Types of Rules

Measuring system, Rulers, Calipers and Gauges

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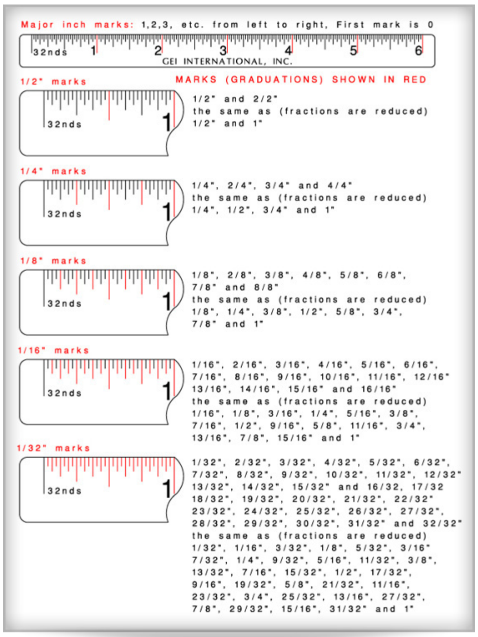
Module: #12 – Taking and Interpreting Measurements

Contents

Measuring System

❖ Imperial System

Imperial measuring uses either fractional inch (graduations) system or decimal inch system:



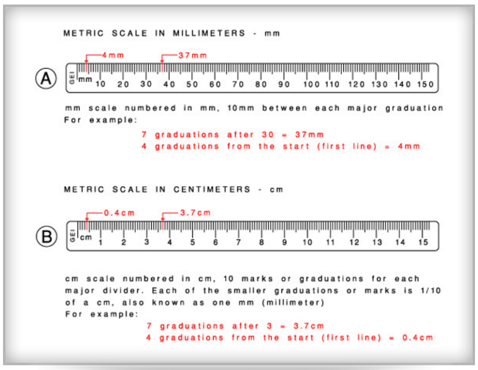
1. **Fractional Inch:** Fractional Rulers have graduations or marks based on fractions, for example 1/2", 1/4" 1/8", 1/16", etc.

2. **Decimal Inch:** Decimal Rulers have graduations or marks which are based on the decimal system such as 0.5, 0.25, 0.1, 0.05, etc.

The drawing on the right side shows a fractional ruler with a smallest graduation of 1/32" (indicated with a scale legend of 32nds beside the scale) and describes how to measure each fraction of an inch.

❖ Metric System

Metric Rulers may have any combination of: Meters - abbreviated as **m**, Centimeters - abbreviated as **cm**, Millimeters - abbreviated as **mm**.



In the drawing we show various options for cm and mm and how to correctly read the ruler; remember 10mm = 1cm and 100cm = 1m.

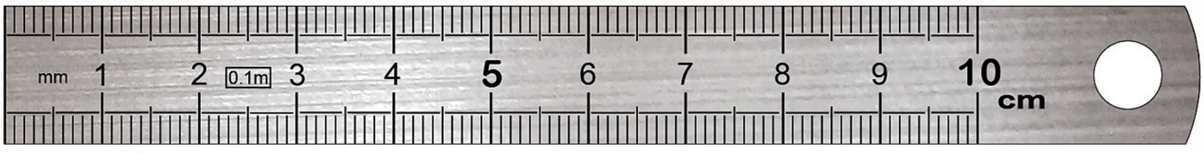
Rulers

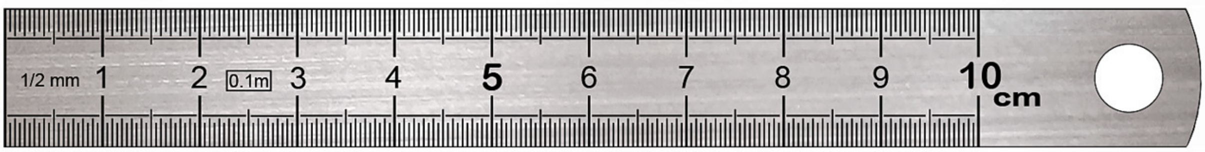
❖ Pocket Rule

An accurate pocket rule most commonly used fractions (8ths, 16ths, 32nds, and 64ths) is invaluable in woodworking. The typical one (6" x 3/4") is easy to read, with a satin finish, milled edges and tips, and a nice extra — it is graduated (in 32nds) on the ends as well.

