Unit 7 Precision Measurement

Tolerances:

It is not possible to machine a part to an absolutely exact size. It might end up .001" (one thousandth of an inch) too small or too big, or perhaps .0001, or .00001, or .0000000000000001" too small or too big. Of course, the very tiny inaccuracies do not matter usually. When you are making a part, how accurate does it have to be? Is it still usable if it is .001" (.02 mm) too big? Is it still usable if it is .005" (.10mm) too big?

In order to machine parts, we need to know the accuracy level needed. No one wants to spend the extra time or money it takes to make a part exact to a tenth of a thousandth of an inch (.0001") if it is only going to be used as a hook to hang up a shovel, for example. So machined parts are always given a tolerance, which is the range of sizes that can be tolerated and still have the part usable.

There are several ways to write or describe a tolerance. If a part has to be between .500 and .510 in order to be usable, it could be written several ways:

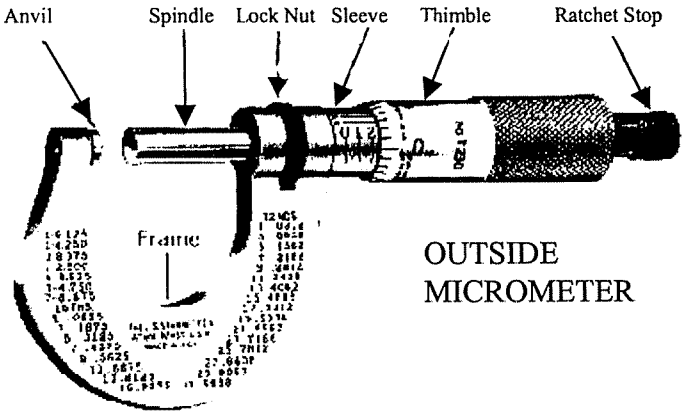
$.500 \begin{matrix} +.010 \\ -\ 0 \end{matrix}$ or $.505 \pm .005$ or $.510 \begin{matrix} +\ 0 \\ -.010 \end{matrix}$ or $\begin{matrix} .500 \\ .510 \end{matrix}$

Each of these choices results in the same acceptable size.

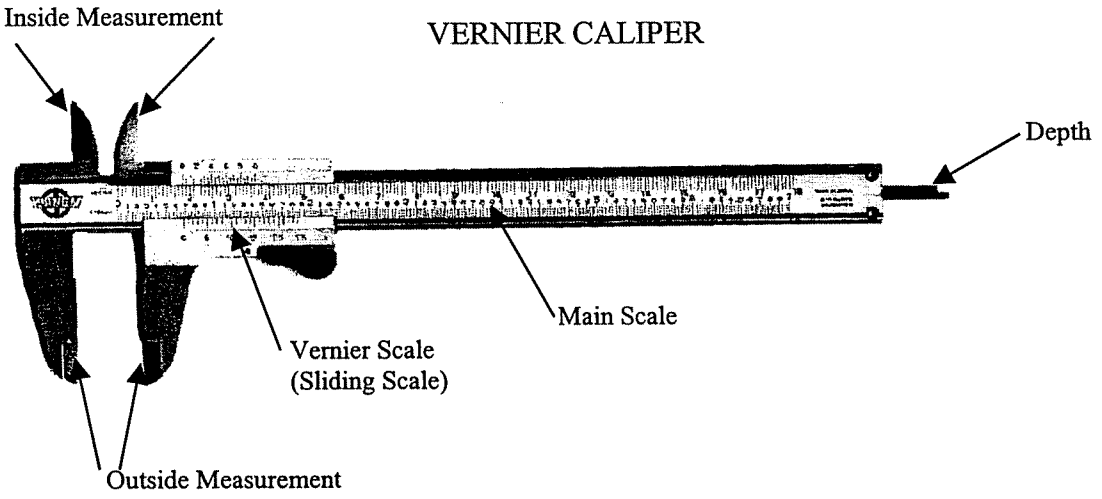
If no tolerance is given it is generally accepted that a decimal size (such as .375) has a tolerance of + or - .005 (plus or minus .005). If it is a fractional size, such as 1/2", the tolerance is + or - 1/64.

Micrometers and Verniers

The two most common tools we use for precision measurement are the micrometer and the vernier slide caliper. Both tools measure to within .001 inch (one thousandth of an inch).



