[ME 472]

Engineering Metrology & Quality Control

[CHAPTER 7]

Measurement of Screw Threads

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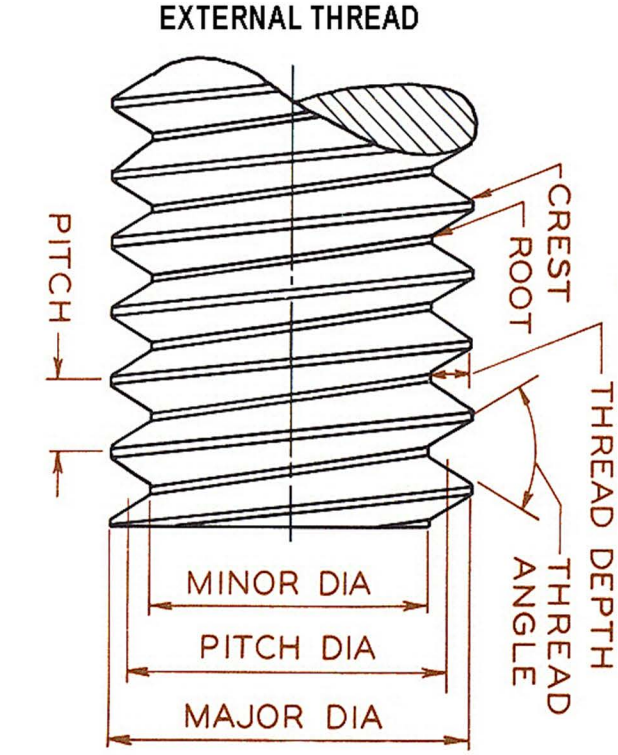
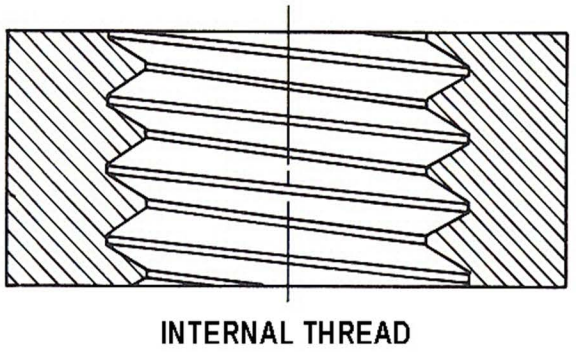
Thread Terminology