❖ Narrow Rule

A narrow rule is usually made from steel, and is very widely used in the schools and offices. The typical stainless steel narrow ruler is 100~300mm long; 13 mm wide; 0.5 mm thick graduated in 1 mm increments on the top edge and in 0.5mm increments on the bottom edge.





❖ Flexible Rule

A flexible ruler is usually rubber or plastic coated with a metal "backbone", which can be smoothly shaped to follow a desired curve and allows drawing a smooth line between initial reference points. Sometimes a spline is temporarily held in position with small weights.

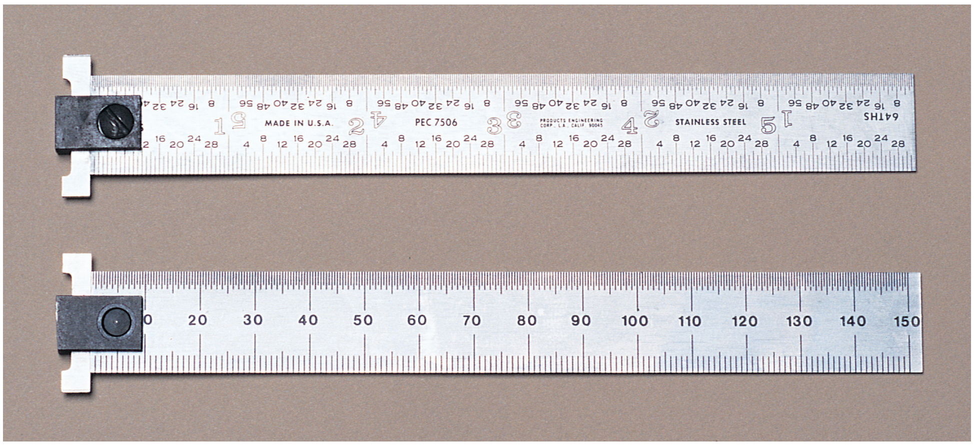
❖ Narrow Rule With Holder

A narrow rule with holder can be used as handy for depth gages.

The typical rule holder holds any rule or combination square blade from 3/4 - 1-9/16 in wide in an upright position for use in transferring measurements with surface gauges.

❖ Hook Rule With Fixed Hook

Hook rule permits a quick registration against the edge of a work piece, each of these rules has a hardened steel hook at one end. The hook rules have scales accurately zeroed to the hooks on one face for measuring from an edge and zeroed to the square end on the other for use as a regular rule and for depth measurements.



Micrometer Calipers

A micrometer, sometimes known as a micrometer screw gauge, is a device incorporating a calibrated screw widely used for accurate measurement of components[1] in mechanical engineering and machining as well as most mechanical trades, along with other metrological instruments such as dial, Vernier, and digital calipers. Micrometers are usually, but not always, in the form of calipers (opposing ends joined by a frame). The spindle is a very accurately machined screw and the object to be measured is placed between the spindle and the anvil. The spindle is moved by turning the ratchet knob or thimble until the object to be measured is lightly touched by both the spindle and the anvil.

Micrometers use the screw to transform small distances (that are too small to measure directly) into large rotations of the screw that are big enough to read from a scale. The accuracy of a micrometer derives from the accuracy of the thread-forms that are central to the core of its design. In some cases it is a differential screw.

❖ Operating Principles Of A Micrometer

1. The amount of rotation of an accurately made screw can be directly and precisely correlated to a certain amount of axial movement (and vice versa), through the constant known as the screw's lead. A screw's lead is the distance it moves forward axially with one complete turn (360°). (In most threads [that is, in all single-start threads], lead and pitch refer to essentially the same concept.)

