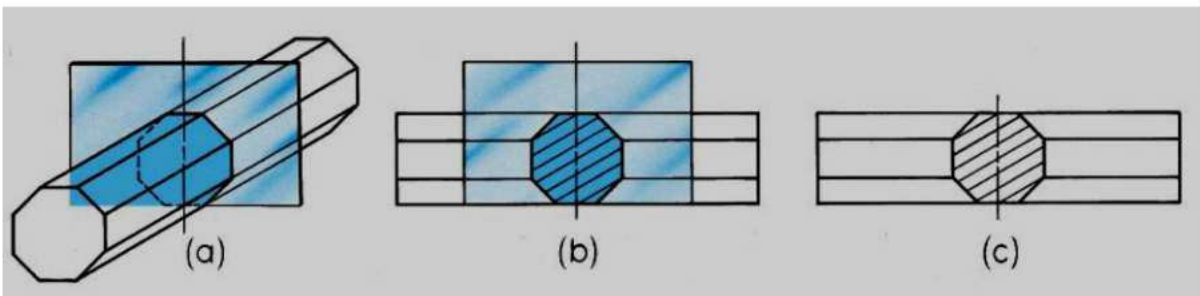


Staggered section:

Staggered sections are often used to illustrate particularfeatures
Figure shows a part with two holesat differentdistances.
Since most of the dimensions will be marked in the top view, a side view can be drawn by cutting a plane along thetwo
holes, to mark the dimensions related to the two holes (like distance between them or distance between each hole and the objects center)

Revolved section view:

The shape of the cross-section of a bar, arm, spoke, or other elongated object maybe shown by means of a revolvedsection.
Revolved sections are made by assuming a plane perpendicular to the centerline or axis of the bar or other object, and then revolving the plane through 90 degrees about a centerline at right angles to theaxis.

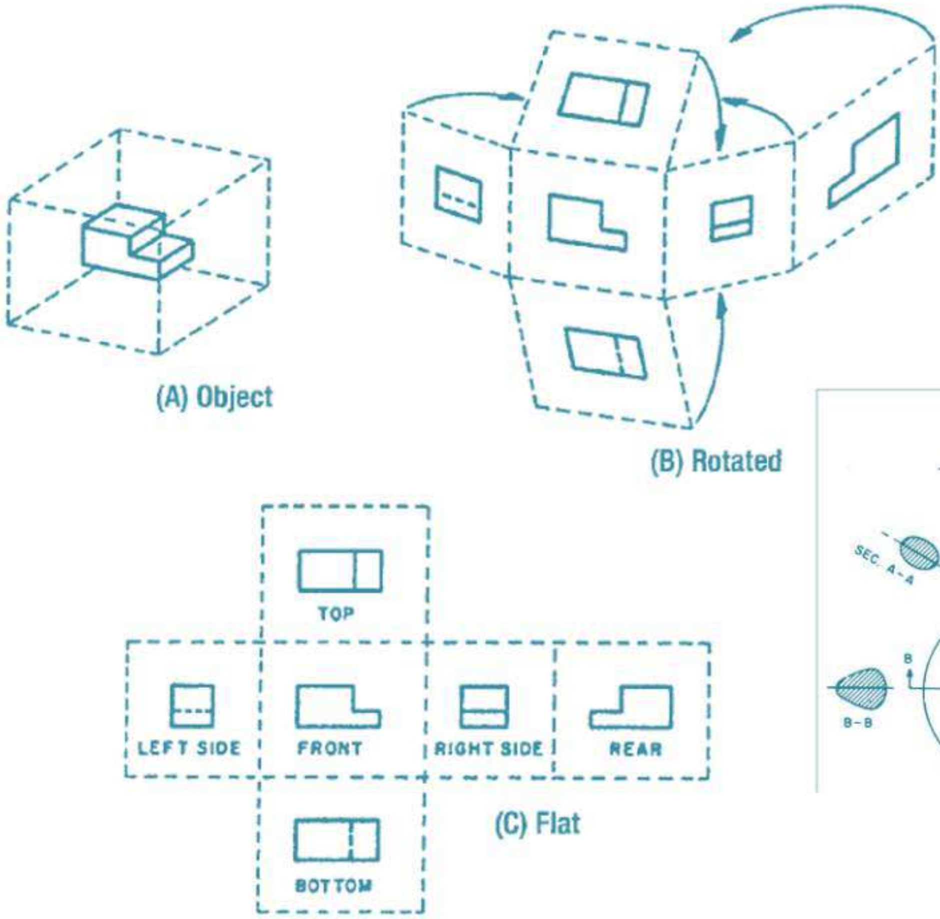


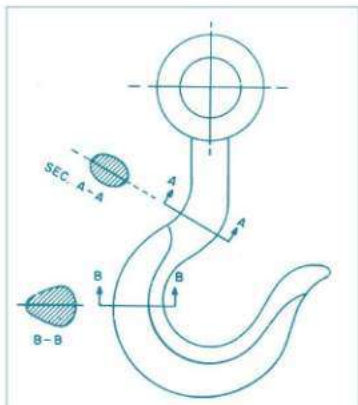
Removed section view:

A removed section illustrates particular parts ofan object.
It is drawn like revolved sections, except it is placed at one side and, to bring out pertinent details, often drawn to a larger scale than the view on which it is indicated.

Diagrams from Projections ofparts

Orthographic projection (Viewing perpendicular to the object's side):
Inordertoshowtheexactsizeandshapeofallthepartsofcomplexobjects,anumber of views are necessary. This is the system used in orthographicprojection.
In orthographic projection, there are six possible views of an object, because all objects have six sides/faces-front, top, bottom, rear, right side, and leftside.
Figure 5-12(A) shows an object placed in a transparent box, hinged at the edges. The projections on the sides of the box are the views as seen looking straight at the object through eachside.
If the outlines of the object are drawn on each surface and the box opened as shownin Figure 5-12(B) then laid flat as shown in Figure 5-12(C}, the result is a six-view orthographicprojection.
To simply say, all sides of a 3D object is drawn as a 2D diagram in an orthographic view





Only those views necessary to illustrate the required characteristics of the objectare drawn.
One-, two-, and three-view drawings are the mostcommon.
Regardless of the number of views used, the arrangement is generally as shown in Figure, with the front view as principalview.
Iftheright-sideviewisshown,itwillbetotherightofthefrontview.Iftheleftside view is shown, it will be to the left of the frontview.
The top and bottom views, if included, will be shown in their respective positions relative to the frontview.

One-view drawings:

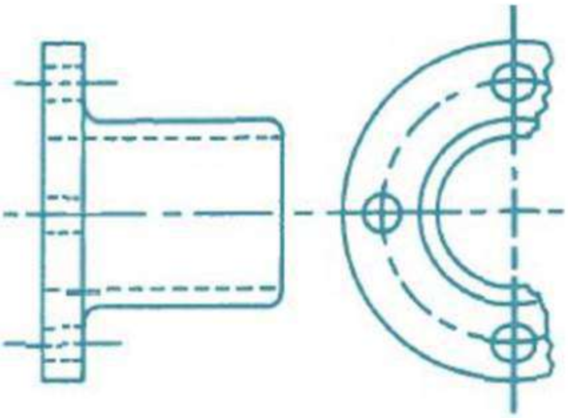
One-view drawings are commonly used for objects of uniform thickness such as gaskets, shims, andplates.
A dimensional note gives the thickness as shown in Figure.
One-view drawings are also commonly used for cylindrical, spherical, or square parts if all thenecessary dimensions can be properly shown in oneview.

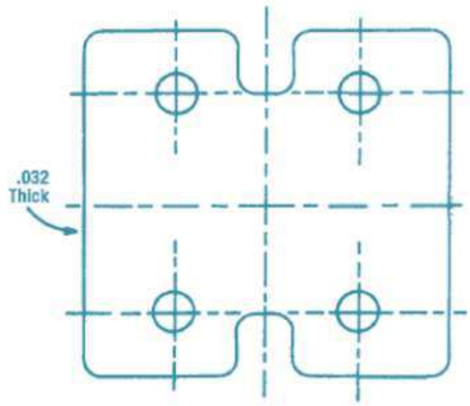
Half-view drawings:

When space is limited and two views must be shown, symmetrical objects are often represented by half views

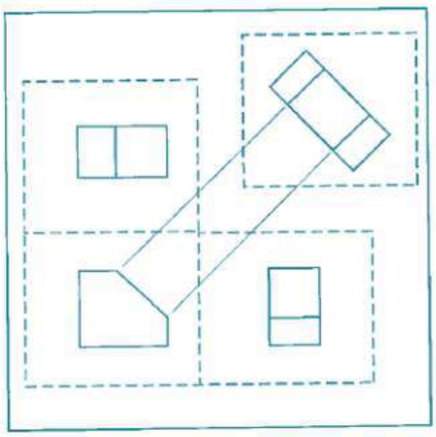
Auxiliary view drawings:

Although an orthographic drawing can represent upto six individual views, it is sometimes necessary to see a view



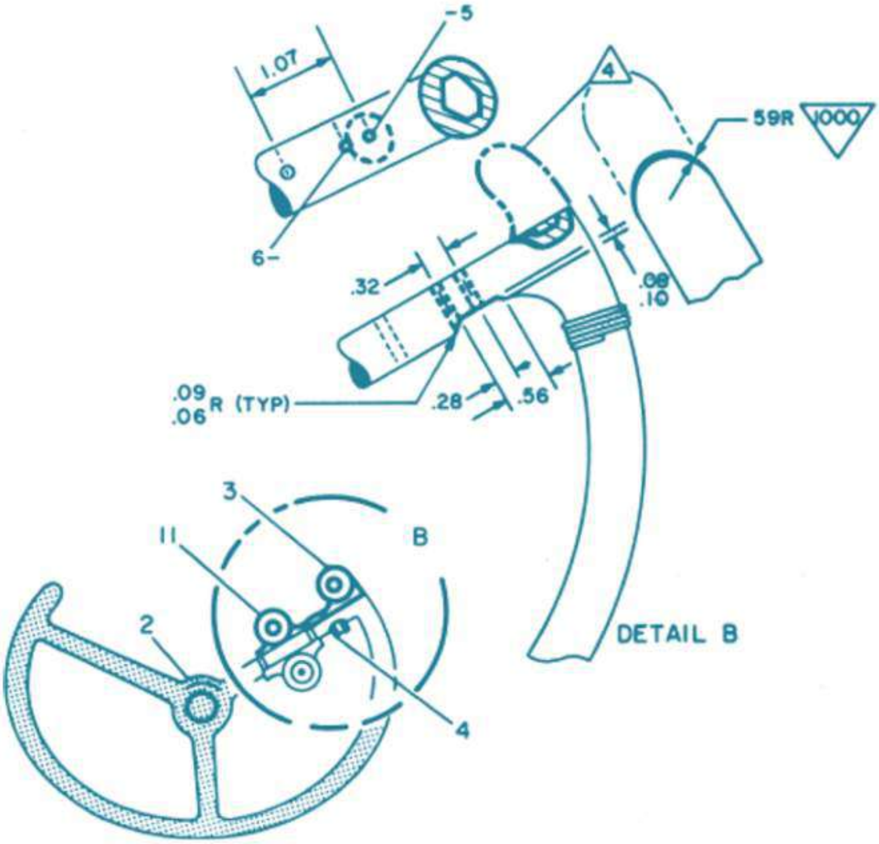


that is not a 90-degree angle to the face of an object. In this situation, an auxiliary drawing isused.



Detail view:

A detail view shows only a part of the object but in greater detail and to alarger scale than the principalview.
The part that is shown in detail elsewhere on the drawing is usually encircled by a heavy line on the principalview.

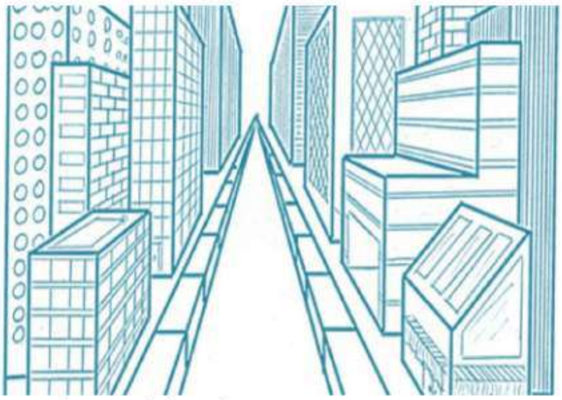


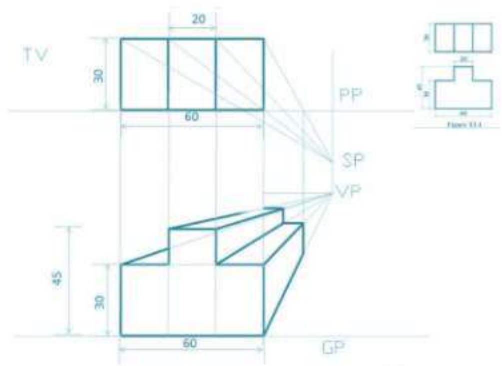
PictorialDiagrams:

A pictorial drawing is similar to a photograph. It shows an object as it appears tothe eye, but it is not satisfactory for showing complex forms andshapes.
Pictorial drawings are useful in showing the general appearance of an object andare used extensively with orthographic projectiondrawings.
Pictorial drawings are used in maintenance, overhaul, and partnumbers.
Three types of pictorial drawings are used frequently by aircraft engineersand technicians: (1) perspective, (2) isometric, and (3)oblique.

Pictorial Diagrams – Perspective view:

A perspective view shows an object as it appears to human eye (3D). It most closely resembles the way an object would look in a photograph. These are not generally used in aircraftdrawings.
Because of perspective, lines of an object are not parallel and converges to acommon vanishing point and therefore the actual angles and dimensions are not accurate.





Pictorial Diagrams – Isometric view:

These are pictorial views of an object, which are drawn with the three axesinclined, usually at an angle of 30°, to the plane ofprojection.
An isometric view uses a combination of views of an orthographic projection andtilts the object forward so that portions of all three views can be seen in oneview.
This provides the observer with a three-dimensional view of theobject.
Unlike a perspective drawing where lines converge and dimensions are not true, lines in an isometric drawingare parallel and dimensioned as they are in an orthographic projection.
They may be used with adequate dimensions forsimple components, but should not used for complexparts.

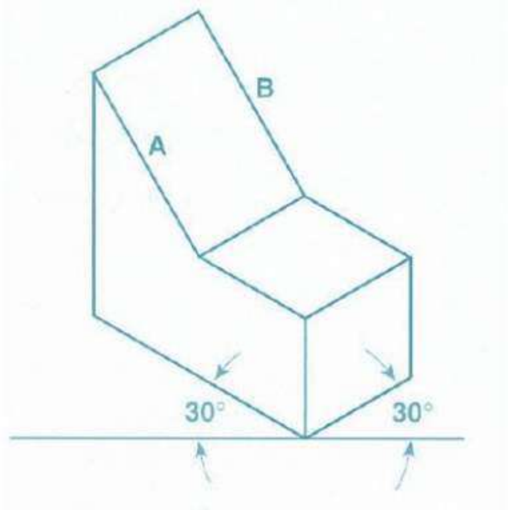
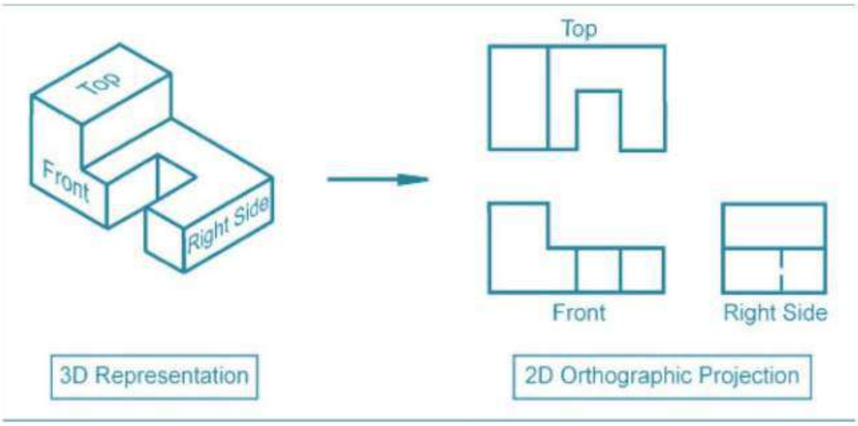
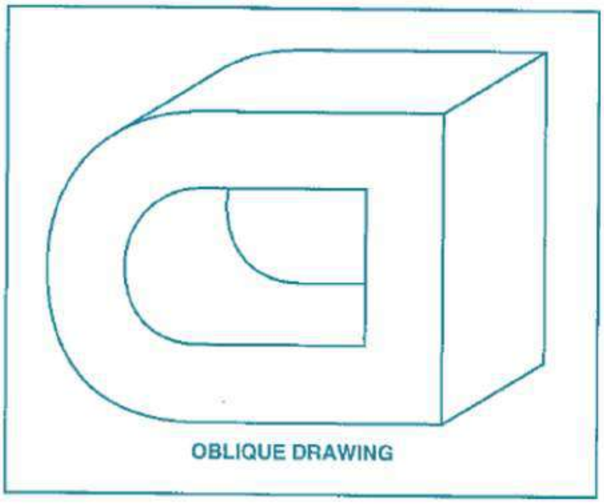


Figure 5-15. *Three surfaces of an isometric view are visible, and all lines in this drawing are true length except A and B.*

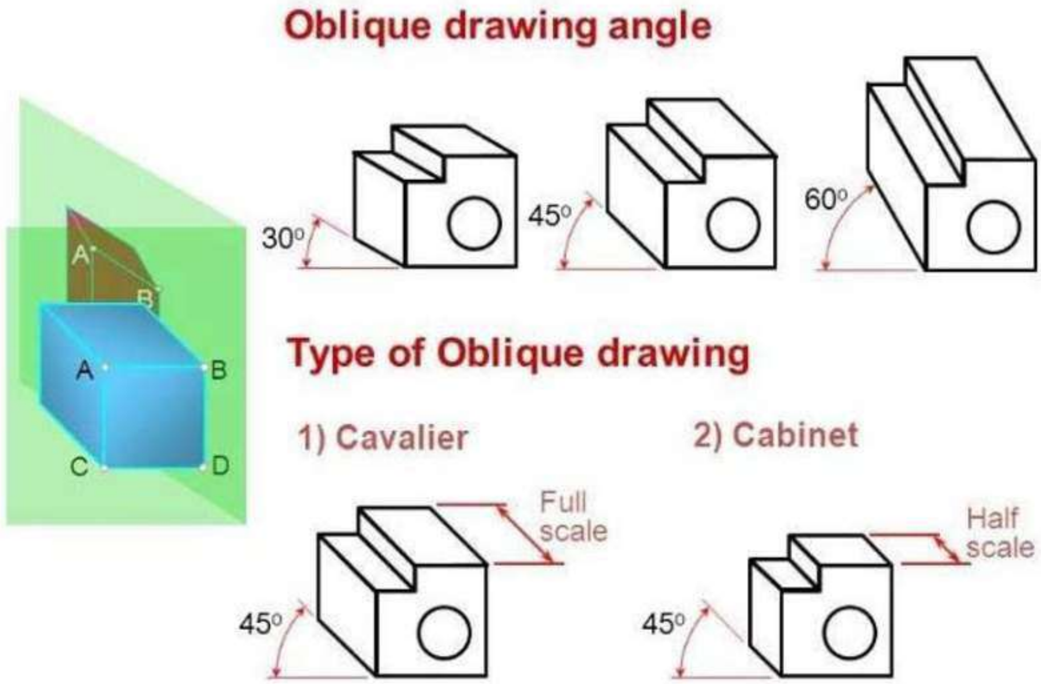


Pictorial Diagrams – Oblique view:

An oblique view is similar to an isometric view except for one distinct difference. In an oblique drawing, two of the three drawing axes are always at right angles to eachother, with the front of the object identical to the front view, and one of the object's face is parallel to the drawingplane.
The depth axis of the oblique drawing is typically any convenient angle and most often about 30degrees.

