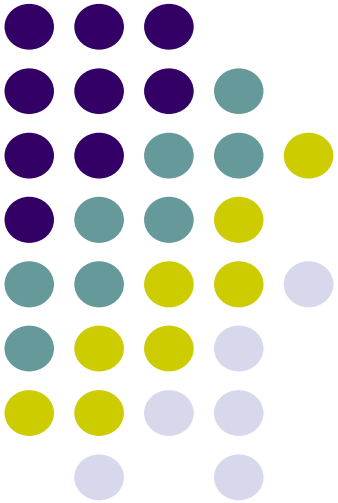
ME 472 – Engineering Metrology and Quality Control

Chp 9 - Measurement of Screw Threads



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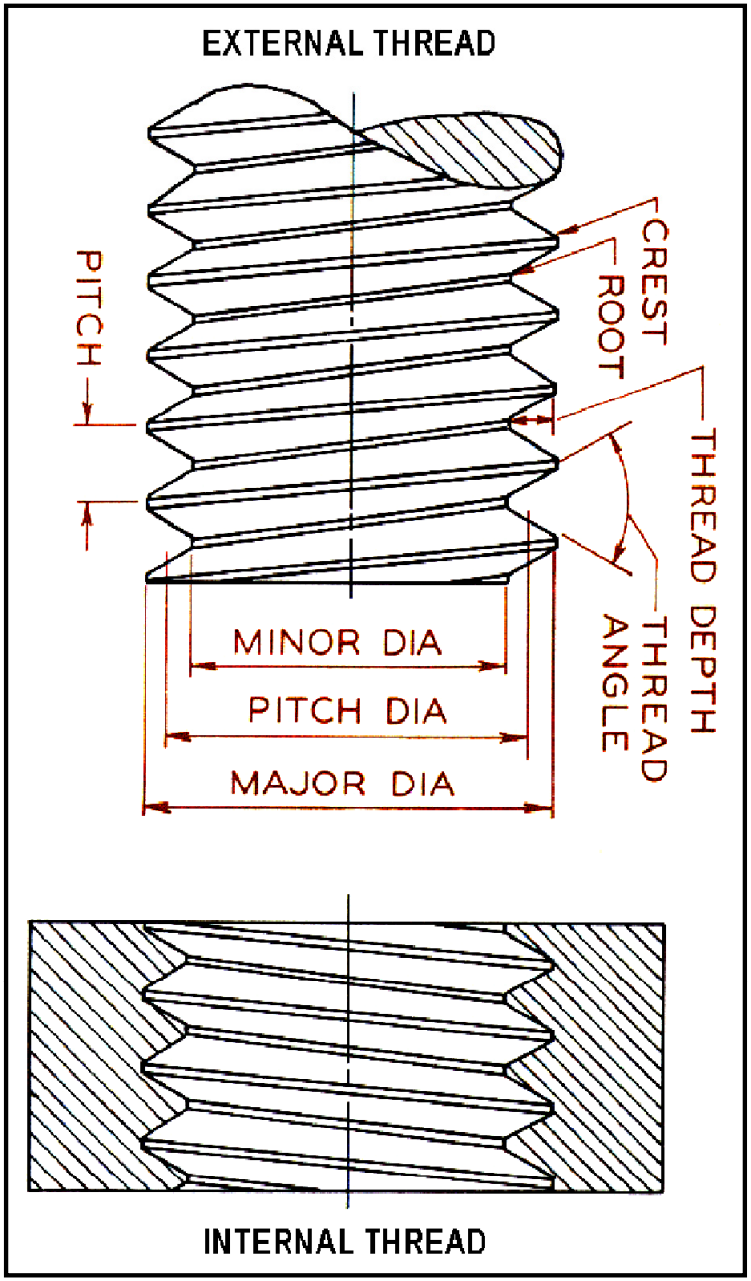
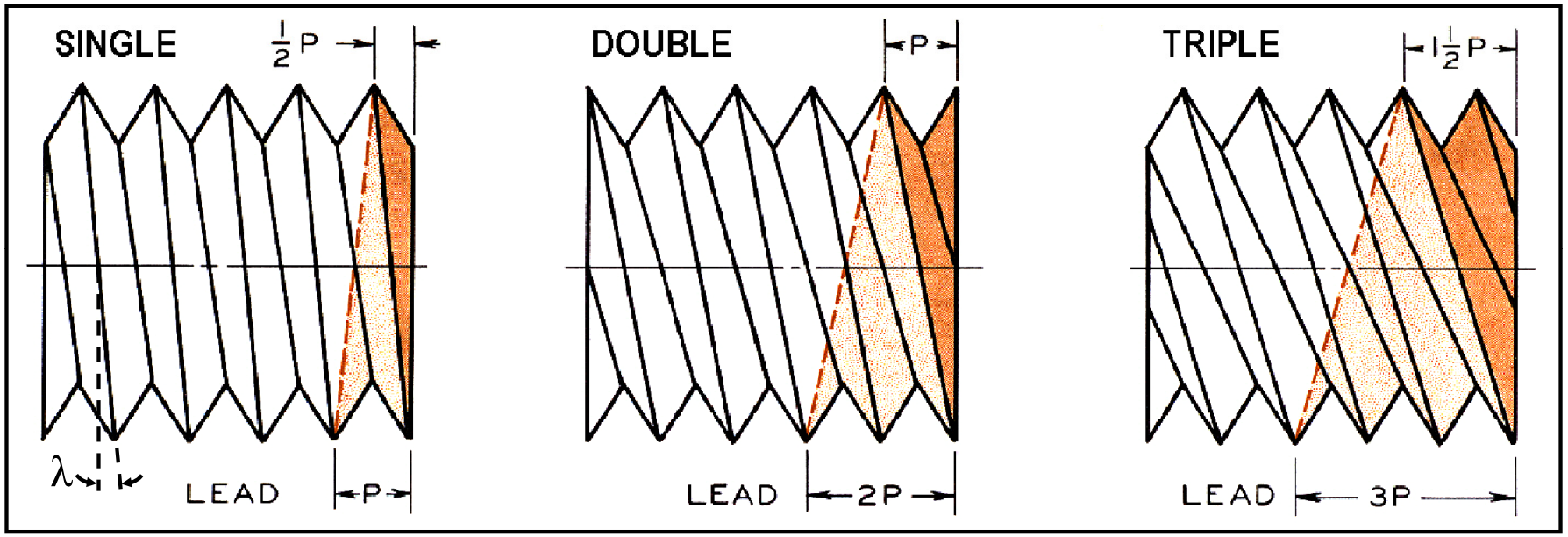
Thread Terminology

