Fundamentals
M7
MAINTENANCE PRACTICES

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M7.2
Workshop Practices

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CAT B1

Training Manual

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M7 MAINTENANCE PRACTICES

M7.2 WORKSHOP PRACTICES

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TOOLS AND WORKSHOP MATERIALS

Maintenance and Servicing of Tools

General

Good tools are expensive, should be treated with respect and kept in good condition.

A bad condition of tools can lead to bad working results and is potentially dangerous.

- Lubricate them regularly to prevent corrosion and seizing up.
- Inspect them before use for any damage (cracks, splits, rounding-off of edges, bluntness etc).

Damaged tools beyond repair should be demonetized.

Tool inspection

Employees take the responsibility for their tools and the whole working area should be clean and free from foreign objects.

Tool Stores

Tool stores will often have a system in place whereby all tools on loan to a tradesman will be accounted. In this way, it can be quickly established that a tool is missing from the store and who booked it out.

This is to prevent the theft of tools, but also (and more importantly) to minimize the chance of the tool being left in the aircraft, becoming a potential loose-article hazard.

Personal Tools

All personal tools should be marked by the individual so that they are traceable to him.

Precision measuring and test equipment

Precision measuring and test equipment must, by definition, be accurate. To be able to rely on the equipment's accuracy, it must itself be checked (calibrated) periodically.

Standards for calibration are laid down by the authorities, and companies performing the calibration must meet exacting criteria.

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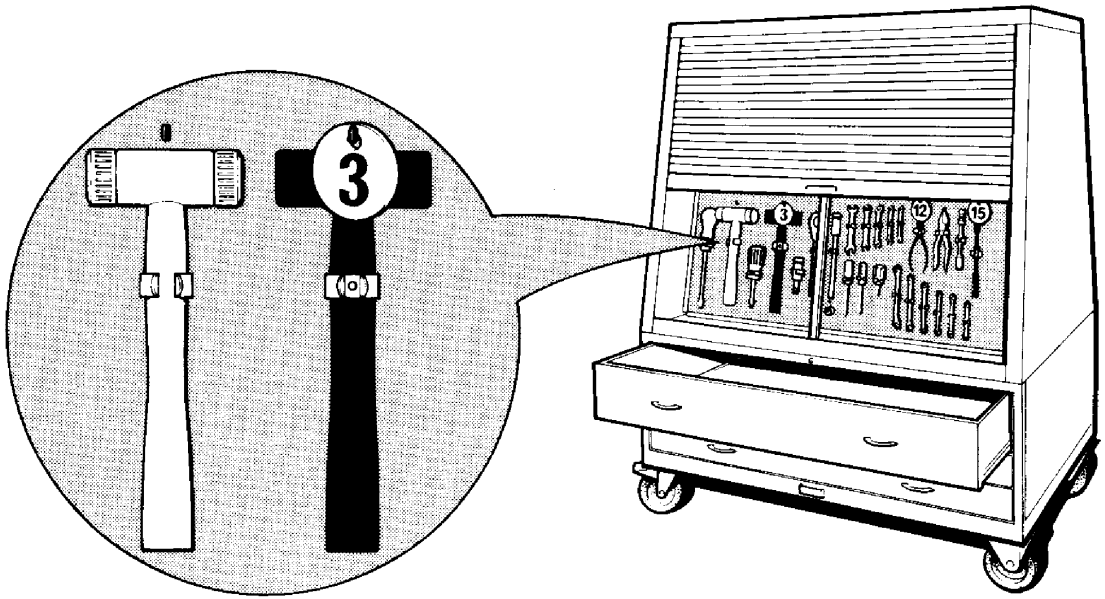


Figure 1 Tool Inspection

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Use of Workshop Equipment

Safety

Workshops contain a variety of items that may

- be heavy
- be sharp
- flammable
- be toxic
- give off noxious fumes
- electrically loaded
- irritate the eyes etc.

The list is seemingly endless, but it is important to

- recognize that workshops are potentially dangerous places
- know how to minimize the risks.

Because of danger it is important to wear work clothes and to engage with the materials themselves.

The correct handling of materials, especially the high strength aluminium alloys, is of extreme importance. Great care is necessary during loading and unloading and storage to ensure that the material is not damaged by chafing, scratching, bruising or indentation.

The parts must be protected from any influences that my change the material properties.

Heavy forgings, extrusions and castings should be carried and stored singly, ensuring that there is adequate support to maintain the material in its intended shape without strain.

Storage

Aircraft supplies should be stored in clean, well-ventilated premises maintained at an even dry temperature to minimize the effects of condensation. Very often, the manufacturer will specify the ideal conditions.

All materials of a flammable nature (dope, thinners, paint and other solvents) should be stored in special rooms or safety cabinets.

Items that can adversely affect other items should be segregated:

- Acid should not be placed whereby its fumes may affect raw materials or finished parts.
- Phenolic plastics should be segregated from cadmium-plated steel parts.
- Magnesium alloys should not be stored with flammable materials.
- All parts should remain in its delivery packaging as long as is practicable.
- Materials in long lengths (extrusions, tubes, bars etc) should be stored vertically or well supported along their length thereby reducing the risk of bowing and handling damage.
- All pipe and hose assemblies should be stored with their ends blanked to prevent ingress of dirt. Hoses should be unrolled.
- Tyres should be stored vertically in special racks embodying tubes that ensure each tyre is supported at two points, reducing distortion to a minimum. They should be rotated every two or three months and any delivery wrapping should be kept in place.
- Sheet metal should be stored on edge in racks clear of the floor with transport protection (grease, paper or plastic coating) left in place. Flat stacking is not acceptable to minimize scratching.
- Fasteners (nuts, bolts, rivets etc) should be kept in their delivery packaging (with their identification labels) as long as possible prior to use. This is a safety issue; it reduces the possibility of an incorrect item being fitted if it is clearly identified.

Identification

All materials in storage should have sufficient information attached to them to provide an audit trail, so they can be identified to a manufacturer's batch.

This information should be copied to work documents.

Care

Care should be taken with all material used in the workshop.

Scratches in metal surfaces are stress-raisers that can initiate cracks or corrosion.

Environment

Environmental guidelines have to be followed. Dispose of waste according to local instructions in approved containers.

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Figure 2 Typical Equipment Stores

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DIMENSIONS, ALLOWANCES AND TOLERANCES, STANDARDS

Dimensions

Introduction

In order to arrive at values of distance, weight, speed, volume, temperature, pressure etc., it is necessary to be familiar with the accepted methods for measuring these values and the units used to express them.

Measurements used today in aviation are the Imperial system and the SI (metric) system.

SI is the abbreviation for the **S**ystème **I**nternational d'Unités, the modernized version of the metric system that Europe and other nations have agreed to use.

Measurement of Dimensions

Measuring of material and machined subjects involves the use of measuring tools to determine sizes of length, width, thickness, diameters etc.