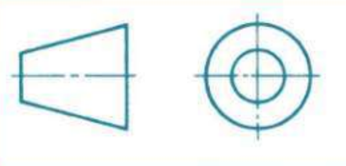
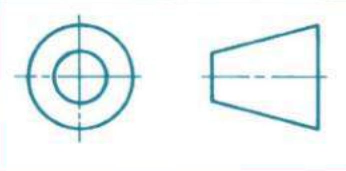


A cabinet drawing gets its name from drawings used for cabinet work. In this, the oblique side is set at 45-degree angle to the front side and is half the scale. Thisallows for accurate and undistorted frontview.
A Cavalier drawing uses the same scale for front view as the oblique sidelines. These drawings are primarily used when detailing is required on the obliqueside.



Method of illustration:

An object has 6 faces and 6 views can be drawn by orthographic view, if the object is complex or more details are required toshow.
Sometimes 3 views are enough for simple objects to understand the objectcompletely.
In such cases, the orthographic view can be drawn with first angle or third angle projection, to show only 3 views of anobject.

Projection	Symbol
First angle	
Third angle	

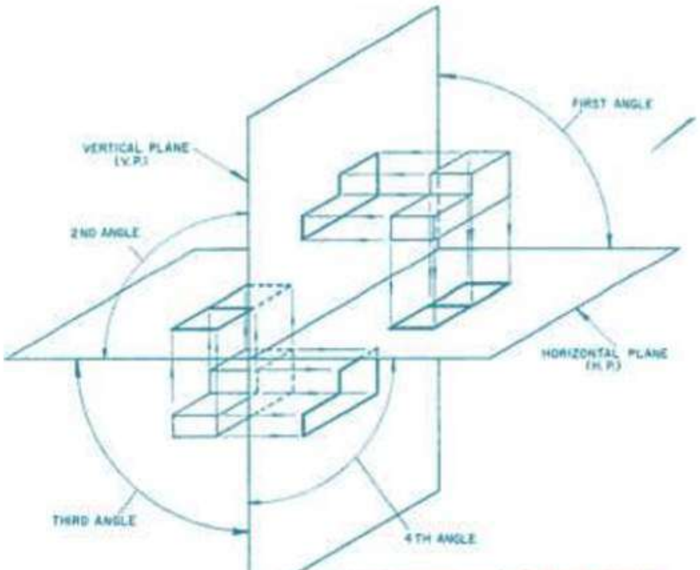
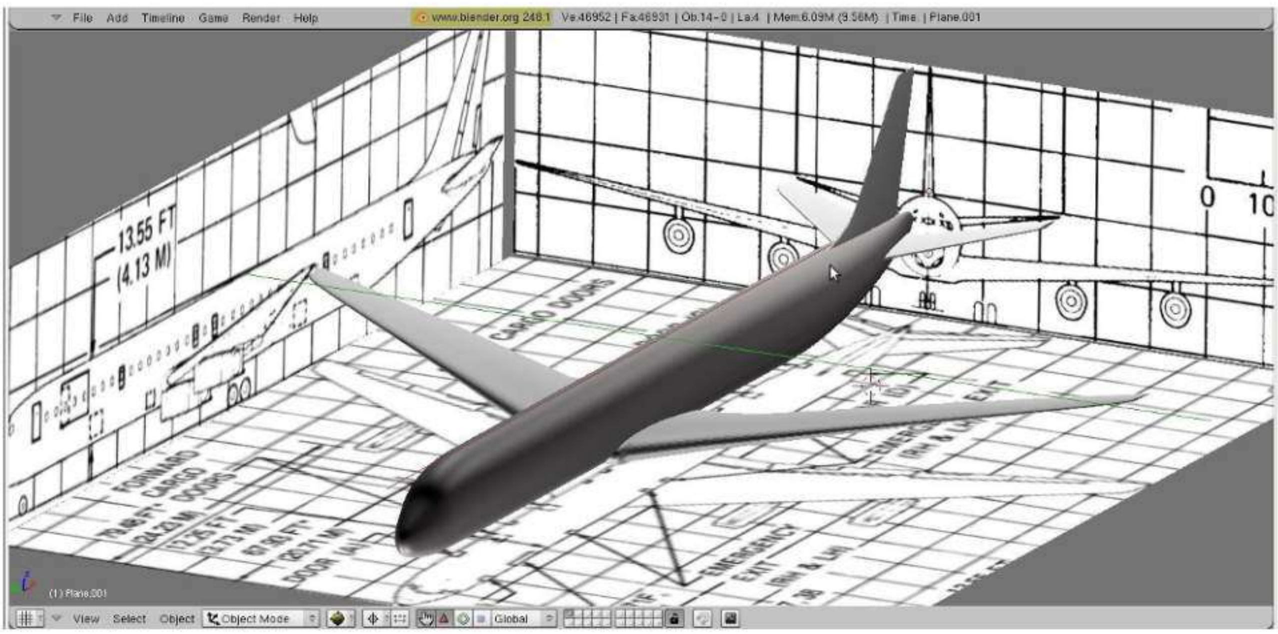
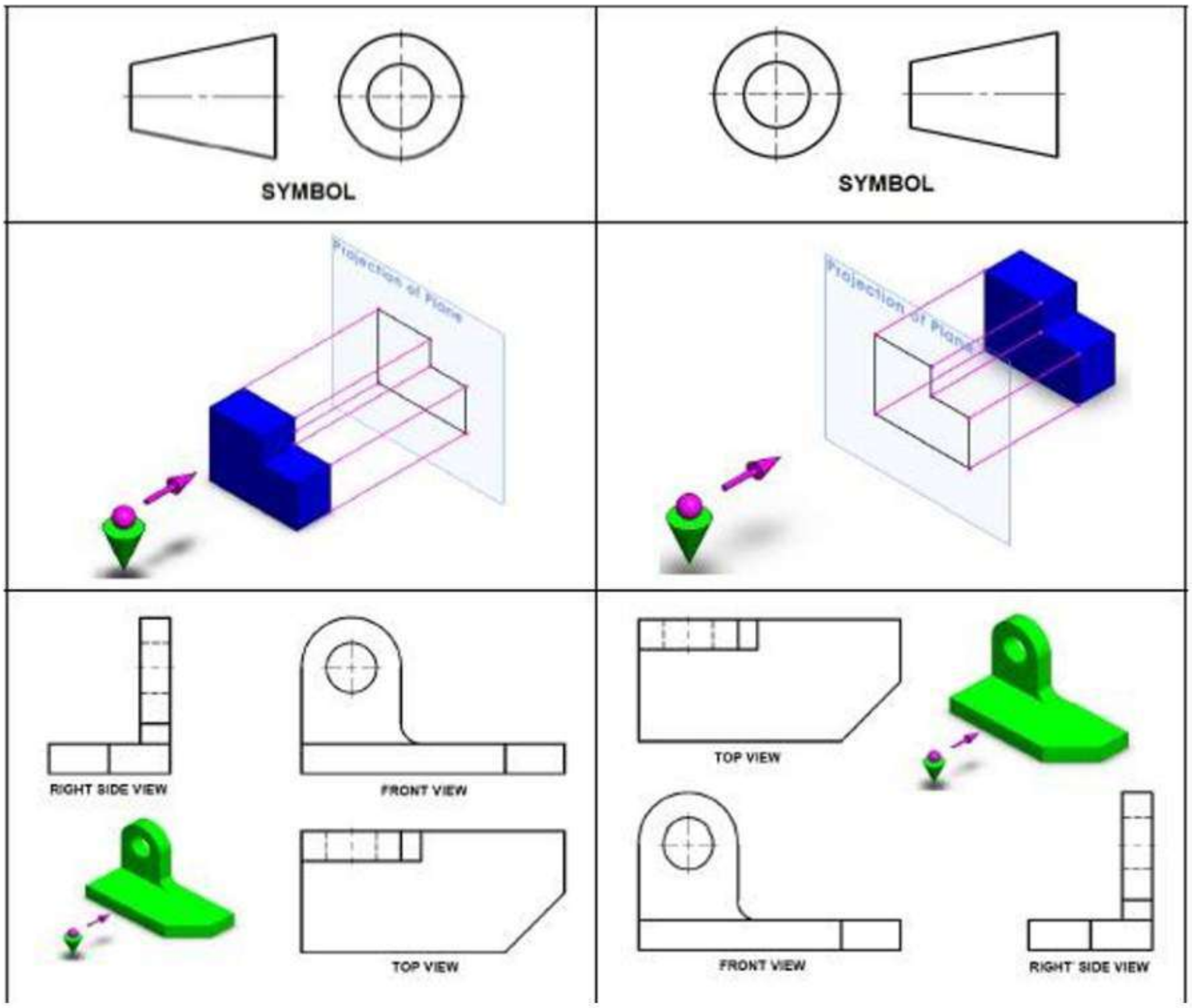


Fig. 10/3 Relative positions of 1st and 3rd angle projections



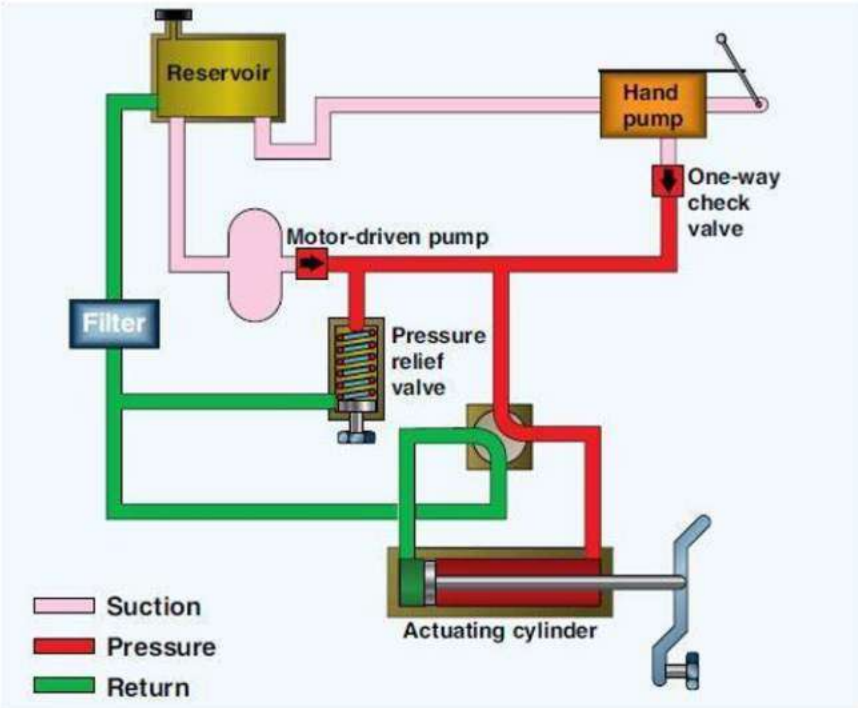
In first angle and third angle projection, the arrangement of views is different.



Drawings indicating methods ofoperation

Schematic drawing:

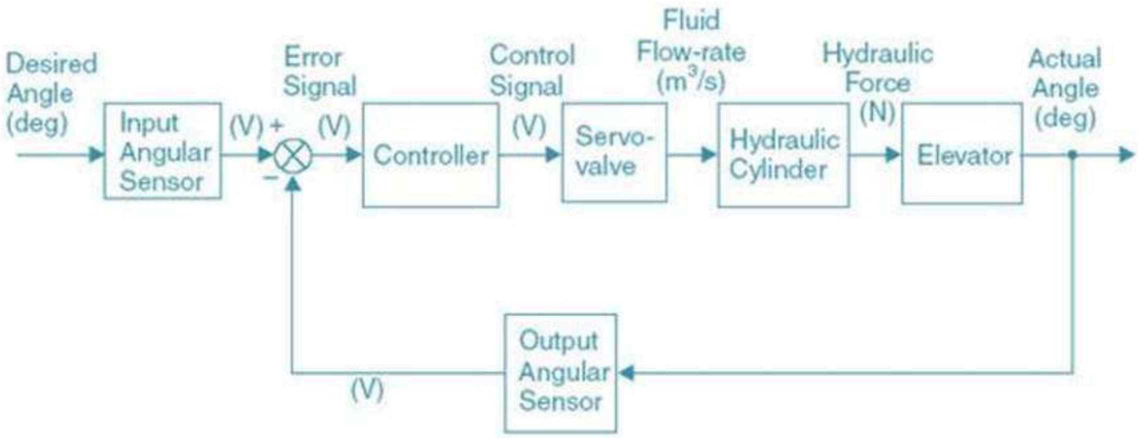
Schematic diagrams do not indicate the location of individual components in the aircraft, but locate components with respect to each other within thesystem.
Schematic diagrams are used mainly introubleshooting.
Note that each line is coded for ease of reading and tracing the flow. Each component is identified by name, and its location within the system can be ascertained by noting the lines that lead into and out of theunit.
Schematic diagrams and installation diagrams are used extensively in aircraftmanuals



Block diagram:

Block diagrams are used to show a simplified relationship of a more complex systemof components.
Individual components are drawn as a rectangle (block) with lines connecting it toother components (blocks) that it interfaces with duringoperation

Block diagram of elevator control system

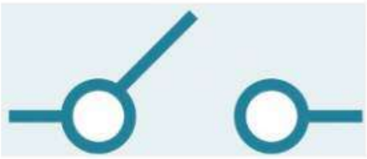


Wiring diagram:

Electrical wiring diagrams are involved in most aircraft service manuals and specify things like the size of wire and the type of materials to be used for a particular application.
Wiring diagrams show the electrical wiring and circuitry, coded for identification, of all the electrical appliances and devices used on aircraft. These diagrams, even for relatively simple circuits, can be quitecomplicated.
For technicians involved with electrical repairs and installations, a thoroughknowledge of wiring diagrams and electrical schematics isessential.

Wiring diagram symbols:

Most symbols used on a wiring diagram look like abstract versions of the real objects they represent.
For example, a switch will be a break in the line with a line at an angle to the wire, much like a light switch you can flip on and off.
A resistor will be represented with a series of squiggles symbolizing the restrictionof currentflow.
An antenna is a straight line with three small lines branching off at its end,much like a realantenna.



Note:The circuit diagram is the one neatly presented in the books systematically. Pretty useful for understanding theory and working of the circuit.
But this is not useful for a wire-man / Technician. He wants to see the actual switch contact, their numbering etc in an implementable way.

Exploded view drawings:

An exploded view drawing is a pictorial drawing of two or more parts that fit together as an assembly.
The view shows the individual parts and their relative position to the other parts before they are assembled.
They are typically found in integrated parts catalogue.

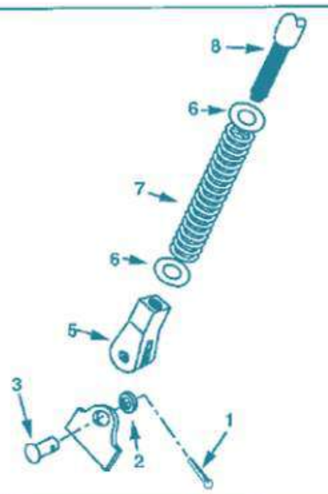
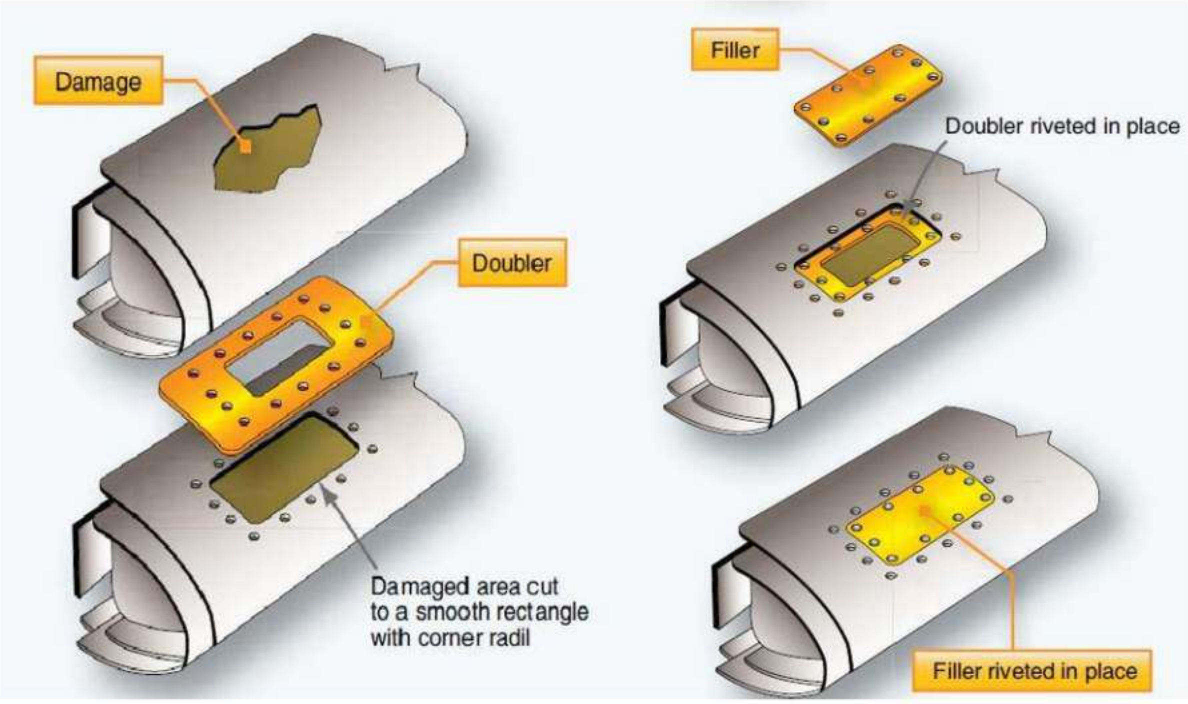


FIGURE AND INDEX NUMBER	PART NUMBER	DESCRIPTION	QTY PER ASSY
-1	MS9245-01	•PIN••••••••••••••••••	7
-2	LJ509	•WASHER•••••••••••••••	7
-3	LP632	•PIN,CLEVIS••••••••••	7
-4	6J004	•LINK•••••••••••••••••	1
-5	L21018	•CLEVIS•••••••••••••••	5
-6	LJ514	•WASHER•••••••••••••••	2
-7	LS534	•SPRING•••••••••••••••	1
-8	KJ202	•SPACER,SPRING••••••••	1

Repair drawing:

Aircraft maintenance technicians are often required to repair an aircraftstructure.
Some maintenance manuals show methods recommended by the manufacturer for various types ofrepairs.
Since all damages are different, no dimension is given, but there is enoughinformation provided that an experienced technician can make an airworthyrepair.