- **Thread:** the helical grooves opened to inner and outer surfaces.
- **External thread (screw):** A thread on the external surface of a cylinder.
- **Internal thread (nut):** A thread on the internal surface of a cylinder.
- **Major diameter (diş üstü çap):** The largest diameter of a screw thread.
- **Minor diameter (diş dibi çap):** The smallest diameter of a screw thread.
- **Pitch diameter (bölüm çapı):** The diameter of an imaginary cylinder having a surface of which cuts the thread forms where the width of the thread and groove are equal.
- **Crest (diş üstü):** The edge/surface that joins the sides of a thread, and it is farthest from the cylinder/cone from which the thread projects.
- **Root (diş dibi):** The edge/surface that joins the sides of adjacent thread forms and coincides with the cylinder or cone from which the thread projects.
- **Thread Depth (diş derinliği):** The distance between crest and root.
- **Pitch (adım, hatve):** The distance between corresponding points on adjacent thread forms measured parallel to the axis.
- **Right-hand (RH) thread:** A thread that when viewed axially winds in a CW and receding direction. Threads are RH unless otherwise specified.
- **Left-hand (LH) thread:** A thread that when viewed axially winds in a CCW and receding direction. These threads are designated as LH.



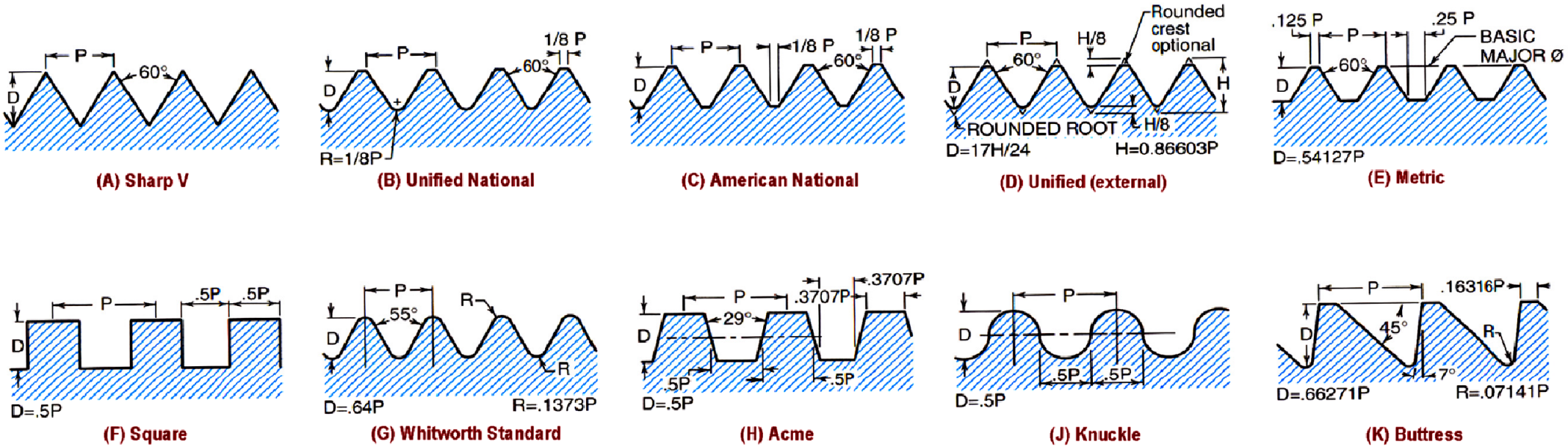
Single & Multiple Threads

- **Lead:** The distance that a threaded part moves axially in one complete revolution.
- **Lead (Helix) Angle:** The angle made by the pitch helix, defined as: $\lambda = \arctan\left(\frac{Lead}{\pi * Pitch\ \ Dia.}\right)$
- **Single thread:** A thread having the form produced on only one helix of cylinder. On a single thread, lead and pitch are equivalent. Threads are always single unless otherwise specified.
- **Multiple thread:** A thread combination having the same form produced on two or more helices where the lead is an integral multiple of the pitch (e.g. on a double thread, lead is twice the pitch). A multiple thread permits a more rapid advance without a coarser (larger) thread form.



Thread Types and Designation

- There are several thread forms used for specific applications. Selection of the appropriate thread form depends upon functionality, size, and purpose of the required job.
- The threads are designated in Metric or British system (as shown below).



British System

$$\underbrace{.250}_{a} - \underbrace{20}_{b}\ \underbrace{UNC}_{c} - \underbrace{2A}_{d} - \underbrace{LH}_{e}$$

- a: Major diameter (inch)
- b: Threads per inch
- c: Form (i.e. *Unified National Coarse*)
- d: External thread (*B for internal*)
- e: Left-hand thread (*RH for right-hand*)

Metric System

$$\underbrace{M}_{x}\ \underbrace{20}_{y}\ x\ \underbrace{2}_{z}$$

- x: Metric screw thread
- y: Major diameter (mm)
- z: Pitch (mm)