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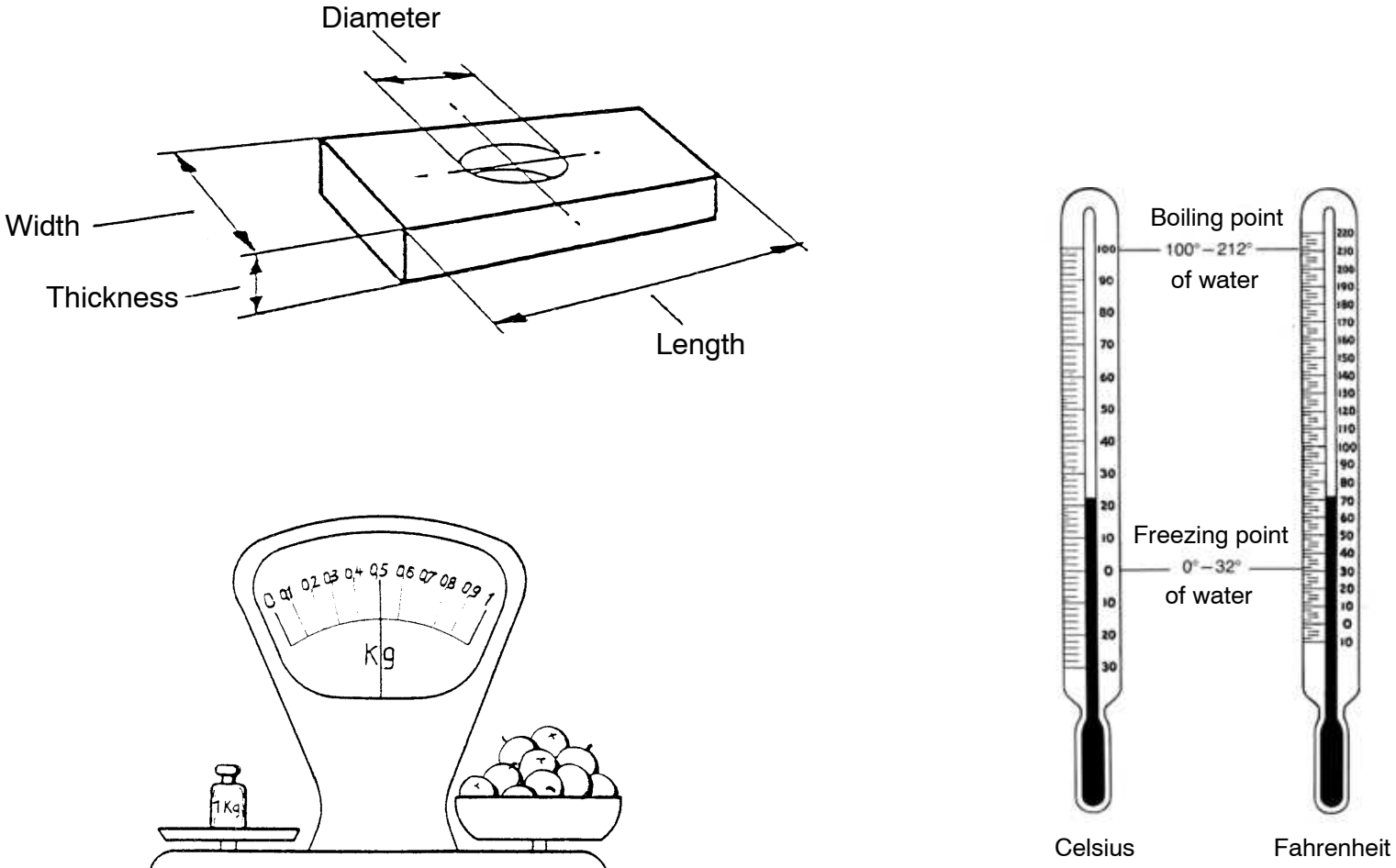


Figure 3 Measurement

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MEASUREMENT UNIT SYSTEM

Metric System General

The International System of Units (SI) defines the meter as the unit of length and the kilogram as the unit of mass.

These units were created by the National Academy of Science and adopted by the National Assembly of France in 1795.

The United States Congress legalized the use of the metric system throughout the United States on July 28, 1866, but it was not until December 23, 1975 that the metric Bill was signed into law in the United States to convert all measurements into the metric system.

One of the great advantages of the metric system is the fact that it is built on decimal units.

Each basic unit may be multiplied or divided by ten as many times as it is necessary to get a convenient size. Each of these multiples has a definite prefix, symbol and name.

Metric Length System

The length of a meter is based on a distance equal to one ten−millionth of the distance from the equator to the poles measured along a meridian, along the earth's surface.

In order to provide an exact reference meter for scientific purposes, a bar of platinum−iridium was inscribed with two lines exactly 1m apart at the freezing point of water (32°Fahrenheit (F) or 0°Celsius (C)).

The International Meter bar is kept at the Bureau of Weights and Measures near Paris. Copies of this bar have been made and are kept in depositories in all the principal nations.

In the metric system, all measurements of length are either multiples or sub-divisions of the meter based on multiples of 10 e.g.:

- 10 millimeter = 1 centimeter
- 10 centimeters = 1 decimeter
- 10 decimeter = 1 meter
- 10 hectometers = 1 kilometer

In practice the units of length most commonly used are the millimeter, the centimeter, the meter and the kilometer.

Imperial System

The majority of people in English−speaking countries are familiar with the Imperial unit system. Its units of length, time and weight are the inch, second and pound. The imperial system is used i.e. in the complete documentation of Boeing aircraft, but often the metric equivalent is also given.

Airbus documentation uses largely both units: Imperial and metric.

Imperial Length System

Originally the units inch, foot, yard and mile had no connection to one another.

But this connection has been created to make the system easier.

Therefore the following equations are valid:

- 1 Foot = 12 Inch
- 1 Yard = 3 Feet
- 1 Mile = 5282 Feet or 1760 Yards.

Historically the inch was the width of a male thumb. The foot was the length of a human foot and the yard was the distance from the tip of the nose to the tip of the thumb when the arm was extended to the side with the thumb pointing forward and the head faced forward.

The mile was originated by the Romans and represented 1,000 paces, each pace being two steps (or 5 ft.).

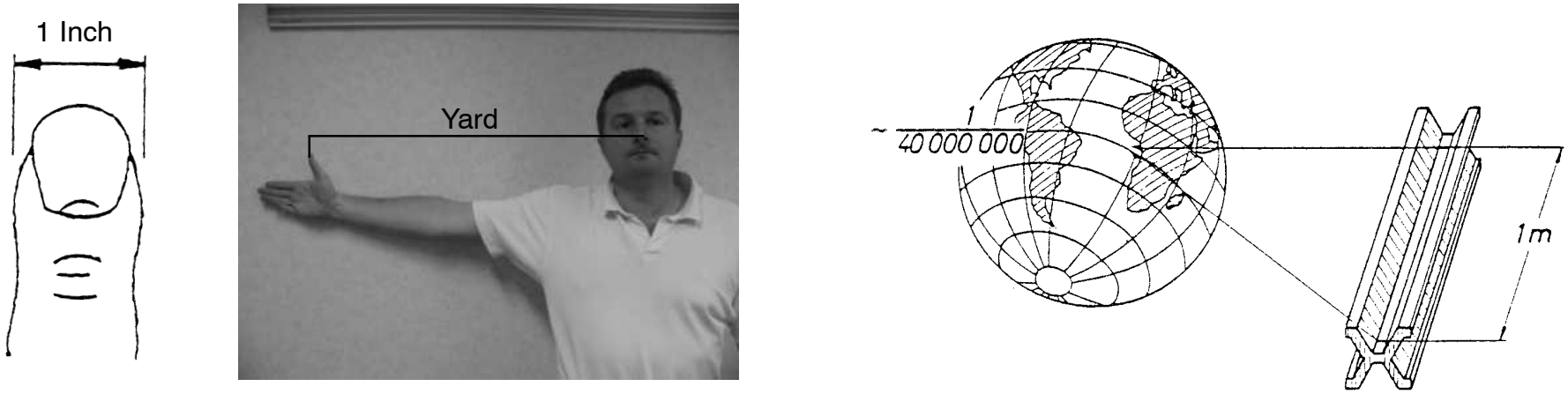
This distance was later changed to 5280 ft., which is the present statute mile in both Great Britain and the United States.