2. With an appropriate lead and major diameter of the screw, a given amount of axial movement will be amplified in the resulting circumferential movement.

❖ Components Of A Micrometer

1. Frame

The C-shaped body that holds the anvil and barrel in constant relation to each other. It is thick because it needs to minimize flexion, expansion, and contraction.
The frame is heavy and consequently has a high thermal mass, to prevent substantial heating up by the holding hand/fingers. It is often covered by insulating plastic plates which further reduce heat transference.
Explanation: if one holds the frame long enough so that it heats up by 10 °C, then the increase in length of any 10 cm linear piece of steel is of magnitude 1/100 mm. For micrometers this is their typical accuracy range.

2. Anvil

The shiny part that the spindle moves toward, and that the sample rests against.

3. Sleeve / Barrel / Stock

The stationary round component with the linear scale on it, sometimes with Vernier markings. In some instruments the scale is marked on a tight-fitting but movable cylindrical sleeve fitting over the internal fixed barrel. This allows zeroing to be done by slightly altering the position of the sleeve.[11][12]

4. Lock Nut / Lock-Ring / Thimble Lock

The knurled component (or lever) that one can tighten to hold the spindle stationary, such as when momentarily holding a measurement.

5. Screw

(not seen) The heart of the micrometer, as explained under "Operating principles". It is inside the barrel. This references the fact that the usual name for the device in German is Messschraube, literally "measuring screw".

6. Spindle

The shiny cylindrical component that the thimble causes to move toward the anvil.

7. Thimble

The component that one's thumb turns. Graduated markings.

8. Ratchet Stop

Device on end of handle that limits applied pressure by slipping at a calibrated torque.

❖ Precisions Of Micrometers

Some micrometers are provided with a Vernier scale on the sleeve in addition to the regular graduations. These permit measurements within 0.001 millimetre to be made on metric micrometers, or 0.0001 inches on inch-system micrometers.

The additional digit of these micrometers is obtained by finding the line on the sleeve Vernier scale which exactly coincides with one on the thimble. The number of this coinciding Vernier line represents the additional digit.

Thus, the reading for metric micrometers of this type is the number of whole millimeters (if any) and the number of hundredths of a millimeter, as with an ordinary micrometer, and the number of thousandths of a millimeter given by the coinciding Vernier line on the sleeve Vernier scale.

❖ Different Types Of Micrometers

There are Conventional Micrometer, Jaw Type Micrometer, Depth Gauge, etc.

