

Verification of Muzzle Velocity Approximation Formulas

Feb 2019

Verify the accuracy of **four muzzle velocity formulas** against empirical data measured by BBTI.

We selected **seventeen cartridges across eight calibers in BBTI's measured data** that best correlated with SAAMI test standards using non-vented barrels, which we use as the reference points for our formulas. This gave us a starting point where all muzzle velocities were, for the most part "equal" between BBTI, SAAMI and our muzzle velocity formulas. The exceptions to this selection process were the .22 LR and the .223 Rem calibers which were tested by SAAMI with 24-inch test barrels. BBTI's tests only went up to 18 inches. For these two calibers, matches were based solely on bullet mass. Where BBTI tested multiple brands of cartridges of a given caliber with the same bullet mass we averaged those test results together at each inch for a composite muzzle velocity for that caliber and bullet mass.

SAAMI Test Standards for Reference Cartridges

Caliber	Bullet Mass	Muzzle Velocity	Test Barrel Length
.22 LR	40 grains	1255 ft/sec	24 inches
.25 Auto	50 grains	760 ft/sec	2 inches
.380 Auto	90 grains	1000 ft/sec	3.75 inches
9 mm	124 grains	1150 ft/sec	4 inches
357 SIG	125 grains	1350 ft/sec	4 inches
.40 S&W	180 grains	1000 ft/sec	4 inches
.45 Auto	230 grains	850 ft/sec	5 inches
.223 Rem	55 grains	3200 ft/sec	24 inches

Correlated BBTI Test Cartridges

Caliber	Sample1	Sample2	Sample3	Average MV	@ Barrel Length
.22 LR	CCI 40 gr. CPRN Mini-Mag	Winchester 40 gr. Super X RN		1231 ft/sec	18 inches**
.25 Auto	American Eagle 50 gr. TMJ	Winchester 50 gr. FMJ		767 ft/sec	2 inches
.380 Auto	Speer 90 gr. Gold Dot	Hornady 90 gr. HP/XPT FPD		980 ft/sec	4 inches*
9 mm	Federal 124 gr. Hydra Shock JHP	Speer 124 gr. Gold Dot		1132 ft/sec	4 inches
357 SIG	Cor-Bon 125 gr. JHP	Cor-Bon 125 gr. DPX	Federal Premium 125 gr. JHP	1404 ft/sec	4 inches
.40 S&W	Federal 180 gr. JHP	Federal 180 gr. Hydra-Shok	Speer 180 gr. Gold Dot	1016 ft/sec	4 inches
.45 Auto	Federal 230 gr. HST JHP	Buffalo Bore 230 gr. FMJ-RN		888 ft/sec	5 inches
.223 Rem	Remington UMC 55 gr. MC			2983 ft/sec	18 inches**

**Bullet Mass match only – SAAMI tests this caliber with a 24-inch barrel. BBTI's max barrel length is 18 inches.

*Near match – SAAMI tests this caliber with a 3.75-inch barrel. BBTI's closest match barrel is 4 inches.

Muzzle Velocity Approximation Formulas

Genitron: Homegrown formula based on a rule-of-thumb reference of 25 ft/sec change per inch of barrel length for an average bullet mass of 200 grains.

Powley1: Powley's full formula using a "normalizing" constant of 8000.

Powley2: Powley's full formula using a "normalizing" constant of 8959.

Powley3: Powley's modified formula relying solely on expansion ratios derived from chamber and bore volumes.

Verification Process

Formulas were converted into C programming language methods. Then, they were run against the reference cartridges across the **range of operational barrel lengths** for pistols using those calibers in the Genitron.com database. The accuracy of the approximations is determined by taking the difference between the measured muzzle velocity values and the calculated values for each inch of barrel length. Accuracy is represented in percentages, where 100% would indicate that a formula result matched a measured result. Results for each barrel length are then averaged together to get a single average accuracy percentile for each of the reference calibers. Then those percentiles are averaged together to determine which formula had the highest overall accuracy across all reference calibers.

The table below shows the overall accuracy percentage and the point of maximum difference between measured and calculated values for each caliber. The total averages of these two tables were used to determine which formula to select for making muzzle velocity approximations going forward.