The nautical mile, used internationally for navigation, is based on 1/60 of one degree of the earth's circumference at the equator. It is approximately 6,080 ft., or 1,853.2m.

Because of the increase in travel, international commerce and scientific exchanges, there was a need for the standardization of measurements. This has taken place through the use of the metric system.

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Imperial **Metric**

Number	Prefix	Symbol	Scientific Notation
1,000,000,000,000	tera	t	$1x10^{12}$
1,000,000,000	giga	g	$1x10^{9}$
1,000,000	mega	M	$1x10^{6}$
1,000	kilo	k	$1x10^{3}$
100	hecto	h	$1x10^{2}$
10	deka	dk	$1x10^{1}$
0.1	deci	d	$1x10^{-1}$
0.01	centi	c	$1x10^{-2}$
0.001	milli	m	$1x10^{-3}$
0.000,001	micro	u	$1x10^{-6}$
0.000,000,001	nano	n	$1x10^{-9}$
0.000,000,000,001	pico	p	$1x10^{-12}$

Figure 4 Measurement Systems

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UNIT CONVERSION

Conversions between the Imperial and Metric Length System

In Aviation it is essential to know the conversion between meters and inches because hole sizes, material gauges, dimensions etc. are often given in inches, the measurement equipment and the tools are often using the metric system.

Conversion Examples:

- 1 Inch = 25,4 mm
- 1/2 in = 25,4 ÷ 2 = 12,7mm
- 3/8 in = 25,4 ÷ 8 x 3 = 9,53mm
- 5/16 in = 25,4 ÷ 16 x 5 = 7,94mm
- 1/4 in = 25,4 ÷ 4 = 6,35mm
- 3/16 in = 25,4 ÷ 16 x 3 = 4,76mm
- 5/32 in = 25,4 ÷ 32 x 5 = 3,97mm
- 1/8 in = 25,4 ÷ 8 = 3,18mm
- 0.032 in = 25,4 x 0,032 = 0,81mm
- 0.040 in = 25,4 x 0,040 = 1,01mm
- 0,050 in = 25,4 x 0,050 = 1,27mm
- 0.063 in = 25,4 x 0,063 = 1,60mm

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INCHES, DECIMAL FRACTIONS AND MILLIMETERS				
Inches			Decimal fraction Inch	Millimeter
1/64			0.0156	0.379
	1/32		0.0313	0.794
3/64			0.0469	1.191
		1/16	0.0625	1.588
5/64			0.0781	1.985
	3/32		0.0938	2.381
7/64			0.1094	2.778
		1/8	0.1250	3.175
9/64			0.1406	3.572
	5/32		0.1563	3.969
11/64			0.1719	4.366
		3/16	0.1875	4.762
13/64			0.2031	5.159
	7/32		0.2188	5.556

Figure 5 Decimal and Metric Equivalent of Inches

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Allowance and Tolerances

Dimensional Tolerances

A general tolerance is usually given for all dimensions on a drawing and is stated in a printed box on the drawing. When the general tolerance is not appropriate, an individual tolerance may be given to a dimension.

Tolerances may be expressed by:

- Quoting the upper and lower limits

or:

- Quoting the nominal dimension and the limits of tolerance above and below that dimension.

Maximum and Minimum Allowable Size

For every part a minimum and maximum size is given. Dimensions are still considered acceptable if their size falls within the range given.

The difference between the basic dimension and the upper or lower limit is called the allowance or tolerance.

Example:

A dimension is depicted as .3125 inches +/- .0005 (20 mm +/- 0,3 mm), the allowable dimensions are between .3120 and .3130 inches (19,7 to 20,3 mm).

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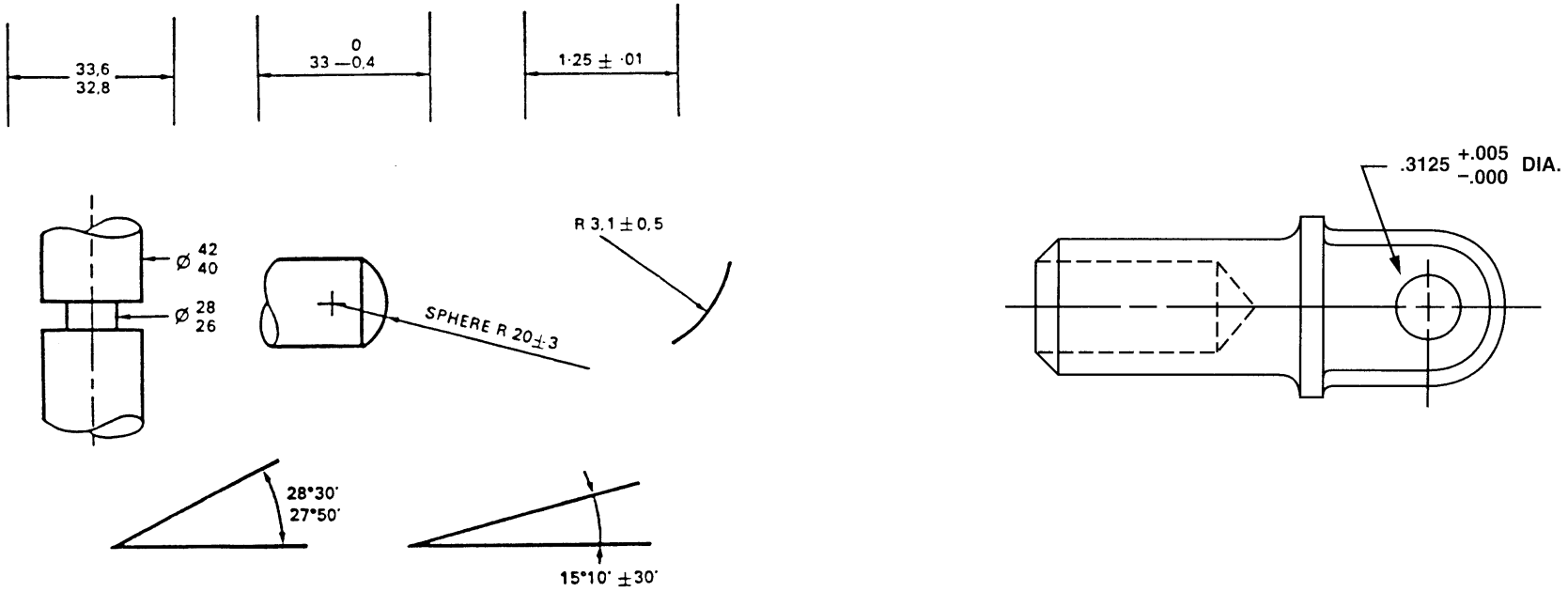


Figure 6 Dimensions and Tolerances

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Standards of Workmanship

General

Safety in the aircraft business is judged to be of the utmost importance.