Thread Gauges

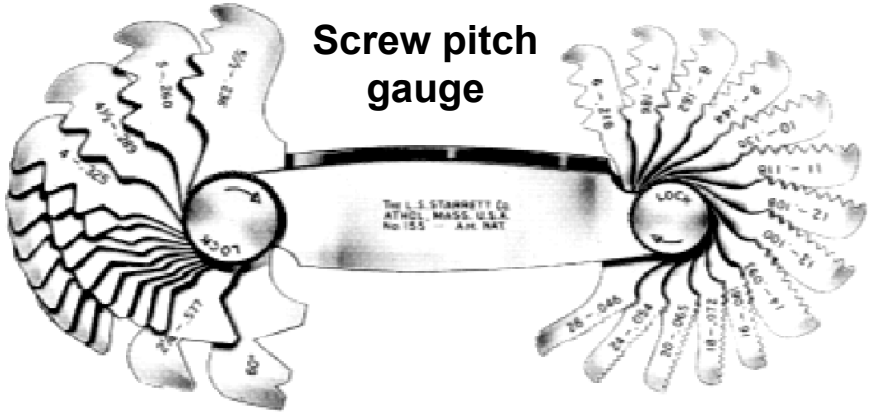
- External/internal threads can be **inspected (checked)** with **adjustable thread ring/plug gauges**. Such inspection provide **GO (green)** or **NOT-GO (red)** type of measurement. Note that the portion of GO gauge is usually longer than that of NOT-GO gauge.

Thread ring gauge (for external threads)

- **Screw pitch gauge** (consisting of a metal case having several leaves) can also be used. Each leaf has teeth corresponding to a definite pitch. By matching these teeth with threads on work to be measured, **the correct pitch can be read directly from the leaf**.

Thread plug gauge (for internal threads)

- **Thread rolls** (with various forms and known dimensions) are used for **checking internal threads**.