Drawing data onsheet

Title block:

Every print must have some means of identification. This is provided by a titleblock.
The title block consists of a drawing number and certain other data concerningthe drawing and the object itrepresents.
This information is grouped in a prominent place on the print, usually in the lower right- handcorner.
Sometimes the title block is in the form of a strip extending almost the entire distance across the bottom of thesheet.
Although title blocks do not follow a standard form insofar as layout is concerned, allof them present essentially the followinginformation:
Adrawingnumbertoidentifytheprintforfilingpurposesandtopreventconfusingitwith any otherprint.
The name of the part orassembly.

The scale to which it isdrawn.

Thedate.

The name of thefirm.

The name of the draftsmen, the checker, and the person approving thedrawing

Drawing number:

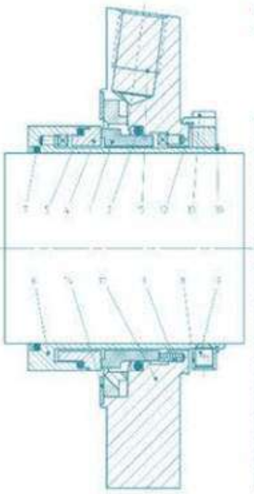
All prints are identified by a number, which appears in a number block in thelower right-hand corner of the titleblock.
It may also be shown in other places such as near the top border line, in the upper right- hand corner, or on the reverse side of the print at both ends so that the number will show when the print is folded orrolled.
The purpose of the number is quick identification of a print. If a print has more than one sheet and each sheet has the same number, this information is included in the number block, indicating the sheet number and the number of sheets in theseries.
Reference numbers that appear in the title block refer you to the numbers of other prints.
When more than one detail is shown on a drawing, dash numbers are used. Both parts would have the same drawing number plus an individual number, such as 40267-1 and 40267-2.
In addition to appearing in the title block, dash numbers may appear on the face of the drawing near the parts theyidentify.

Drawing number for handed parts:

Dash numbers are also used to identify right-hand and left-hand parts. In aircraft, many parts on the left side are like the corresponding parts on the right side but inreverse.
The left-hand part is always shown in the drawing. The right-hand part is called for in the titleblock.
Above the title block a notation is found, such as: 470204-ILH shown; 470204-2RH opposite. Both parts carry the same number, but the part called for is distinguished bya dashnumber.
Some prints have odd numbers for left-hand parts and even numbers for right-hand parts

Bill of material:

A list of the materials and parts necessary for the fabrication or assembly ofa component or system is often included on thedrawing.
The list is usually in ruled columns in which are listed the part number, name of thepart, material from which the part is to be constructed, the quantity required, and the source of the part ormaterial.
On drawings that do not have a bill of material, the data may be indicated directlyon the drawing. On assembly drawings, each item is identified by a number in a circle or square.
An arrow connecting the number with the item assists in locating it in the bill of material.



Company X — Bill of Material

Identity No: T10436000
Drawing No: 02-SESUM-SEMP/2.500"-00
Description: Mechanical Seal

Original Job No: T232453211
Due Date: 12-12-2014
Cost Expectation: USD 8,200.00 (GST included)

Item	Part No.	Qty	Drawing Number	Description	Material	Remarks
1	581063114	1	ST272-2.500"	SEAL FACE	A-Carbon	
2	101351330	1	75.79x3.53	O-RING	EPDM	BS234
3	498211262	10	ST34.3-2	SPRING	Hast. C4	
4	579985146	1	ST271-2.500"	SEAT	Silicon Carbide	
5	100460330	1	72.69x2.62	O-RING	EPDM	BS150
6	592451246	1	ST290/2.500"-M	SHAFT SLEEVE		
6.1	592452246	1	ST290/2.500"-1	SHAFT SLEEVE	316 st.st.	
6.2	581237206	2	ST152-03	SQUARE PIN	Bright key steel	
7	100402330	1	63.17x2.62	O-RING	EPDM	BS144
8	814441246	1	ST270.2-2.500"	DRIVER	316 st.st.	
9	133722205	6	ISO4029-M6x8	SET SCREW	304 st.st.	
10	558670287	1	WN174-62	RETAINING RING	316 st.st.	
11	T10638246	1	O2-SESUM-SEMP/2.500"-11M	COVER		Modify SESUM-SEMP/2.500"-11&M
11.1	T10639246	1	O2-SESUM-SEMP/2.500"-11-1	COVER	316 st.st.	Modify SESUM-SEMP/2.500"-11&M
11.2	T10640246	1	O2-SESUM-SEMP/2.500"-11-2	INSERT	316 st.st.	
12	821208242	4	SESUM-SE/50-12	ASSEMBLY FIXTURE	304 st.st.	
13	226038205	4	ISO4762-M4x8	HSH CAP SCREW	304 st.st.	
14	561819364	1	ST165-87.5x104x1	GASKET	Burasil	
15	569883204	1	ST8-3/8NPT	HEAD SCREW PLUG	316 st.st.	

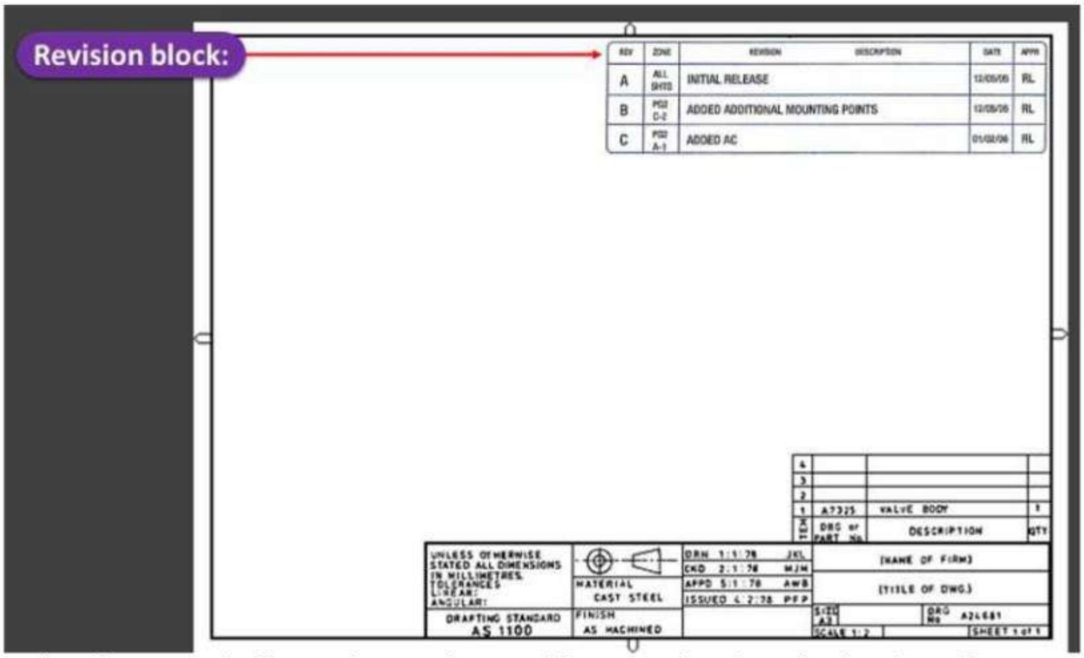
Size:

Letters are typically used to specify the size of a drawing (drawingsheet).
An A-size drawing is 8x 11 inches, a B-size drawing is 11 x 17 inches, a C-size is 17 x22 inches, a D-size is 22 x 34 inches. Large drawings are made on paper 36 to 42 inches wide and are specified as R-size drawings.

Revision block:

Revisions to a drawing are necessitated by changes in dimensions, design, ormaterials. The changes are usually listed in ruled columns either adjacent to the title block or at one corner of thedrawing.
All changes to approved drawings must be carefully noted on all existing prints of the drawing.
When drawings contain such corrections, attention is directed to the changes by lettering or numbering them and listing those changes against the symbol in a revision block.
The revision block contains the identification symbol, the date, the nature of the revision, the authority for the change, and the name of the draftsman who madethe change.
To distinguish the corrected drawing from its previous version, many firms areincluding, as part of the title block, a space for entering the appropriate symbol to designate that the drawing has been changed orrevised.

Zone numbers:



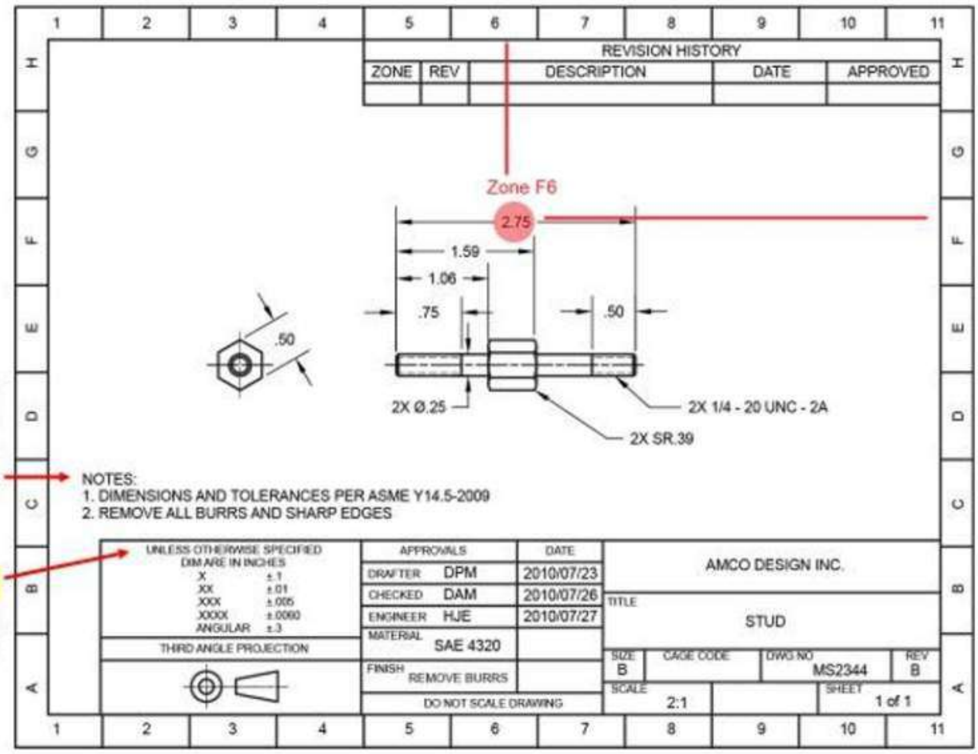
Zone numbers on drawings are similar to the numbers and letters printed on the borders of a map. They help locate a particularpoint.

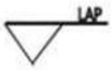
To find a point, mentally draw horizontal and vertical lines from the lettersand numerals specified; the point where these lines intersect is the areasought.
Use the same method to locate parts, sections, and views on large drawings,particularly assemblydrawings.
Parts numbered in the title block can be located on the drawing by finding thenumbers in squares along the lower border. Zone numbers read from right toleft.

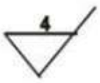
Zone number:

Notes are used only when the information cannot be conveyed in the conventional manner or when it is desirable to avoid crowding the drawing.

In the column entitled "**Unless otherwise specified**", are the standards of manufacturing tolerances used by the design company.

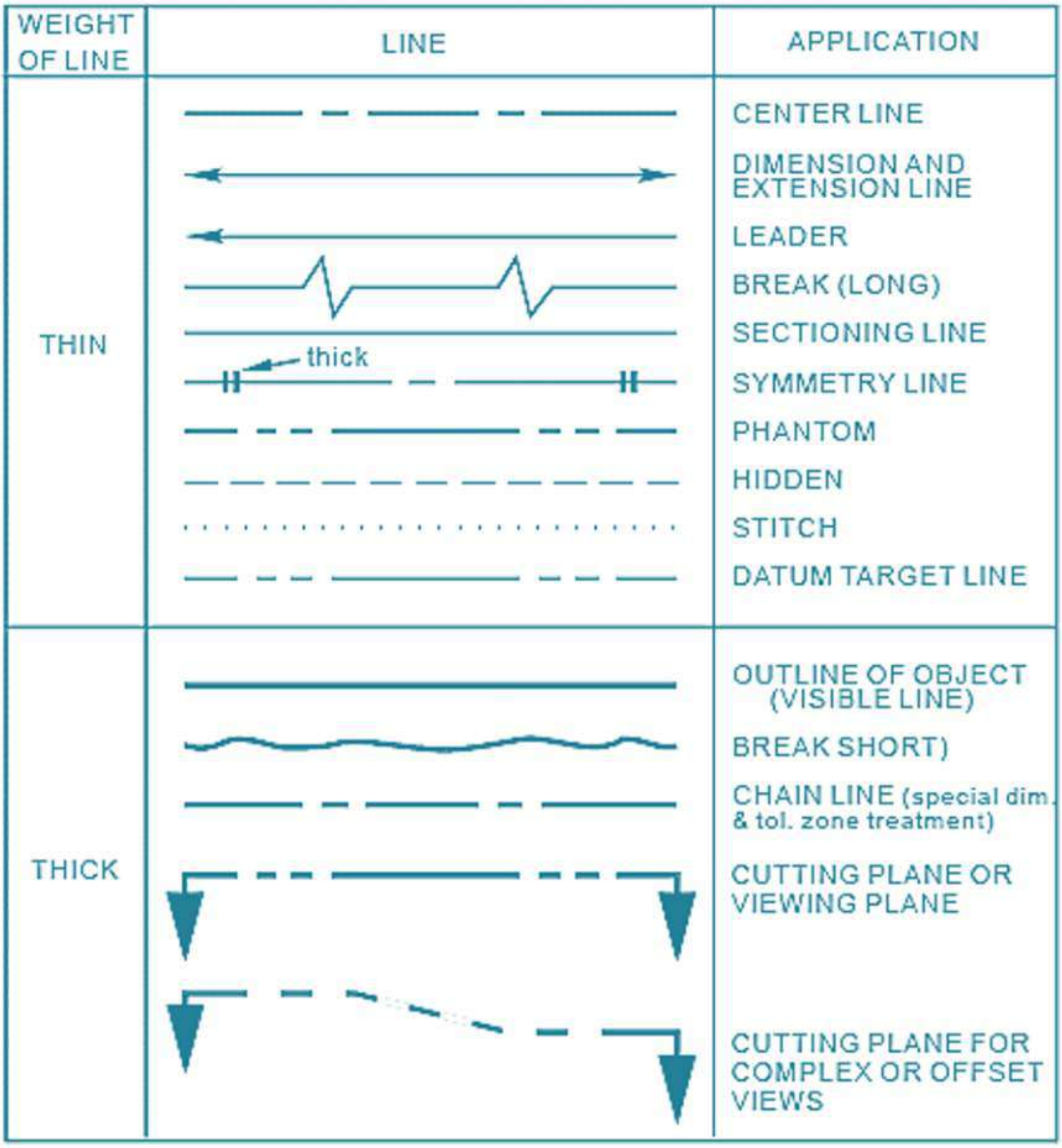


- ✓ When a machining operation is required on a particular surface, the symbol  is used, and is located normal to that surface.
- ✓ When the component is to be machined all over, the symbol "  **ALL OVER"** is used, and, in some cases, the type of machining is indicated with a note such as 

- ✓ The machining symbol is also used to indicate the surface finish required; the maximum roughness figure being added to the symbol thus 

Material finish marks:

Drawing lines and theirmeanings
Every drawing is composed of lines.
Lines mark the boundaries, edges, and intersection ofsurfaces.
Lines are used to show dimensions and hidden surfaces and to indicatecenters.
Obviously, if the same kind of line is used to show all of these variations, adrawing becomes a meaningless collection oflines.
For this reason, various kinds of standardized lines are used on aircraftdrawings.