Caliber	Overall Accuracy				MAX Difference			
	Genitron	Powley1	Powley2	Powley3	Genitron	Powley1	Powley2	Powley3
.22 LR	82.5%	93.1%	84.6%	97.2%	278 ft/s @ 4"	93 ft/s @ 6"	219 ft/s @ 2"	50 ft/s @ 8"
.25 Auto	96.7%	95.9%	97.6%	98.0%	65 ft/s @ 3"	64 ft/s @ 3"	47 ft/s @ 3"	38 ft/s @ 3"
.380 Auto	95.9%	97.6%	97.5%	98.0%	69 ft/s @ 2"	43 ft/s @ 5"	37 ft/s @ 4"	39 ft/s @ 4"
9 mm	96.1%	98.1%	98.4%	96.7%	98 ft/s @ 10"	52 ft/s @ 3"	34 ft/s @ 10"	75 ft/s @ 10"
357 SIG	96.0%	96.8%	96.9%	97.0%	93 ft/s @ 5"	61 ft/s @ 5"	64 ft/s @ 3"	54 ft/s @ 5"
.40 S&W	98.7%	98.8%	98.0%	98.0%	22 ft/s @ 5"	25 ft/s @ 3"	41 ft/s @ 3"	41 ft/s @ 3"
.45 Auto	96.8%	96.3%	96.1%	96.3%	51 ft/s @ 6"	53 ft/s @ 3"	75 ft/s @ 3"	49 ft/s @ 3"
.223 Rem	77.1%	88.2%	95.9%	92.5%	850 ft/s @ 3"	349 ft/s @ 3"	145 ft/s @ 3"	256 ft/s @ 3"
Total Avg	92.5%	95.6%	95.6%	96.7%	191 ft/sec	93 ft/sec	77 ft/sec	75 ft/sec

The tables on the following pages detail the averaged BBTI data collected for the eight respective calibers across barrel lengths from 18 inches to 2 inches, along with the calculated values for the same calibers using the 4 formulas selected for verification. The difference in muzzle velocity between the measured data averages and the calculated muzzle velocities is shown in the graphs and is represented in the summary table as the average percentage of accuracy across the range of working barrel lengths from the handguns in our database.

The one constraint we have is that we only verified with tests on pistol/rifle cartridges. In testing muzzle velocities against barrel length BBTI did not consider revolver barrel measurements or the impact of revolver cylinder gap. In all of the barrel-length tests the barrel was measured from muzzle to breech face (i.e. pistol). As such we could not use calibers where SAAMI used vented barrels (i.e. revolver). BBTI addressed cylinder gap impact in separate tests, who's data we also used in developing a cylinder gap formula.

REFERENCE CARTRIDGE .22 LR

Bullet Mass: 40 grain
 Muzzle Velocity 1255 ft/sec
 Test Barrel Length: 24 inches
 Test Barrel Type: Non-vented rifle