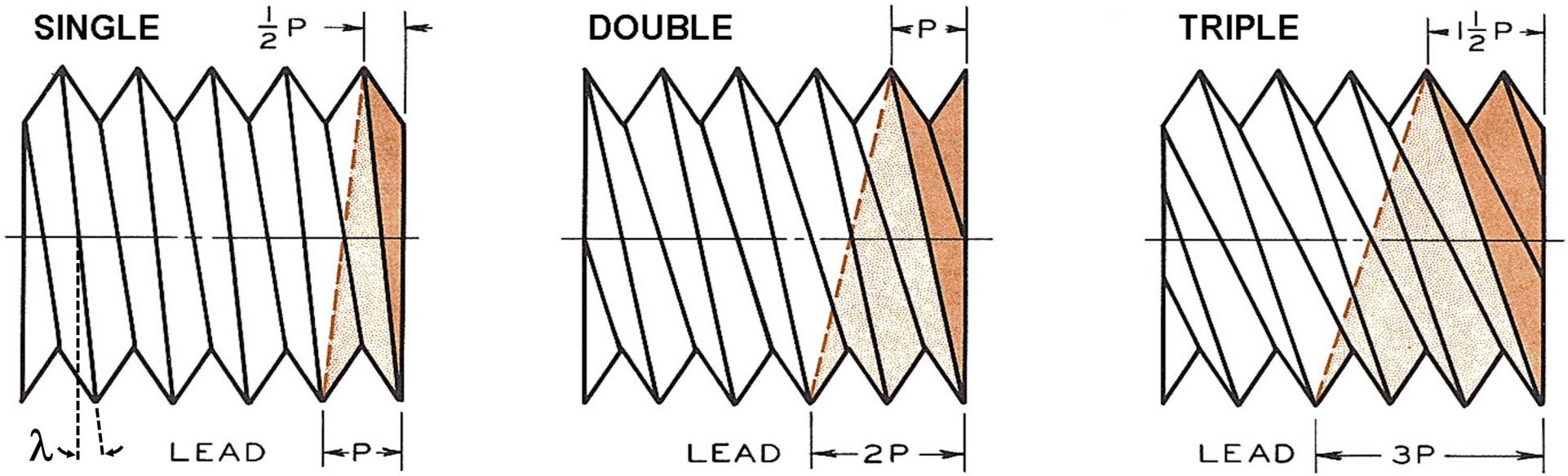
- **Thread:** the helical grooves opened to inner and outer surfaces
- **External Thread (screw, bolt, stud):** threads on the external surface of a cylinder
- **Internal Thread (nut):** threads on the internal surface of a cylinder
- **Crest (diş üstü):** the edge/surface that joins the sides of a thread (the farthest from the cylinder/cone from which the thread projects)
- **Root (diş dibi):** the edge/surface that joins the sides of adjacent threads (coincides with the cylinder/cone from which the thread projects)
- **Thread Depth (diş derinliği):** the distance between crest and root
- **Thread Angle (diş açısı):** the included angle between the thread flanks
- **Pitch (adım/hatve):** the distance between corresponding points on adjacent threads
- **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/böğür çapı):** the diameter of an imaginary cylinder having surface of which cuts the thread forms where width of thread and groove are equal.
- **Right-Hand (RH) Thread:** threads axially winds in clockwise (CW) direction (threads are always RH unless otherwise specified)
- **Left-Hand (LH) Thread:** threads axially winds in counter-clockwise (CCW) direction (such threads are specially designated as LH)





Thread Terminology

- **Lead:** the distance that a threaded part moves axially in one complete revolution
- **Lead/Helix Angle:** The angle made by the pitch helix, which is defined as: $\lambda = \arctan\left(\frac{\text{lead}}{\pi * \text{pitch dia.}}\right)$
- **Single Thread:** threads produced on single (one) helix of cylinder, **lead and pitch are equivalent** (threads are always single unless otherwise specified)
- **Multiple Thread:** threads produced on two or more helices, **lead is multiple of pitch** (e.g. **double thread: lead = 2 * pitch**) (multiple threads permit more rapid advance without a coarser (i.e. larger) thread form)



Thread Types & Designations

- Threads are designated in **Metric or British system**.
- Selection of **the appropriate thread form** depends upon **functionality, size, and purpose of the job**.

British System

.250 - 20 UNC - 2A - LH

a b c d e

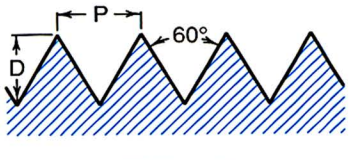
a: Major diameter *(inch)*
b: Threads per inch
c: Form *(i.e. Unified National Coarse)*
d: External thread *(B for internal)*
e: Left-hand thread *(RH for right-hand)*

Metric System

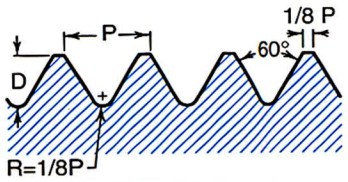
M 20 x 2

x y z

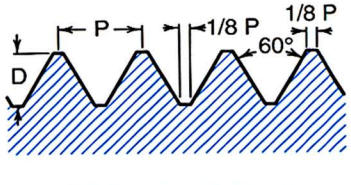
x: Metric screw thread
y: Major diameter *(mm)*
z: Pitch *(mm)*