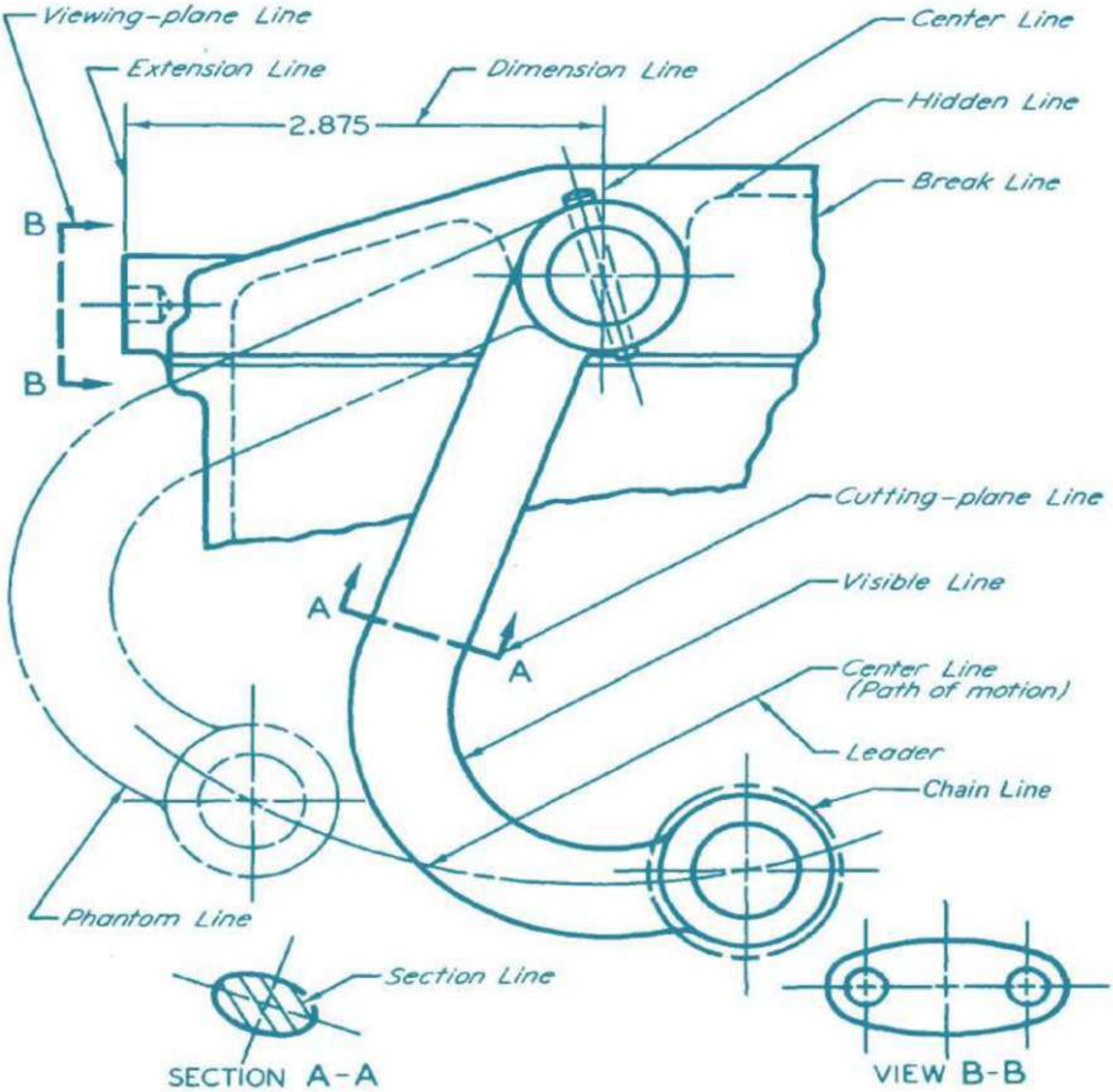
Outline / Visible line:

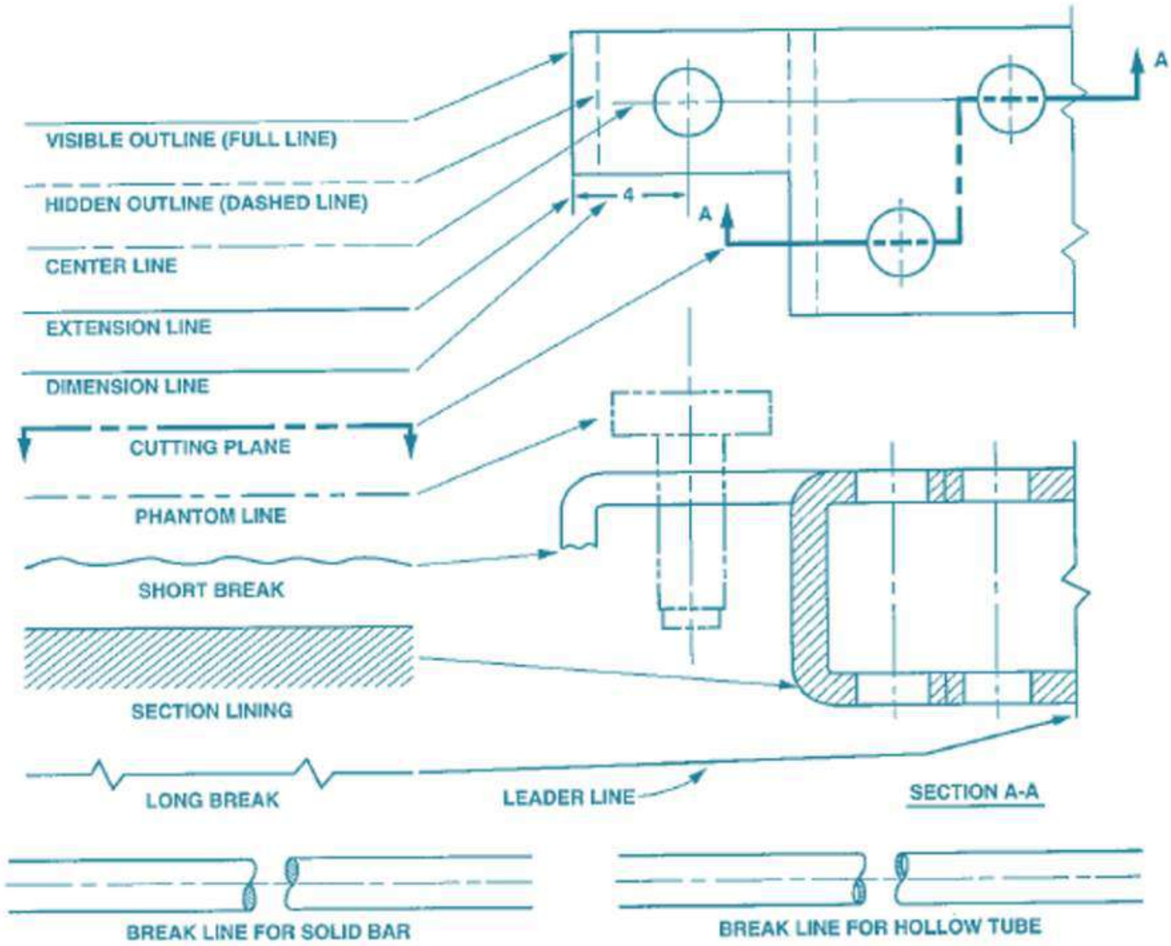
The outline or visible line is used for all lines on the drawing representing visiblesolid lines on theobject.

Hidden line:

Hidden lines indicate invisible edges or contours.

Hidden lines consist of short dashes evenly spaced and are frequently referred toas dash lines.


Viewing-plane Line
Extension Line
Dimension Line
Center Line
Hidden Line
Break Line
2.875
B
B
Cutting-plane Line
Visible Line
A
A
Center Line
(Path of motion)
Leader
Chain Line
Phantom Line
Section Line
SECTION A-A
VIEW B-B



Center line:

Centerlines are made up of alternate long and short dashes. They indicate the center of an object or part of an object. Where centerlines cross, the short dashes intersect the partsymmetrically.

In the case of very small circles, the centerlines may be shownunbroken.

Extension line:

Extensions are used to extend the line showing the side or edge of a figure for the purpose of placing a dimension to that side oredge.

They are very narrow and have a short break where they extend from the object and extend a short distance past the arrow of the dimensioningline.

Dimension line:

A dimension line is a light solid line, broken at the midpoint for insertion of measurement indications, and having opposite pointing arrowheads at each end to show origin and termination of ameasurement.

They are generally parallel to the line for which the dimension is given, and are usually placed outside the outline of the object and between views if more than one view is shown.

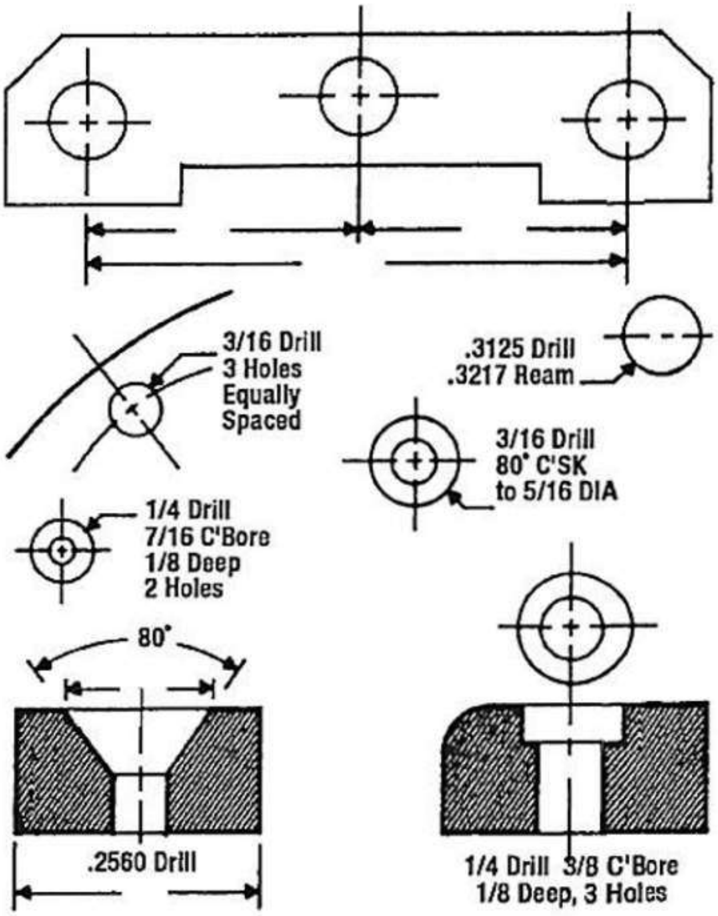
The dimension of an angle is indicated by placing the degree of the angle in itsarc.

The dimensions of circular parts are always given in terms of the diameter of the circle and are usually marked with the letter D or the abbreviation DIA following the dimension.

The dimension of an arc is given in terms of its radius and is marked with the letter R following thedimension.

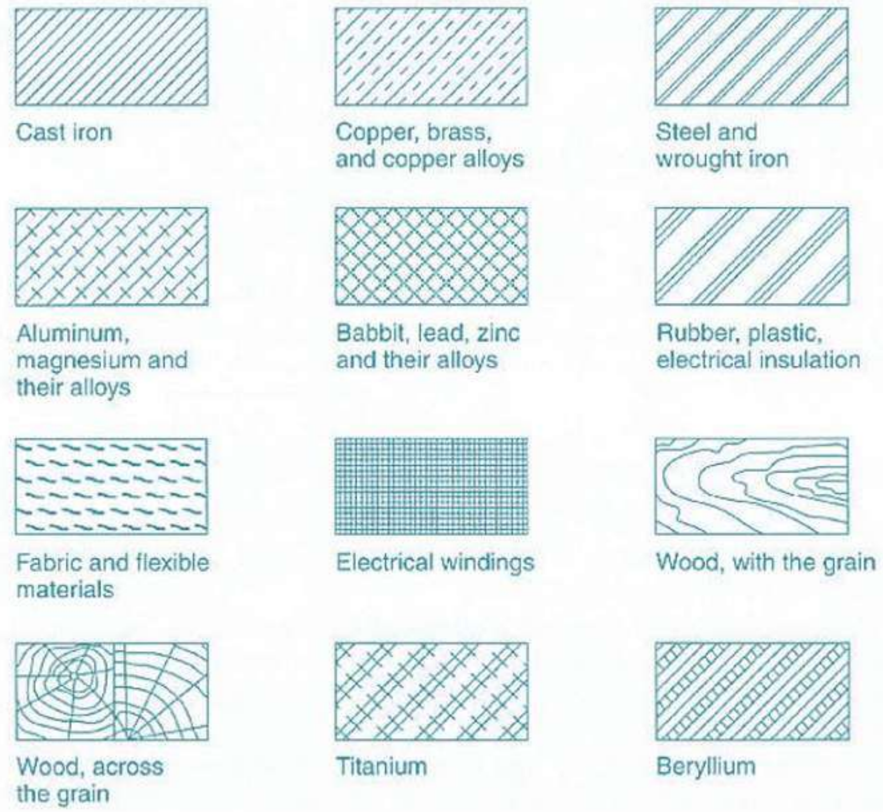
Parallel dimensions are placed so that the longest dimension is farthest from the outline and the shortest dimension is closest to the outline of theobject.

On a drawing showing several views, the dimensions will be placed upon each view to show its details to the bestadvantage.
In dimensioning distances between holes in an object, dimensions are usually given from center to center rather than from outside to outside of theholes.
When a number of holes of various sizes are shown, the desired diameters are given on a leader followed by notes indicating the machining operations for eachhole.
If a part is to have three holes of equal size, equally spaced, this information is explicitly (Clearly) stated, with all necessary information.



Sectioning line:

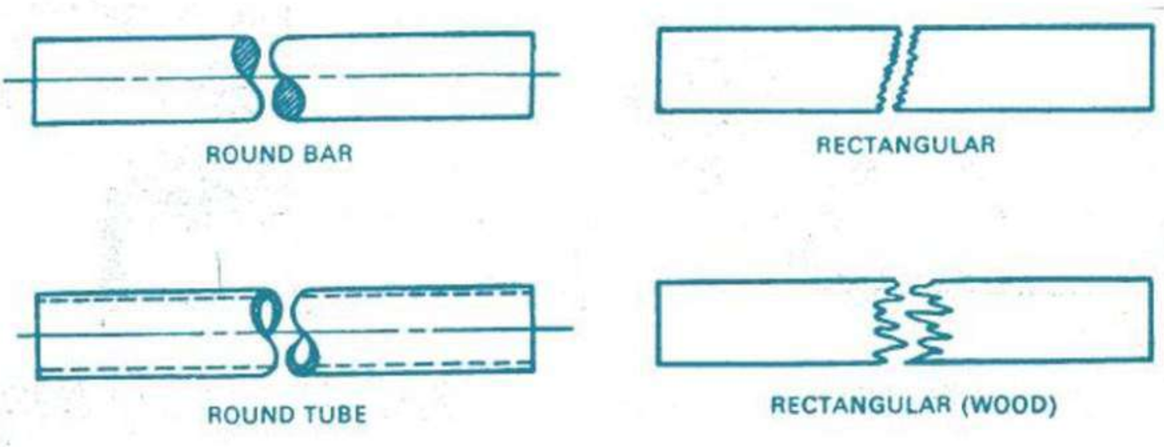
Sectioning lines indicate the exposed surfaces of an object in sectional view andare used to identify the material of which a part ismade.
They are generally thin full lines but may vary with the kind of material shown in section.
Note: Although various materials can be illustrated by different section lines, if the materials used are listed in the bill of materials, the symbol for cast iron is frequently used to represent all metals.



Phantom line:

Phantom lines, composed of one long and two short evenly spaced dashes, indicatethe alternate position of parts of the object or the relative position of a missingpart.
Break lines:

Break lines indicate that a portion of the object is not shown on thedrawing.
Short breaks are made by solid, freehand lines. For long breaks, solid ruled lineswith zigzags areused.
Also Shafts, rods, tubes, and other such parts which have a portion of theirlength broken out have the ends of the break drawn with break lines, as shown infig.



Stitch line:

Stitch lines indicate stitching or sewing lines and consist of a series of evenlyspaced smalldashes.

Cutting plane and viewing plane line:

Cutting plane lines indicate the plane in which a sectional view of the object istaken.
Viewing plane lines indicate the plane from which a surface isviewed.

Leader line:

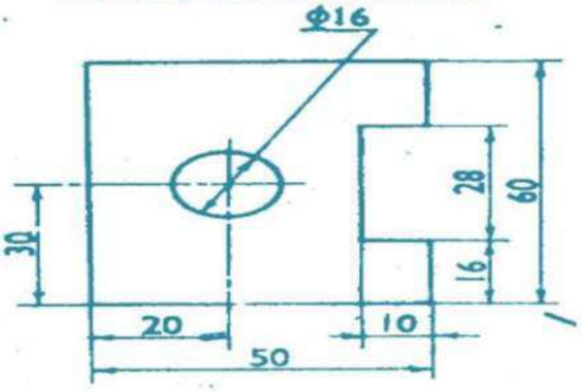
Leader lines are solid lines with one arrowhead and indicate a part or portion to whicha note, number, or other referenceapplies.

Dimensioning

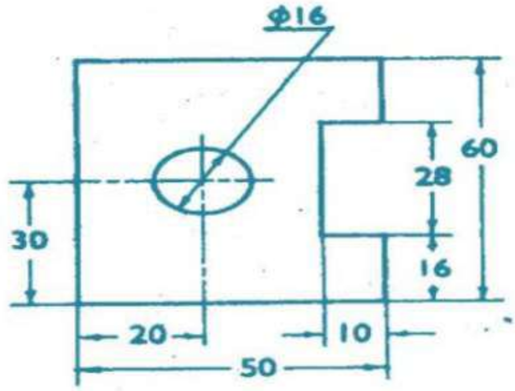
Dimensions that appear on a drawing represent the perfect (actual) size and are called basic or nominaldimensions.
All dimensions necessary for the manufacture of the part or assembly are given on the drawing; it should not be necessary to deduce any dimension from otherdimensions.
To avoid confusion, dimensions are normally given once only. The units of measurement used are usually stated on the drawing, to avoid repetition, but any dimension to which this general statement does not apply will be suitablyannotated.
Dimensions are placed so that they may be read from the bottom or right-hand side of the drawing.

Types of dimensioning:

- **Aligned**
  - Dimension are aligned with the entity being measured.
  - They are placed perpendicular to the dimension line such that they may be read from the bottom or right-hand side of the drawing sheet.
  - Dimensions are placed at the middle and on top of the dimension lines.

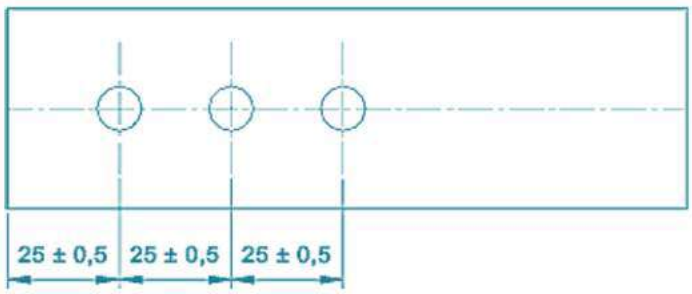


- **Unidirectional**
  - Dimensions are placed in such a way that they can be read from the bottom edge of the drawing sheet.
  - Dimensions are inserted by breaking the dimension lines at the middle.



Placement of dimensions:

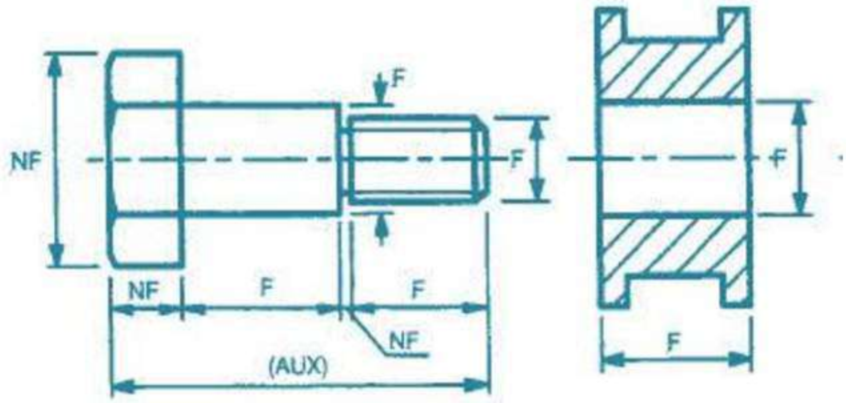
Chain dimensioning, i.e. dimensioning between adjacent holes, is not often used, since it allows a build up of tolerances, which may not beacceptable.



An alternative method called Parallel or staggering dimensioning, used with riveted joints, is to locate the end holes and add a note such as '3 rivets equally spaced'; this method is useful on curvedsurfaces.

Types of Dimensions:

Machined components are usually measured by a system of functional and non-functional dimensions.
The functional dimensions are those which directly affect the function of the component, e.g. Component's size like the length of abolt.
A non-functional dimension would be the depth of the bolt head, and other dimensions chosen to suit production orinspection.
A location or Datum dimension shows location or exact position of various constructionaldetails.
An Auxiliary dimension is given for information purpose only. It does not govern the production or inspection operations and is derived from other values shown on drawing. Usually given in brackets and no tolerance applies toit.

