ENGINEERING METROLOGY
(DIMENSIONAL METROLOGY)

ACADEMIC YEAR 92-93, SEMESTER ONE

FIXED GAGES & DIMENSIONAL TOLERANCES

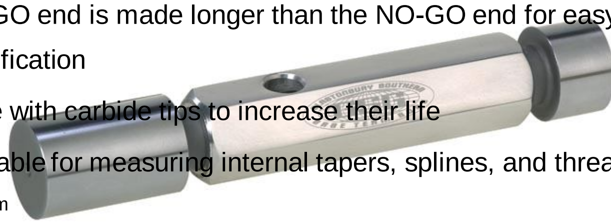
DEPARTMENT OF MECHANICAL ENGINEERING
ISFAHAN UNIVERSITY OF TECHNOLOGY

Fixed gages

- ✓ Replicas of the shapes of the parts to be measured
- ✓ Used for inspection purposes only because they provide a quick means of checking a specific dimension
- ✓ Indicate whether a part is too small or too large when compared to an established standard
- ✓ Easy to use and inexpensive
- ✓ Generally finished to one tenth the tolerance they are designed to control

Fixed gages

- ✓ **Plug gages**:
  - ✓ Commonly are used for checking holes
  - ✓ The *GO gage* is smaller than the *NOT GO* (or *NO GO) gage,* and checks the lower limit of the hole
  - ✓ The *NO-GO* gage checks the upper limit of the hole
  - ✓ Two gages may be on the same device, either at opposite ends or in two steps at one end
  - ✓ The GO end is made longer than the NO-GO end for easy identification
  - ✓ Made with carbide tips to increase their life
  - ✓ Available for measuring internal tapers, splines, and threads



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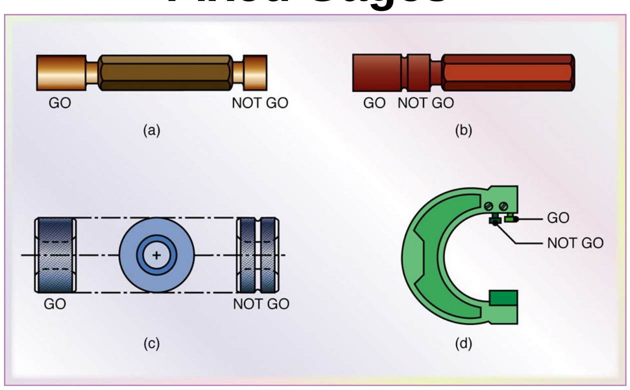
Fixed Gages



(a) Plug gage for holes with GO and NOT GO on opposite ends.

(b) Plug gage with GO and NOT GO on one end.

(c) Plain ring gages for gaging round rods. Note the difference in knurled surfaces to identify the two gages.

(d) Snap gage with adjustable anvils.

Ring gages

- ✓ Commonly are used for checking shafts and similar round parts
- ✓ The *GO gage* and *NOT GO* features on these gages are identified by the type of knur
- ✓ Taper ring gages are used to check both the accuracy and outside diameter of the taper
- ✓ The most popular thread ring gage is the adjustable thread ring gage
- ✓ It is used to check the accuracy of an external thread and has a hole in the centre with three radial slots and a setscrew to permit small adjustments

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Fixed gages

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Fixed gages

- **Snap gages**:
  - Commonly are used for measuring external dimensions
  - Faster to use than micrometers but are limited in their applications
  - Made with adjustable gaging surfaces for use with parts which have different diameters
  - One of the gaging surfaces can be set at a different gap from the other, thus making it a one-unit *GO* and *NOT GO* gage



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Air gages

- The gage head (air plug) has two or more holes, typically 1.25mm in diameter, through which pressurized air escapes
- The smaller the gap between the gage and the hole, the more difficult it is for the air to escapes, and hence, the higher the back pressure
- The back pressure is sensed and indicated by a pressure gage, and is calibrated to measure the dimensional variations of the holes
- Easy to use and the resolution can be as fine as 0.125 μm
- Can indicate out-of-roundness; external diameters; non-contacting method