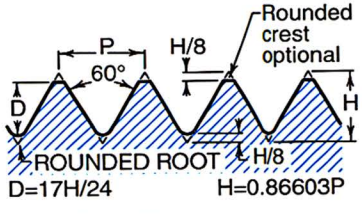
(A) Sharp V



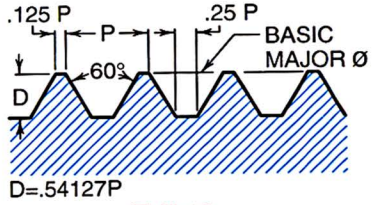
(B) Unified National



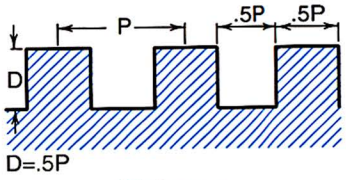
(C) American National



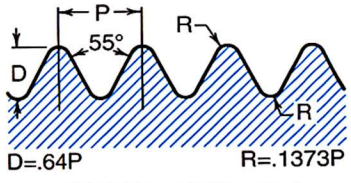
(D) Unified (external)



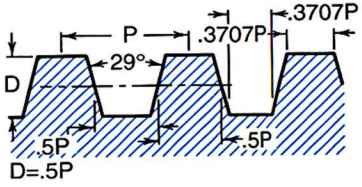
(E) Metric



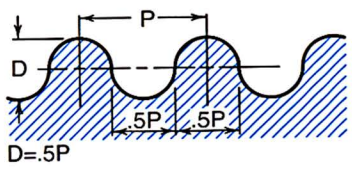
(F) Square



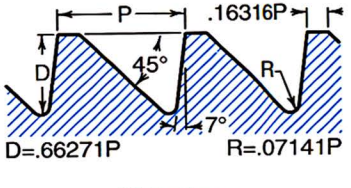
(G) Whitworth Standard



(H) Acme



(J) Knuckle



(K) Buttress

Thread Gauges

- **Both external & internal threads** can be **inspected (checked)** by means of **thread ring & plug gauges** of **GO (green)** & **NO-GO (red)**.

Thread Ring Gauge (for external threads)

Thread Plug Gauge (for internal threads)

Screw Pitch Gauge

- Consist of **a metal case having several leaves**.
- Each leaf has teeth corresponding to definite pitch.
- **The pitch is read directly** from the leaf by matching the teeth on leaves with the threads on workpiece.

Thread Rolls

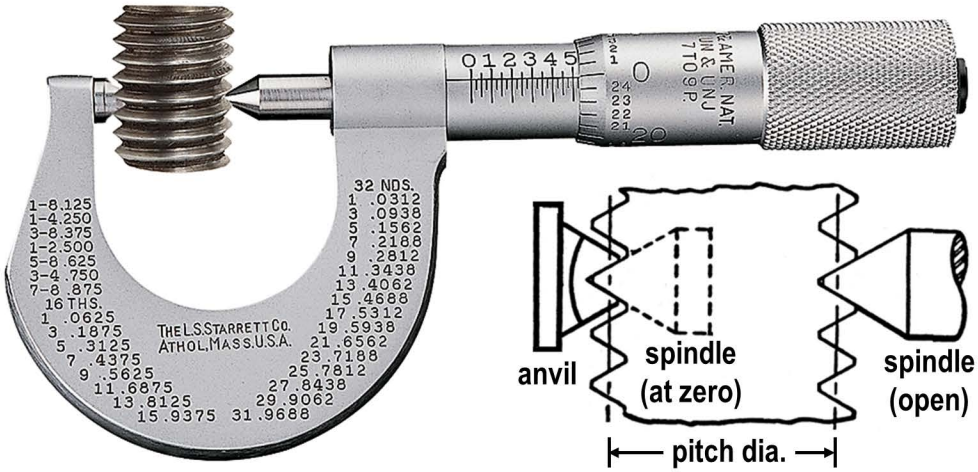
- Used for **checking the internal threads only**.
- They have various forms and dimensions.