Conventional Micrometer

Jaw Type Micrometer

Depth Gauge Micrometer

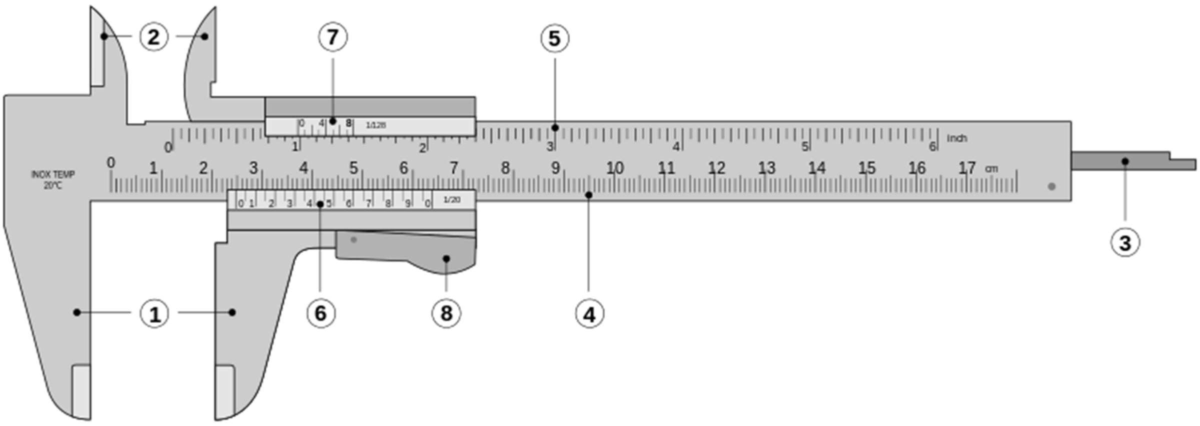
Vernier Calipers

The Vernier, dial, and digital calipers give a direct reading of the distance measured with high accuracy and precision. They are functionally identical, with different ways of reading the result. These calipers comprise a calibrated scale with a fixed jaw, and another jaw, with a pointer, that slides along the scale. The distance between the jaws is then read in different ways for the three types.

The simplest method is to read the position of the pointer directly on the scale. When the pointer is between two markings, the user can mentally interpolate to improve the precision of the reading. This would be a simple calibrated caliper; but the addition of a Vernier scale allows more accurate interpolation, and is the universal practice; this is the Vernier caliper.

Vernier, dial, and digital calipers can measure internal dimensions (using the uppermost jaws in the picture at right), external dimensions using the pictured lower jaws, and in many cases depth by the use of a probe that is attached to the movable head and slides along the centre of the body. This probe is slender and can get into deep grooves that may prove difficult for other measuring tools.

The Vernier scales may include metric measurements on the lower part of the scale and inch measurements on the upper, or vice versa, in countries that use inches. Vernier calipers commonly used in industry provide a precision to 0.01 mm (10 micrometres), or one thousandth of an inch. They are available in sizes that can measure up to 1,829 mm (72 in).



❖ **Diagram of Vernier calipers.**

1. **Outside large jaws:** used to measure external diameter or width of an object
2. **Inside small jaws:** used to measure internal diameter of an object

3. **Depth probe/rod:** used to measure depths of an object or a hole

4. **Main scale (Metric):** scale marked every mm

5. **Main scale (Imperial):** scale marked in inches and fractions

6. **Vernier scale (Metric):** gives interpolated measurements to 0.1 mm or better

7. **Vernier scale (Imperial):** gives interpolated measurements in fractions of an inch

8. **Retainer:** used to block movable part to allow the easy transferring of a measurement

❖ Different Types Of Calipers

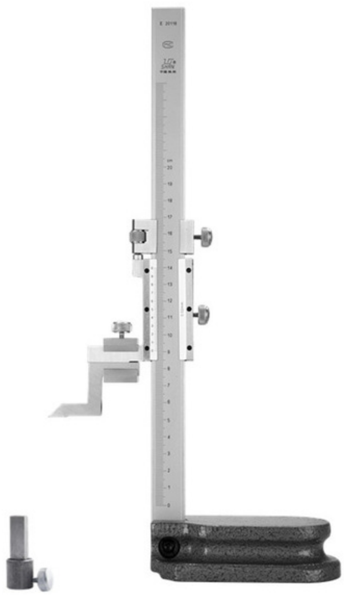
There are Vernier Height Gauge, Vernier Depth Gauge, Gear Tooth Vernier, Universal Vernier Bevel Protractor etc.

Vernier Height Gauge

A height gauge is a measuring device used for determining the height of objects, and for marking of items to be worked on.