OUTSIDE MICROMETER

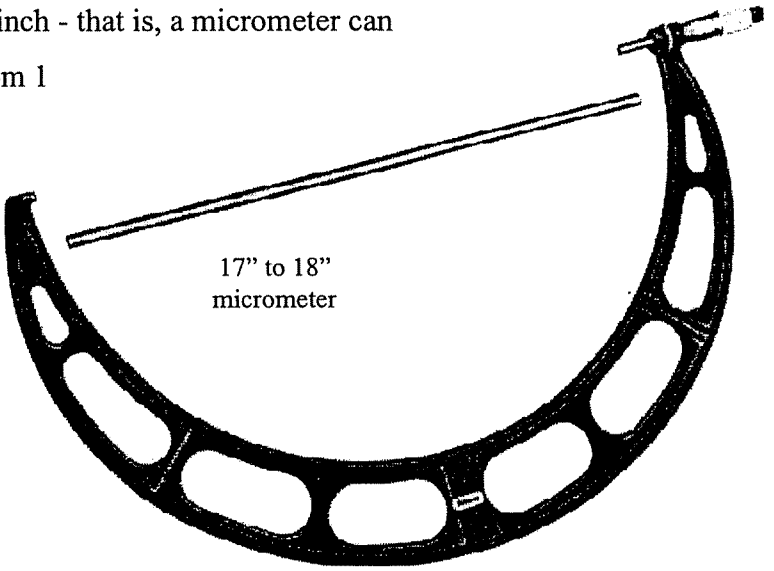


VERNIER CALIPER

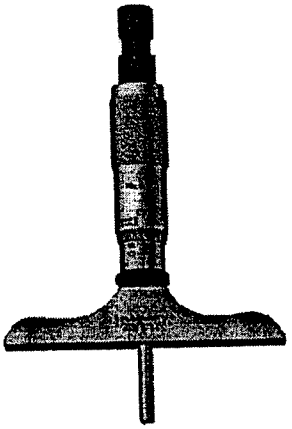
The Micrometer:

The micrometer is a little more accurate than a vernier caliper because it allows you to read parts of a thousandth of an inch. This means you can tell if the measurement is halfway between .010 and .011, for example. You might end up reading this measurement as .0105, a measurement that you cannot get with a conventional vernier caliper. Some micrometers allow you to read to .0001 (one ten thousandths of an inch). They have an extra series of lines on the sleeve.

Micrometers can span only one inch - that is, a micrometer can read from 0 to 1 inch, or from 1 inch to 2 inches, or from 17 inches to 18 inches. Therefore, you usually need several micrometers if you have several sizes to measure.



There are three common types of micrometer. One is the outside micrometer shown above, used to measure the outside diameter or size. Another type is the inside micrometer, used to measure the inside diameter or size (inside of a large pipe, for example).

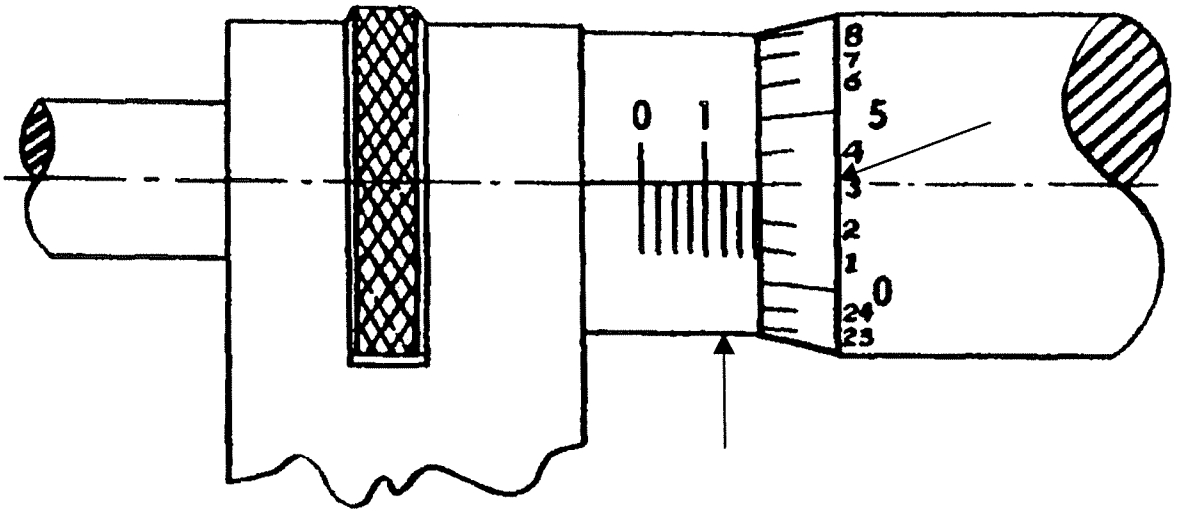


A third type is a depth micrometer, used to measure the depth of a hole or slot. It is pictured at left.

Steps to Reading a Micrometer:

1. Read the largest numbered line that is visible. Each numbered line = .100
2. See how many small (not numbered) lines appear after the above numbered line. These lines are .025" apart, so count .025 for each line.
3. See which of the lines on the revolving thimble lines up with the main line on the sleeve. The numbers on the thimble each represent .001" of distance. Add this number to the other two numbers found in steps 1 & 2. The total is the reading in thousandths of an inch.