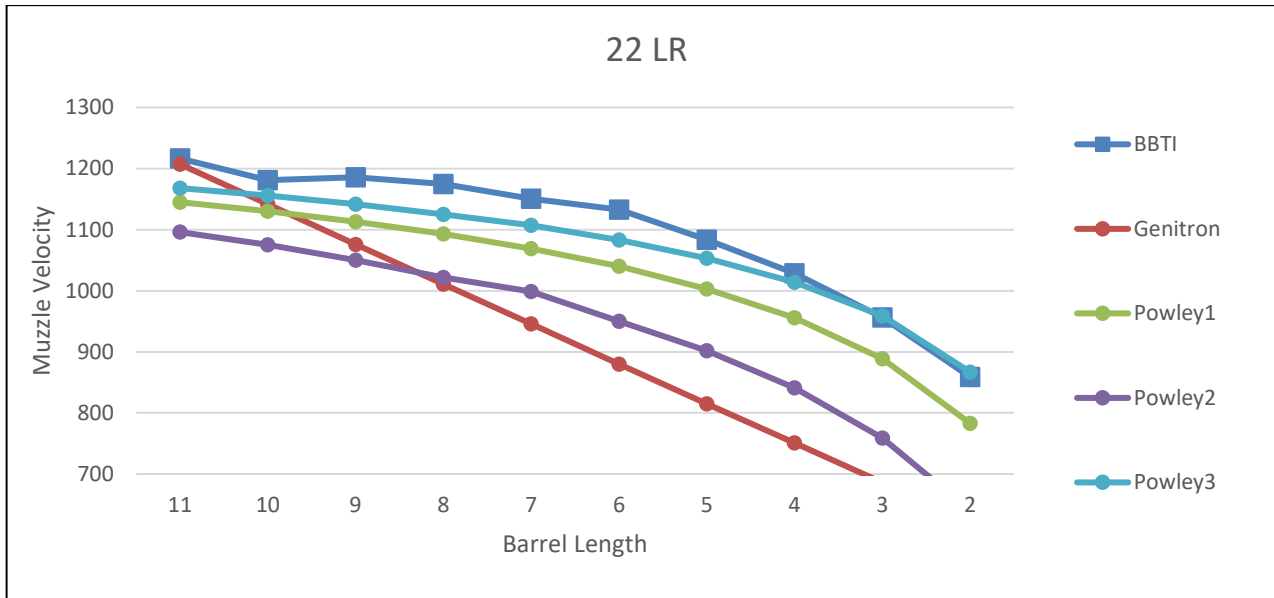
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 2
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 11 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	82.5%	278 ft/sec @ 4"
Powley1	93.1%	93 ft/sec @ 6"
Powley2	84.6%	219 ft/sec @ 2"
Powley3	97.2%	50 ft/sec @ 8"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1231	1663	1217	1200	1226
17	1217	1598	1210	1189	1219
16	1229	1533	1201	1177	1212
15	1226	1468	1192	1164	1205
14	1223	1403	1182	1149	1197
13	1216	1337	1172	1133	1188
12	1228	1272	1159	1116	1179
11	1217	1207	1145	1096	1168
10	1181	1142	1130	1075	1156
9	1186	1076	1113	1050	1142
8	1175	1011	1093	1022	1125
7	1151	946	1069	999	1107
6	1133	880	1040	950	1083
5	1084	815	1003	902	1053
4	1029	751	956	841	1014
3	957	686	889	759	959
2	859	620	783	640	867



REFERENCE CARTRIDGE .25 Auto

Bullet Mass: 50 grain
 Muzzle Velocity 760 ft/sec
 Test Barrel Length: 2 inches
 Test Barrel Type: Non-vented pistol

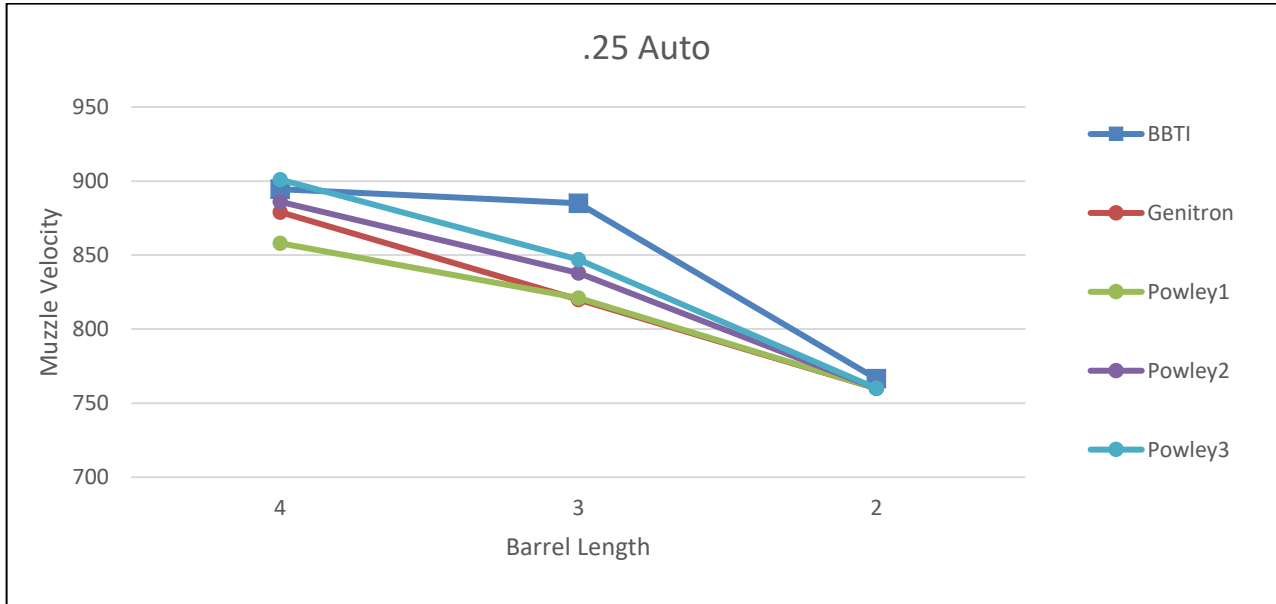
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 2
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 4 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	96.7%	65 ft/sec @ 3"
Powley1	95.9%	64 ft/sec @ 3"
Powley2	97.6%	47 ft/sec @ 3"
Powley3	98.0%	38 ft/sec @ 3"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1014	1715	993	1065	1107
17	989	1655	989	1060	1101
16	1016	1595	985	1054	1094
15	1016	1535	980	1048	1087
14	1037	1476	975	1041	1079
13	1013	1416	970	1034	1071
12	1015	1357	963	1026	1061
11	1012	1297	957	1017	1051
10	1011	1237	949	1006	1039
9	994	1177	940	994	1025
8	1005	1118	929	980	1009
7	1005	1058	917	964	991
6	973	999	902	944	968
5	927	939	883	919	939
4	895	879	858	886	901
3	885	820	821	838	847
2	767	760	760	760	760