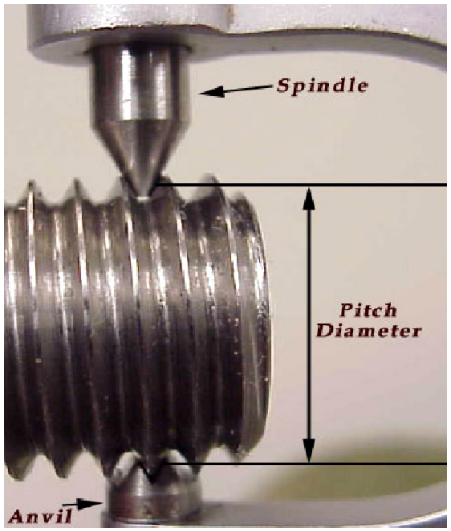
Screw pitch gauge

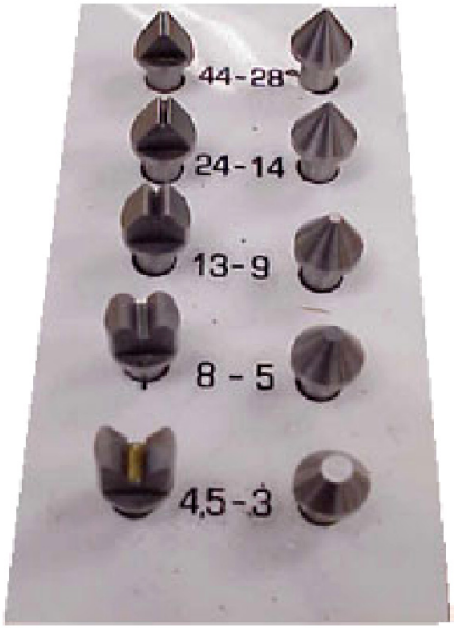
Thread rolls

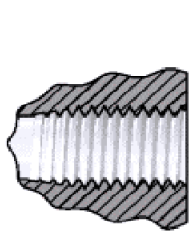
Thread Micrometers

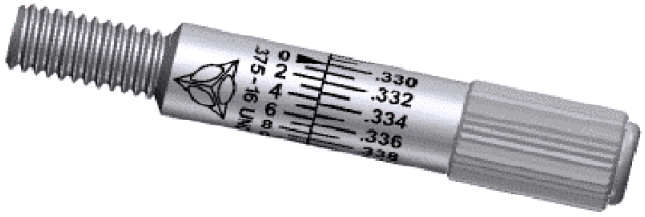
- **Screw thread micrometers** having various type and size of interchangeable spindle and anvils are used for measuring **the pitch diameter of external threads**.
- **The pitch diameter of internal threads** are measured by **inside thread micrometers** having various type and dimensions for different applications.