Example:

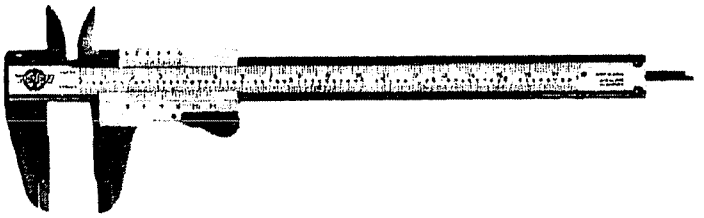


The line "1" on the sleeve is visible, representing .100	1 x .100 =	**.100**
There are 3 small lines visible, each representing .025	3 x .025 =	**.075**
Line "3" on the Thimble coincides with the longitudinal line on the sleeve, each line representing .001	3 x .001 =	**.003**
The micrometer reading is		**.178**

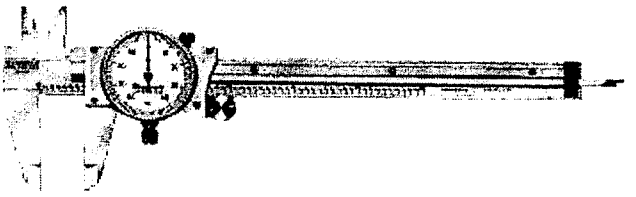
An easy way to remember how to do this is to think of it as making change from a bill. Count the numbers on the sleeve as dollars, the vertical lines on the sleeve as quarters, and the numbers on the thimble as cents. Simply add up your change and put a decimal point in front of your total instead of a dollar sign.

Calipers:

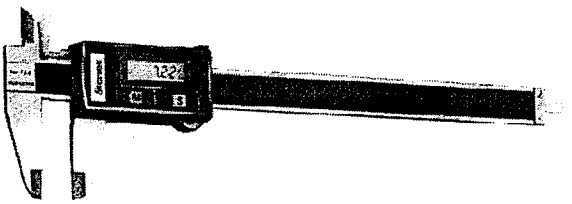
There are three types of caliper in common use. The traditional one is the **vernier caliper**, which uses exactly spaced lines to produce a size reading (see the directions below). These calipers read to plus or minus .001 inch (one thousandth).



A newer, easier to read but more fragile type is the **dial caliper**, using a rotating needle to show the size.



The third type is the easiest to read, but is the most expensive as well. It is a **digital caliper**, using a digital read-out to tell you the size. These calipers often read ½ thousandths, or .0005.



Advantages of these calipers:

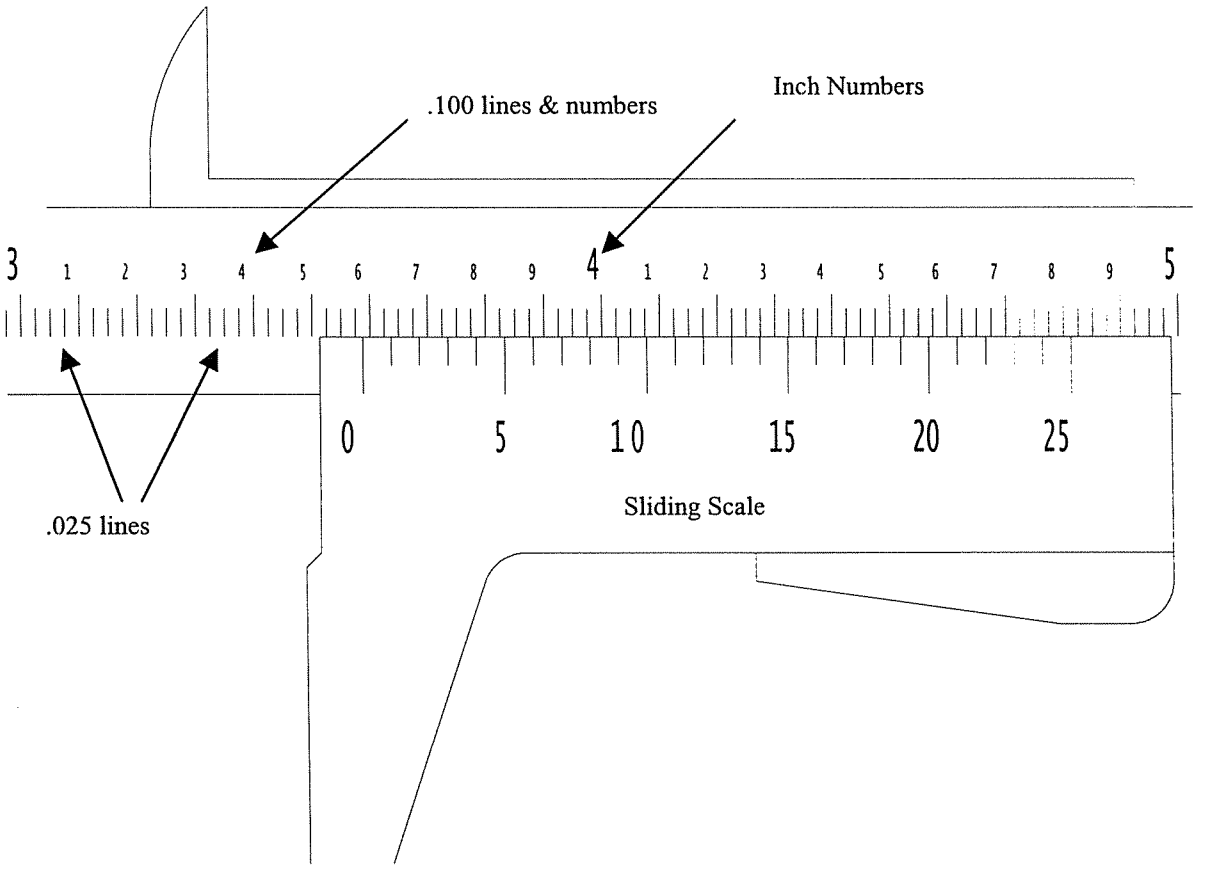
1. The vernier and digital calipers read metric as well as imperial measurements
2. Calipers read inside measurements, outside measurements and depth, all with the same tool (you need separate micrometers to do these different things).
3. Calipers read from 0 to 6" or 0 to 8" commonly, some large calipers read from 0 to 36" (0 to 1000 mm). Micrometers only have a range of one inch (25mm).
4. Calipers are much faster to adjust to different sizes, as they slide quickly.
5. Calipers can be used to transfer sizes from inside to outside (to see if a shaft will fit into a bore, for example)