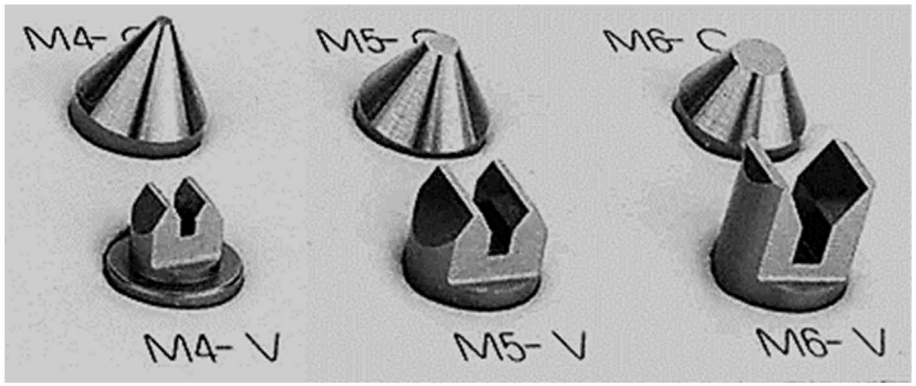
Screw Pitch Gauge

Thread Rolls

Outside Thread Micrometer

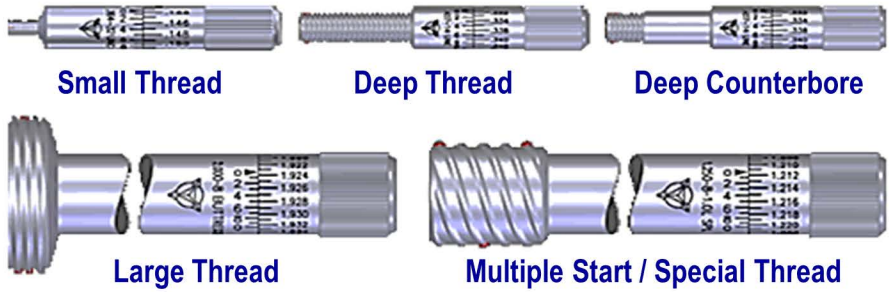
- Measuring **the pitch diameter of external threads**.
- Various sizes of interchangeable spindle & anvil.