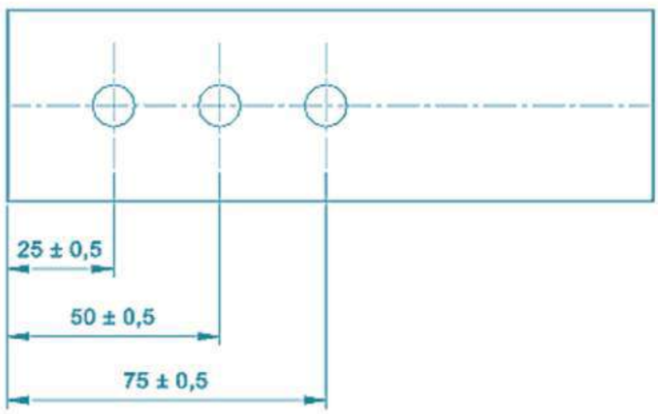


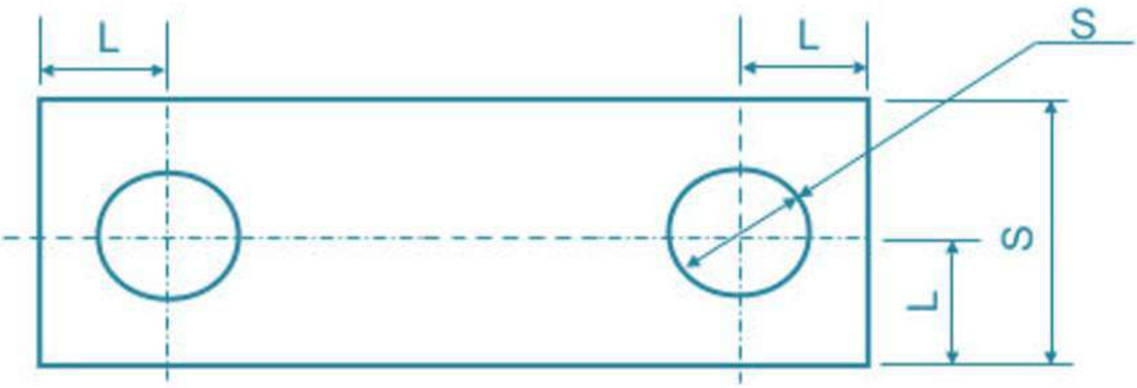
F and S – Size or Functionaldimension

NF – Non-functionaldimension

L – Location or datumdimension

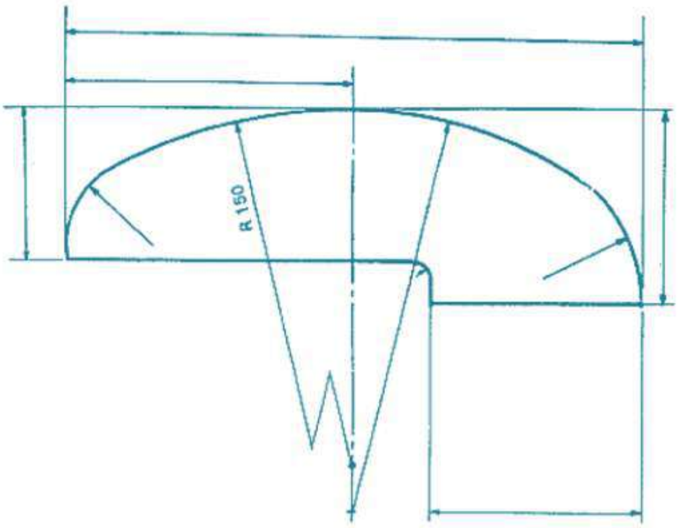
(AUX) – Auxiliary dimension



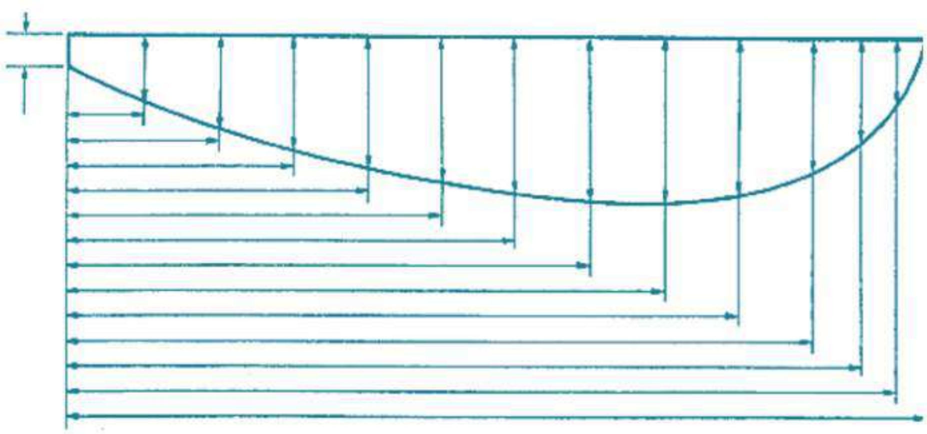


Dimensioning of curved profiles:

Items the profiles of which are curved, are where practicable, dimensioned by means of radii.
Dimensioning profiles by radii - Where a radius is very large, and the centre of the arc could not be shown on the drawing, the method shown for the R150 dimension in figure may be used; the portion of the radius which touches the arc being in line with the true centre.



Dimensioning profiles by Ordinates - Where Radii method cannot be employed, a system of ordinates may beused.



The radii method is usually preferred, since accurate arcs can be produced; whereas with the ordinate system, deviations from the required curve may occur as a result of connecting the plottedpoints.

Allowance and Tolerance:

Allowance – The Difference between the nominal dimension and the upper or lower limit that a part is allowed to vary in service, is called the allowance.
Eg; If a dimension is depicted as 0.3125 ± 0.0005, the allowable dimensions are0.3120 and 0.3130inches.
Where allowance is +0.0005 and -0.0005

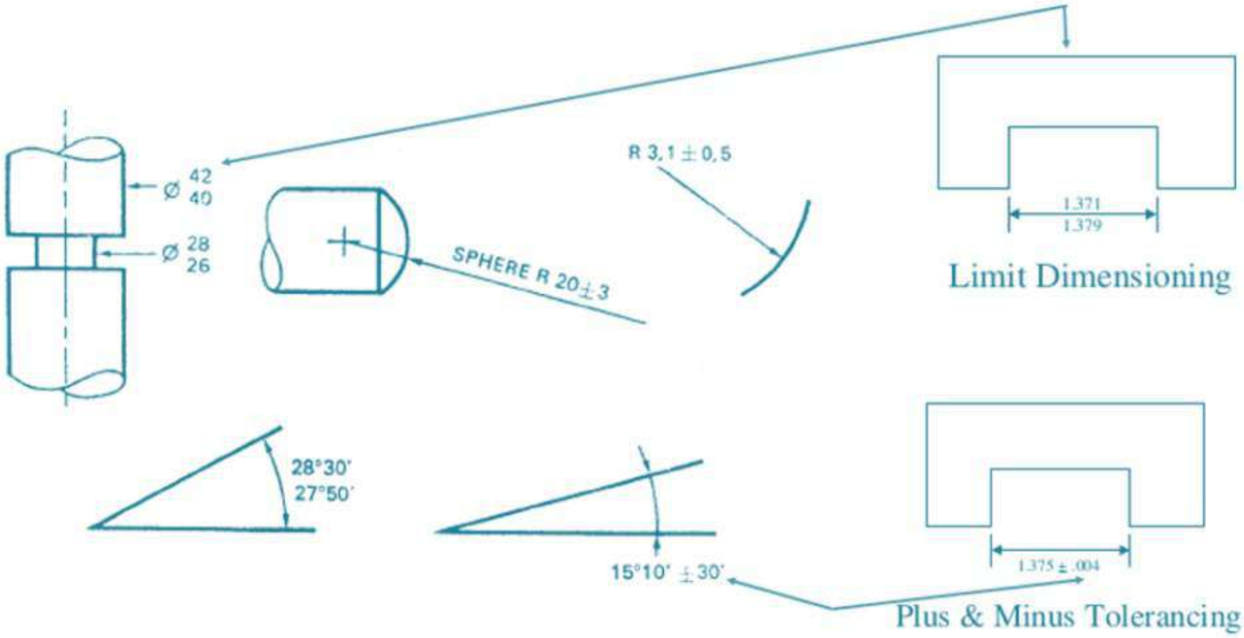
Tolerance is the difference between the extreme allowable dimensions or allowance.

From the above example, the tolerance would be,

0.3130 (maximum allowable dimension) – 0.3120 (Minimum allowance dimension)

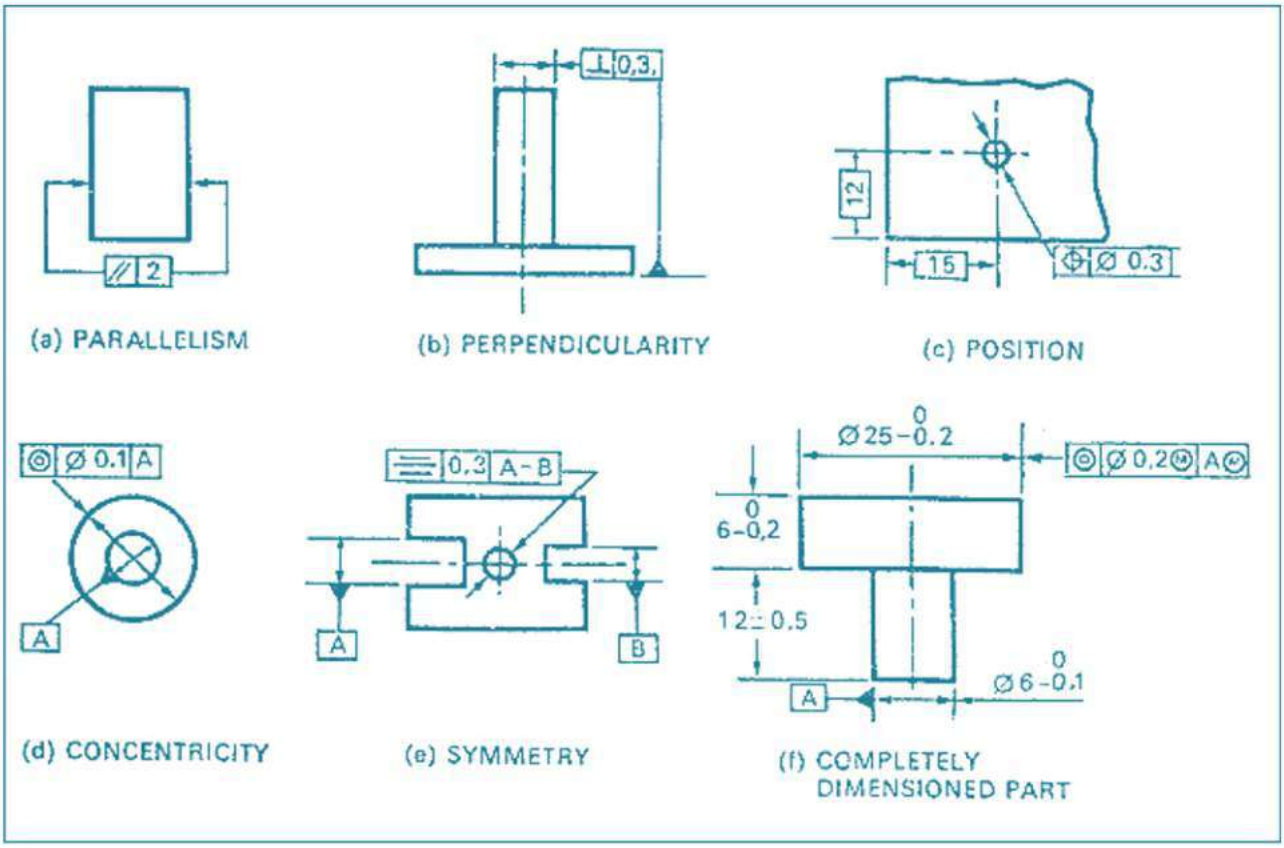
= 0.0010 inches.

Or, Difference between the maximum and minimum allowance is 0.0010 inches . 0.0010-inch is the tolerance given for the part.
Note: Based on allowance and tolerance, different kind of fits can be achieved. We will discuss about it in a separate chapter called Fits and clearances

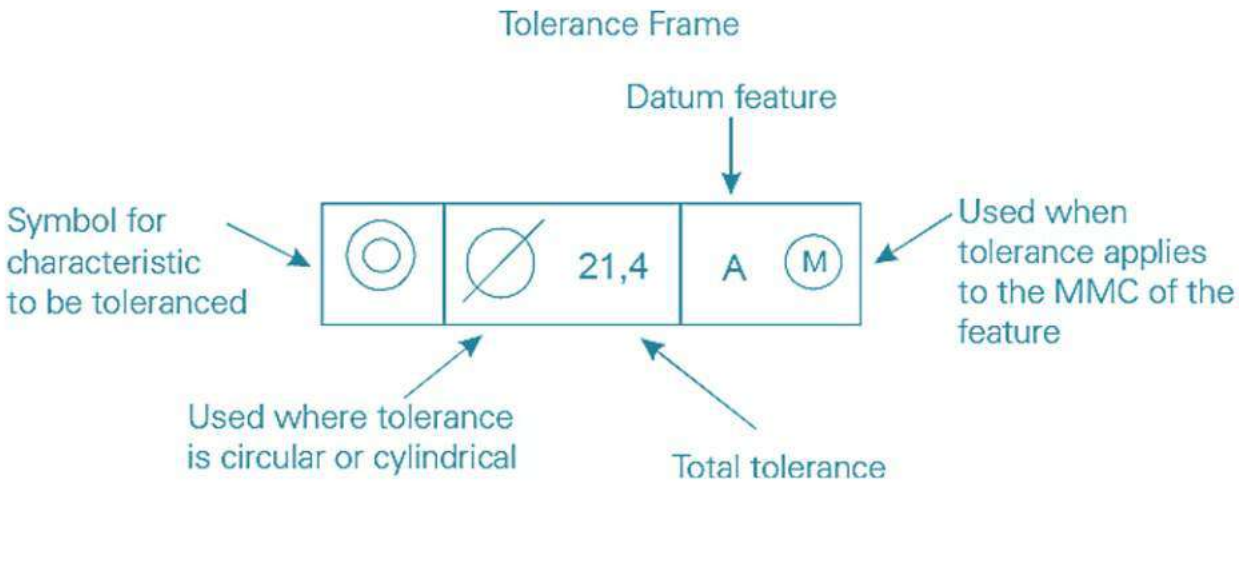


Geometric tolerancing:

Linear and Angular Tolerances that we seen above, may be expressed by quoting the upper and lower limits, or by quoting the nominal dimension and the limits of tolerance above and below thatdimension.
It is sometimes necessary to place tolerances on both geometric features and dimensions, in order to adequately control the shape of a part. This is done in Geometrictolerancing.
On newer drawings, the international system recommended in BS 308 isused.
Information relating to a particular geometric tolerance is enclosed within a rectangular frame on the drawing, an arrow from the frame indicating the location of the feature to which the tolerance applies.
If the tolerance is related to a particular datum, a leader line is drawn from the frame to the datum position, or the datum is referenced separately, and identified by a letter in theframe.
Unless the datum is a dimension, it is defined by a solid equilateraltriangle.



As a guide to the interpretation of a geometric tolerance, reference may be made to detail (e) of Figure. This indicates that a symmetry tolerance of 0·3 mm is required, with respect to datum features A andB.
This tolerance indicates that the axis of the hole must be between two parallel planes, 0·3 mm apart, which are symmetrically disposed about the common median plane of the slots in the end of thepart.
The hole could also, if necessary, be marked to indicate a symmetry tolerance at 90° to the plane specified, and the tolerance for this could bedifferent.
The symbol (M) in detail (f) of Figure 16, indicates that the tolerance applies only to the maximum material condition of the dimension or datum feature and may be greater at the actual finishedsize.



Geometric toleranc

Feature	Type of tolerance	Characteristic	Symbol
Single	Form	Straightness	⏤
		Flatness	▱
		Roundness	○
		Cylindricity	⌭
		Profile of a Line	⌒
		Profile of a surface	⌓
Related	Attitude	Parallelism	∥
		Squareness	⊥
		Angularity	∠
	Location	Position	⌖
		Concentricity	◎
		Symmetry	⌯
	Composite	Run-out	↗
Maximum material condition			Ⓜ
Dimension which defines a true position			▭

Charts and Graphs –Nomograms

The need to show how two or more variable affects a value is common in maintenance industry.

Nomograms are special type of graphs that allows you to solve complex problems involving more than onevariable.

Most nomogram charts contain a great deal of information and require the use of scales on three sides of the chart, as well as diagonallines.

Charts are used by both pilots and technicians to properly operate and maintain complex modern aircraft.

Electrical wire chart:

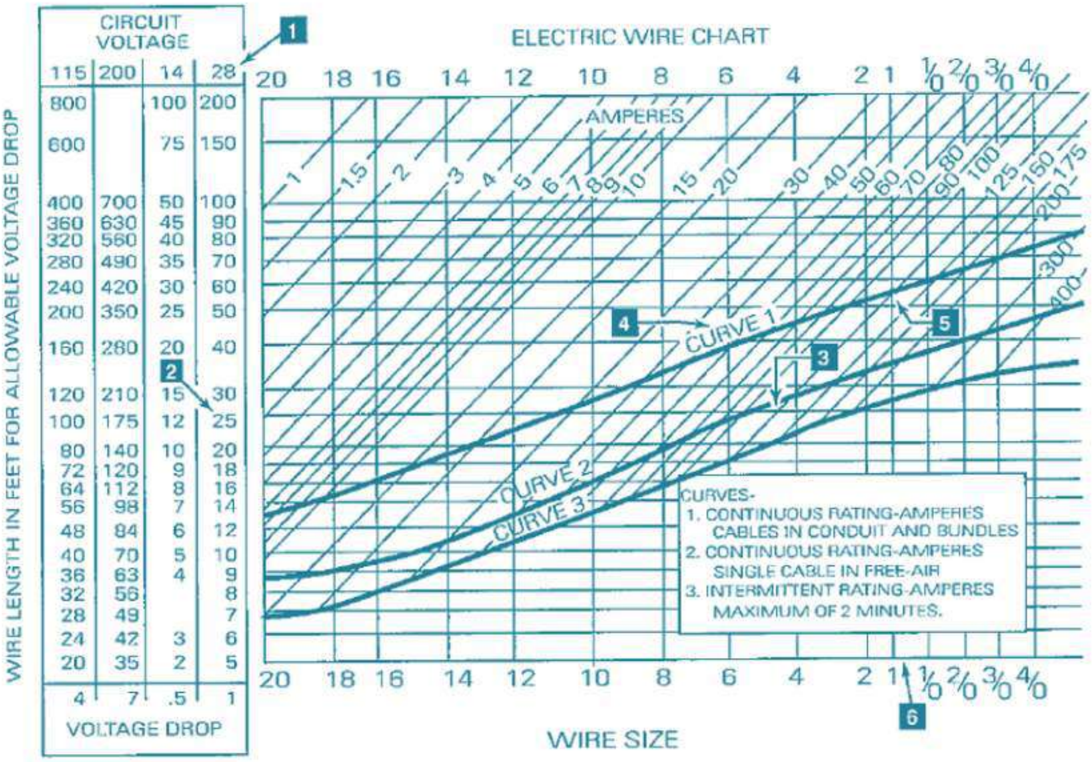
An example of nomogram that is used extensively in the maintenance industry is the electric wirechart.