Disadvantage: Not quite as accurate as a micrometer.

Reading a Vernier Caliper:

The vernier caliper uses lines on the main beam, as well as lines on the slide. The lines on the main beam are very similar to the lines on the sleeve of the micrometer, except that the vernier scale has inch numbers as well as .100 numbers, and the .025 lines (not numbered).

The main idea behind the vernier caliper is that only one line (of the 25 lines on the slide) will line up with a line (any line) on the main beam. The line that lines up gives you the number of thousandths, from .001 to .025, read off the sliding scale.

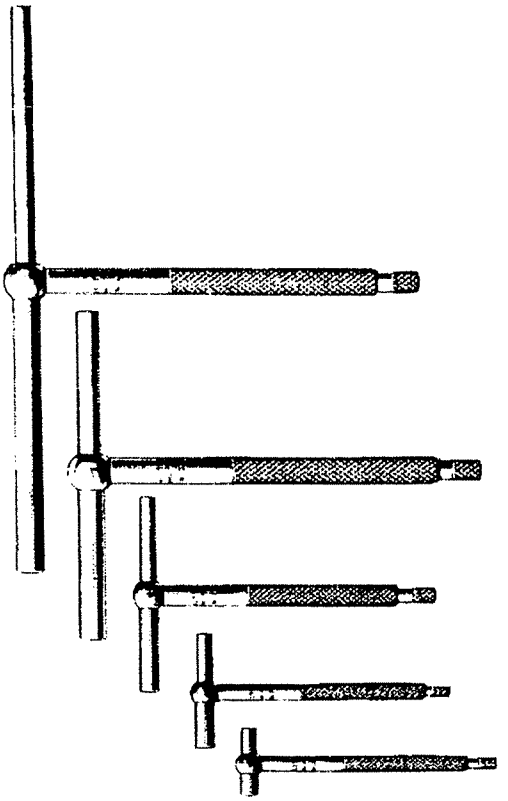


So the steps to read a vernier are:

1.	read the number of inches that the "0" has passed	**3** x 1 inch =	**3.000**
2.	read the number of .100 lines that the "0" has passed	**5** x .100 =	**.500**
3.	read the number of .025 lines the "0" has passed next	**3** x .025 =	**.075**
4.	which line on the sliding scale lines up	**15** x .001 =	**.015**
	TOTAL		**3.590**

Telescoping Gauges

Sometimes a telescoping gauge is needed to measure a hole size. The inside micrometer may be too large to fit the bore, or may not be available for some reason. In this case telescoping gauges may be used. These gauges come in various sizes, from about 5/16" (8mm) to 6" (150mm). Similar tools, called small hole gauges, are available to measure very small holes.



Method of use:

- Place the telescoping gauge in the bore
- Snug up the tightening knob at the end of the handle
- Move the gauge in the bore so that the bore compresses the arms to the exact size of the bore
- Measure the gauge with a micrometer