Screw thread micrometer with interchangeable spindle and anvil







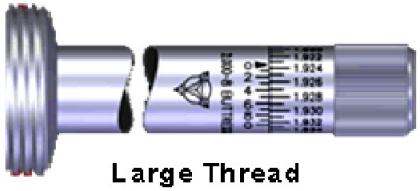


Inside thread micrometer with various type and size

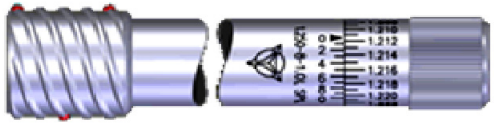
Small Thread

Deep Thread

Deep Counterbore



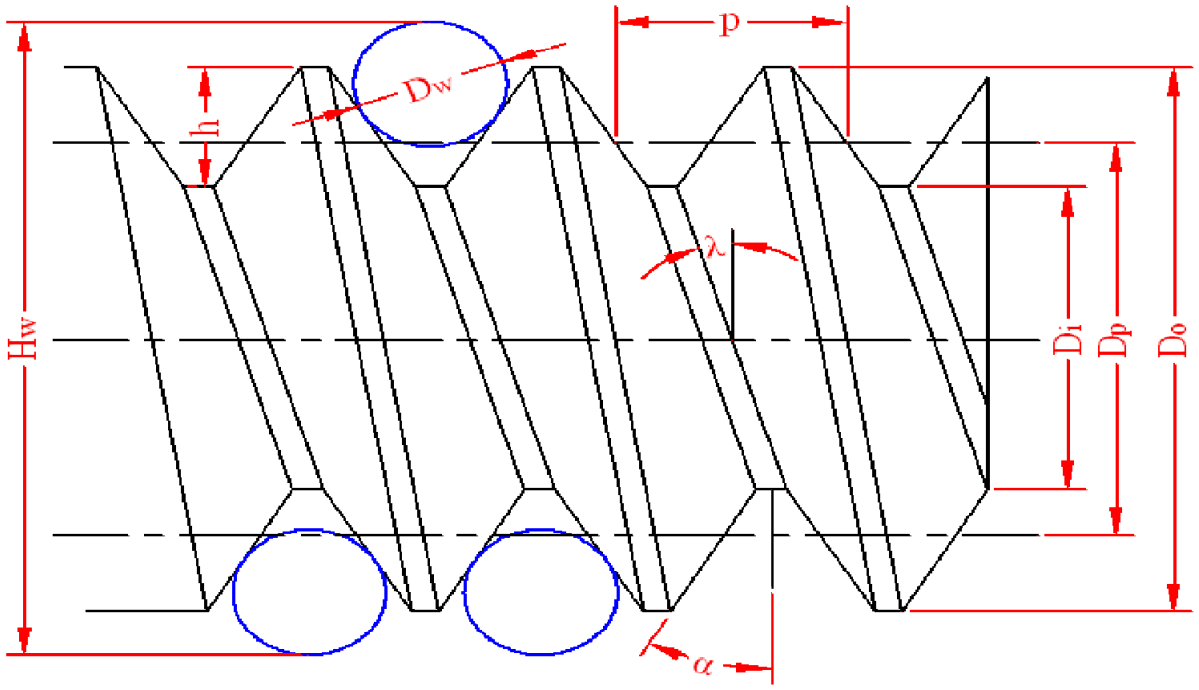
Large Thread



Multiple Start / Special Thread Form

Three-Wire Method

- **Three-wire method** is one of the most accurate and versatile ways of measuring **the pitch diameter** of a thread by using three lapped and polished wires and a micrometer.
- Wires touching the threads at the pitch diameter are **"Best Size Wires"**. Such wires are used since the measurements are least affected by errors that may be present in the angle of the thread.



D_i : Minor diameter **h :** Depth of thread **p :** Pitch

D_p : Pitch diameter **λ :** Lead (helix) angle **D_w :** Wire diameter

D_o : Major diameter **α :** Flank angle **H_w :** Measurement over wires

Three-Wire Method

➤ The table gives the pitch diameter for some thread types having lead angle from 0° to 5.

Thread Type	Thread Angle (2α)	Thread Depth (h)	Wire Size (D_w) [a]	Measurement over wires (H_w)	Pitch Diameter (D_p) [b, c]
Unified National	60°	0.649519 p	0.57735 p	D_o - 1.51555 p + 3 D_w	H_w – (3 D_w - 0.86603 p)
American National	60°	0.8 p	0.57735 p	$\frac{(D_o - 0.8660254\,p + 3.00049\,D_w)}{1.00049}$	1.00049 H_w – (3.00049 D_w - 0.86603 p)
Sharp V	60°	0.8660254 p	0.57735 p	D_o - 1.73205 p + 3 D_w	H_w – (3 D_w - 0.86603 p)
Metric	60°	0.649519 p	0.57735 p	D_o - 1.51553 p + 3 D_w	H_w – (3 D_w - 0.86603 p)
Whitworth	55°	0.64033 p	0.56369 p	D_o - 1.60082 p + 3.16568 D_w	H_w – (3.16568 D_w - 0.96049 p)