All working procedures are strictly specified. Service tasks have to be carried out correctly, safely and in the tolerances. A difference between the procedures and the guidelines of the designer is not acceptable!

When working with aircraft you are often under pressure to complete work quickly. Always remember that you should take enough time to look after care and completeness of the work. Possible failures can maybe not be corrected anymore.

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MEASURING EQUIPMENT

Rules General

Steel scales or steel rules are found in almost all tool kits in both 6– and 12-inch lengths (15 - 30 cm.). They are used for sheet metal layout and for making measurements where the accuracy of a slide gauge or a micrometer is not needed.

The scale on the brink is made in fractions or in decimal fractions, some rulers have both.

Fractionally graduated scales usually have one scale divided in increments of 1/32 inch and the other in 1/64 inch increments.

Decimal scales have one scale in 1/10 or 1/50 of an inch and the other scale in increments of 1/1,000 inch.

Metric graduations are in centimeters and millimeter.

Scales are available in both the flexible form (about 0.015 inch (0,4 mm) thick) and the rigid form (about 0.040 inch (1 mm) thick).

Flexible Steel Tape

The flexible steel tape is a very useful instrument for taking measurements up to several feet.

The steel tape is equipped with a hook on one end so that it will hold onto a corner or ledge, thus making it possible for the rule to be used by one individual. The hook is attached to the tape with rivets and is slotted to allow it to move slightly to account for its thickness in calculations.

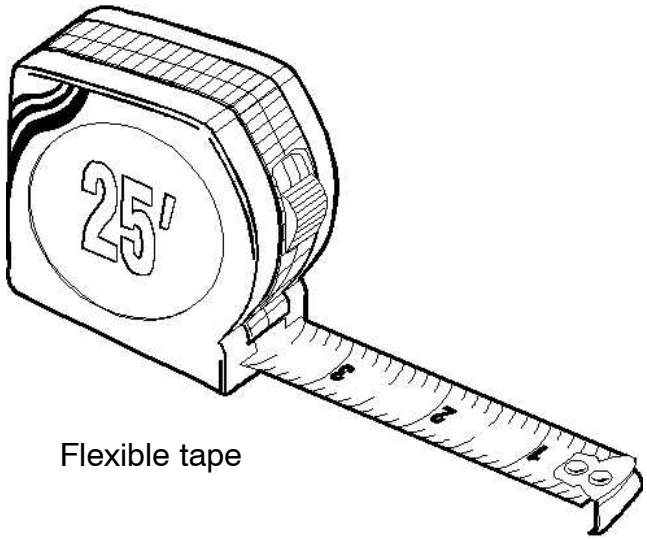
Steel tapes are graduated in inch or in metric measurements.

Scale Handling

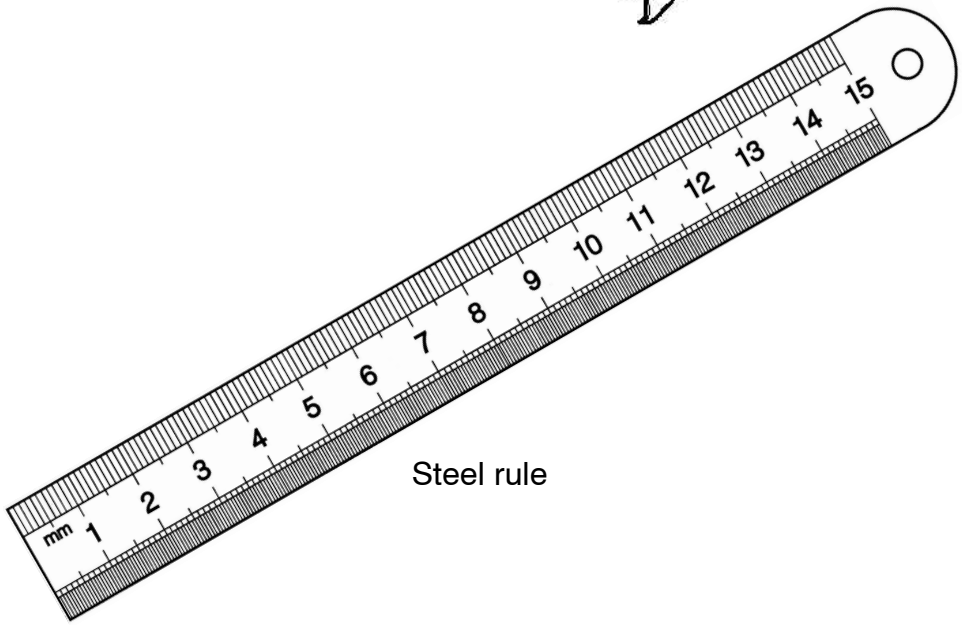
When taking measurements with a scale, it should be so held that the graduation lines are as close as possible to the face. The eye which is observing the reading should be as near as possible opposite to the mark being read, to minimize the possibility of reading (parallax) error.

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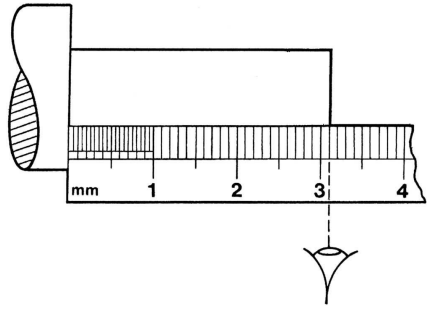
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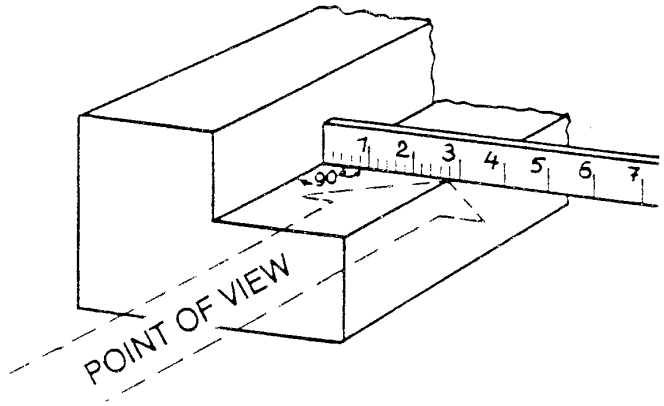


Flexible tape



Steel rule





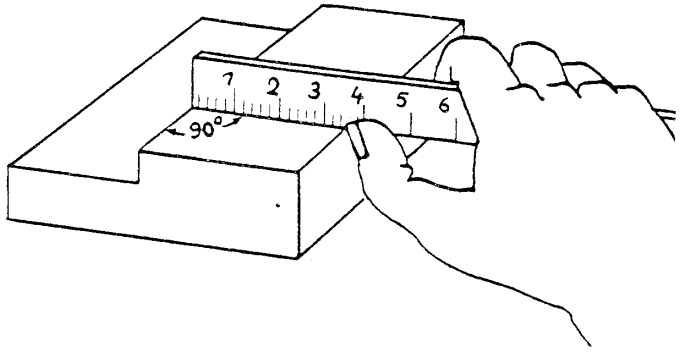


Figure 7 Rules and Scale Handling

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TRI SQUARES AND PROTRACTORS

Tri square

The tri square is the most common tool for testing squareness of components and parts. A tri-square is therefore not suited for measuring but for gauging, that means comparison of angles.

