

Chapter 3: Measurement and Inspection (4 Weeks)

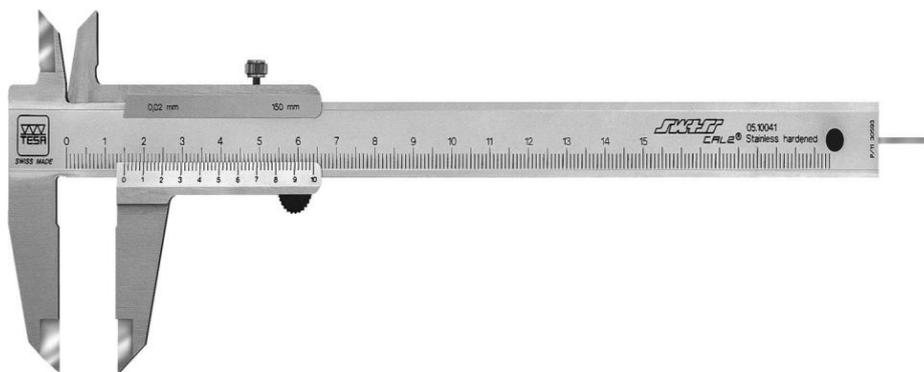
- 3.1. Direct Measurement of Lengths and Angles (Use of rulers, vernier calipers, micrometers, and universal protractors);
- 3.2. Indirect Measurement (Use of dial indicators and gauge blocks);
- 3.3. Dimensional Inspection (Use of plug gauges, snap gauges, etc.);
- 3.4. Measurement and Inspection Machines Used in Mechanical Workshops (Use of pneumatic comparators, profile projectors, and roughness testers);

Chapter 3: Measurement and Inspection

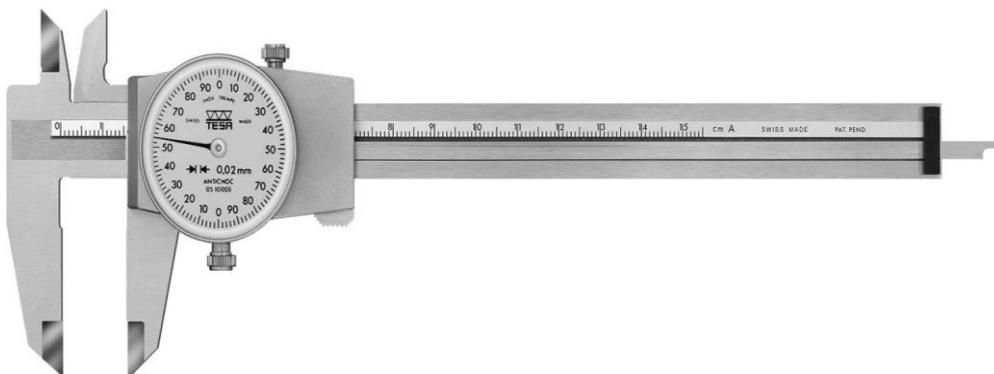
3.1. Direct Measurement of Lengths and Angles

3.1.1 Vernier Calipers

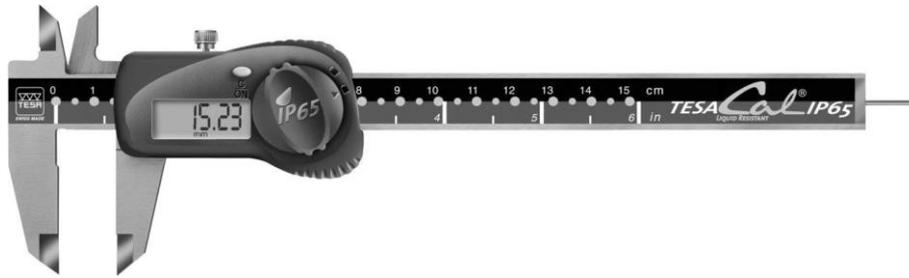
Vernier calipers are particularly well suited for rapid measurements, especially since they allow the measurement of external, internal, and depth dimensions of a part. Due to their multiple measurement capabilities, simple construction, and ease of use, they are among the most widely used measuring instruments in mechanical engineering.