REFERENCE CARTRIDGE .380 Auto

Bullet Mass: 90 grain
 Muzzle Velocity 1000 ft/sec
 Test Barrel Length: 3.75 inches
 Test Barrel Type: Non-vented pistol

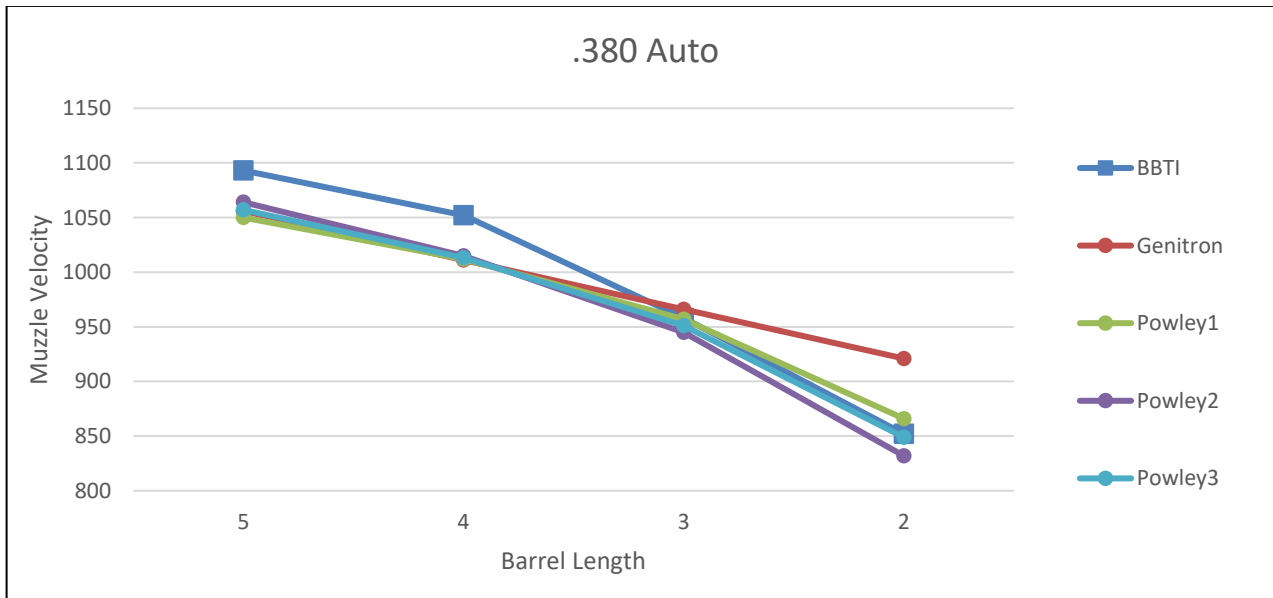
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 2
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 5 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	95.9%	69 ft/sec @ 2"
Powley1	97.6%	43 ft/sec @ 5"
Powley2	97.5%	37 ft/sec @ 4"
Powley3	98.0%	39 ft/sec @ 4"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1130	1640	1214	1284	1247
17	1128	1596	1208	1276	1240
16	1137	1551	1202	1267	1233
15	1196	1505	1195	1258	1225
14	1141	1461	1187	1248	1216
13	1119	1416	1179	1237	1207
12	1184	1371	1170	1225	1196
11	1129	1326	1160	1211	1184
10	1114	1281	1148	1195	1170
9	1103	1236	1135	1177	1155
8	1094	1191	1119	1156	1137
7	1071	1146	1100	1132	1116
6	1046	1101	1078	1102	1089
5	1015	1056	1050	1064	1057
4	980	1011	1012	1015	1013
3	909	966	957	945	951
2	816	921	866	832	849



