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Measuring accuracy in the field

Measuring with the Tooke® Gage

Measurement with a Tooke Gage is a function of the cutting tip face angle and NOT of the microscope scale.

This information applies to measurements made using the current (metric-unit) "universal" scope; to the old-style English or metric scopes (with the green anodized barrel); and will apply to the new enhanced Dual-Measure English / metric scopes when they become available. (Watch the Micro-Metrics blog for updates!)

The TookeGage precision-ground tungsten-carbide cutting tip cuts an angled incision into the coating down to the substrate. The V-groove incised by the cutting tip is observed vertically through the Tooke Gage illuminated microscope. The *coating thickness* is calculated based on the *distance (visually) measured through the scope* across the cut. (Essentially, you incise the hypotenuse of a right-angle triangle (see diagrams, page 3); because you know the angle of the tip face and the length of the "bottom" side of the triangle created, you can calculate the opposite side = the coating thickness).

Maximum coating thickness for the cutting tips

Cutting tip designation	*Maximum coating thickness in:*		*Precision of thickness determinations in:*	
	English	*Metric*	*English*	*Metric*
	mils	*microns (µm)*	*mils*	*microns (µm)*
1×	100	2 500	±0.25	± 5
2×	20	500	±0.13	± 2.5
5×	6	150	±0.05	± 1
10×	3	75	±0.025	± 0.5

(Reminder: The current universal scope is **marked in metric units, conversion is necessary for English units**.)

The "cut width" (A′) in the groove wall is related to the film thickness by the equation:

$$A = A' \tan\theta$$

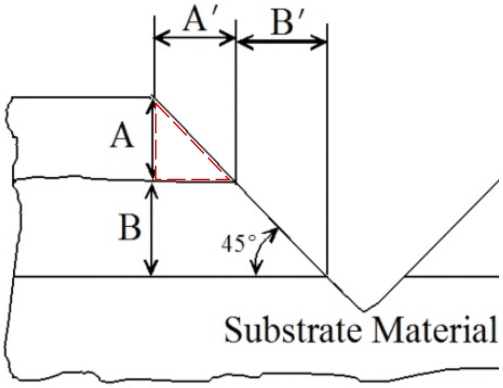
Example: The 1× tip cuts a 45° incision (which make an equilateral triangle), where A (the *coating thickness*) = A′ (the *distance visually measured* across the cut width). Therefore, the ratio for the 1× tip is 1 : 1, as shown at right:

Thus (using the 1x tip): A : A′ = 1 : 1

At a 45° groove angle: $\tan\theta = 1$

And so (using the 1× tip): $A = A'$

Visualization of an incision using a 1× (45° face) cutting tip



Universal scope, multiplier per smallest hashmark space by cutting tip face

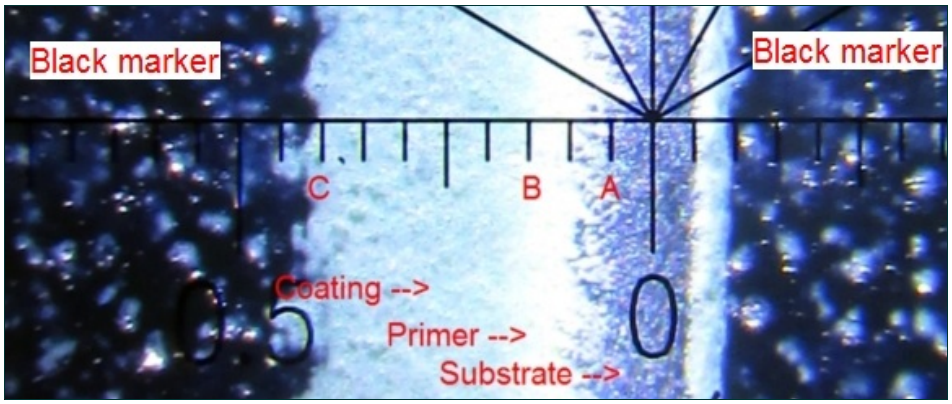
	1×		2×		5×		10×		
Mils*	2	(1.97)	1	(0.984)	0.4	(0.394)	0.2	(0.197)	Mils
Microns**	50	(50.0)	25	(25.0)	10	(10.0)	5	(5.0)	Microns
Millimeters	0.05	(0.050)	0.025	(0.025)	0.010	(0.010)	0.005	(0.005)	Millimeters

*1 mil = 1 "thou" = 0.001" = one thousandth of an inch **micron = micrometer = µm

(Measurement is a function of the cutting tip and NOT of the microscope.)

A measuring demonstration

The "zero-line" of the reticle is shown **not** lined up with the edge of a coating (nor does it need to be, as any hashmark line will do). The zero-line is approximately centered in the substrate (silver-gray color). A cutting tip was used to draw the incision through the black marked line.