A common example is a testing of squareness of components/parts. In this case the tri-square is used as a gauge, which has an exact right angle (90 degrees). By holding the tri-square at the part that has to be checked the angle of the part can be compared with the right angle of the tri-square and therefore a difference angle can be seen.

Tri-Squares with different angles than 90 degrees are also available.

When using the square, care should be taken to ensure that its blade is held perpendicular to the surface being tested or errors may occur.

Protractor

The protractor consists of a half round dial that is graduated from 0° to 180° and is suited for measuring angles of components and parts.

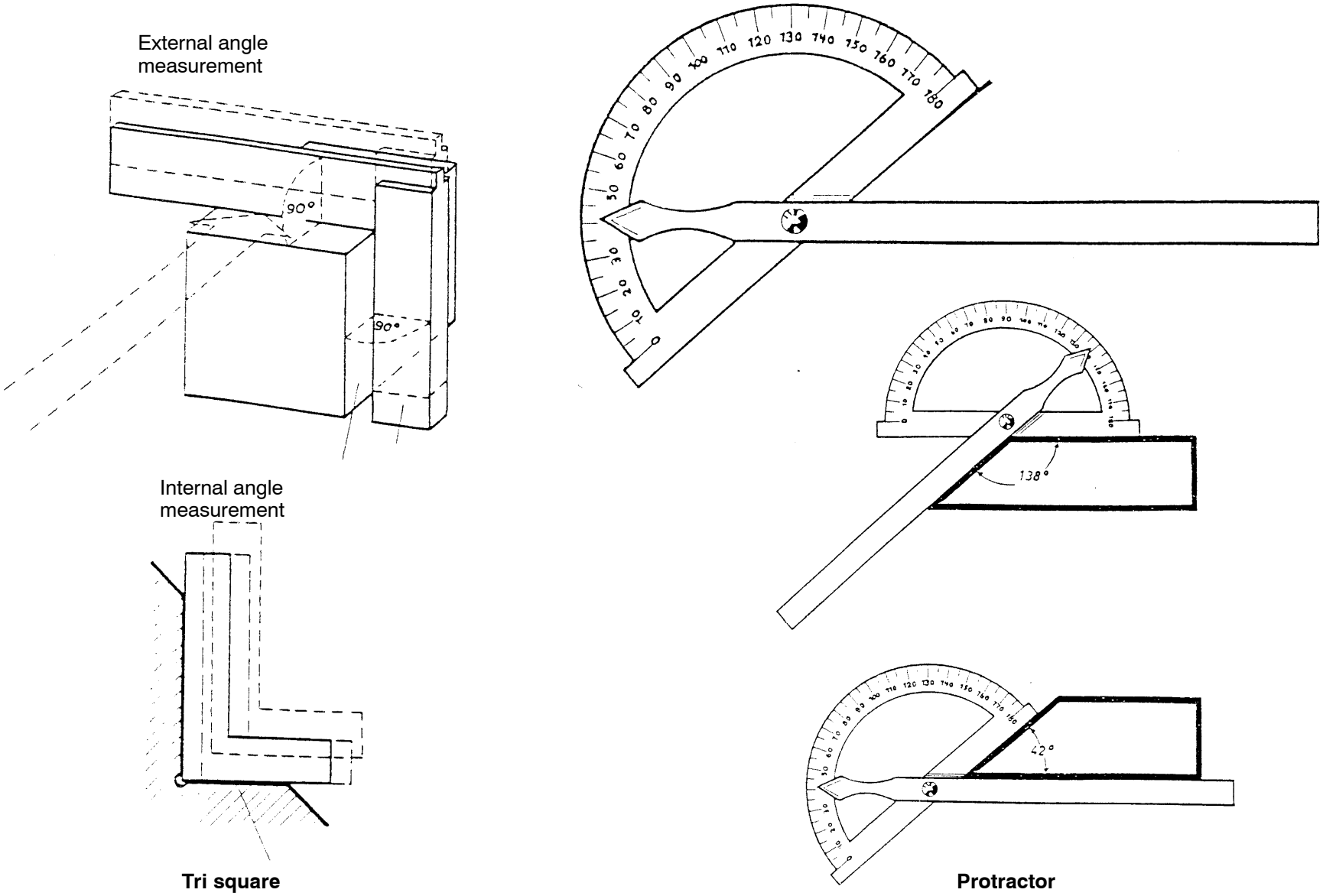
It consists of an adjustable blade, which is hold at the being to checked angle and then locked by a nut. The existing angle can be read on the scale.

The protractor is generally used in assembly areas to check part flanges or to verify angles, bore series, etc.

To produce a good result the edge of the protractor should be hold perpendicular to the surface of the part being tested.

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Tri square

Protractor

Figure 8 Squares

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GAUGES

Radius Gauge

Radius gauges are used to measure either inside or outside radii.

Find a blade that fits the surface being checked and hold it to the radius. It is now possible to see a correlation or a difference of the radii.

Thickness (Feeler) Gauge

The feeler gauge is made up of a number of thin steel leaves with different thickness that fold into a handle.

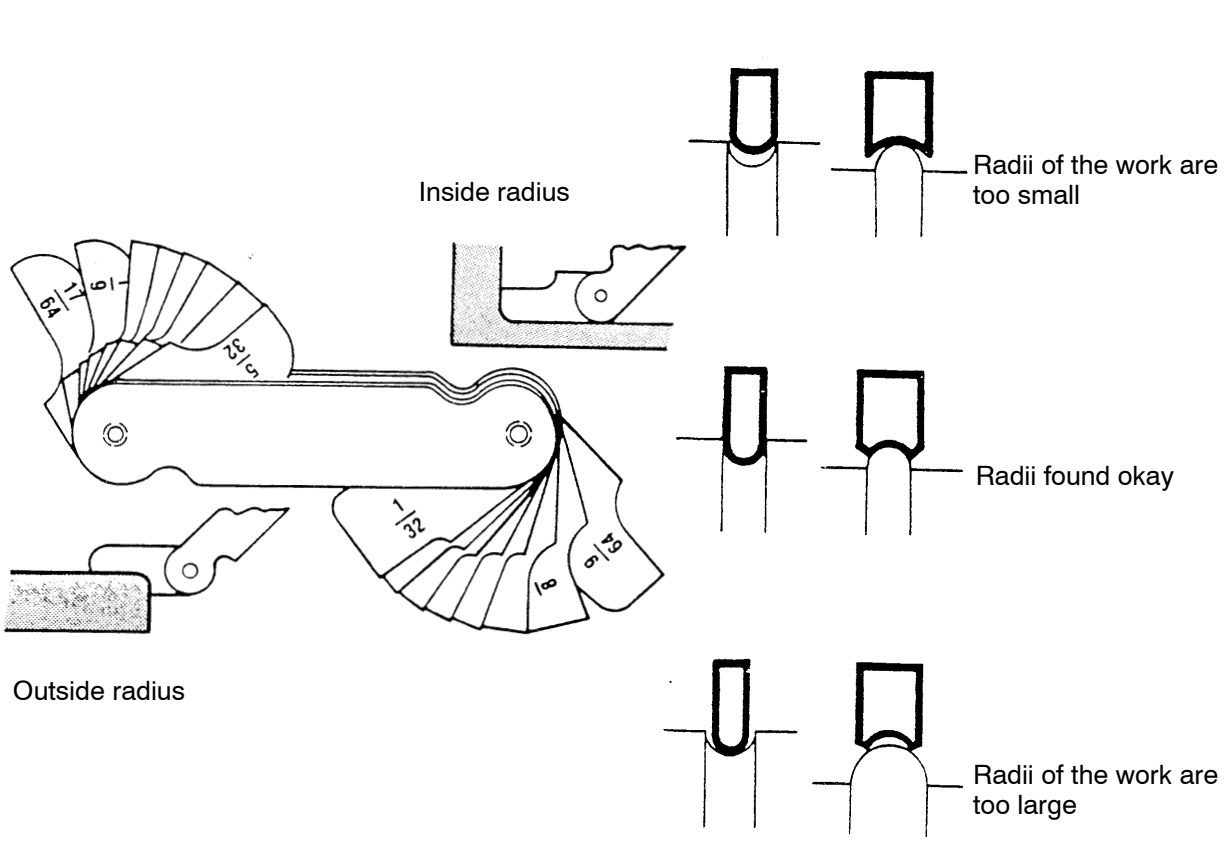
The thickness in thousandths of an inch or in hundreds of a millimeter is marked on each leaf.

