The Truth About Ballistic Coefficients

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Abstract:
The ballistic coefficient of a bullet describes how it slows in flight due to air resistance. This article presents experimental determinations of ballistic coefficients showing that the majority of bullets tested have their previously published ballistic coefficients exaggerated from 5-25% by the bullet manufacturers. These exaggerated ballistic coefficients lead to inaccurate predictions of long range bullet drop, retained energy and wind drift.

Keywords: Ballistic Coefficient, Chronograph, Bullet Velocity

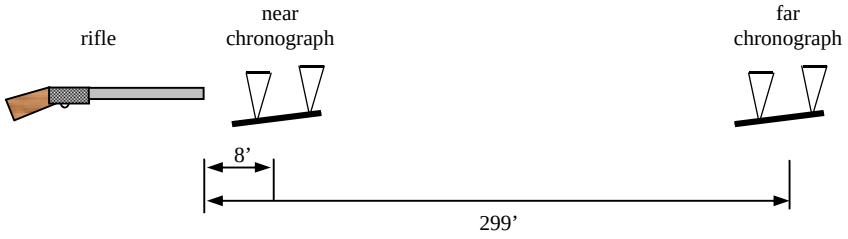
Introduction
The ballistic coefficient (BC) describes how air resistance slows a projectile in flight [SPE94, BAR97, HOR91, NOS96]. Accurate quantification of BC can be important in predicting long-range bullet drop, wind drift, and retained energy. The models and equations describing how BC determines velocity loss over flight distance are well known [RES06]. To a rough approximation, the BC can be estimated as the fraction of 1000 yards over which a projectile loses half of its initial kinetic energy. In other words, a bullet with a BC of 0.300 should lose roughly half of its initial kinetic energy at a range of 300 yards.

However, many bullet manufacturers exaggerate BC specifications for marketing purposes because BC is perceived to be important by customers, and because many manufactures rely on overly optimistic theoretical predictions that ignore the effects of the engraving of rifling, manufacturing defects, imperfect alignment of bullet axis and velocity vector, and other factors.

This paper presents the results of careful BC measurements for fourteen bullets. The test bullets represent five manufacturers, a weight range of 40-220 grains, calibers from 0.224 to .308, and published BC values between 0.200 and 0.523. Results (*Table 1*) show that manufacturer claims regarding bullet BC are often exaggerated. This exaggeration leads to inaccurate predictions of bullet drop, wind drift, impact energy, and impact velocity.

Method
Two chronographs are used to measure near and far bullet velocities at distances of 8 feet and 299 feet from the muzzle. The velocity loss over the separation distance of 291 feet is used along with the relative humidity, air temperature, atmospheric pressure, and altitude to compute the bullet BC using the G1 resistance model [JBM07]. The BC is determined individually for three to six separate shots, and these BC measurements are used to compute the mean

measured BC and estimate the measurement uncertainty due to shot-to-shot variations.



Results

The table compares the results of careful BC measurements with the manufacturers' claims. Numbers in parentheses represent the estimated uncertainty in the last significant digit(s) of the measured BC.

Table 1:

Manufacturer	Caliber	Weight	Style	Published	Reference	Measured	Exaggeration	Near Velocity
	(inches)	(grains)		BC		BC	(percent)	(fps)
Hornady	0.224	40	VMAX	0.200	[HOR07]	0.199(1)	0.50%	3137
Hornady	0.224	55	SP	0.235	[HOR91]	0.218(3)	7.80%	2400
Barnes	0.224	53	XFB	0.231	[BAR97]	0.197(10)	17.26%	2874
Nosler	0.308	150	BT	0.435	[NOS96]	0.381(7)	14.17%	2570
Hornady	0.308	150	FMJBT	0.398	[HOR91]	0.361(23)	10.25%	2656
Winchester	0.308	168	CTBST	0.475	[WIN07]	0.421(4)	12.83%	2644
Hornady	0.308	110	VMAX	0.290	[HOR07]	0.247(28)	17.41%	3501
Nosler	0.308	125	BT	0.366	[NOS96]	0.306(5)	19.61%	2245
Nosler	0.308	125	BT	0.366	[NOS96]	0.308(10)	18.83%	2794
Nosler	0.308	125	BT	0.366	[NOS96]	0.319(11)	14.73%	3010
Barnes*	0.308	150	TSX	0.428	[BAR05]	0.349(20)	22.64%	2567
Hornady	0.308	150	RN	0.186	[HOR91]	0.163(6)	14.11%	2624
Hornady	0.308	165	SPBT	0.435	[HOR91]	0.406(30)	7.14%	2750
Hornady	0.308	220	RN	0.300	[HOR91]	0.249(9)	20.48%	2444
Winchester	0.257	85	CTBST	0.329	[NOS07]	0.309(9)	6.47%	3449
Berger	0.257	115	VLD	0.523	[BER07]	0.419(4)	24.82%	3148

Discussion and Conclusion

An example demonstrates the implications of an exaggerated ballistic coefficient for the Berger 115 grain VLD shot at 3148 fps. For a zero range of 200 yards and a 10 mph cross wind, using the manufacturer's claimed ballistic coefficient of 0.523 gives a drop of 45.1 in, a wind drift of 19.6 in, and an impact energy of

* Barnes has recently undertaken to more carefully determine ballistic coefficients and have measured the BC of this bullet to be 0.369 [BAR07].

1180 ft-lbs at 550 yards for atmospheric conditions of 30º F, 0% relative humidity, and 29.92 mm Hg. In contrast, using the more accurate BC of 0.419 gives a drop of 49.8 in, a wind drift of 25.7 in, and impact energy of 956 ft-lbs under the same conditions.

Errors in trajectory and wind drift predictions lead to the point of impact being different from expectations. Errors in impact velocity predictions can cause unexpected failures in bullet performance, because many bullet designs have a window of impact velocities over which they expand reliably. Projectiles impacting below a threshold velocity can result in failure to expand and sub-optimal terminal performance. Errors in impact energy predictions lead to overly optimistic expectations regarding terminal performance.

In conclusion, manufacturers' published values for BC are exaggerated for many bullets, some by nearly 25%. Bullets also exhibit shot-to-shot variations of 1-5% in BC that suggest an inherent accuracy limit in predictions based on BC measurements. It should be noted that the BC can depend on the muzzle velocity and on the particular firearm used. If a BC is needed with less than 5% uncertainty, the BC should be determined with the same firearm.

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