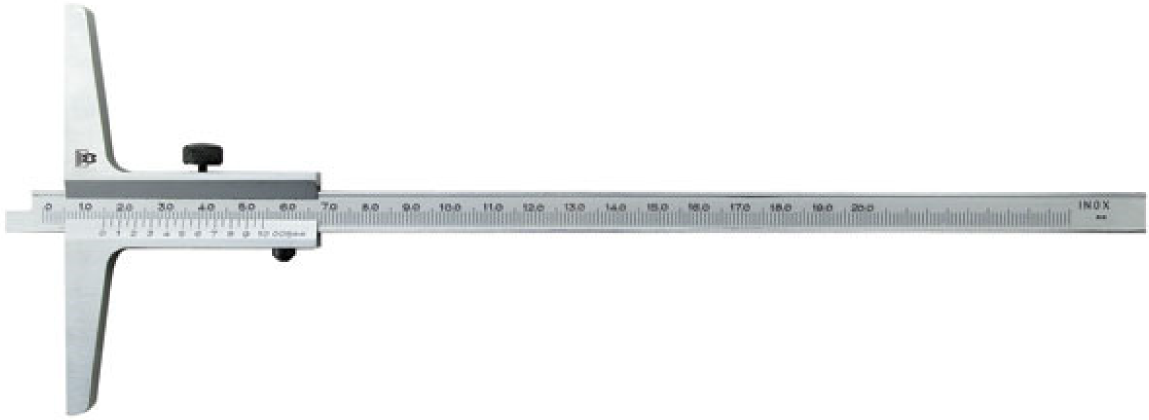
These measuring tools are used in metalworking or metrology to either set or measure vertical distances; the pointer is sharpened to allow it to act as a scriber and assist in marking out work pieces.

Height gauges may also be used to measure the height of an object by using the underside of the scriber as the datum.



Vernier Depth Gauge

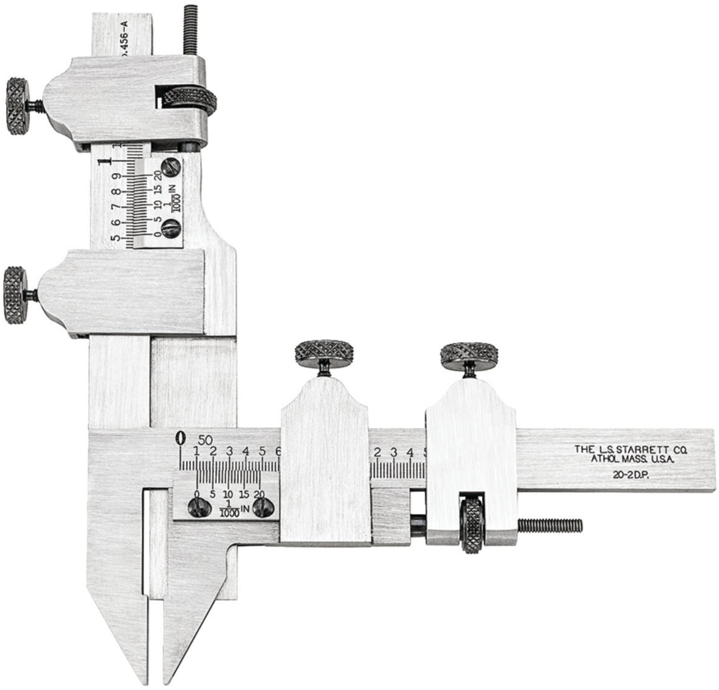
A Vernier depth gauge is a more versatile instrument, which can measure up to 0.01 mm or even finer accuracy. Figure 1 illustrates the constructional features of a Vernier depth gauge. The lower surface of the base has to butt firmly against the upper surface of the hole or recess whose depth is to be measured.



Depth can be measured by inserting the depth rod into the hole you are measuring. When you adjust the jaws using the thumb screw, the rod will protrude from the end of the caliper.

Gear Tooth Vernier

A typical gear tooth Vernier caliper is designed to measure in .001" or 0.02mm the thickness of gear teeth at the pitch line (the chordal thickness of the teeth) using the distance from the top of a tooth to the chord. For the same purpose, it can also be used for measuring hobs, form and thread tools, etc.



Universal Vernier Bevel Protractor

A universal bevel protractor is used to measure angles of objects. You might see it used with various objects, including jigs, and when producing engineering/machine drawings. The base is placed on the bottom side of the angle, whilst the blade is moved to match the opposing side. In addition to a degree scale, many bevel protractors will have a Vernier scale on them as well, normally found underneath the degree scale.