Acme	29°	0.5 p	0.51645 p	D_o - 2.43334 p + 4.9939 D_w	H_w – (4.9939 D_w - 1.933357 p)

[a] The general formula is: $D_w = 0.5 \text{ secant}(\alpha)\, p$

[b] The general formula is: $D_p = H_w - [\, D_w\,(1 + \text{cosec}(\alpha)) - 0.5\, p\, \cot(\alpha)]$

[c] For tapered threads, the taper angle (β) is used: $D_p = H_w - [\, D_w\,(1 + \text{cosec}(\alpha)) - 0.5\, p\, (\cot(\alpha) - \tan^2(\beta)\tan(\alpha))]$

Comparison of Measurement Methods

METHOD	ADVANTAGES	DISADVANTAGES
Thread Gauges & Thread Rolls	☺ Inspects the complete thread profile ☺ Simple to use with minimum training ☺ The inspected thread can be judged correct or incorrect by assuming use of both GO and NOT-GO	☹ Reveals only if the thread is correct or incorrect (i.e. it gives no information related to its tolerance) ☹ Time consuming when setting up and controlling the process, and difficult and/or expensive to calibrate ☹ Manufacturing tolerances and wear allowances on the gauge give reduced tolerances on the thread ☹ Only suitable for the specific thread denomination (tolerance) stated on the gauge
Thread Micrometers	☺ Accurate if the flank angle is correct ☺ Can be used on most thread types with the same flank angle ☺ Suitable for machine set-up and process control	☹ Requires special (and thus costly) micrometer ☹ Measures only pitch diameter
Three-Wire Method	☺ Very accurate results if the flank angle and pitch of threads are correct ☺ Can be used for almost all thread types ☺ Suitable for machine set-up and process control	☹ Only external threads can be inspected ☹ Requires calculation to find the correct measurement result ☹ Measuring wires must fit the appropriate micrometer