REFERENCE CARTRIDGE 9 mm

Bullet Mass: 124 grain
 Muzzle Velocity 1150 ft/sec
 Test Barrel Length: 4 inches
 Test Barrel Type: Non-vented pistol

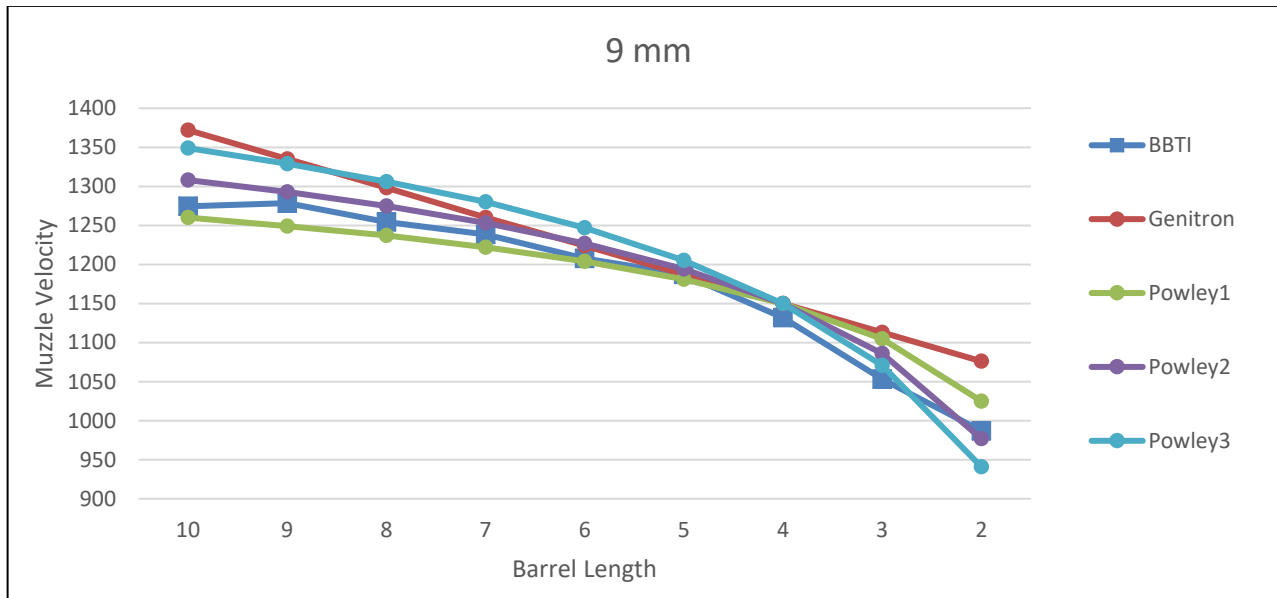
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 2
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 10 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	96.1%	98 ft/sec @ 10"
Powley1	98.1%	52 ft/sec @ 3"
Powley2	98.4%	34 ft/sec @ 10"
Powley3	96.7%	75 ft/sec @ 10"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1313	1667	1312	1387	1446
17	1325	1630	1307	1377	1437
16	1311	1593	1302	1370	1428
15	1310	1556	1297	1362	1418
14	1316	1520	1291	1353	1407
13	1308	1483	1284	1344	1395
12	1293	1446	1277	1333	1381
11	1286	1409	1269	1321	1366
10	1275	1372	1260	1308	1349
9	1279	1335	1249	1293	1329
8	1255	1298	1237	1275	1306
7	1239	1260	1222	1253	1280
6	1208	1224	1204	1227	1247
5	1187	1187	1181	1194	1205
4	1132	1150	1150	1150	1150
3	1053	1113	1105	1086	1071
2	987	1076	1025	977	941