Universal vernier caliper (with jaws)



Dial vernier caliper

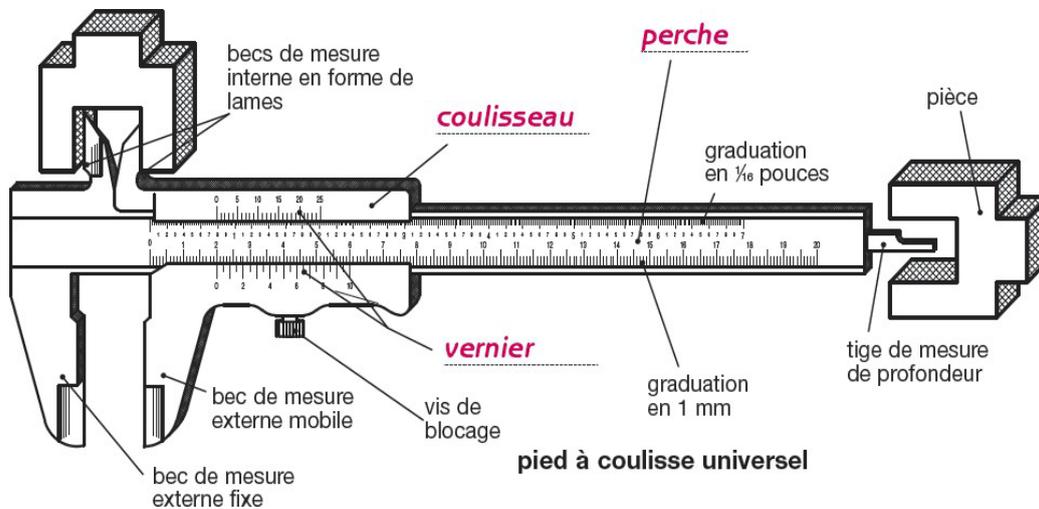


Electronic (digital) vernier caliper



Vernier caliper with fine-adjustment pointed jaws

Vernier calipers consist of a beam graduated in millimeters. The movable slider is also fitted with jaws and a secondary scale called the vernier. When the caliper is fully closed, the zero mark of the vernier aligns with the zero mark of the main scale on the beam.



The Vernier Scale

The reading of a vernier scale results from the difference between the main scale on the beam and the vernier scale on the slider. For a tenth-millimeter vernier, 9 mm are divided into 10 equal parts. The distance between two successive lines on the vernier scale is therefore:

$$\frac{9}{10} = 0.9 \text{ mm}$$

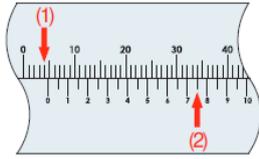
while the division on the main scale is 1 mm. The difference between these two divisions:

$$1 - 0.9 = 0.1 \text{ mm}$$

corresponds to the *vernier constant* (least count). This value is equivalent to the resolution of dial measuring instruments.

Comment lire les graduations

Pieds à coulisse à vernier



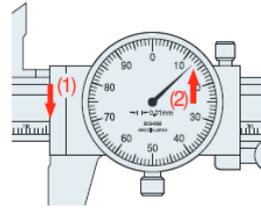
Graduation : 0,05 mm

(1) Lecture de la graduation principale 4,00 mm
(2) Lecture du vernier 0,75 mm

Lecture du pied à coulisse 4,75 mm

Remarque : la valeur de 0,75 mm ci-dessus à gauche (2) correspond à la coïncidence entre une graduation de la règle principale et une graduation du vernier.

