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Measuring with the Tooke Gage

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

This information applies to measurements viewed through the enhanced English (OG202 / OG204) and enhanced metric (OG202M / OG204M) scopes, and any of the older (the metric universal or the old-style English or metric) scopes. (The new enhanced scopes should be available in mid-2015: Watch the Micro-Metrics blog for updates!)

Maximum coating thickness

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

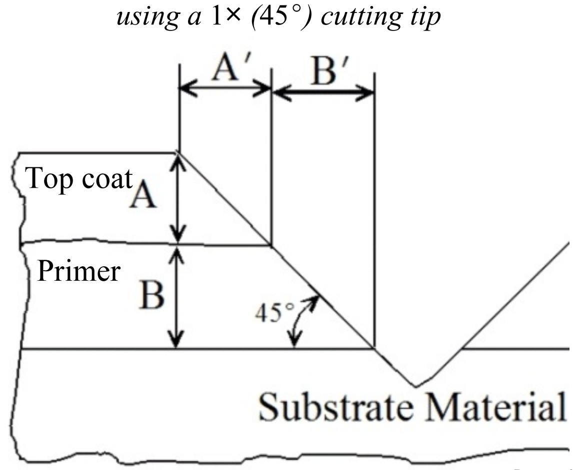
(Reminder: The current universal scope is **marked in metric units**, so **conversion is necessary for English units**.)

The Tooke Gage precision-ground tungsten-carbide cutting tip incises an angled face 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're measuring the hypotenuse of an equilateral triangle).

The observed horizontal projection of the film in the groove wall is related to the film thickness by the equation:

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

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



Example: The 1× tip cuts a 45° incision (which make an equilateral triangle), where A (the *coating thickness*) = A′ (the *distance measured* through the scope across the cut); therefore, the ratio for the 1× tip is 1 : 1, as shown:

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

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

And, so (using the 1× tip): $A = A'$

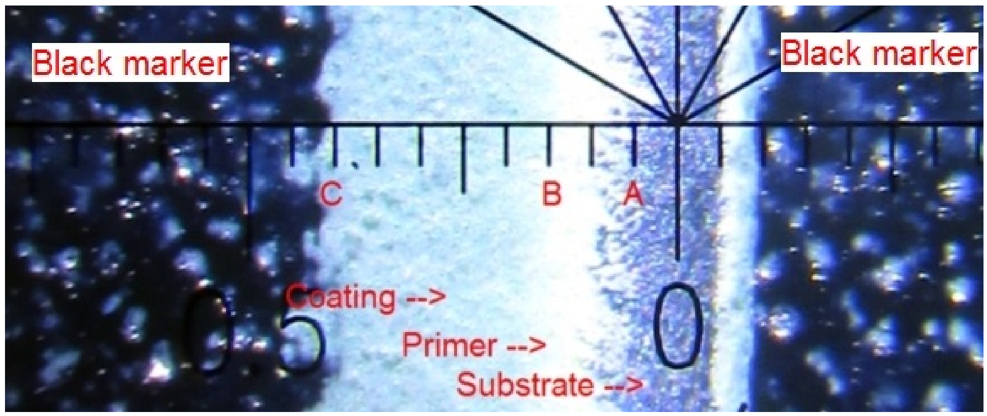
The current “universal” microscope reticle accommodates measuring in mils, microns, and millimeters.

(Universal scope, per smallest hashmark)

	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

A measuring demonstration



The “zero-line” of the reticle shown is **not** lined up with the edge of a coating (nor does it need to be; as any hashmark will do). The zero-line is approximately centered in the substrate (the silver-gray line). 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:

Through the universal (metric-marked) 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 enhanced or the old-style (English-marked) 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 enhanced or the old-style (metric-marked) 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

The 1× tip with its 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").

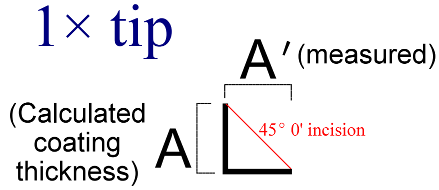
The 10× tip with its cutting face of 5° 42' has a ratio of 1 : 0.1 (*measured cut* A' : *calculated coating thickness* A) so, A = 1/10th of A'.

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

Cutting tip ratios: A : A′

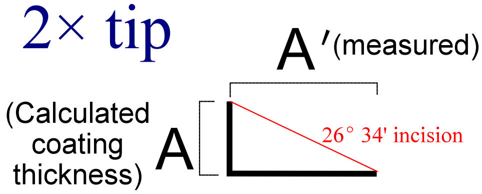
Tip	*Face angle*	*Ratio*
1×	45° 0'	A : A' = 1 : 1
2×	26° 34'	A : A' = 1 : 0.5
5×	11° 18'	A : A' = 1 : 0.2
10×	5° 42'	A : A' = 1: 0.1

1× tip



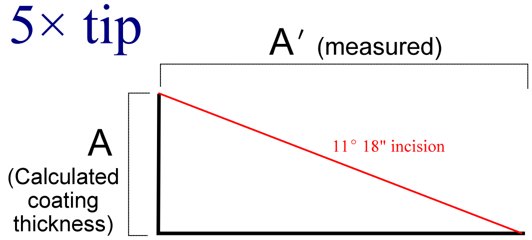
A = A'

2× tip



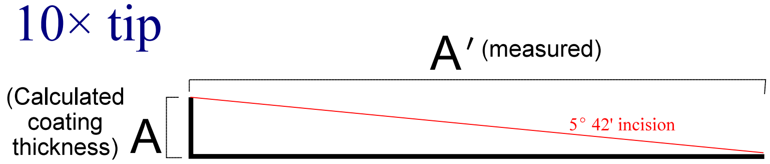
A = (0.5)A'