REFERENCE CARTRIDGE 357 SIG

Bullet Mass: 125 grain
 Muzzle Velocity 1350 ft/sec
 Test Barrel Length: 4 inches
 Test Barrel Type: Non-vented pistol

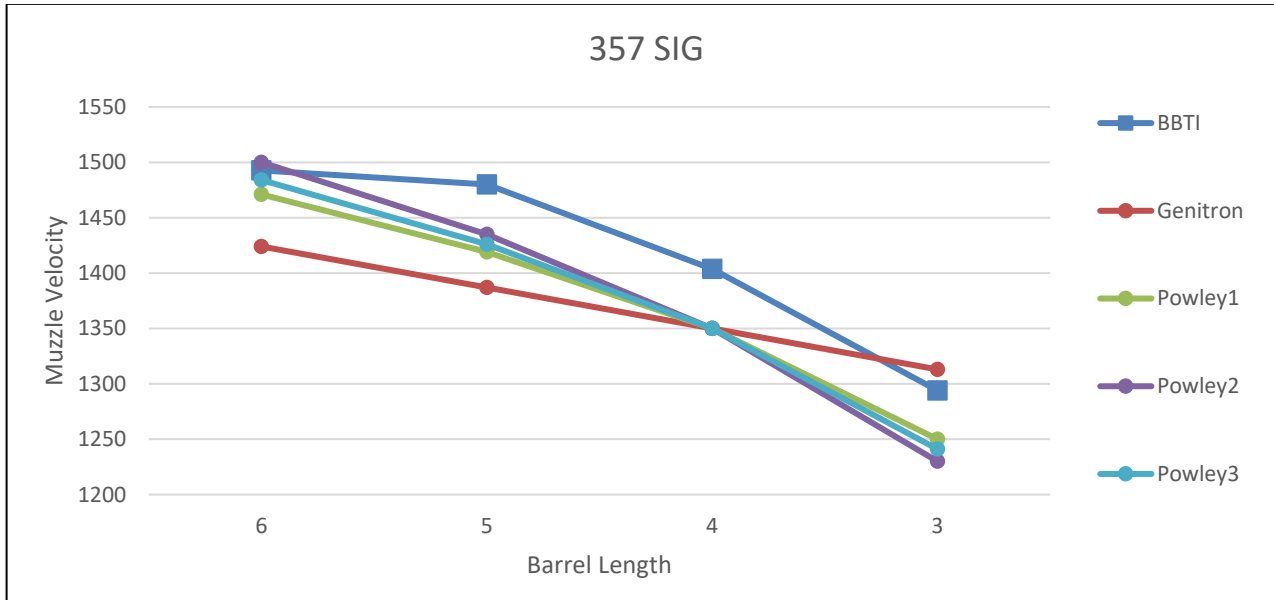
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 3
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 10 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	96.0%	93 ft/sec @ 5"
Powley1	96.8%	61 ft/sec @ 5"
Powley2	96.9%	64 ft/sec @ 3"
Powley3	97.0%	54 ft/sec @ 5"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1653	1865	1717	1815	1760
17	1661	1828	1706	1801	1748
16	1649	1791	1695	1786	1735
15	1675	1754	1682	1770	1721
14	1663	1718	1669	1753	1706
13	1649	1681	1654	1733	1689
12	1632	1644	1637	1712	1671
11	1620	1607	1619	1688	1650
10	1607	1571	1598	1661	1626
9	1591	1534	1574	1630	1599
8	1563	1497	1545	1594	1567
7	1538	1460	1512	1552	1530
6	1493	1424	1471	1500	1484
5	1480	1387	1419	1435	1426
4	1404	1350	1350	1350	1350
3	1294	1313	1250	1230	1241
2	1148	1276	1083	1036	1061



REFERENCE CARTRIDGE .40 S&W

Bullet Mass: 180 grain
 Muzzle Velocity 1000 ft/sec
 Test Barrel Length: 4 inches
 Test Barrel Type: Non-vented pistol