- Line A is on the edge between the substrate and the primer-coat (the white line to the left of the zero-line): begin your measurement there.
- Line B marks the top of the primer coating/beginning of the (light blue) top coat.
- Line C is the end of the incision at the top coat, made easier to see by using the black marker provided with the Tooke Gage.

So, in the photo above, and using each type of microscope, the thickness measured for each tip will be (see page 3 to understand the multiplication factor used to determine these measurements):

Through the universal (metric-units) scope: the thickness calculated for each tip is:

Coating	0.05mm (50 µm) /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	100 µm	50 µm	20µm	10 µm
Blue topcoat	5 hashmark spaces	250 µm	125 µm	50 µm	25 µm

Through the new Dual-Measure or old-style (English-units) scope: the thickness calculated for each tip equals:

Coating	1mil /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	2 mils	1 mil	0.4 mils	0.2 mil
Blue topcoat	5 hashmark spaces	5 mils	2.5 mils	1.0 mil	0.5 mil

Through the new Dual-Measure or old-style (metric-units) scope: the thickness calculated for each tip equals:

Coating	0.02mm (20 µm) /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	40 µm	20 µm	4 µm	2 µm
Blue topcoat	5 hashmark spaces	100 µm	50 µm	20 µm	10 µm

Example

The 1× tip with a cutting face of 45° has a ratio of 1 : 1 (*measured cut* A' : *calculated coating thickness A*) so, A = A' ("what you see is what you measure").

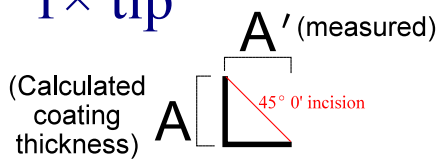
The 10× tip with its cutting face of 5° 42' has a ratio of 1 : 0.1 *(measured cut* A' *: calculated coating thickness A*) so, A = 1/10th of A'

Reminder: measurement is a **function of the cutting tip** and not of the microscope reticle.

Cutting tip ratio – A : A′

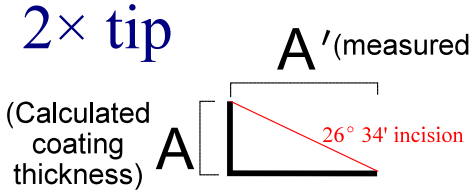
Tip	*Face angle*	*Ratio*
1×	45° 0'	A : A' = 1 : 1
2×	26° 34'	A : A' = 1 : 0.5
5×	11° 18'	A : A' = 1 : 0.2
10×	5° 42'	A : A' = 1: 0.1

1× tip



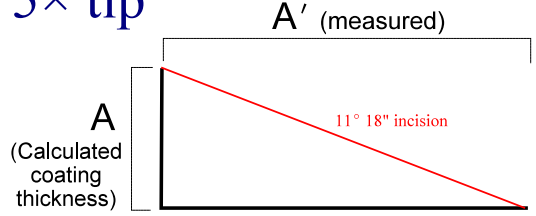
A = A'

2× tip



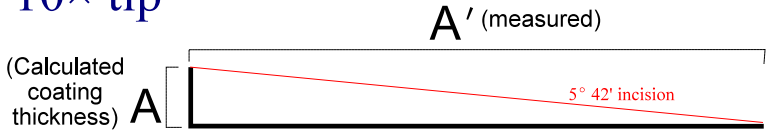
A = (0.5)A'

5× tip

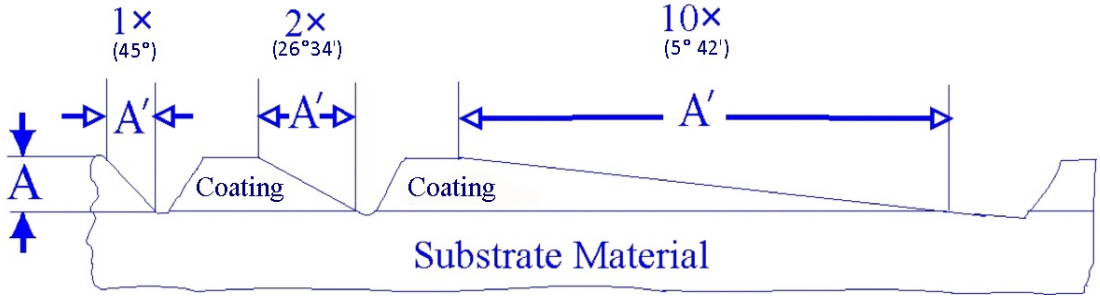


A = (0.2)A'

10× tip



A = (0.1) A'



Validation and calibration

Note: Every microscope is validated before sale against a certified gage block traceable to the U.S. National Institute of Standards & Technology (NIST). An OEM calibration certificate can be ordered with a new gauge, or your gauge can be sent in for calibration. Please call or email Micro-Metrics for pricing.