This chart is made up of vertical lines that represent the American wire gauge (AWG) wire sizes.

Horizontal lines represent the length of wire in feet that produces an allowable voltage drop for each electrical systemlisted.

Drawn diagonally across the chart is a series of parallel lines representing currentflow.

A common use for this chart is to find the wire size required to carry a given amount of current without exceeding the allowable voltage drop.



How to use an Electrical wire chart:

For example: Determine the maximum size wire of a single cable in a bundle, required to carry 125 amps continuous rated, 25 feet in a 28-volt system.

Curves 1,2,3:

The three curves extend diagonally across the chart from the lower left corner to the right side of thechart.

These curves represent the ability of a wire to carry the current withoutoverheating.

Curve one represents the continuous rating of a wire when routed in bundles or conduit. If the intersection of the current and wire length lines are above this curve, the wire can carry the current without generating excessiveheat.

If the intersection of the current and wire length lines falls between curve one and two, the wire can only be use to carry current continuously in freeair.

If the intersection falls between curves two and three, the wire can only be used to carry current intermittently.

To begin, locate the column on the left side of the chart representing a 28 volt system (Item1)

Move down in this column until you find the horizontal line representing a wire length of 25-ft (Item2)

Follow this line to the right until it intersects the diagonal line for 125 amps (Item3)

Because the wire is in a bundle and carries a continuous current, you must be at or above curve 1 on the chart (Item4)

Follow along the diagonal line representing 125 amps until it intersects curve 1 (Item5)

From this point, drop down vertically to the bottom of the chart. The line falls between wire sizes 1 and 1/0 (Item6)

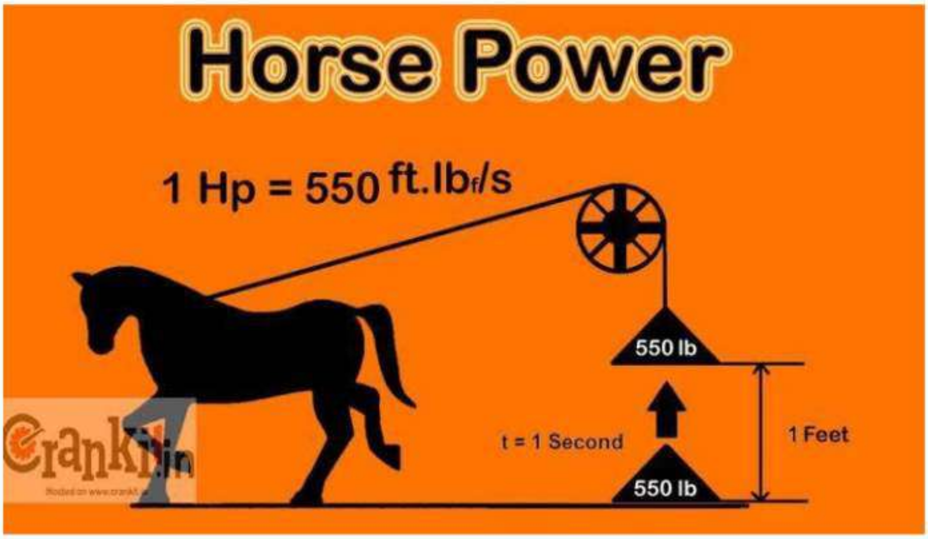
Whenever the chart indicates a wire size between two sizes, you must always select the large wire. In this case, a 1/0, or a single aught wire isrequired.

Note: In AWG system, 1/0, 2/0, etc; indicates the values between 0 and 1.

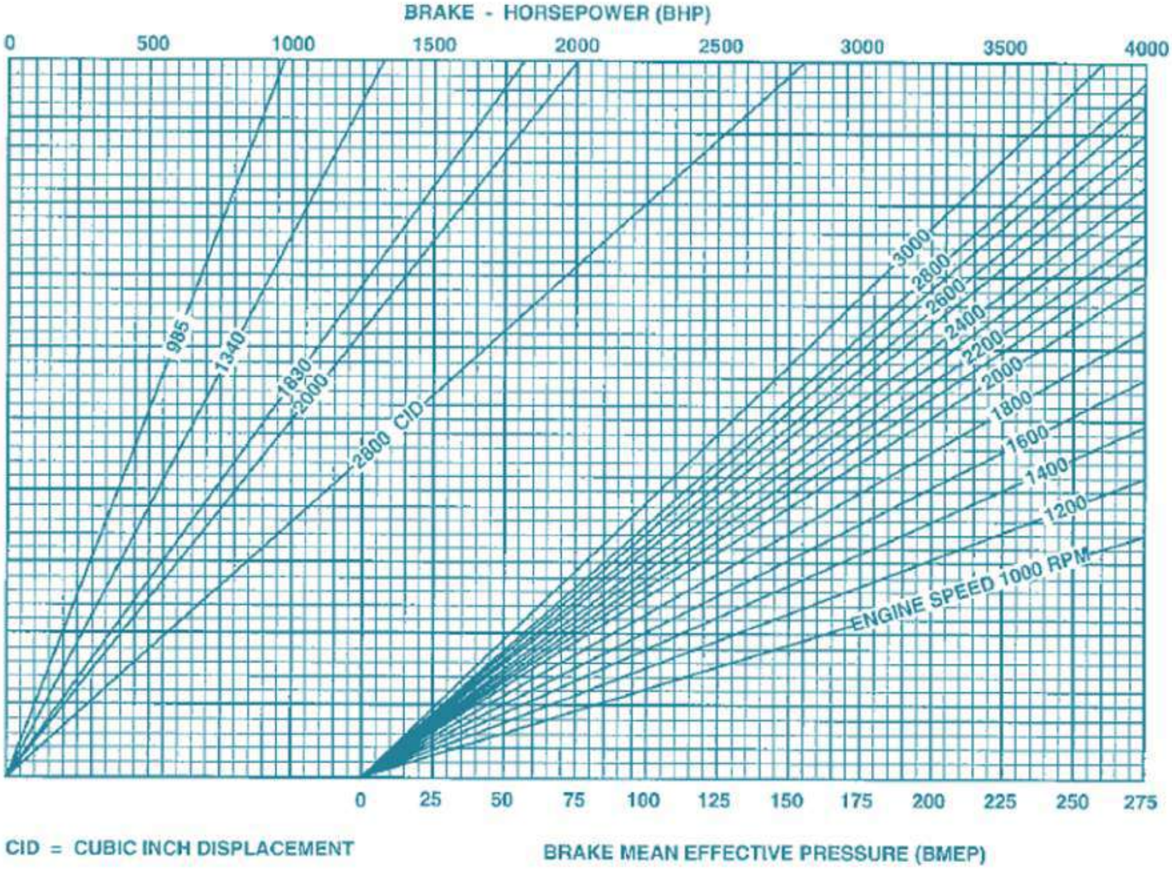
1/0 indicates values with 1 decimal place like 0.5 or 0.9, 2/0 indicates values with two decimal places like 0.55 or 0.11

Brake horse power chart:

Terms to know:
Brake horse power – Power at the output shaft of an engine or aturbine.
Brake mean effective pressure – the total pressure of all strokes of an engine that gives the brakehorsepower.
CC (cubic cm) or CID (cubic inch displacement) of an engine – is the volume the piston sweeps (moves up and down) inside acylinder.



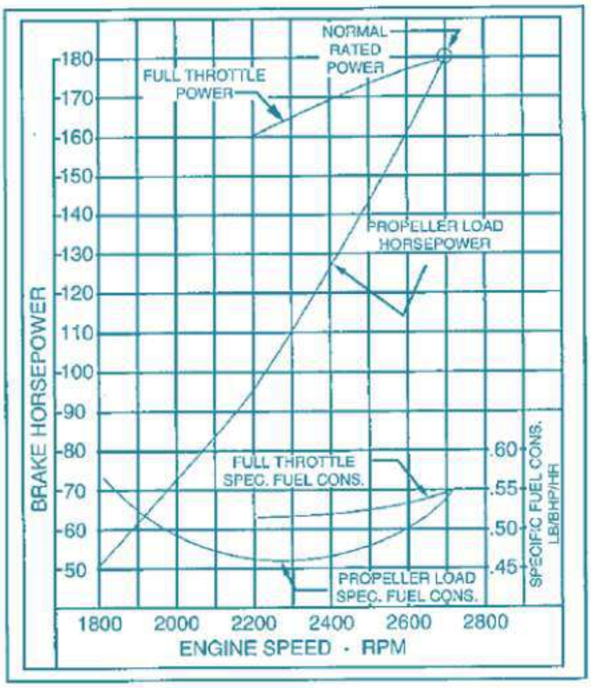
Another common type of graph you will encounter as a technician is the performance chart. One common performance chart is the brake-horsepowerchart.
These charts represent many hours of calculation by engineers but are presentedso that you can quickly determine if the performance being observed isacceptable.
For this simple chart, assume you have an engine that has a 2000 cubic-inch displacement and develops 1500 brake-horse power at 2400rpm.
To calculate the brake mean effective pressure, BMEP, begin by locating 1500 brake- horsepower on the top of thechart.
From this value, drop down vertically until you reach the line representing 2000cubic inches of displacement (CID).
Fromthisintersectionextendalinehorizontallytotherightuntilyouintercepttheline representing 2400 rpm.
Now drop down vertically to read the BMEP on the bottom of the chart, whichis approximately248.



Fuel consumption chart:

The fuel consumption chart is another type of performance chart that you mustbe familiar with.
For this simple chart, assume that you are tryingto determine how much fuel an engine consumes when it is operating at a cruise of 2400rpm.
First determine the SFC (Specific fuel consumption = Amount of fuel consumed foreach unit of power output).
To do this, locate 2400 rpm on the bottom of the chart and follow the line up until it intersects the propeller load SFCcurve.
Fromthisintersection,extendalinetotherightsideofthechartandyoucanreadaSFC of .47 (lb/hr) / (1BHP).

Now, go back to the bottom of the chart and locate 2400 rpm again. From thispoint move up to the propeller load horsepowercurve.
Fromthisintersection,extendalinetotheleftsideofthechartandreadthebrake horsepower of 127 hp.
To determine the fuel burn, multiply the SFC by Brake-horsepower. Therefore, the engine burns 59.69 pounds per hour (.47 x 127 = 59.69lb/hr)

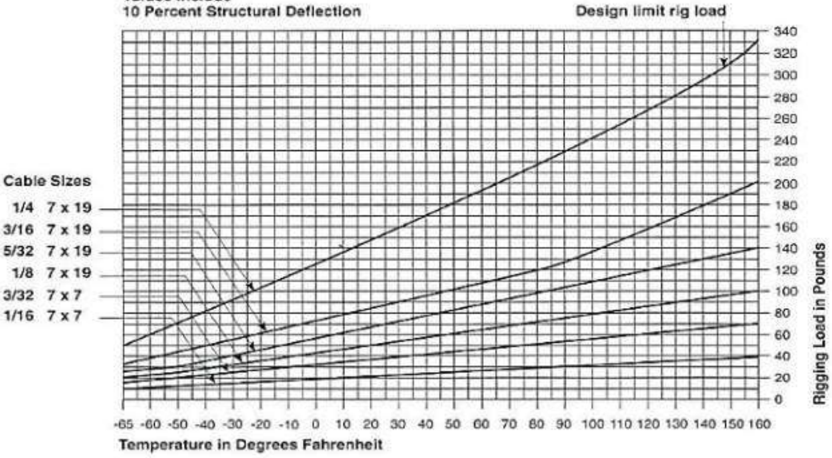


Engine Horsepower Vs Altitude chart:

This chart represents the relationship between engine horsepower and altitude.

To determine the percentage of sea level horsepower developed at an altitude of 7000- ft, begin by finding the point on horizontal axis that represents the desiredaltitude.
From this point, move upward until you intersect the horsepowercurve.
Then move horizontally left to the chart's vertical axis and read the percentage ofSea level horsepoweravailable.

Control Cable tension

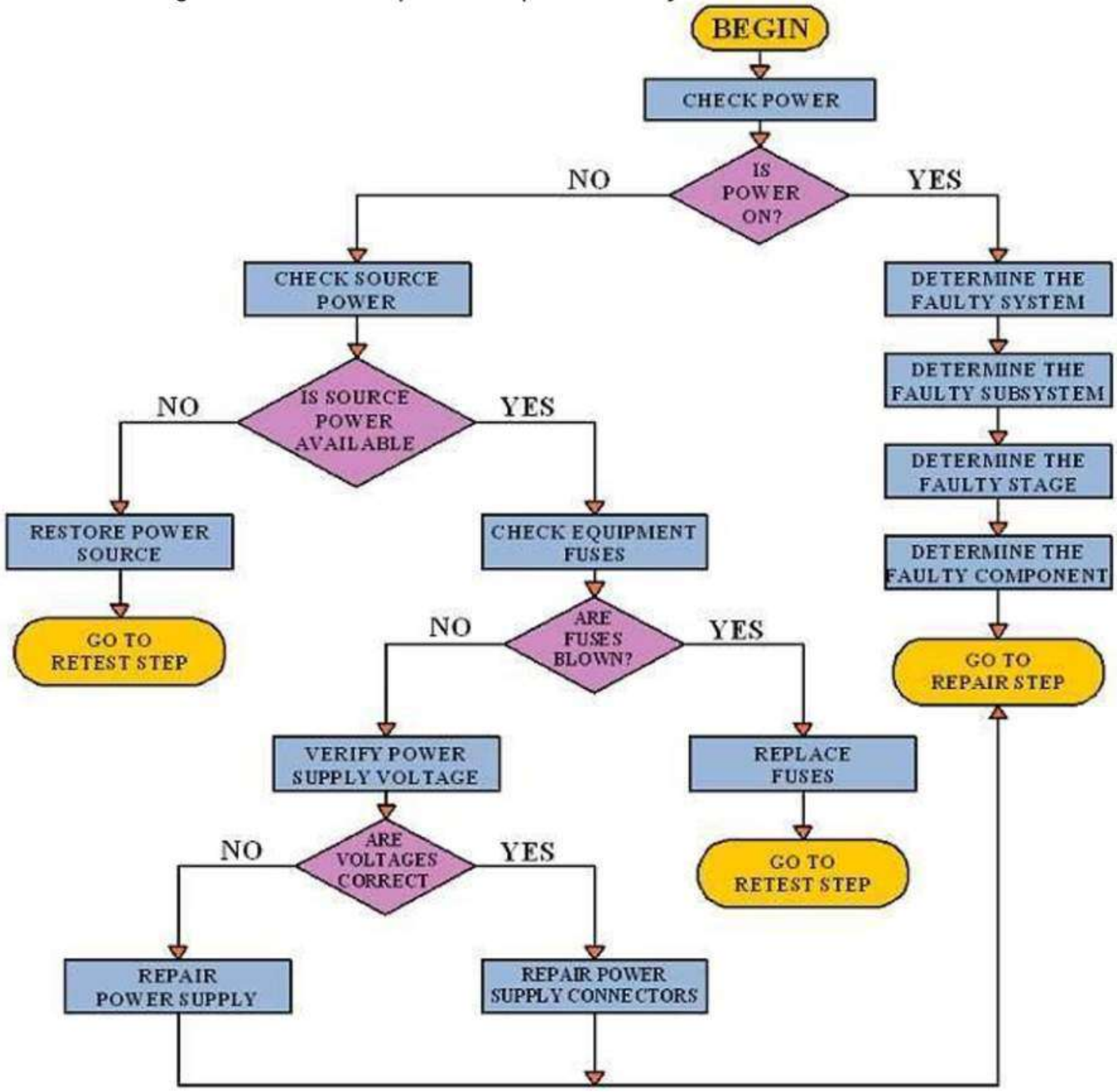


To find the correct cat
temperature the area w

1. From the existing temperature on the Fahrenheit temperature scale at the bottom of the chart, draw a line vertically upward until it intersects the curve for the size and type of cable being

adjusted.
2. From this intersection, draw a horizontal line to the right until it intersects the rigging load. This is the desired cable tension in pounds.
Troubleshooting flowchart:

Troubleshooting flowcharts are frequently used for the detection of faulty components. They often consist of a series of yes or noquestions.
If the answer to a question is yes, one course of action isfollowed.
If the answer is no, a different course of action isfollowed.
In this simple manner, a logical solution to a particular problem may beachieved

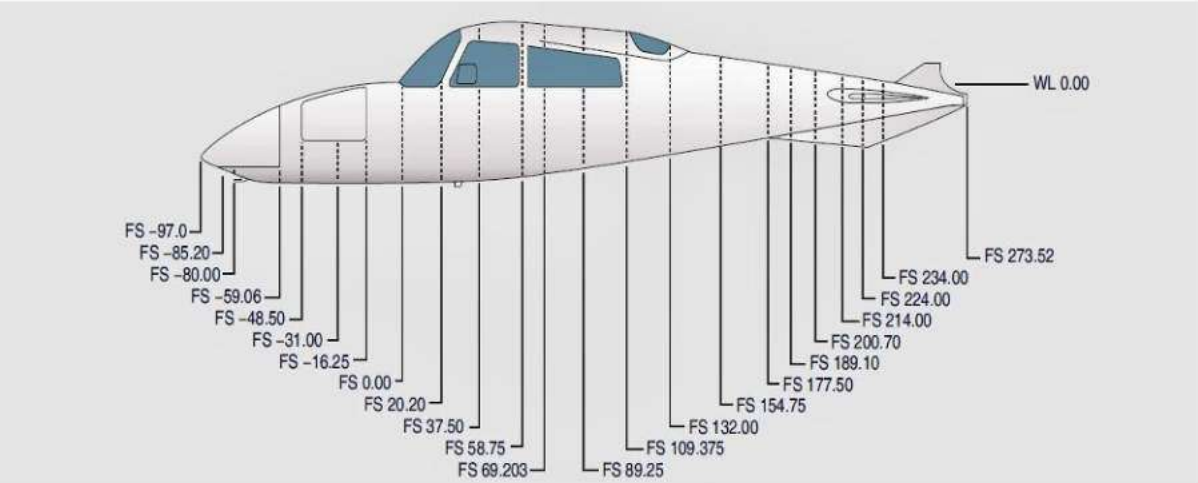


Station numbering
In the service, maintenance, and repair of aircraft, it is necessary to establish a method of locating components and reference points on theaircraft.
This has been accomplished by establishing reference lines and station numbers for the fuselage, wings, nacelles, empennage, and landinggear.
Even on small, light aircraft, a method of precisely locating each structural component is required. Various numbering systems are used to facilitate the location of specific wing frames, fuselage bulkheads, or any other structural members on anaircraft.

Most manufacturers use some system of station marking. For example, the nose of the aircraft may be **designated "zero station," and all other stations are located at measured distances in inches behind the** zerostation.
Thus, when a blueprint reads "fuselage frame station 137," that particular frame station can be located 137 inches behind the nose of theaircraft.