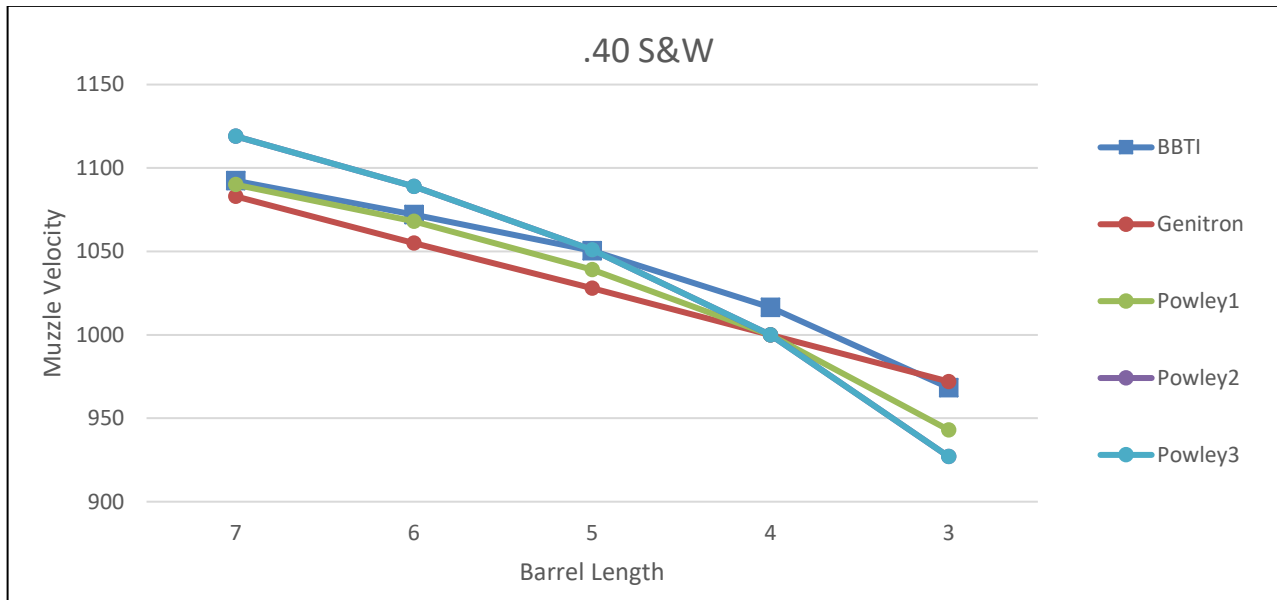
BBTI Test Range: 18 inches to 2 inches
 Cartridges Tested/Averaged: 3
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 7 inches to 3 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	98.7%	22 ft/sec @ 5"
Powley1	98.8%	25 ft/sec @ 3"
Powley2	98.0%	41 ft/sec @ 3"
Powley3	98.0%	41 ft/sec @ 3"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	1153	1387	1202	1270	1269
17	1179	1359	1196	1263	1261
16	1153	1332	1190	1254	1253
15	1165	1304	1184	1245	1244
14	1153	1276	1176	1235	1234
13	1148	1248	1168	1224	1223
12	1142	1221	1159	1212	1211
11	1127	1193	1149	1198	1197
10	1132	1166	1137	1183	1181
9	1127	1138	1124	1165	1164
8	1106	1110	1109	1145	1143
7	1092	1083	1090	1119	1119
6	1072	1055	1068	1089	1089
5	1050	1028	1039	1051	1051
4	1016	1000	1000	1000	1000
3	968	972	943	927	927
2	909	945	844	804	805



REFERENCE CARTRIDGE .45 Auto

Bullet Mass: 230 grain
 Muzzle Velocity 850 ft/sec
 Test Barrel Length: 5 inches
 Test Barrel Type: Non-vented pistol