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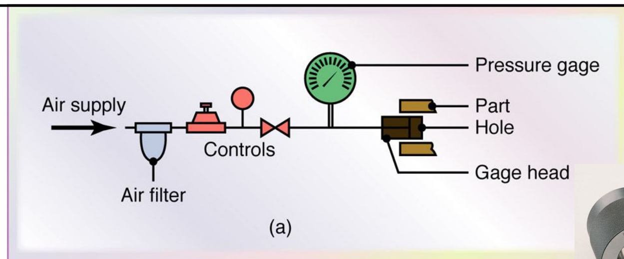
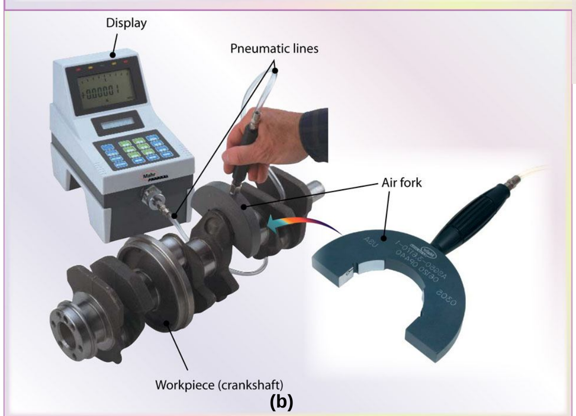
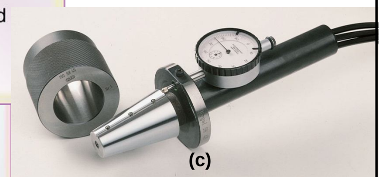
Air Gages







(a) Schematic illustration of the principle for an air gage. (b) Three types of plugs used for air gaging. The gage on the right is an air snap gage. (c) A conical head for air gaging; note the small air holes on the conical surface. *Source:* (b) Courtesy of Mahr Federal Inc. (c) Courtesy of Stotz Gaging Co.

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Electronic Gage

An electronic gage for measuring bore diameter. The measuring head is equipped with three carbide-tipped steel pins for wear resistance. The LED display reads 29.158 mm. *Source*: Courtesy of TESA SA.

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Electronic Gage Measuring Vertical Length

An electronic vertical-length measuring instrument with a resolution of 1 μm (40 μin). *Source*: Courtesy of TESA SA.

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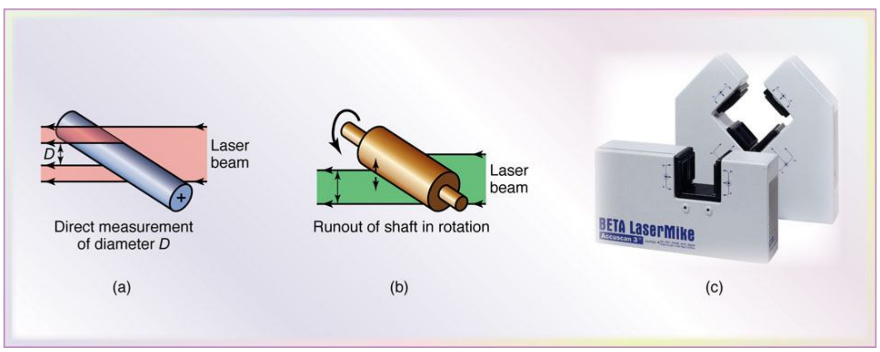
Laser Micrometers



(a) and (b) Two types of measurements made with a laser scan micrometer. (c) Two types of laser micrometers. Note that the instrument in the front scans the part (placed in the opening) in one dimension; the larger instrument scans the part in two dimensions. *Source*: Courtesy of BETA LaserMike.

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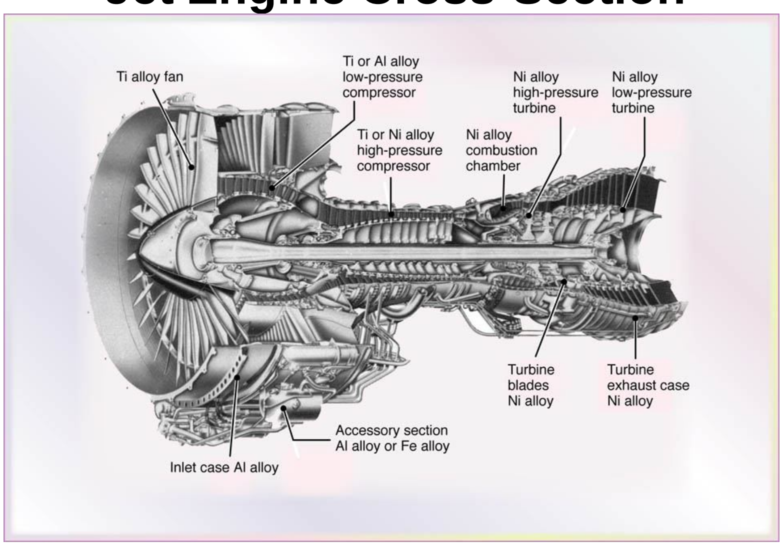
Dimensioning and Tolerancing

- ✓ A device is made by assembling individual manufactured parts and components
- ✓ Produced parts must be *interchangeable*

Dimensional tolerance:

- ✓ the permissible or acceptable variation in the dimensions (height, width, depth, diameter, and angles) of a part
- ✓ Tolerances are unavoidable, because it is virtually impossible (and unnecessary) to manufacture two parts that have precisely the same dimensions

Jet Engine Cross-Section



Cross-section of a jet engine (PW2037) showing various components and the alloys used in manufacturing them. Source: Courtesy of United Aircraft Pratt & Whitney.