Pieds à coulisse à montre



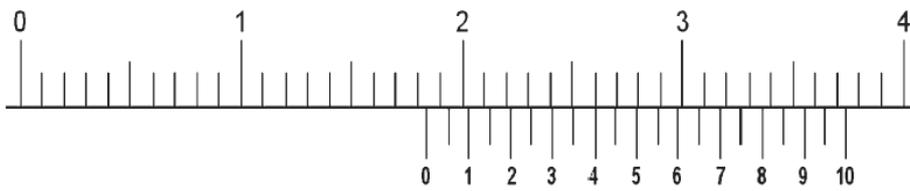
Graduation : 0.01 mm

(1) Lecture de la graduation principale 16,00 mm
(2) Lecture du vernier 0,13 mm

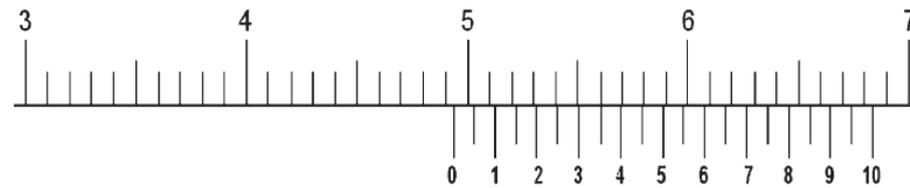
Lecture du pied à coulisse 16,13 mm

vernier au 1/20

différence de graduation : 1 mm – 0.95 mm = 0.05 mm



cote relevée : **18.4 mm**



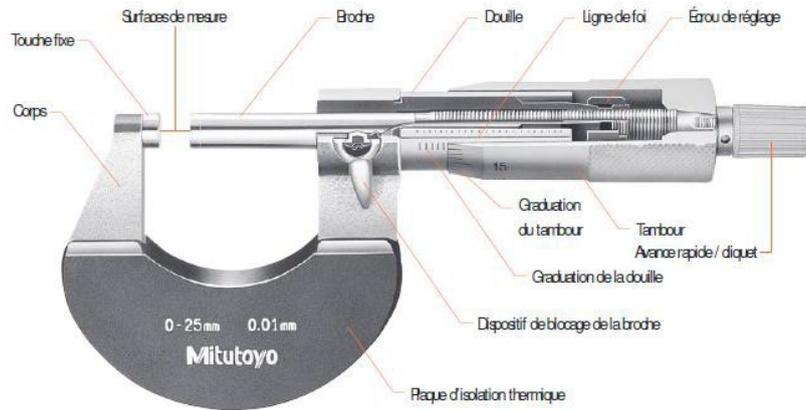
cote relevée : **49.35 mm**

3.1.2 Micrometers (Palmer Micrometers)

A micrometer is characterized by:

- Measuring ranges: 0–25 mm, 25–50 mm, 50–75 mm, 75–100 mm, etc.
- Screw pitch: 0.5 mm or 1 mm
- Resolution on the order of 0.01 mm to 0.001 mm
- Shape of the measuring faces (anvils)

Standard analog micrometer

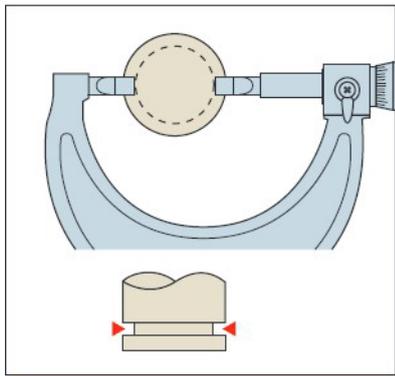


Electronic micrometer with digital display



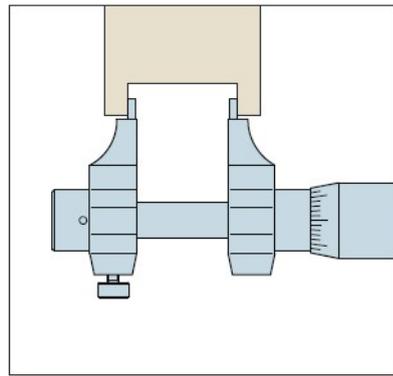
Special Applications of Micrometers

Micromètre à touches couteaux



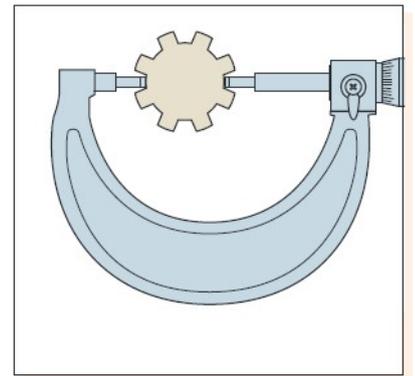
> Pour la mesure du diamètre dans des gorges étroites.