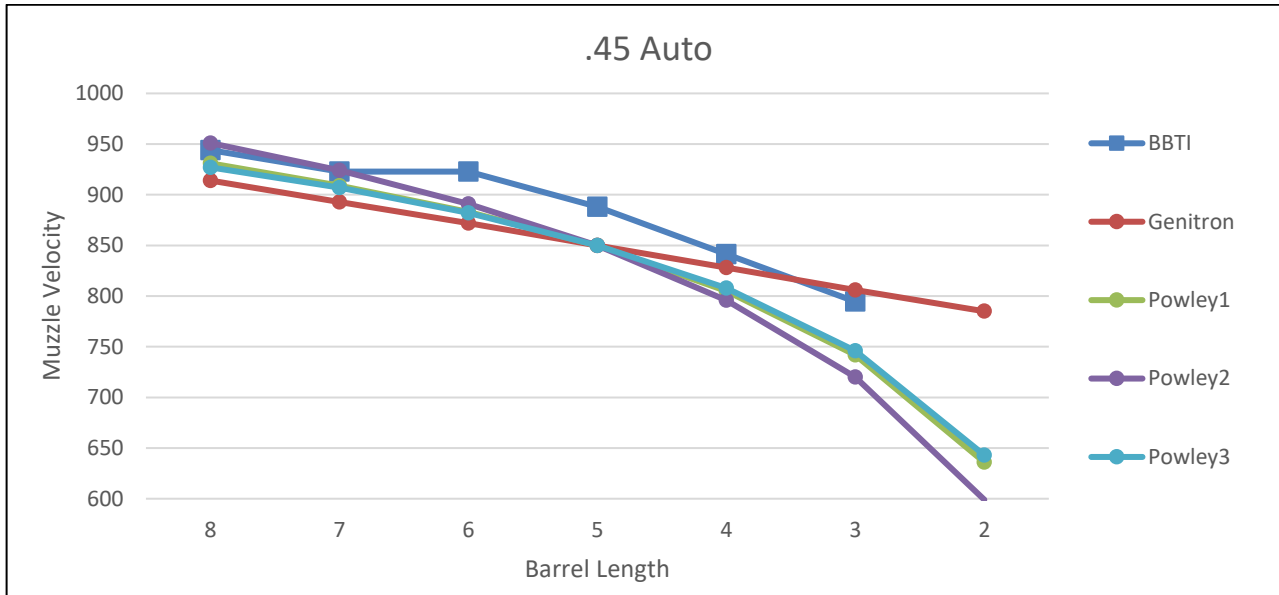
BBTI Test Range: 18 inches to 3 inches
 Cartridges Tested/Averaged: 2
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 8 inches to 2 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	96.8%	51 ft/sec @ 6"
Powley1	96.3%	53 ft/sec @ 3"
Powley2	96.1%	75 ft/sec @ 3"
Powley3	96.3%	49 ft/sec @ 3"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	956	1129	1040	1093	1032
16	1016	1086	1026	1074	1019
14	996	1044	1010	1053	1003
12	960	1001	989	1027	983
10	955	957	964	994	959
9	952	936	949	974	945
8	944	914	931	951	927
7	923	893	909	924	907
6	923	872	883	891	882
5	888	850	850	850	850
4	842	828	805	796	808
3	795	806	742	720	746
2		785	636	599	643



REFERENCE CARTRIDGE .223 Rem

Bullet Mass: 55 grain
 Muzzle Velocity 3200 ft/sec
 Test Barrel Length: 24 inches
 Test Barrel Type: Non-vented rifle

BBTI Test Range: 18 inches to 3 inches
 Cartridges Tested/Averaged: 1
 Test Constraint: Pistol Only
 Operational Barrel Lengths: 10 inches to 3 inches

Approximation Formulas

Percentage of accuracy within operational barrel lengths:

Formula	Accuracy	MAX Diff.
Genitron	77.1%	850 ft/sec @ 3"
Powley1	88.2%	349 ft/sec @ 3"
Powley2	95.9%	145 ft/sec @ 3"
Powley3	92.5%	256 ft/sec @ 3"

BL	Muzzle Velocities (ft/sec)				
	BBTI	Genitron	Powley1	Powley2	Powley3
18	2983	2856	3034	2988	3015
16	2943	2742	2961	2897	2935
14	2878	2627	2875	2790	2839
12	2742	2513	2770	2662	2725
10	2616	2398	2639	2504	2582
8	2380	2284	2466	2303	2396
6	2041	2169	2221	2029	2138
5	1861	2112	2051	1847	1961
4	1564	2055	1825	1614	1731
3	1147	1997	1496	1292	1403