Dimensional tolerance

- ✓ A narrow tolerance is undesirable economically
- ✓ Close dimensional tolerances can increase the product cost significantly
- ✓ Some products such as precision measuring instruments and gages, hydraulic pistons, and bearing for aircraft engines need close tolerances
- ✓ Measuring dimensional tolerances and features of parts rapidly and reliably can be a challenging task

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Dimensional tolerance

- ✓ State-of-the-art manufacturing methods shrink the dimensional tolerances by a factor of 3 every 10 years
- ✓ It is estimated that accuracies of

a) Conventional turning and milling machines will rise from the present 7.5 to 1 *μm*

b) Diamond-wheel wafer-slicing machines for semiconductor fabrication to 0.25 *μm*

c) Precision diamond turning machines to 0.01 *μm*

d) Ultra-precision ion-beam machining to less than 0.001 *μm*

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Importance of tolerance control

- ✓ Dimensional tolerances become important when a part is to be assembled or mated with another part
- ✓ The mating surfaces should have a *range* in their sizes to fit together
- ✓ *Nominal size*: an approximate dimension that is used for the purpose of general identification
- ✓ *Limits* are the maximum and minimum dimensions of a part
- ✓ *Clearance*: the space between mating parts
- ✓ *Interference:* negative clearance
- ✓ Allowance: the intentional difference in the dimensions of mating parts

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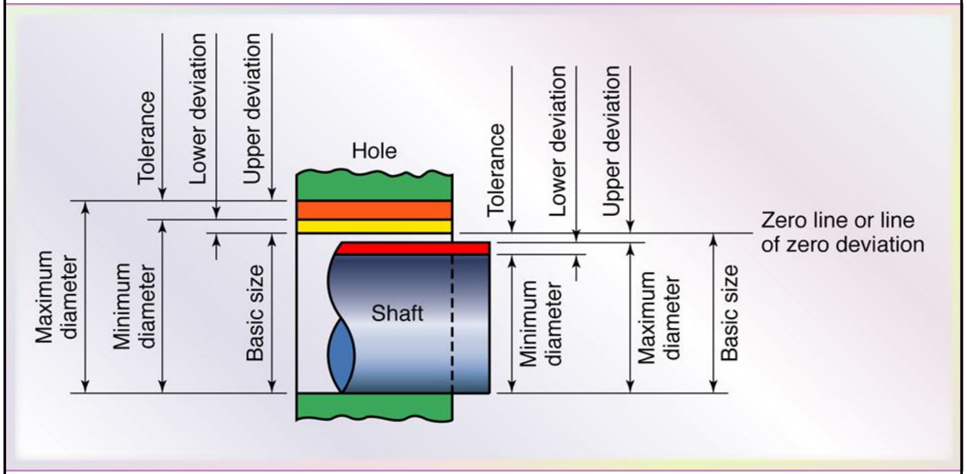
Tolerance Control



Basic size, deviation, and tolerance on a shaft, according to the ISO system.

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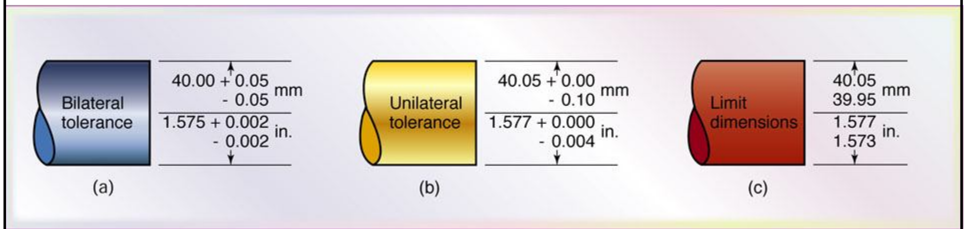
Methods of assigning tolerances



Various methods of assigning tolerances on a shaft:

(a) bilateral tolerance,

(b) unilateral tolerance,

(c) limit dimensions.