The marked leaves are inserted into a gap until the closest fitting leaf is found. The thickness of that leaf represents the size of the gap.

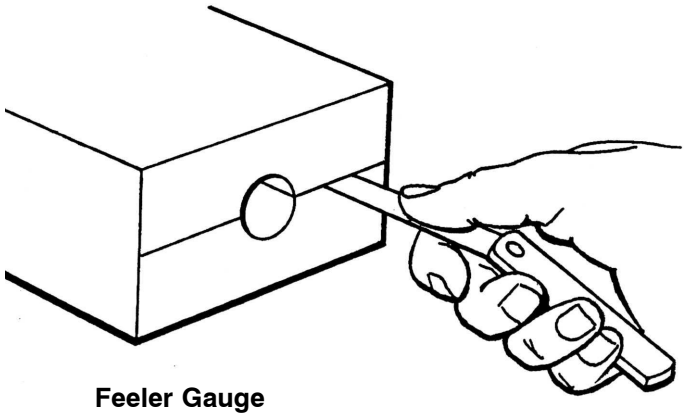
The gauge is generally used in assembly areas to check interface gaps or gaps under bolt heads or nuts.

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Radius Gauge



Feeler Gauge

Figure 9 Gauges

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TEMPERATURE

Temperature and their units in General

With the temperature you are measuring the degree of heat of a body, a fluid or a gas. There are three common temperature scales in use today; Fahrenheit, Celsius and Kelvin.

Fahrenheit Unit

In the English/American unit system all temperatures are given in degrees Fahrenheit.

Fahrenheit temperature scale is a scale based on 32° F for the freezing point of water and 212° F for the boiling point of water with a difference of 180° F between the two points. Absolute zero is −460° F.

The 18th−century German physicist Daniel Gabriel Fahrenheit originally took as the zero of his scale the temperature of an equal ice−salt mixture and selected the values of 30 and 90 for the freezing point of water and normal body temperature, respectively; these later were revised to 32° and 96°, but the final scale required an adjustment to 98.6° for the latter value.

Celsius Unit

The Celsius scale is in general use wherever metric units have become accepted, and it is used in scientific work everywhere.

Celsius temperature scale (also called centigrade temperature scale) is the scale based on 0° for the freezing point of water and 100° for the boiling point of water. Absolute zero = −273°.

Invented in 1742 by the Swedish astronomer Anders Celsius, it is sometimes called the centigrade scale because of the 100−degree interval between the defined points.

The conversion formula from Fahrenheit (F) to Celsius (C) value is:

- °C = 5/9 x (°F − 32).

The conversion formula from Celsius (C) to Fahrenheit (F) value is:

- °F = 9/5 x °C + 32.

Conversion Examples:

A:

63°F = ?° C

63°F = 5/9 (63−32)

63°F = 5/9 x 31

63°F = 17,2° C

B:

27°C = ?° F

27°C = 27 x 9/5 + 32

27°C = 80,6° F

Kelvin Unit

Kelvin temperature scale is the base unit of thermodynamic temperature measurement in the International System (SI) of measurement. It is defined as 1/ 273.16 of the triple point (equilibrium among the solid, liquid, and gaseous phases) of pure water.

The scale is named for the British physicist Baron Kelvin. The Kelvin-scale is not noted in degree, but is given with the symbol „K“. Zero K describes the absolute zero temperature point. (equals -273°C).

This absolute zero point describes the theoretical temperature at which the molecules of a substance have the lowest energy.

Many physical laws and formulae can be expressed more simply when an absolute temperature scale is used; accordingly, the Kelvin scale has been adopted as the international standard for scientific temperature measurement.

The Kelvin scale is related to the Celsius scale. The difference between the freezing (273 K or 0°C) and boiling points (373 K or 100°C) of water is 100 degrees in each, so that the Kelvin has the same magnitude as the degree Celsius.

Therefore the conversion from Kelvin (K) to Celsius (°C) is very easy:

- °C = (K − 273).

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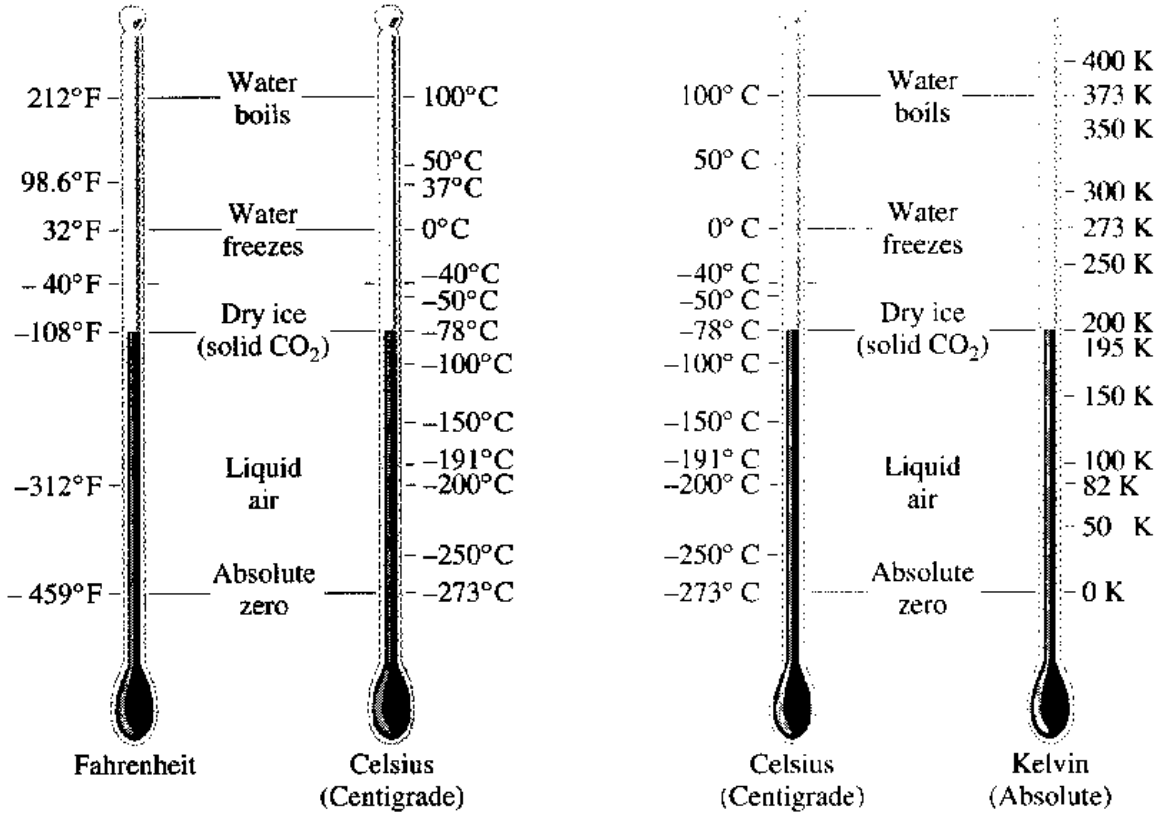