New Dual-Measure scope

Please note that Micro-Metrics will have the new (custom-made) enhanced Dual-Measure microscopes with a finer reticle than the universal one beginning in mid-2018. The top line is English units (each hash is 1 mil); the bottom line is metric (each hash is 20 microns (20µm).) See the Micro-Metrics blog for updates: http://micro-metrics.com/blog.

Considerations when measuring

Several cautions are called for in this type of estimation.

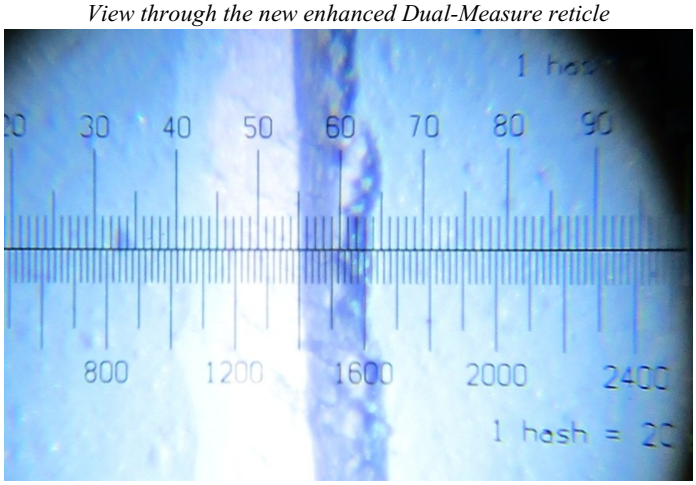
- Different operators may chose a different visual "approximation of half-way between" two hashmarks. Operators should measure several different spots in a coating and average the measurements to ensure the measurement was not taken in a thicker-than-normal or thinner-than-normal spot in the coating.
- Because the reticle scale markings themselves represent a perceptible width, when very thin films are measured, the operator should adopt a convention of measuring from and to the matching left or right edge of the actual lines on the reticle.

Explaining the process

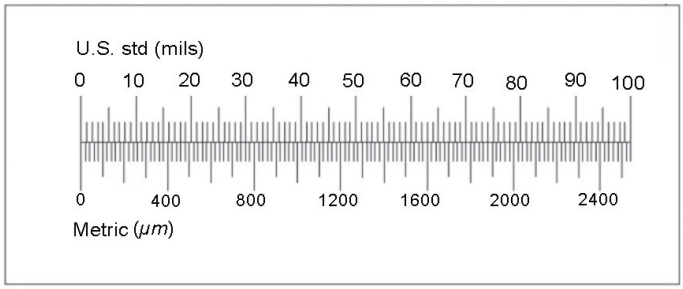
Using the English-unit scale in the new Dual-Measure scope (above right) or the old-style English-unit scope (reticle shown bottom right) and the 1× tip (which cuts the 45° incision and, thus, A = A′), the smallest scale division seen in the reticle represents 1 mil (calculated: 20 microns), and measurements can be visually estimated to the nearest 0.5 mil (calculated: 10 microns) by noting the location of the incision edge in-between two hashmarks.

The current "universal" scope (third down, at right) is "less-fine," so using the 1× tip (which cuts the 45° incision and, thus, A = A′), the smallest scale division seen in the reticle represents 50 microns (calculated: 2 mils). In the new Dual-Measure scope the lower/metric unit scale, smallest scale division represents 20 microns.

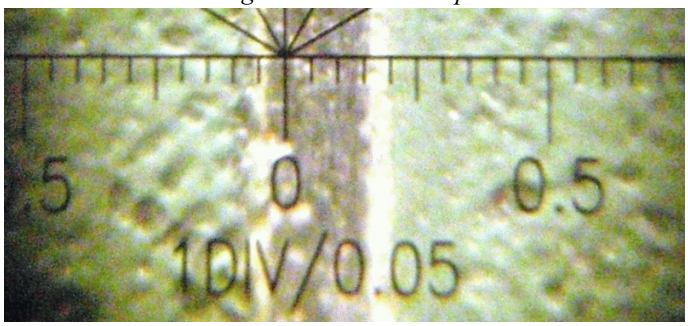
View through the new enhanced Dual-Measure reticle



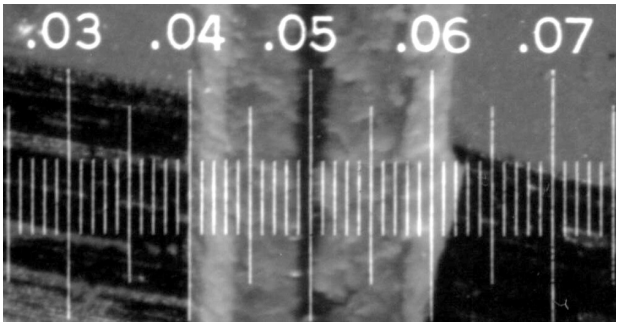
Drawing of the new enhanced Dual-Measure reticle



View through the universal scope reticle.



View through old-style English reticle



View through old-style English reticle