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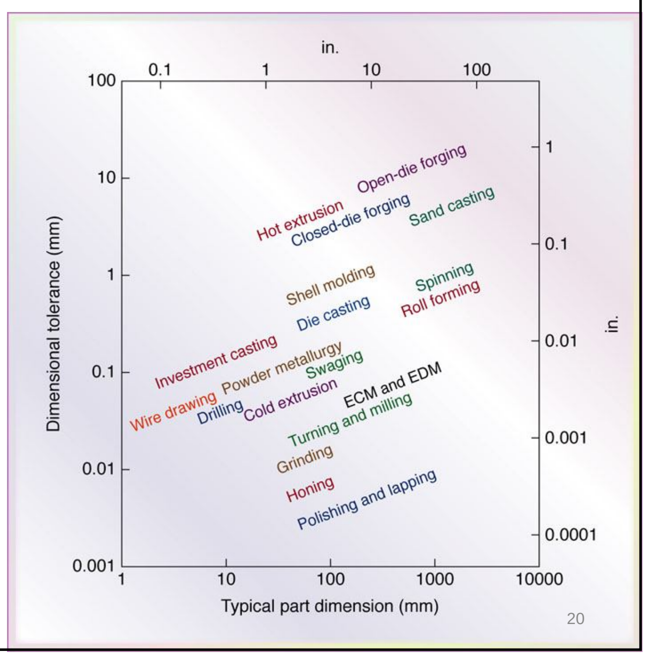
Dimensional tolerances as a function of part size

Dimensional tolerances as a function of part size for various manufacturing processes.

Note that because many factors are involved, there is a broad range for tolerances.



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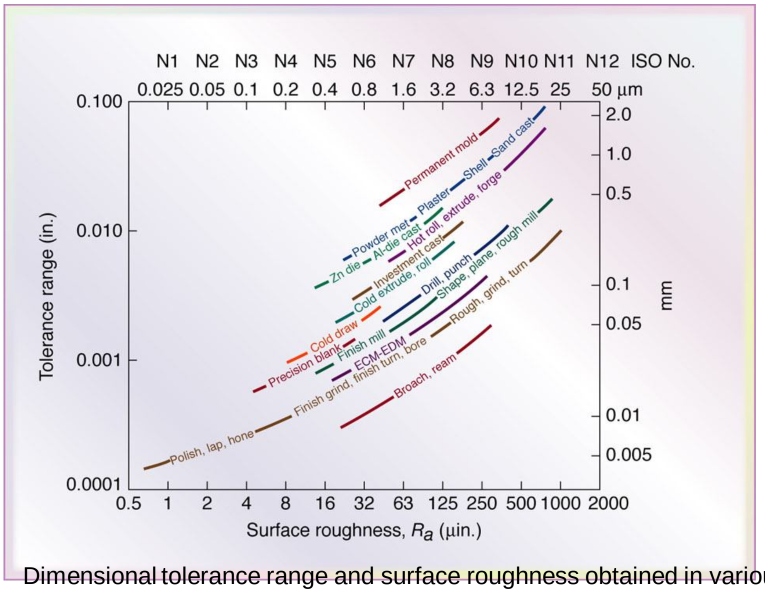
Tolerance range and Surface roughness



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Dimensional tolerance range and surface roughness obtained in various manufacturing processes. These tolerance apply to a 25-mm (1-in.) workpiece dimeinsion. *Source*: After J. A. Schey.

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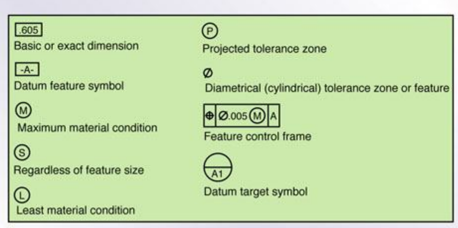
Engineering Drawing Symbols

Geometric characteristic symbols to be indicated on engineering drawings of parts to be manufactured.

Source: Courtesy of The American Society of Mechanical Engineers.

Type of feature	Type of tolerance	Characteristic	Symbol
Individual (no datum reference)	Form	Flatness	▱
		Straightness	—
		Circularity (roundness)	○
		Cylindricity	⌭
Individual or related	Profile	Profile of a line	⌒
		Profile of a surface	⌓
Related (datum reference required)	Orientation	Perpendicularity	⊥
		Angularity	∠
		Parallelism	//
	Location	Position	⊕
		Concentricity	◎
	Runout	Circular runout	↗
		Total runout	⌰

(a)



(b)

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