Micromètre d'intérieur, type pied à coulisse



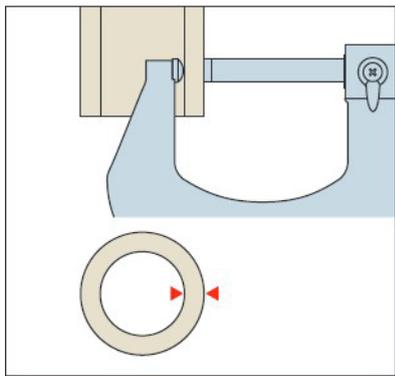
> Pour la mesure du diamètre intérieur et de la largeur des gorges.

Micromètre à touches pour cannelures



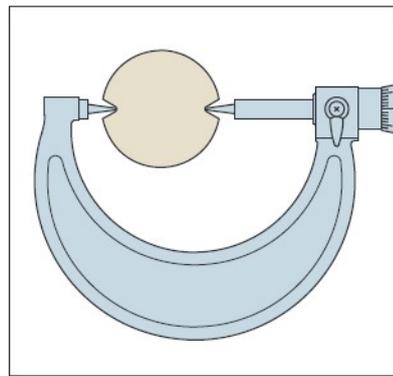
> Pour la mesure du diamètre des arbres cannelés.

Micromètre à touches sphériques pour surfaces incurvées



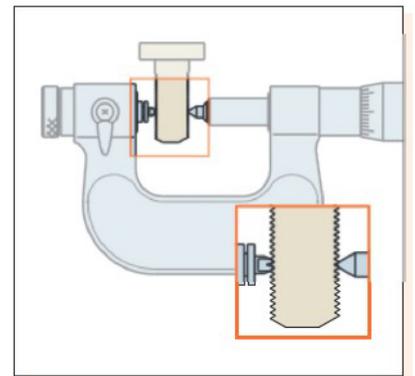
> Pour la mesure de l'épaisseur des parois des tubes.

Micromètre à touches pointues



> Pour la mesure du diamètre à fond de filet.

Micromètre pour la mesure de filetage

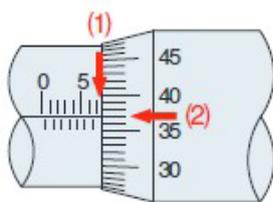


> Pour la mesure efficace du diamètre du filetage.

-Reading the Scales

(The reading procedure depends on the alignment of the sleeve and thimble graduations.)

□ □ Micromètre à vernier (graduation : 0,01 mm)



- (1) Lecture de la graduation de la douille 7,00 mm
 (2) Lecture de la graduation du tambour 0,37 mm

Lecture du micromètre	7,37 mm
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Remarque : la valeur 0,37 mm (2) est indiquée par l'alignement de la ligne de foi de la douille avec une graduation du tambour.

□ Micromètre à vernier (graduation : 0,001 mm)