Gauges

❖ Plug Gauge

These gauges are referred to as plug gauges; they are used in the manner of a plug. They are generally assembled from standard parts, where the gauge portion is interchangeable with other gauge pieces (obtained from a set of pin type and a body that uses the collet principle to hold the gauges firmly. To use this style of gauge, one end is inserted into the part first, and depending on the result of that test, the other end is tried.

In the right image, the gauge is a thread gauge that is screwed into the part to be tested, the "GO" end should fully enter the part; the "NOGO" end should not.

❖ Ring Gauge

A ring gauge, or ring gage, is a cylindrical ring of a thermally stable material, often steel, whose inside diameter is finished to gauge tolerance and is used for checking the external diameter of a cylindrical object.

Ring gauges are used for comparative gauging as well as for checking, calibrating, or setting of gauges or other standards. Individual ring gauges or ring gauge sets are made to variety of tolerance grades in metric and English dimensions for master, setting, or working applications.

❖ Snap Gauge

A snap gage is a form of go/no go gauge. It is a limit gage with permanently or temporarily fixed measurement aperture(s) (gaps) which is used to quickly verify whether an outside dimension of a part matches a preset dimension or falls within predefined tolerances.

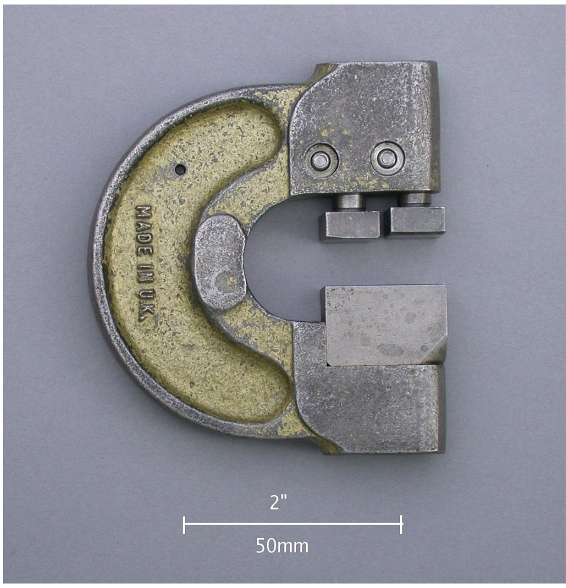
❖ Gauge Blocks

Gauge blocks (also known as gage blocks, Johansson gauges, slip gauges, or Jo blocks) are a system for producing precision lengths. The individual gauge block is a metal or ceramic block that has been precision ground and lapped to a specific thickness.

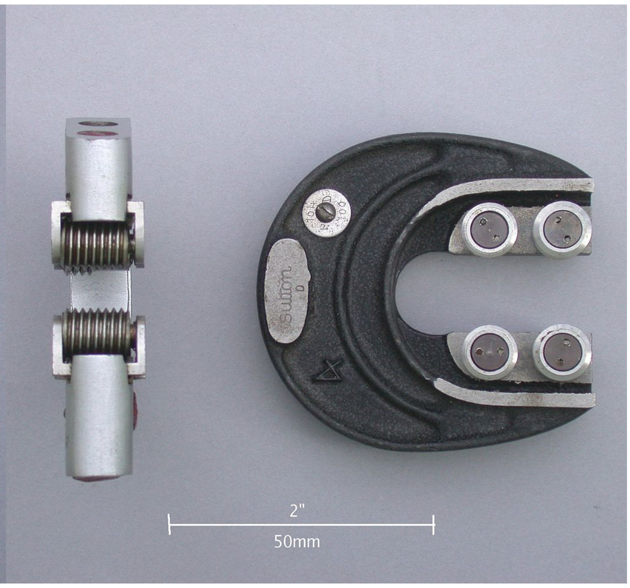
❖ A (Go)-(No Go) Thread Snap Gauge

A go-no gauge (or go/no-go) refers to an inspection tool used to check a work piece against its allowed tolerances. Its name is derived from two tests: the check involves the work piece having to pass one test (go) and fail the other (no-go).