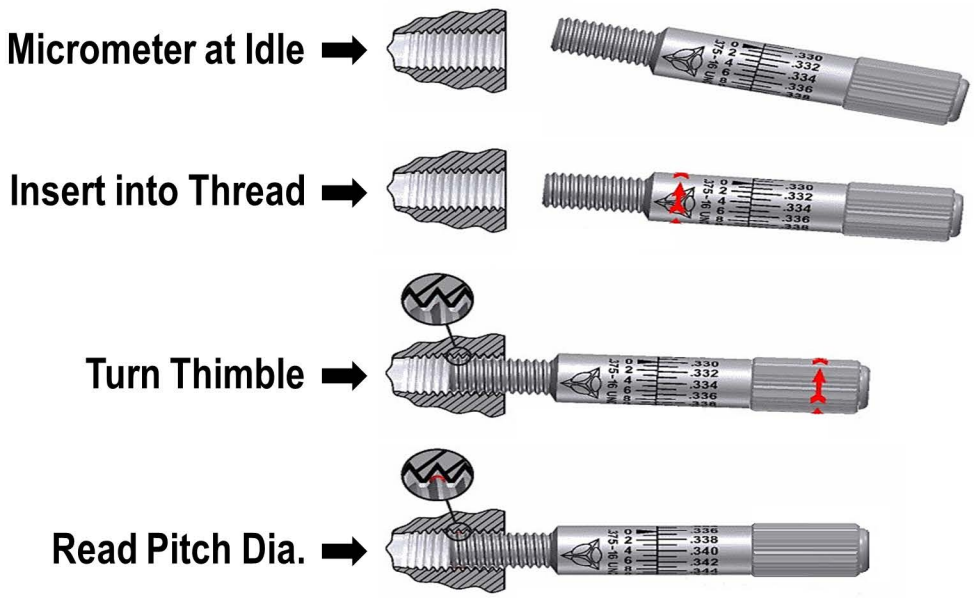




Inside Thread Micrometer

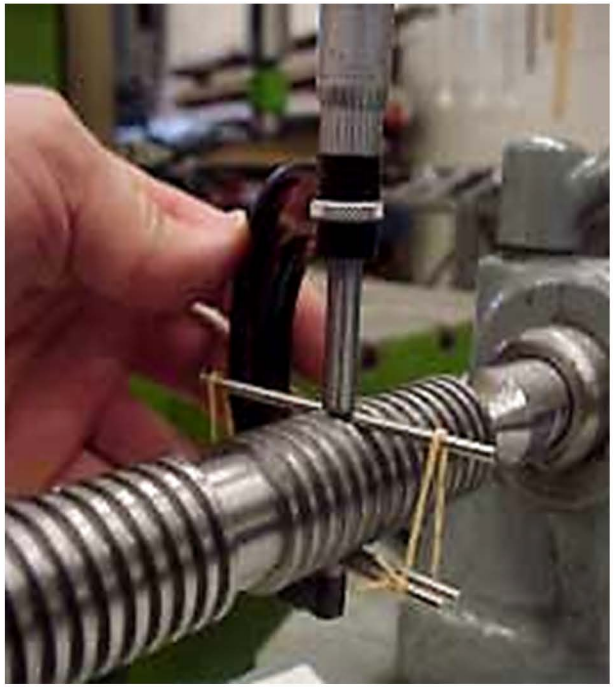
- Measuring **the pitch diameter of internal threads**.
- Various types & dimensions for specific applications.



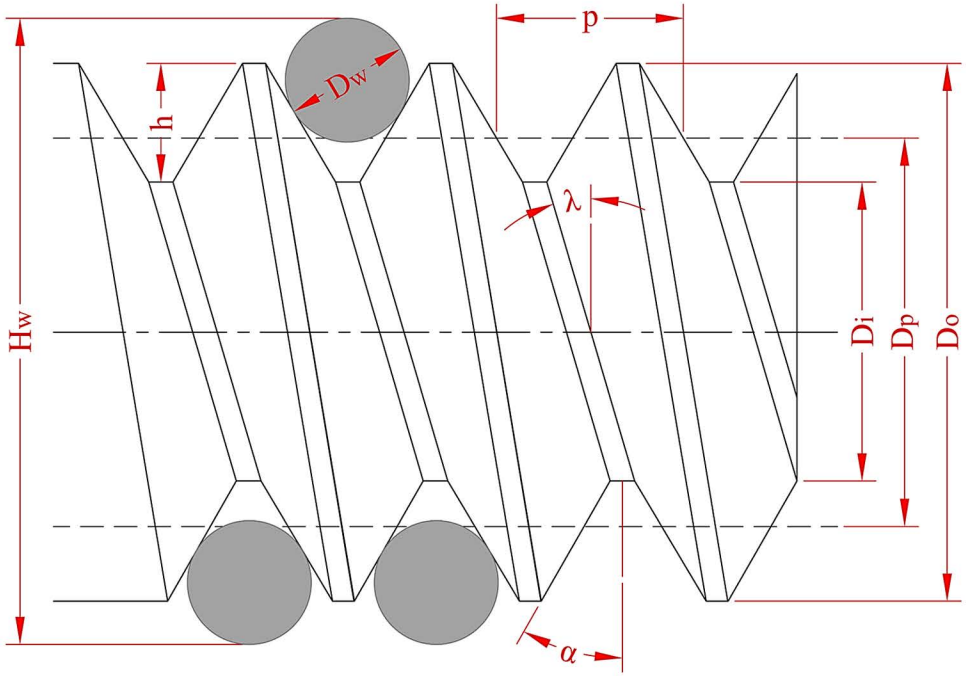


Measurement using Three-Wire Method

- Very accurate way of measuring the threads by **three lapped and polished wires** and **a micrometer**.
- **"Best Size Wires"** are in touch with the threads along pitch diameter. Use of best-size wires provides that measurement is least affected by possible errors to be present in the thread angle.



H_w : Height over Wires
D_w : Wire Diameter
D_i : Minor Diameter
D_0 : Major Diameter
D_p : Pitch Diameter
h : Thread Depth
p : Thread Pitch
α : Flank Angle
λ : Lead (Helix) Angle



Calculating Pitch Diameter by Three-Wire Method

➢ Pitch diameter for various thread types (having **lead angle of 0-5°**) can be determined as follows.