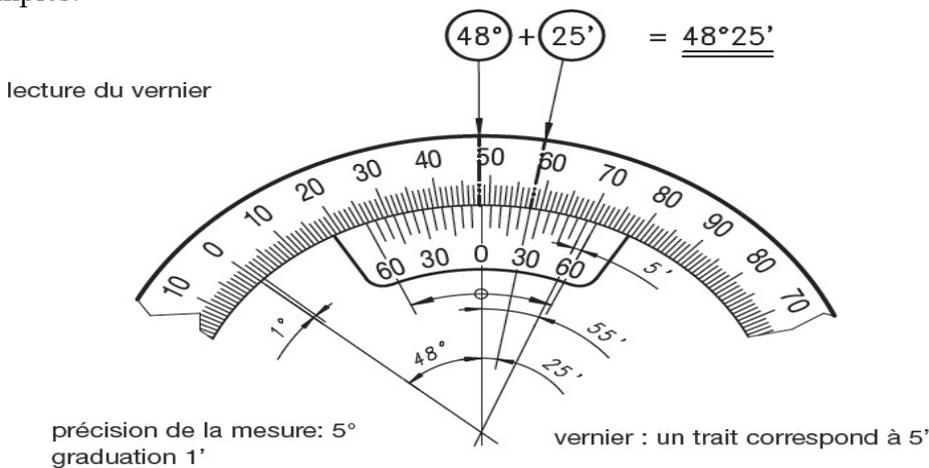


Remarque : La valeur de 0,21 mm (2) est indiquée par la position de la ligne de foi entre deux graduations (21 et 22). La valeur de 0,003 mm (3) est indiquée par l'alignement d'une graduation du vernier sur une graduation du tambour.

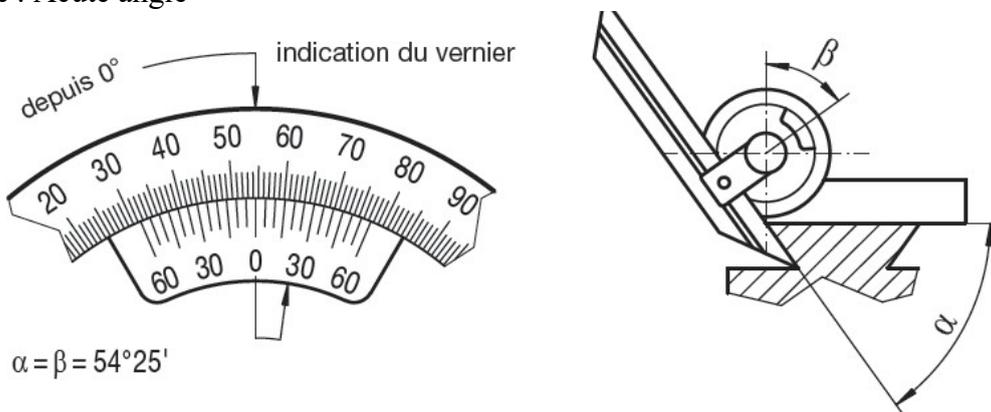
- **Reading Rules for Universal Protractors**

- First, read the whole degrees on the main scale from 0° up to the zero mark of the vernier.
- Then, read the minutes on the vernier scale in the same reading direction.

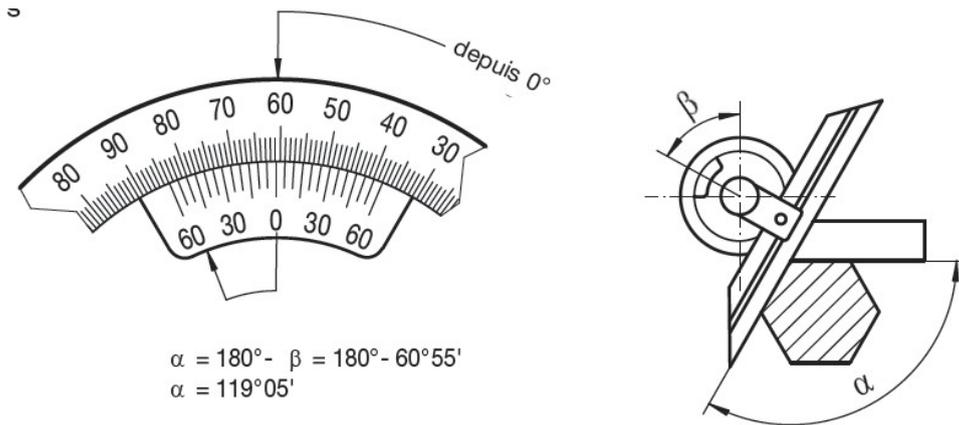
Exemples:



Exemple : Acute angle



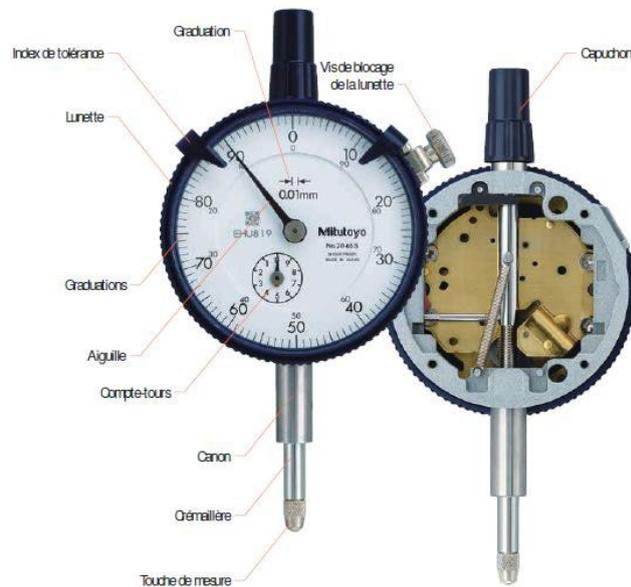
Exemple : Obtuse angle



3.2 Indirect Measurement

3.2.1 Dial Indicators

Dial indicators are used for measuring very small displacements or for comparing closely related dimensions.



A dial indicator is characterized by:

- A limited measuring range, typically 3, 5, or 10 mm
- High precision, commonly 0.01 mm or 0.001 mm
- Shape of the contact tip (interchangeable probes)
- Measuring force of approximately 1.5 N

0.01 mm



> Cadran continu (Graduation bidirectionnelle)



> Cadran symétrique (Multi-tours)

0.001 mm



> Cadran partagé (Graduation bidirectionnelle)



> Cadran symétrique (Multi-tours)



> Cadran continu (Lecture inversée)



> Cadran symétrique (Lh seul tour)



> Cadran continu (Graduation bidirectionnelle)



> Cadran symétrique (Multi-tours)

4.2.2 Gauge Blocks (Slip Gauges)

Gauge blocks are length standards in the form of rectangular parallelepipeds whose opposite faces—called measuring faces—have surface qualities that allow them to adhere to one another (wringing effect).



They are made of metal with hardness ≥ 62 HRC (Rockwell hardness) to prevent scratching. Several grades of gauge blocks exist, corresponding to standardized accuracy classes:

- 00, 0: Laboratory grade
- 1, 2, 3: Workshop use

Use of Gauge Blocks

A wide range of dimensions can be obtained by combining gauge blocks.

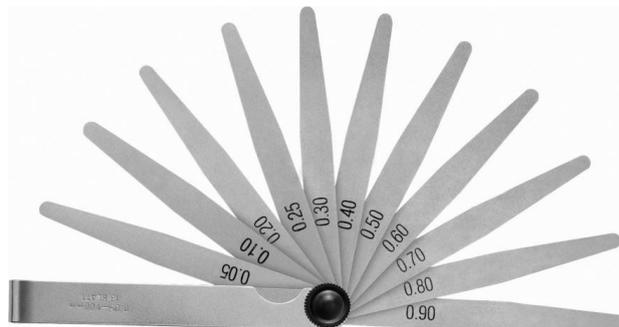
Procedure:

- Clean the gauge blocks using alcohol or ether applied with cotton.
- After use, separate the blocks by twisting them without pulling.
- Clean, lightly grease, and store the blocks in their case.

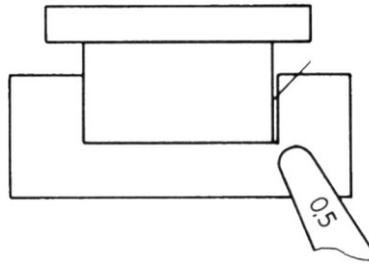
3.3. Dimensional Inspection (Use of gauges, jaws, etc.)