Go/no-go gauges play an integral part in setting the correct headspace during gunsmithing. In order for the chamber to be in-spec, the bolt must close without resistance on the go gauge, but it must not close completely on the no-go gauge.



Snap go/no-go gauge for the OD of a cylindrical work piece



Thread snap gauge

❖ Dial Indicator

A dial test indicator, also known as a lever arm test indicator or finger indicator, has a smaller measuring range than a standard dial indicator.

A test indicator measures the deflection of the arm, the probe does not retract but swings in an arc around its hinge point.

❖ Electronic Gauge

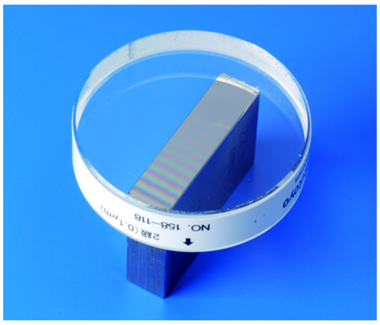
Also as known as digital gauge.

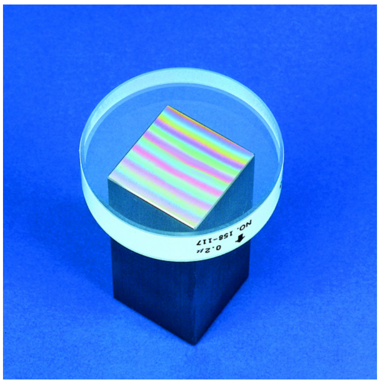
❖ Optical Comparator

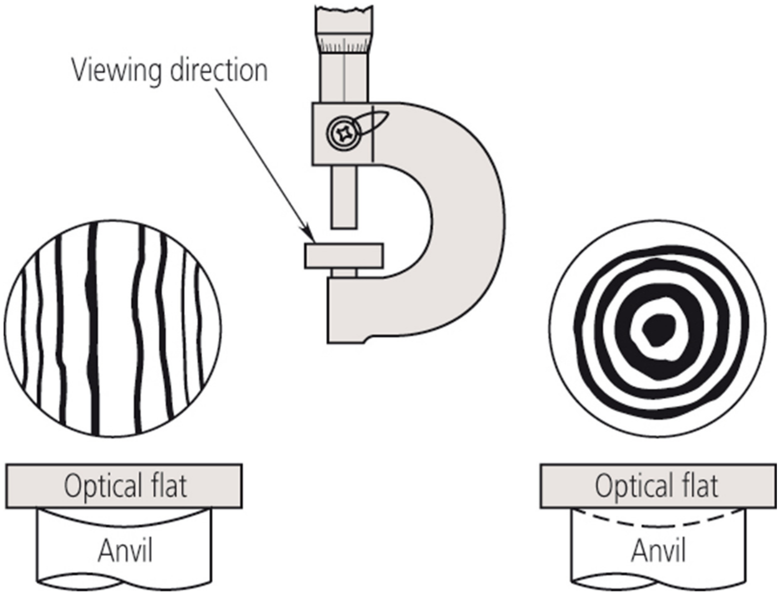
An optical comparator (often called just a comparator in context) is a device that applies the principles of optics to the inspection of manufactured parts.

❖ Optical Flats

An optical flat is an optical-grade piece of glass lapped and polished to be extremely flat on one or both sides, usually within a few tens of nanometers (billionths of a meter).







❖ Thickness (Feeler) Gauge

A feeler gauge is a tool used to measure gap widths. Feeler gauges are mostly used in engineering to measure the clearance between two parts.