Thread Type	Thread Angle (2α)	Thread Depth (h)	Wire Size [a] (D_w)	Height over Wires (H_w)	Pitch Diameter [b,c] (D_p)
Sharp V	60°	$0.8660254\,p$	$0.57735\,p$	$D_0 - 1.73205\,p + 3\,D_w$	$H_w - (3\,D_w - 0.86603\,p)$
Metric	60°	$0.649519\,p$	$0.57735\,p$	$D_0 - 1.51555\,p + 3\,D_w$	$H_w - (3\,D_w - 0.86603\,p)$
Unified National	60°	$0.649519\,p$	$0.57735\,p$	$D_0 - 1.51555\,p + 3\,D_w$	$H_w - (3\,D_w - 0.86603\,p)$
American National	60°	$0.8\,p$	$0.57735\,p$	$\dfrac{D_0 - 0.8660254\,p + 3.00049\,D_w}{1.00049}$	$H_w - \left(\dfrac{3.00049\,D_w - 0.86603\,p}{1.00049}\right)$
Whitworth	55°	$0.64033\,p$	$0.56369\,p$	$D_0 - 1.60082\,p + 3.16568\,D_w$	$H_w - (3.16568\,D_w - 0.96049\,p)$
Acme	29°	$0.5\,p$	$0.51645\,p$	$D_0 - 2.43334\,p + 4.9939\,D_w$	$H_w - (4.9939\,D_w - 1.933357\,p)$

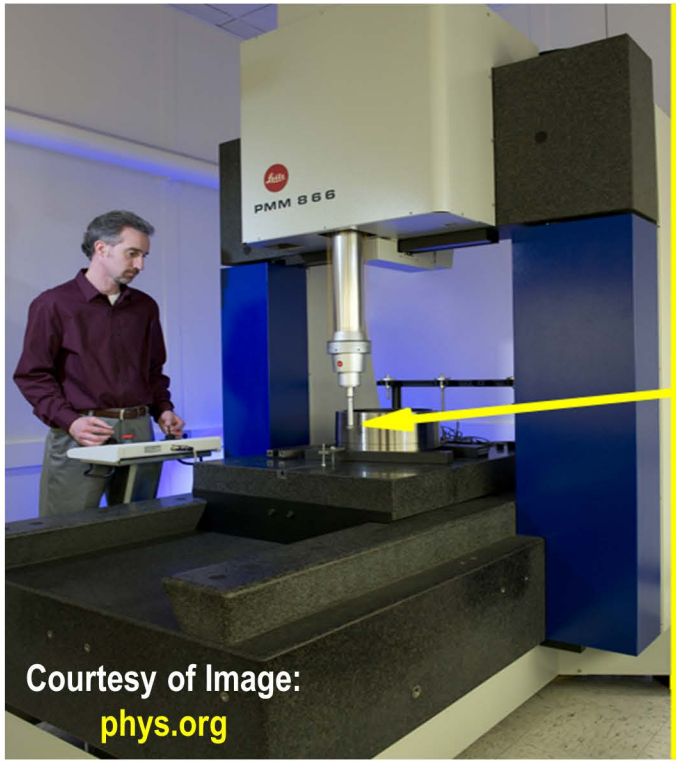
[a] The general equation for wire size: $D_w = 0.5\,\sec(\alpha)\,p$

[b] The general equation for pitch diameter: $D_p = H_w - \left[D_w\left(1 + \mathrm{cosec}(\alpha)\right) - 0.5\,p\,\cot(\alpha)\right]$

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

Thread Measurement by CMM

- Measurement of pitch diameter of **relatively large size of threads** (i.e. difficult to measure by conventional methods).
- **Both internal & external threads** can be measured.
- Need to use **appropriate probe size** for the given thread form.
- **Probe dia. (D)** within allowable limits as in **1/8 of thread depth (h)**.