3.3.1 Thickness Gauges (Feeler Gauges)

Thickness gauges consist of sets of blades of varying thicknesses. The thinnest blades are available from 0.01 mm. Example: inspection using a 0.5 mm steel blade from a feeler gauge set.

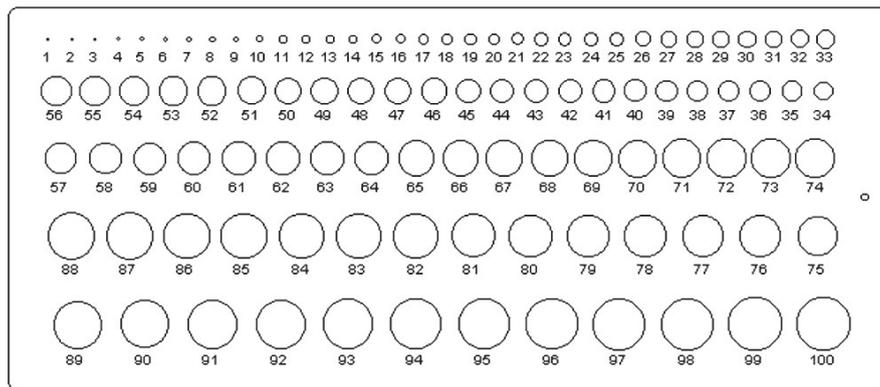


Application



3.3.2 Hole Gauges (Drill Gauges)

These gauges are used to inspect and sort twist drills, drill bits, and steel wires. The drill or wire is inserted into the hole that fits, and the corresponding value is read directly from the gauge.



3.3.3 Plug Gauges and Snap Gauges

Plug gauges and snap gauges are inspection tools used in the mechanical industry to verify, in a simple manner, compliance with functional requirements of machined parts. They are used during production or at reception.

The principle of limit gauging is based on the use of:

- a **GO gauge**, and
- a **NO-GO gauge**.

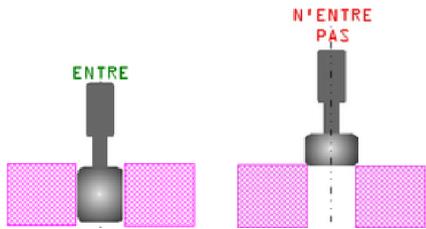
This type of inspection does not provide the numerical value of the measured dimension; rather, it indicates whether the dimension lies within the specified tolerance required for proper mechanical function.

Therefore, it is essentially a manufacturing or acceptance inspection, not a measurement. Limit gauges are not measuring instruments. Their main advantages are simplicity and speed, allowing rapid sorting of parts, but they do not allow diagnosis of the cause of non-conformity.

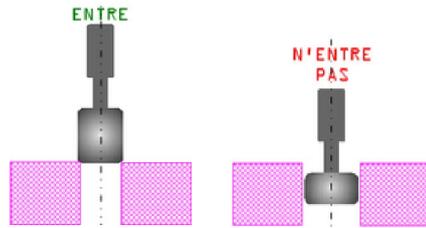
A dimension is considered within tolerance if:

- the **GO gauge** does not interfere with the dimension (i.e., it enters),
- the **NO-GO gauge** interferes with the dimension (i.e., it does not enter).

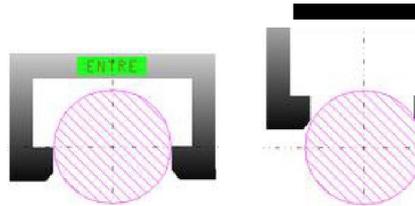
mesure intérieure (exemple :
 alésage) , pièce dans la tolérance



Mesure intérieure pièce dans tolérance



mesure extérieure (exemple :
 diamètre) , pièce dans la tolérance



Mesure extérieure : pièce dans tolérance