Figure 10 Temperature Scales

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MARKING AND THE RELATING TOOLS

General

Marking out means marking on the material all the lines and points which are needed to work with. In general this will be done in accordance with a dimensional drawing. This is a drawing showing the exact shape with all dimensions indicated.

The material must be marked with the given dimensions with as accurate as possible. After that the part can be manufactured according to the marking.

Marking Out Rules

- Never use a lead pencil on titanium. The carbon, when heated, can infuse the metal and cause cracking.
- When using a scriber or pencil with a straight edge, hold it at a slight angle so that the line will be parallel and as close as possible to the straight-edge.
- For marking of aluminium alloy use only a soft lead pencil (except for cut-lines, when a scriber may be used).
- Mark preferably thin lines.
- Mark lines only once.

Pencil

When working with aluminium parts and components, only a soft lead pencil may be used for layout work or for marking reference lines in areas that will not be removed. However, using normal lead pencils on bare aluminium alloy can scratch the surface and introduce graphite into the material, resulting in corrosion.

Pencils with a lead made out soft wax crayon may also be used.

Rule

For marking out length, a rule or steel tape is used.

Tri Square

Tri-squares are used for marking out i.e. right angle lines.

Dividers

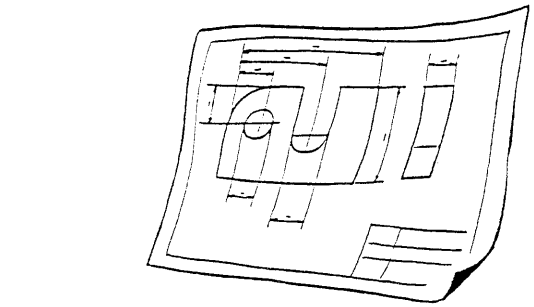
Dividers are used for scribing arcs and circles, for measuring between points and for transferring dimensions. The distance between the sharp ends of the arms is compared with the rule.

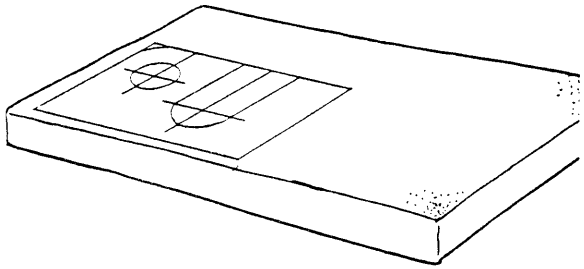
Dividers are difficult to use accurately when the legs are widely extended and the points steeply inclined to the work surface.

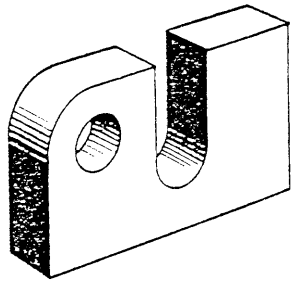
Dividers or compasses should not be used when marks or reference lines are drawn on metal skin surfaces, since the metal points will cause permanent damage. Instead, pencils are commonly used to mark out skins.

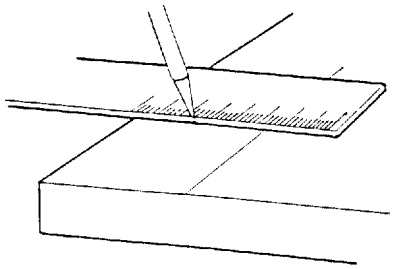
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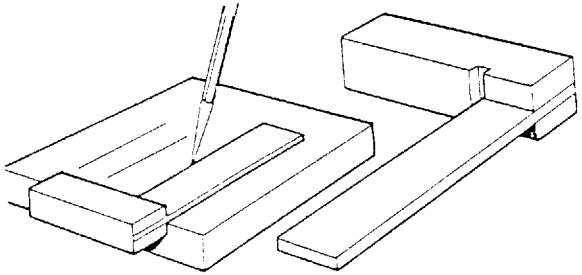




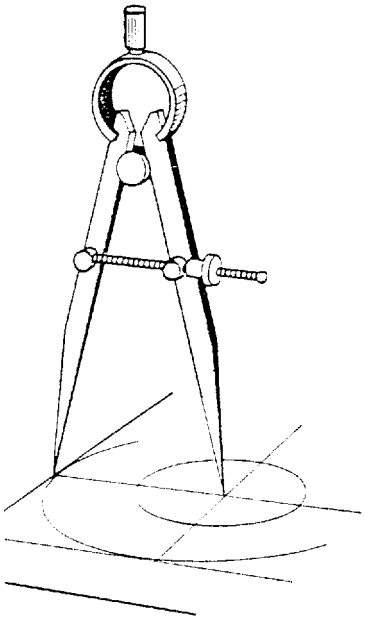




Rule



Tri square



Dividers

Figure 11 Marking Sequence

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SCRIBER

General

The scriber is used to mark permanent lines on component or part surfaces. At this the surface scribed with a sharp point (scriber), that means a thin sharp-edged line type depression is generated.

NOTE: A scriber is used only when the material within the scribed line is to be cut out and the scribe mark is removed as part of the scrap.

Vernier height gauge

The vernier height gauge has a vertical beam scale fixed to a flat base. It is usually used on a surface plate or a marking out table (the datum beam surface).

The instrument can be used for measuring absolute height above the datum surface, but is often used for measuring differences in height between different parts of the item being measured.

The height gauge is also frequently used for making accurate markings on components. A finger with a sharp ground edge is used for this purpose.

Vernier height gauges are often dual scale instruments. These have both millimeter and inch scales on the same instrument.