Fuselage stations (Horizontal locations):

The applicable manufacturer's numbering system and abbreviated designations or symbols should always be reviewed before attempting to locate a structural member. They are not always the same. The following list includes location designations typical of those used by manymanufacturers.
Fuselage stations (Fus. Sta. or FS) are numbered in inches from a reference or zero point known as the referencedatum.
The reference datum is an imaginary vertical plane at or near the nose of the aircraft from which all fore and aft distances aremeasured.
The distance to a given point is measured in inches parallel to a center line extending through the aircraft from the nose through the center of the tail cone. Some manufacturers may call the fuselage station a body station, abbreviatedBS.



Wing stations – Buttock line (left & right locations):

Buttock line or butt line (BL) is taken from longitudinalaxis.
Measurements left (LBL) or right (RBL) can bemade.

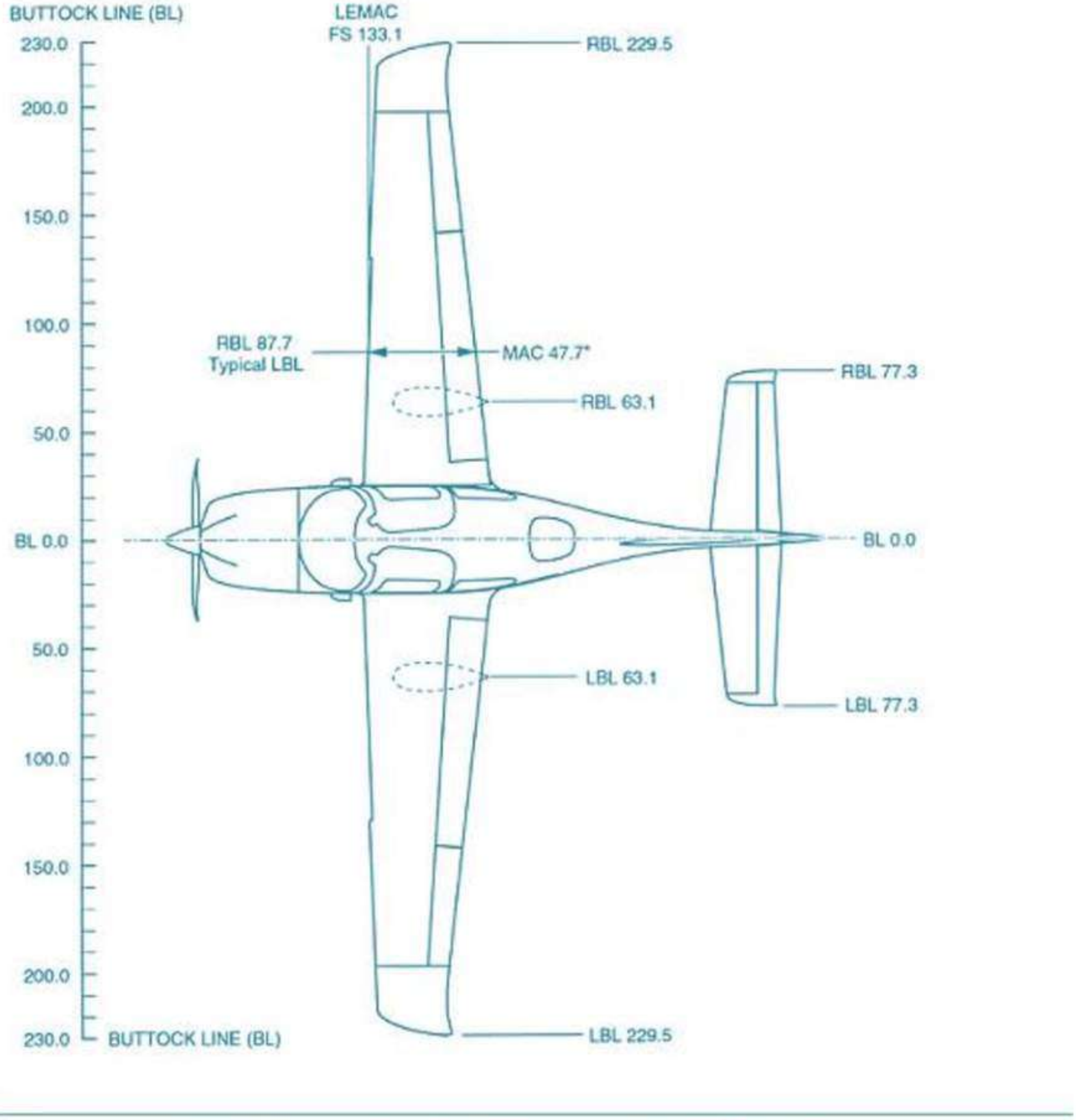
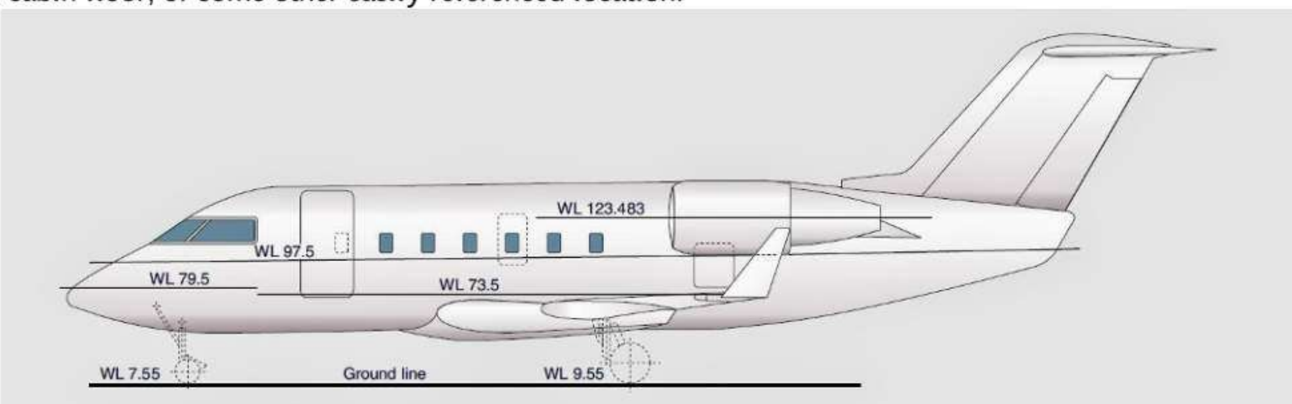
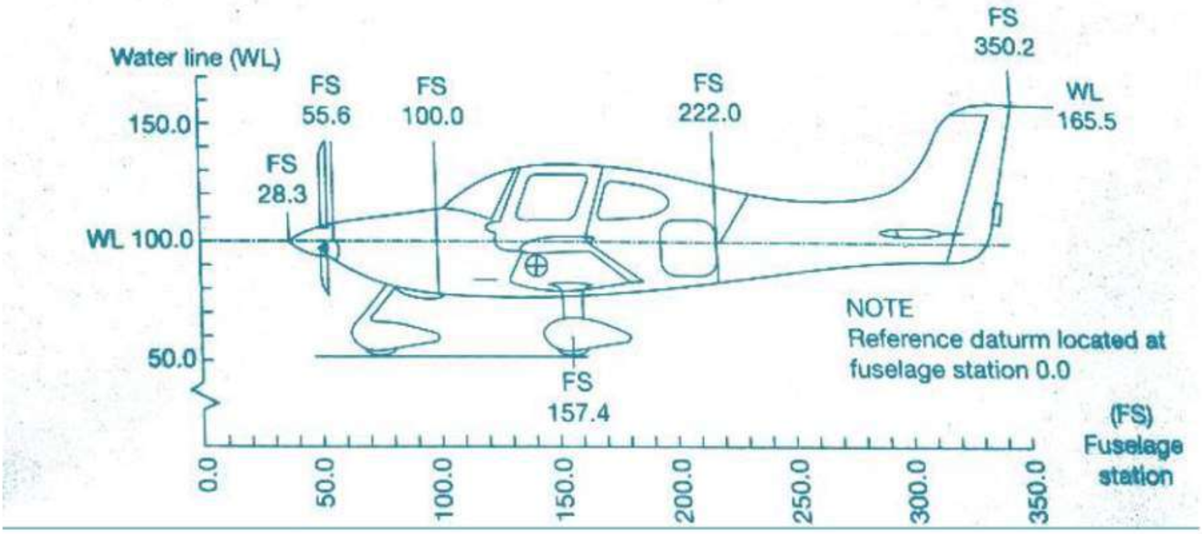


Figure 2-11. Station numbers and location identification on aircraft.

Water line (Vertical locations):

Water line (WL) is the measurement of height in inches perpendicular from a horizontal plane usually located at the ground, cabin floor, or some other easily referenced location.





Aeronautical Standards

ATA Spec.100 (Air transport association Specification No.100

Since 1 June 1956, the Air Transport Association of America (ATA), has used a specification, to establish a standard for the presentation of technical data, by aircraft, engine or component manufacturers, that is required for their respectiveproducts.

This specification is known as ATA Specification No.100 (ATA 100), and its two Chapters clarify the general requirements of the aircraft industry, with reference to thecoverage,

ATA Spec.100

Chapter 2 of the ATA 100 covers policies and standards applicable to specific manuals and it details the names and contents of the various manuals that must be prepared by the manufacturer

Chapter 1 of the ATA 100 covers policies and standards applicable to all publications and provides a uniform method for arranging technical material, within the relevant publications, in an effort to simplify the technician's problem in locating instructions and parts

preparation and organisation of all technical data.
ATA Spec.100 Numbering system:

Table illustrates an example of how the ATA 100 numbering system (in this instance using numbers ranging from
to 27-31-14) is used, to identify the material which is covered at particular locations within a typical MaintenanceManual.

EXAMPLE OF ATA 100 NUMBERING SYSTEM

First Element, Chapter (system)	Second Element, Section (sub-system)	Third Element, Subject (unit)	Coverage
27	00	00	Material which is applicable to the system as a whole (in this instance Flight Controls).
27	31	00	Material which is applicable to the sub-system as a whole (in this instance Elevator and Tab Control System).
27	31	00	Material which is applicable to the sub-sub-system as a whole. This number (digit) is assigned by the manufacturer.
27	31	14	Material applicable to a specific unit of the sub-sub-system (Elevator Feel Computer). Both digits are assigned by the manufacturer

The subject is broken down yet further – into Page Blocks – to provide maintenance personnel with more detailed information on specific topics (or subtopics) which relate to the Subject material.

EXAMPLE OF ATA 100 PAGE BLOCK NUMBERING SYSTEM

Topic or sub-topic	Page Block
Description and Operation	1 to 100
Trouble-shooting	101 to 200
Maintenance Practices (if brief)	201 to 300
(Otherwise) Servicing	301 to 400
Removal/Installation	401 to 500
Adjustment/Test	501 to 600
Inspection/Check	601 to 700
Cleaning/Painting	701 to 800
Approved Repairs	801 to 900

Note: The section and subject changes for different aircrafts, as not all aircraft has all systems and same trouble shooting procedures. But the chapter remains the same for all **aircraft manuals and so it's very important to** remember all the chapter names with their corresponding numbers.

ATA Spec 100

- Referencing standard for commercial aircraft documentation
- Published by the Air Transport Association on June 1, 1956

ATA Spec 2100

- Referencing standard for Electronic documentation

ATA Spec 100 + ATA Spec 2100 = ATA iSpec 2200

ATA described "iSpec 2200" as the current global aviation industry standard for the content, structure, and Electronic exchange of aircraft engineering, maintenance and flight operations information. The content of the manual has only chapters as standard one.

Chapter 2 of ATA Spec.100:

Chapter 2 of ATA Spec.100 details the names and contents of the various manuals that must be prepared by the manufacturer.
The following manuals are supplied to the customer and reflect the customer's configuration:

Maintenance manual
Wiring Diagrammanual
Illustrated partscatalogue
Overhaulmanual
Structural repairmanual
Illustrated tools and equipmentlist

Aircraft Maintenance manual (AMM):

Maintenance manual contains the information necessary to enable the mechanics to service, trouble-shoot, functionally check and repair all systems and equipments installed in theaircraft.
It includes information necessary for the mechanic to perform maintenance practices or make minor repairs to any unit in the aircraft normally requiring such action on the line or in the maintenancehangar.
Note: The maintenance manual does not contain information relative to work normally performed on units or assemblies away from the aircraft.

Illustrated parts catalogue (IPC):

The Illustrated parts catalogue contains information for use in provisioning, requisitioning, storing and issuing replaceable aircraft parts and units and in identifying parts.

Overhaul manual:

The overhaul manual consists of individual subject publications covering the overhaul of components used on aircraft, together with descriptive, disassembly, cleaning, inspection/check, repair, reassemble, functional tests and parts identification information necessary to overhaul thepart.

Structural Repair Manual:

Contains material identification for structure subjected to;

Field Repair – typical repairs generally applicable to structural components of the aircraft that are most likely to bedamaged.

Information relative to materialsubstitution.

Fastener installation.

Aircraft alignment / symmetry check procedure (To check the surface to identify any damages)

A brief description of some procedures that must be performed concurrently with structural repair, such as protective treatment of the repair parts.

Wiring Diagram manual (WDM):

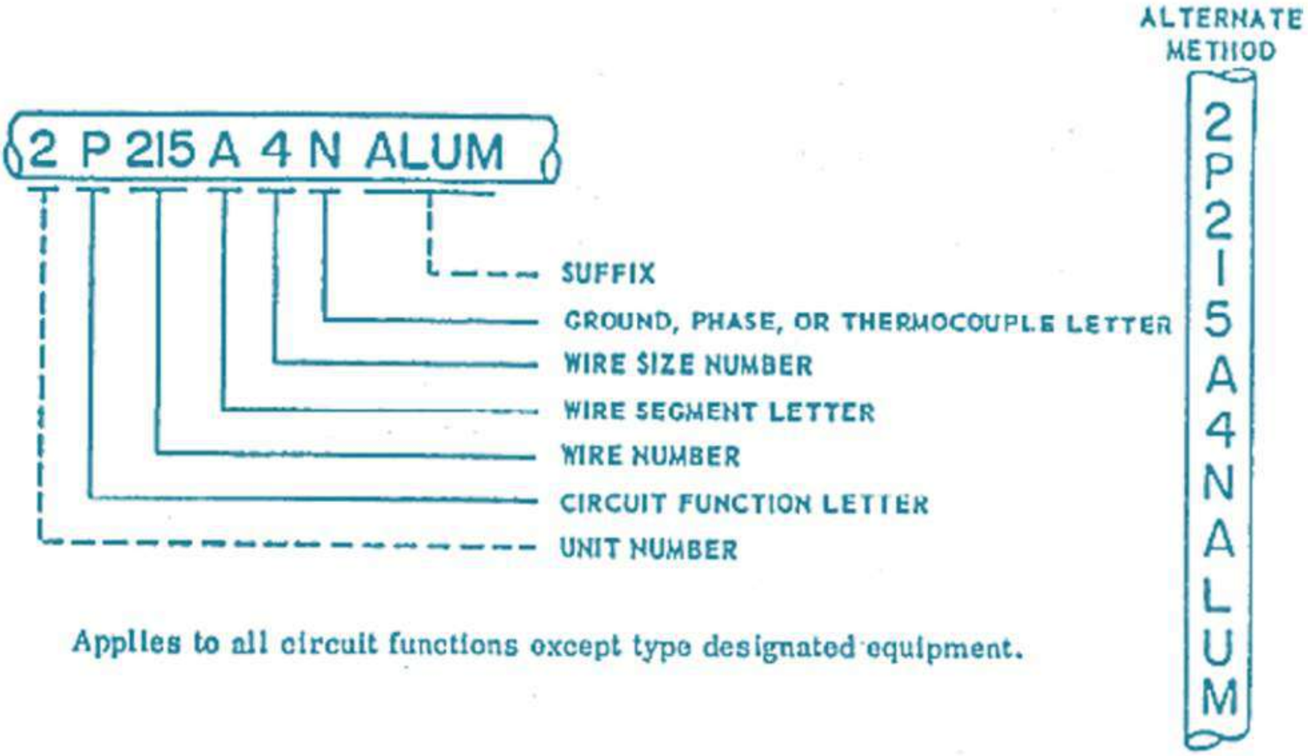
The wiring diagram manual contains the information necessary to enable the electrician to troubleshoot, functionally check and repair all electrical systems and equipments installed in theaircraft.

The information is in the form of Diagrams, codes and symbols and one should know how to read all these things to trace asystem.

Wire codes:

To facilitate locating components and tracing the circuitry of individual diagrams, each wire is identified by the wire code it bears in theairplane.

Wire code:



Unit number – Used only when components have two or more identicalcircuits.

Circuit function letters - indicate a relationship to a particular system (noted in the list of circuit function designations).

Eg; P in the code indicates that the wire is in a DC powersystem.

Wire numbers are provided to differentiate between wires in acircuit.

A wire segment is a conductor between two terminals or connections. Alphabetical sequence is usually followed. Wire segment "A" indicates the power source, "B" next segment,etc.
The wire size number is used to identify the size of the wire orcable.
A suffix to the wire identification code (N) identifies any wire or cable that completes the circuit to ground network. Phase letter "A", "B", or "C", used as a suffix identifies three-phase wiring in AC systems. The phase letter "V" is used as a suffix identifying an ungrounded wire or cable in a single-phase system. ALUM indicates thermocouple cable.

Other Aeronautical Standards:

ISO (International Organisation for Standardisation

ISO is one of the world's largest developers of global standards. It is an institution comprised of the national standards organizations from 156 member countries around the world. Most countries are ISOmembers.
ISO standards contribute to making the development, manufacturing and supply of products and services more efficient, safer andcleaner.
They provide governments with a technical base for health, safety and environmental legislation.
The EASA aviation maintenance professional is exposed to a great deal of the standardization work of theISO.

AN (Army/Navy or Airforce/Navy):

The AN system is one of the most widely used standards in aircraft hardware. It was developed, together with the MS system, by the US military to ensure quality and uniformity.
Items manufactured to this standard are not limited to the military and are found in all classifications ofaircraft.

NAS (National Aerospace Standard):

This standard is based on approval of military hardware for the civilian aerospace industry.