5× tip

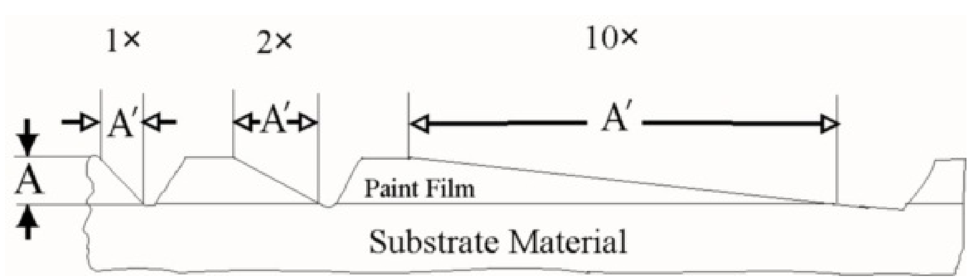


A = (0.2)A'

10× tip



A = (0.1) A'

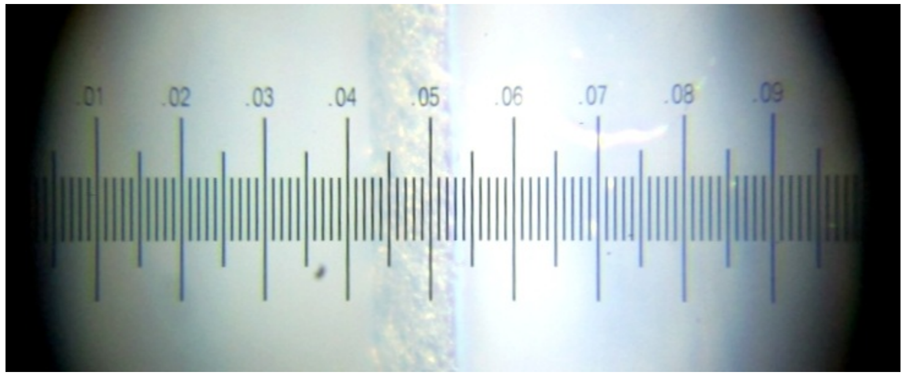


Precision discussion:

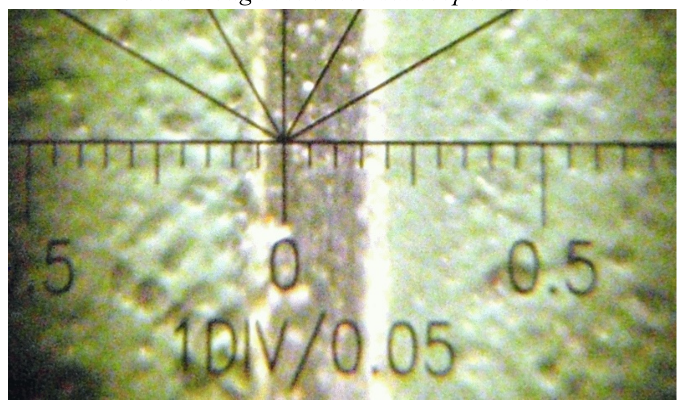
(Note: Every microscope is validated before sale against a certified gage block traceable to the National Institute of Standards & Technology (NIST).)

Please note that Micro-Metrics will have the new (custom-made) enhanced microscopes with a finer reticle than theuniversal one beginning in mid-2015. See blog for updates: http://micro-metrics.com/blog.

View through the new enhanced English reticle



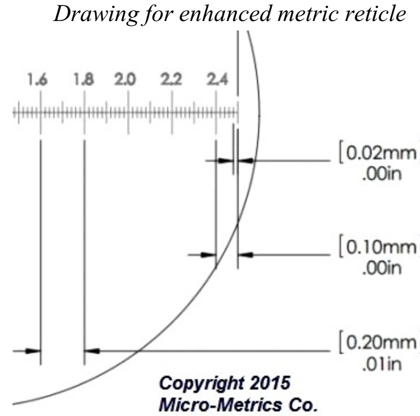
View through the universal scope reticle.



Explaining the process

Using the new enhanced English-unit 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.

Drawing for enhanced metric reticle

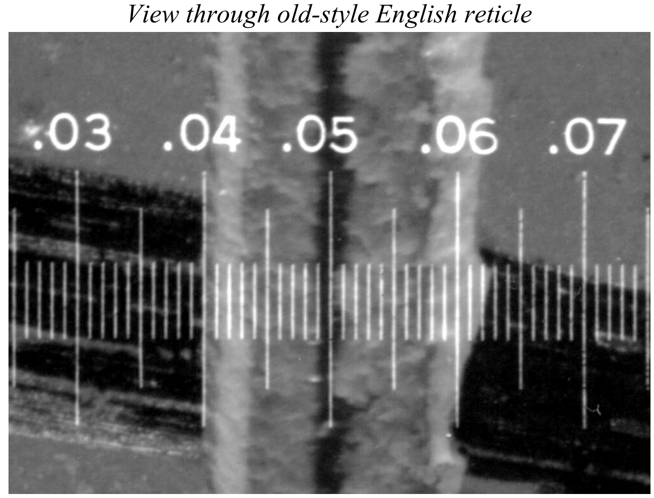


Considerations when measuring

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.

View through old-style English reticle



View through the old-style metric reticle.