Scribing with the Vernier High Gauge

Use a Vernier High Gauge for marking out in the following way:

- Position the Vernier High Gauge approximately to the desired height and tight the Fine Adjustment Clamp. Use the Fine Adjustment Screw to get the height exactly right.
- Slide the Vernier High Gauge across the marking out table until the point of the scriber contacts the work piece at the required position.
- Hold the Vernier High Gauge firmly and slide it on the marking-out table so that the point of the scriber marks a line on the work piece. When doing this you must ensure that:
  - the base of the scribing block remains firmly seated on the marking-out table
  - the point of the scriber bears on the work piece with a steady pressure
  - the point of the scriber trails as it is moved along the work piece.

Using a Height Gauge

When using a vernier height gauge:

- ensure that the base of the height gauge, the surface table and the work piece are kept perfectly clean at all times
- bed the work piece and the base of the height gauge firmly onto the datum surface with the finger slightly above the work piece
- secure the fine adjustment clamp and use the fine adjustment screw to bring the finger lightly into contact with the feature being measured

When you finish using the height gauge it should be carefully returned to proper storage.

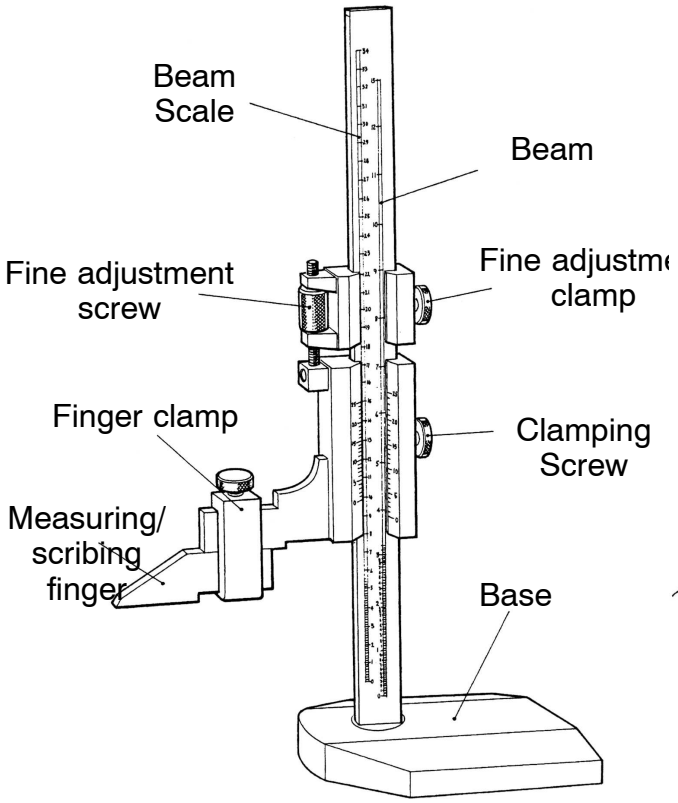
Measuring to the Underside

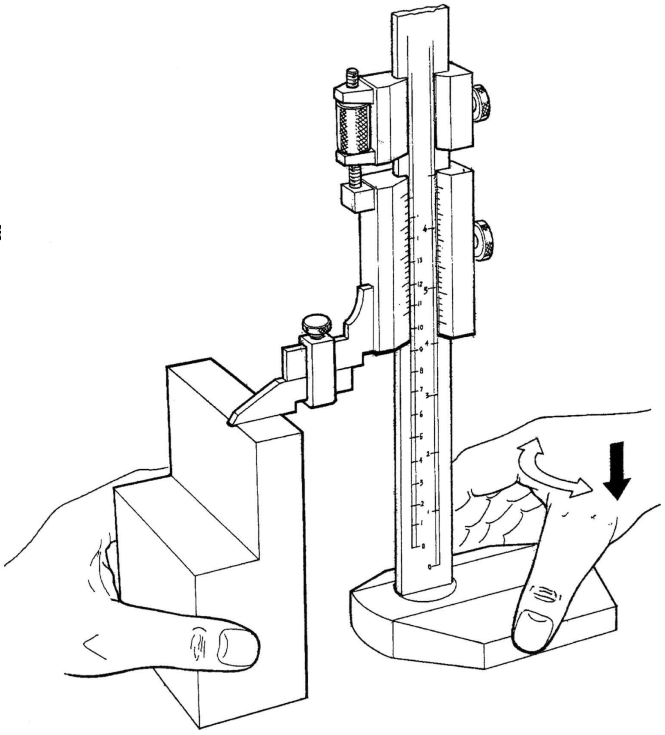
The vernier height gauge can also be used for measuring to the underside of a feature on the component. To do this the finger should be reversed, as shown in the illustrations.

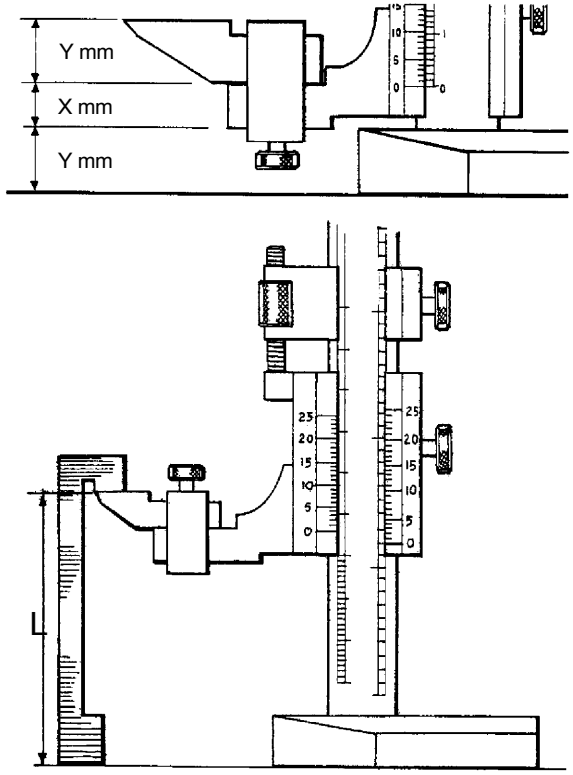
When using the instrument in this way, a further allowance (additional to any allowance for the zero reading) must be added to the scale reading to give the absolute dimension. This allowance is equal to the height of the finger arm plus twice the height of the finger, which is X + 2Y mm.

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Measuring to the underside

Figure 12 Vernier Height Gauge

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CALIBRATION OF TOOLS AND EQUIPMENT

General

Precision measuring and -test equipment has to be calibrated within periodical intervals to ensure that unchanging accuracy of measurement is guaranteed.

Calibrating means to compare measured data of the inspected tool with the true value of the measurement value (reference measure/reference value).

Requirements are that specific conditions are fulfilled, for example to meet allowed temperatures.

Calibrating also includes the documentation of deviation, calculation of measuring allowance (tolerance) and preparation of a certificate.

Calibration intervals

To ensure always accurate measurements, the test equipment has to be calibrated within periodical intervals. The gap between these calibrations is called calibration interval. The extent of this time period is determined among others by:

- accuracy of measurement;
- specification or recommendation of manufacturer;
- specified guidelines;
- operating conditions and/or operation frequency.

Use of Precision Measuring and Test Equipment

When using precision measuring and test equipment, ensure that a calibration certificate accompanies the tool and that it is within its calibration due-date.

If desired, record the equipment’s details and calibration information on the job card.

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Figure 13 Calibration of Tools

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