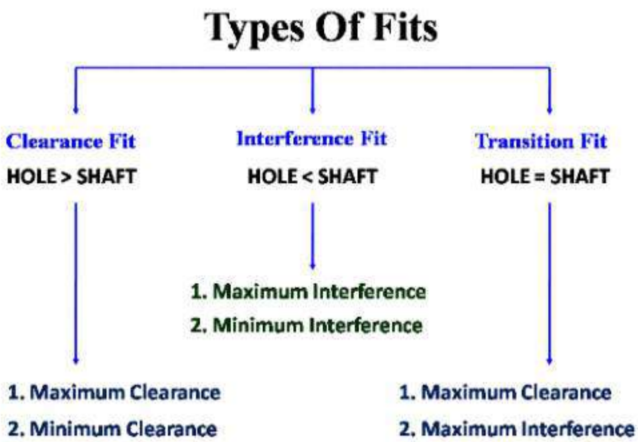
Fits &Clearance:

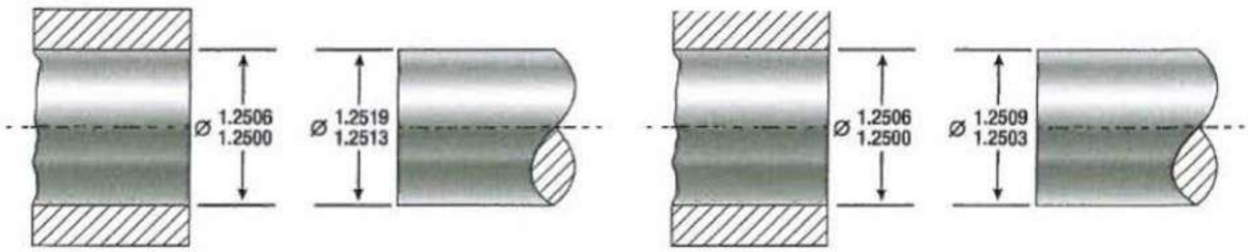
Fit – The dimensional relationship between two parts (Eg; between a shaft and a hole).

Clearance – The space between mating parts.

Classes of fit:

The relationship between the bolt hole and the bolt, for example, determines the classification of fit. Three basic classes of fit are:
Clearance Fit - A clearance fit is one having limits of size defined such that a clearance always results when mating parts areassembled.
Interference Fit - An interference fit is one having limits of size so prescribed that an interference always results when mating parts areassembled.
Transition Fit - A transition fit is one having limits of size so prescribed that either a clearance or an interference may result when mating parts areassembled.





A Interference Fit

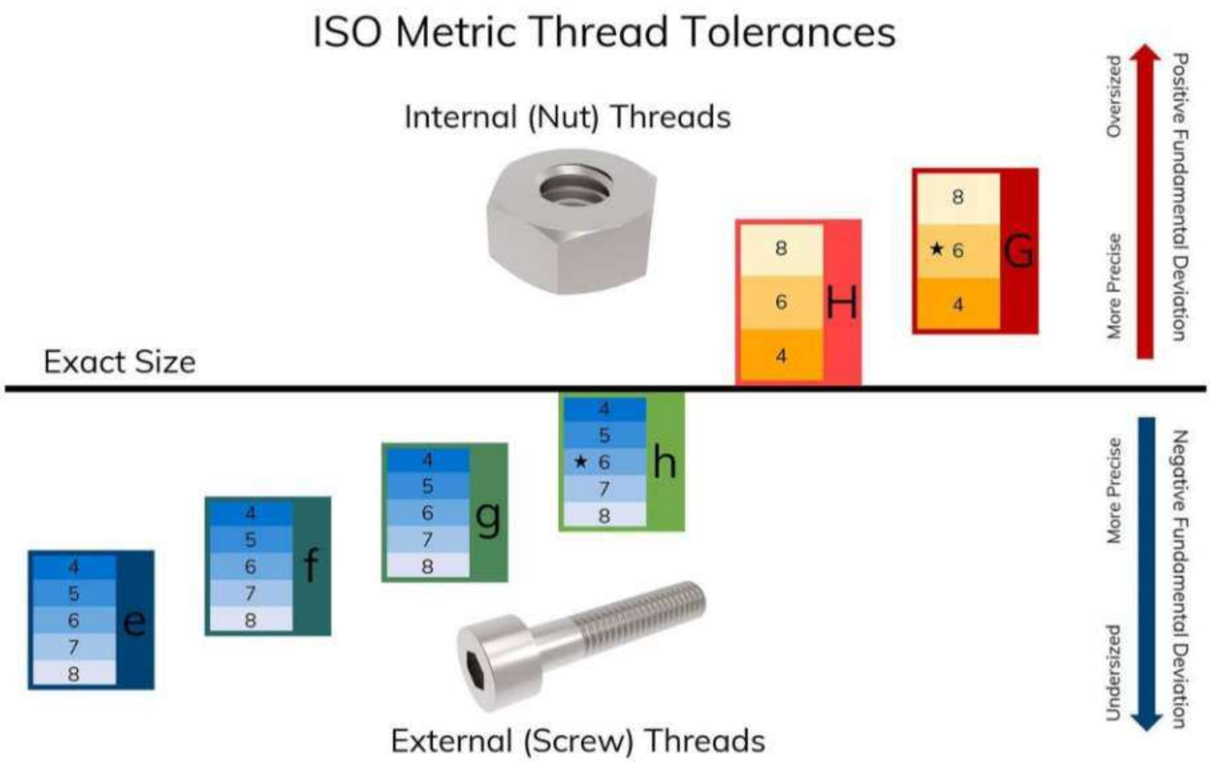
B Transition Fit

Standards of fits andclearance

To ensure consistent specifications, various standard fits have been devised around the world.

The British Standards System (BS1916-1 & 2:1953 and 3:1963) devised by the British Standards Institute (BSI) has a comprehensive system designed to cater for all classes ofwork.
The system provides for 21 types of holes designated by capital letters A,B,C,D, etc., and 21 types of shaft designated by small letters a,b,c,d, etc., from nominal diameters of 0.04 inch up to 19.69inches.
Each type of hole or shaft is provided with 16 grades of accuracy designated by numbers 1-16.

The ISO 286standard established by the International Organization for Standardization (ISO) is very similar to that of the BS, except that the system provides for 28 types for holes and shafts with 20 grades of accuracy.



Note:Star mark in the Figure shows that h6 screw (shaft) can be mated with G6 nut (hole) for a particular fit. That fit can be selected according to the manufacturer from fit chart. Then such screw and bolt can be mated to achieve that fit.

In the United States, The American National Standards Institute (ANSI) has also developed standards. The ANSI standards for metric fits and clearances follows the ISO standard. For Imperial based units (inches), it uses symbols such as RCx for running and sliding fits and FNx for force and shrink fits.

Newall system:

In the early Newall hole-based system of limits, the holes are classified as Class Aand ClassBfits.ClassAholesaremanufacturedtoaclosertolerancethanareClassBholes.Figureshowshow theshaftsare

Class of Fit	Type of Fit	Remarks
Interference F	Force	Mechanical pressure is required for assembly and, once assembled, no dismantling is likely to be required.
D	Driving	These are a little less tight than Force Fit and one part can be driven into the other.
Transition P	Push	Slight manual effort is required to assemble the parts. Suitable for detachable or locating parts but not for moving parts.
Clearance X, Y, Z	Running	Suitable for various types of moving parts. Class Z provides the finest fit .

classified, using the letters F, P, D, X, Y, and Z

British standard BS 4500 – Hole basis system:

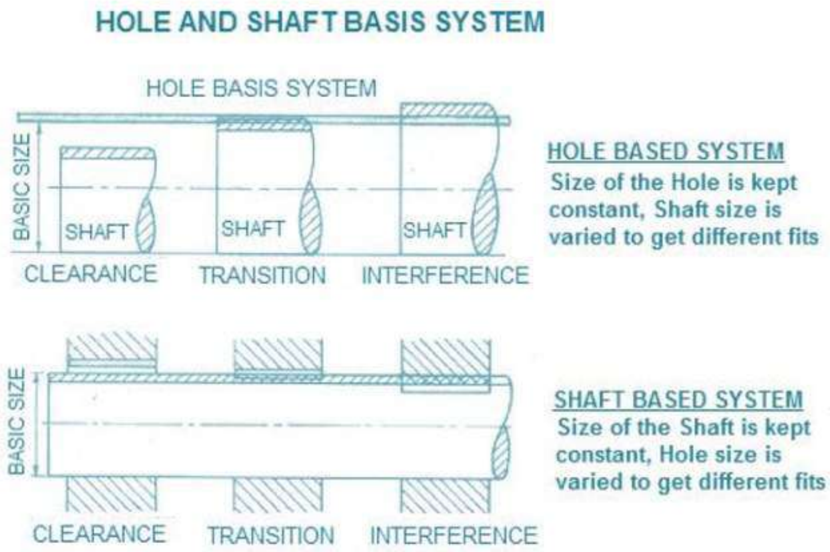
Hole Basis - A system of fits relating to basic or nominal hole size.

The British Institute has now produced a British Standard Specification 4500. This is a system of limits based on standard sized holes and the various fits are obtained by using shafts of varying sizes. This permits the use of standard hole manufacturing tools i.e. drills, reamers, etc. The varying shaft sizes are easily obtained by normal manufacturing processes.
BS 4500 Definitions:

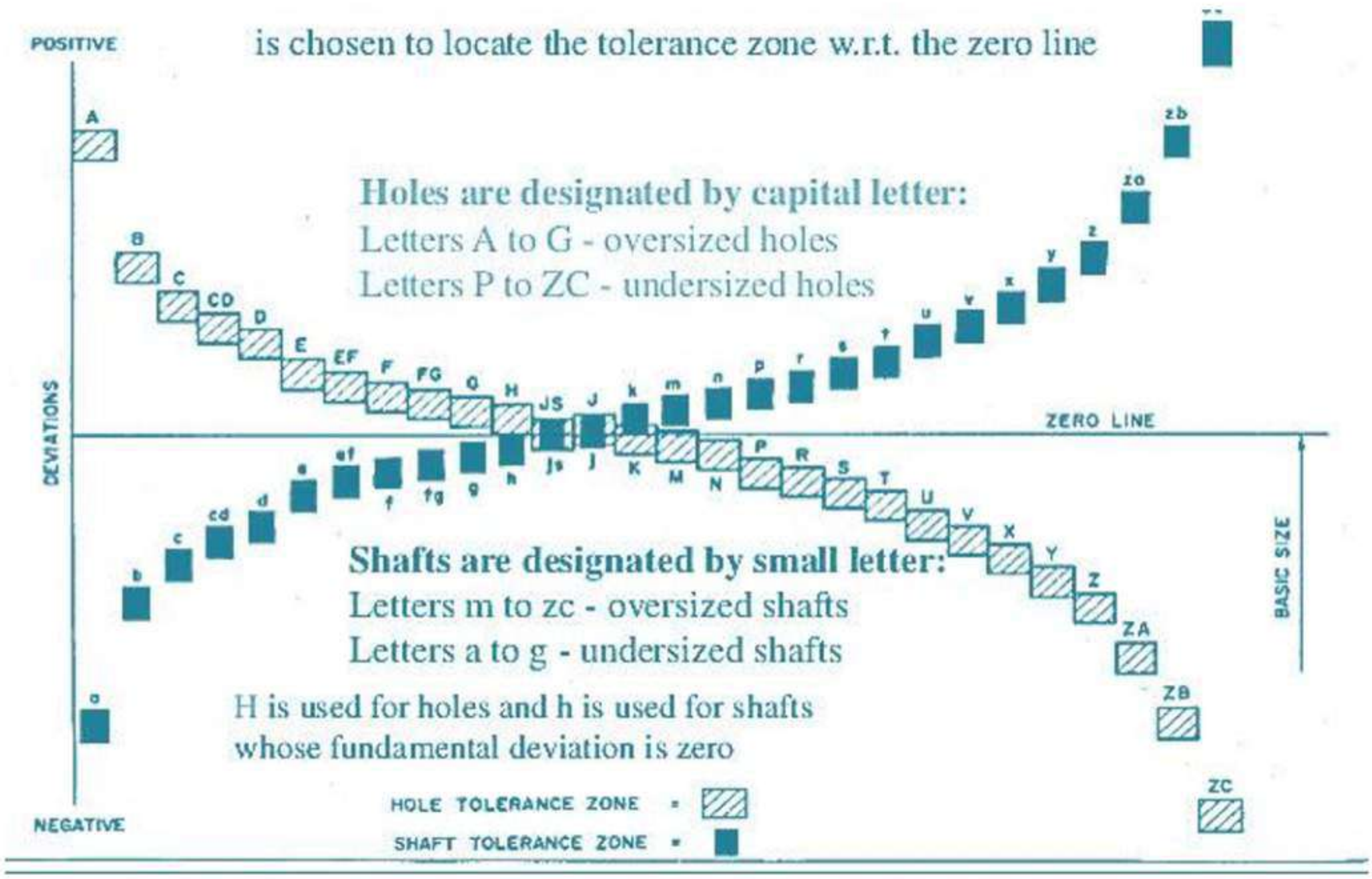
The 'upper limit' is the largest sizeallowed.

The 'lower limit' is the smallest sizeallowed.

The 'tolerance' is the difference between the upper and lowerlimit.



This system uses the letters of alphabet to describe how much bigger or smaller a hole or shaft will deviate from the nominal size. This deviation is called Fundamentaldeviation.



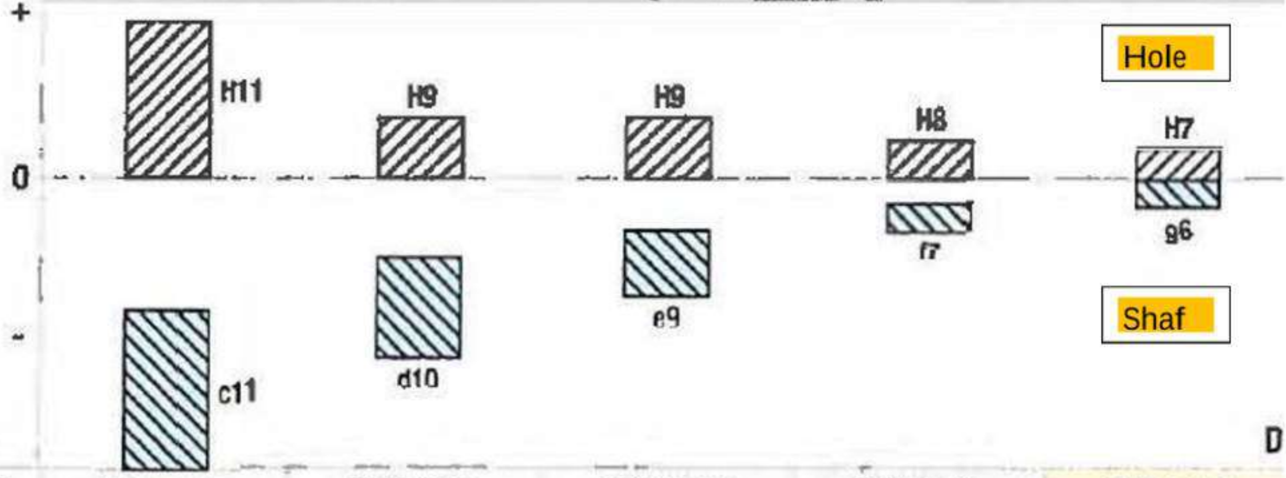
Fundamentaldeviation

In this system, The upper and lower limits of the shaft, in a Clearance Fit, are always less than those of the hole, so that the shaft moves easily within thehole.

In an Interference Fit, the upper and lower limits of the shaft are greater than the corresponding limits of the hole and, thus, force is necessary to achieve thefit.

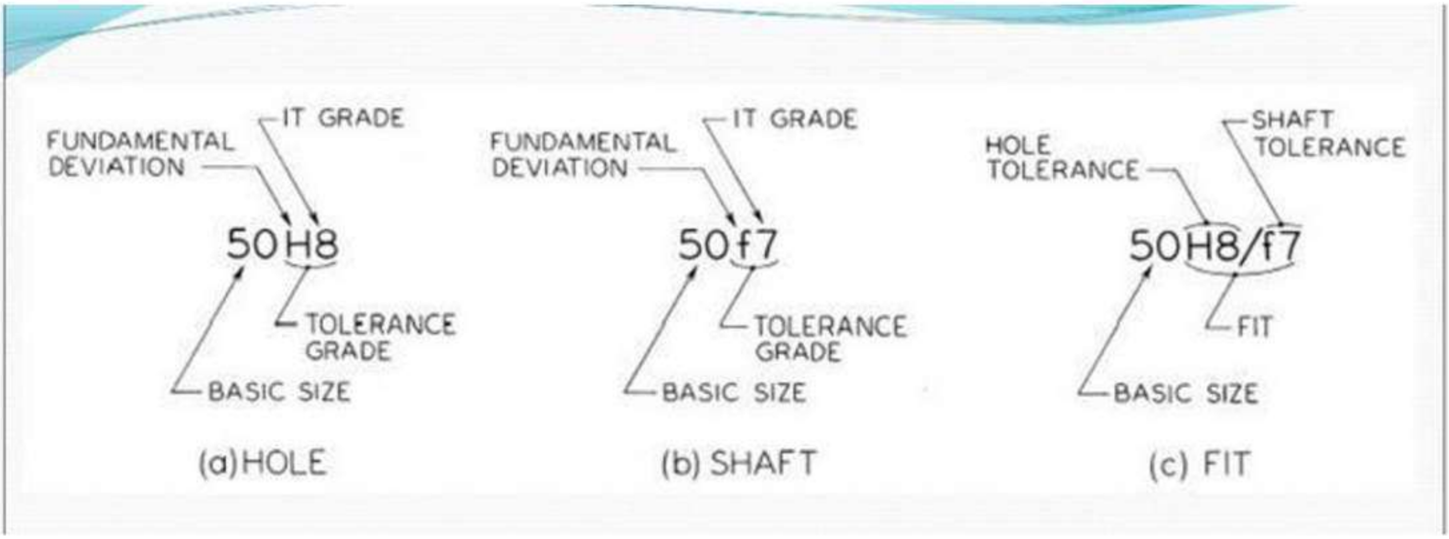
In the Transition Fit, the differences in the upper and lower limits of both items are negligible so that only light effort is required to insert the shaft into thehole.

Clearance Fit



Nominal Size		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance	
Over	To	H11	c11	H9	d10	H9	e8	H8	f7	H7	g6
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm
-	3	60 0	-60 -120	25 0	-20 -60	25 0	-14 -39	14 0	-6 -16	10 0	-2 -8
3	6	75 0	-70 -145	30 0	-30 -78	30 0	-20 -50	18 0	-10 -22	12 0	-4 -12
6	10	90 0	-80 -170	36 0	-40 -98	36 0	-25 -61	22 0	-13 -28	15 0	-5 -14
10	18	110 0	-95 -205	43 0	-50 -120	43 0	-32 -75	27 0	-16 -34	18 0	-6 -17
18	30	130 0	-110 -240	52 0	-65 -149	52 0	-40 -92	33 0	-20 -41	21 0	-7 -20
30	40	160 0	-120 -280	62	-80	62	-50	39	-25	25	-9

Example:



Asseenabove,aholeandashaftarechosenforaparticularfit,wherein50indicatesthe basic or nominal size (actual dimension) of the hole and shaft.
H8 indicates the tolerance chosen for hole, as capital "H" indicates the fundamental deviation for hole and "8" indicates how far it varies (International tolerancegrade)
When this hole is mated with a particular shaft as shown above, the kind of fit achieved is H8/f7, which can be identified from the Fit charts as seenearlier.
What's explained here is in reverse actually. When a design engineer produces a drawing for a particular hole/shaft system like screw/nut, he will mention the type of fit like given here (H8/f7). Then the manufacturer uses the charts and drawings and manufacture the product to the rightfit.