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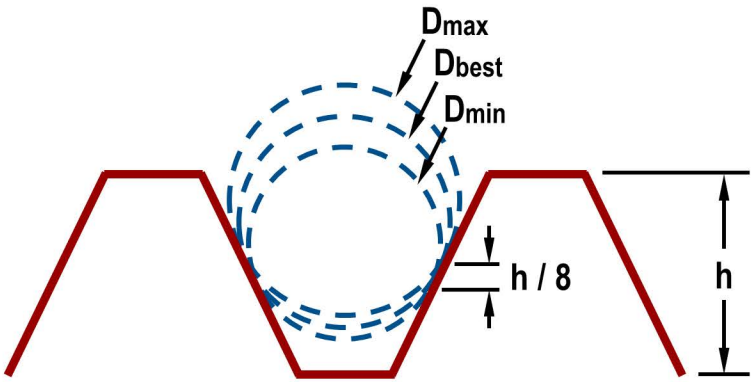

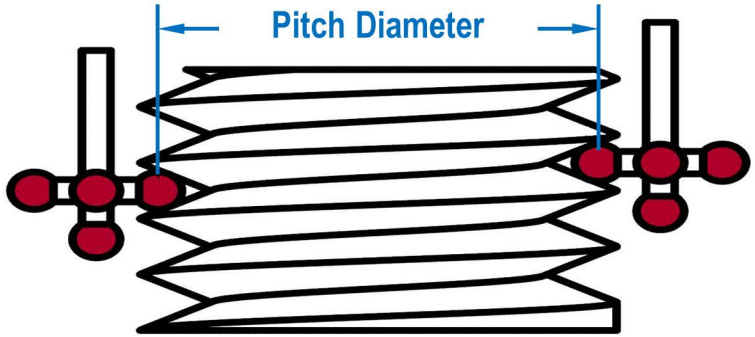

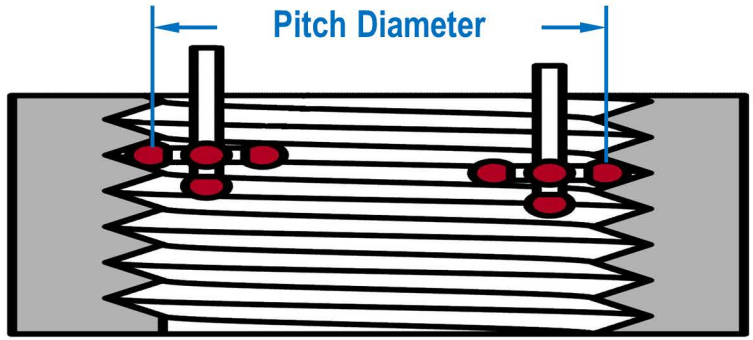

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doi.org/10.1051/metrology/201909001

METHOD	ADVANTAGES	DISADVANTAGES
Thread Gauges & Thread Rolls	☺ Inspects **the complete thread profile** ☺ **Simple to use** with minimum training ☺ Threads are **quickly judged correct/incorrect** simply by use of GO & NO-GO gauge forms	☹ Reveals only if the thread is correct/incorrect (i.e. **no information related to its tolerance**) ☹ **Time consuming** for set-up & process control ☹ Manufacturing tolerances and wear allowances on the gauge give **reduced tolerances on the thread**
Thread Micrometers	☺ **Very accurate** if the flank angle is correct ☺ Used on **threads of the same flank angle** ☺ Suitable for **machine set-up & process control**	☹ Requires **special and costly micrometers** ☹ Measures **only the pitch diameter**
Three-Wire Method	☺ **Very accurate** if flank angle & pitch are correct ☺ Used for **almost all thread types & forms** ☺ Suitable for **machine set-up & process control**	☹ **Only external threads** can be inspected ☹ **Requires calculation** to find measurement result ☹ Wires must fit **the appropriate micrometer**
Measuring with CMM	☺ **Very accurate** if flank angle & pitch are correct ☺ Measurement of **dimensions & form of thread** ☺ Used for **almost all thread types & forms**	☹ **Time consuming** for set-up & process control ☹ **Appropriate probe sizes** must be employed (i.e. small size of threads cannot be measured)