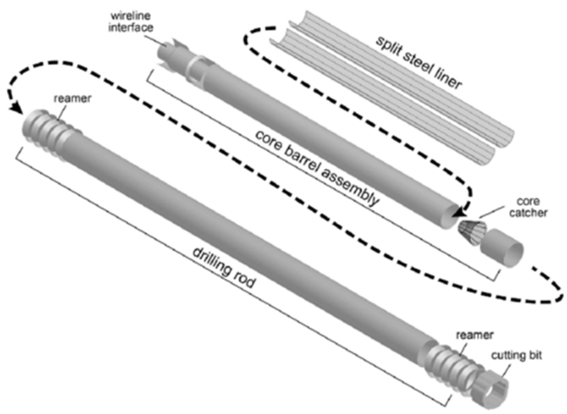
They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece. They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values. It is common to have two sets for imperial units (typically measured in thousandths of an inch) and metric (typically measured in hundredths of a millimeter) measurements.

❖ Screw Pitch Gauge

A thread gauge, also known as a screw gauge or pitch gauge, is used to measure the pitch or lead of a screw thread. Thread pitch gauges are used as a reference tool in determining the pitch of a thread that is on a screw or in a tapped hole. This tool is not used as a precision measuring instrument, rather it allows the user to determine the profile of the given thread and quickly categorize the thread by shape and pitch. This device also saves time, in that it removes the need for the user to measure and calculate the thread pitch of the threaded item.

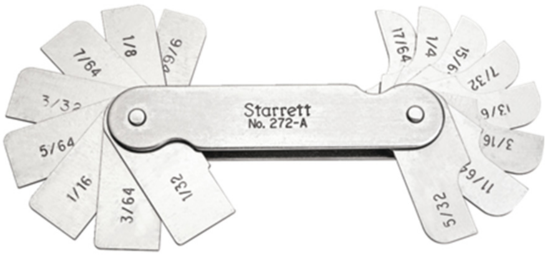
❖ Drill Rod

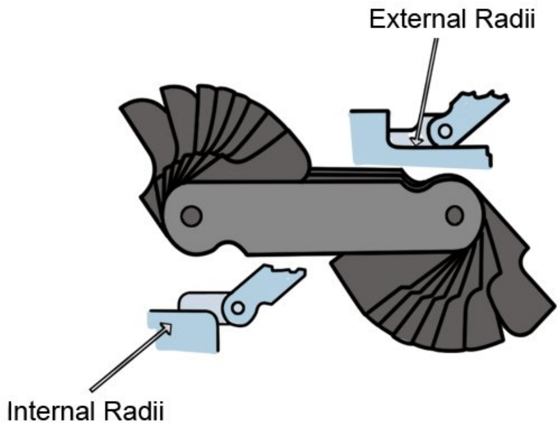
Drill rod is a form of bar stock machined to produce tools such as drill bits, taps, dowel pins, hammers, and reamers.



❖ Fillet And Radius Gauges

A radius gauge, also known as a fillet gauge, is a tool used to measure the radius of an object. Radius gauges require a bright light behind the object to be measured. The gauge is placed against the edge to be checked and any light leakage between the blade and edge indicates a mismatch that requires correction.





❖ Telescoping Gauges

A telescoping gauge is an indirect measuring device, the head of which can be positioned inside holes or openings and then extended to touch the walls. The gauge can then be extracted, and the size of the extended head can be measured with a micrometer or Vernier caliper to determine the interior radius of the hole. This is essentially no different from a set of inside calipers, save that the distance which the head extends can be locked after measurement to ensure it's as accurate as possible.

❖ Small Hole Gauge

A small-hole gauge is a measuring tool with a round expandable head that is used together with an outside micrometer to measure the inside of small holes. Parts , such as valve guides , have very small holes. These holes are too small to use an inside micrometer or telescoping gauge.

❖ Surface Gauges

It is normally used to 'scribe' parallel lines. Its base is heavy and this means it is stable when in used. Surface gauges sometimes have magnetic bases and this means they can be locked onto metal surfaces making it easier to use. ... The surface gauge is then moved across the surface of the steel, scribing a line.