EFFECTS OF BARREL LENGTH ON BORE PRESSURE, PROJECTILE VELOCITY and SOUND MEASUREMENT

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BARREL LENGTH and BORE PRESSURE

There is increasing interest in M16-type weapons having progressively shorter barrels to make highly maneuverable entry weapons. As barrel lengths decrease, weapon reliability decreases while sound and flash increase.

BARREL LENGTH and BORE PRESSURE

One of our compact stainless suppressors was exhibiting swelling of the outer tube over the entrance chamber, but only after significant full auto fire on a 10.5 inch barreled M16, but not on a 14.5 inch barreled M4.

This prompted performing actual entrance chamber pressure measurements, with interesting results.

BARREL LENGTH and BORE PRESSURE

*100 rounds full auto will raise the suppressor temperature to 800F where the yield strength of 300 series stainless steel is approximately 62% of the strength at room temperature.

M855	10.5” BBL	14.5” BBL
Entrance chamber pressure	2,990 psi	1,978 psi
Hoop Stress	15,635 psi	10,343 psi
Safety Factor	1.92	2.90
Safety factor after 100 rds F/A*	1.19	1.8

Yield 300 series stainless steels is 30,000 psi

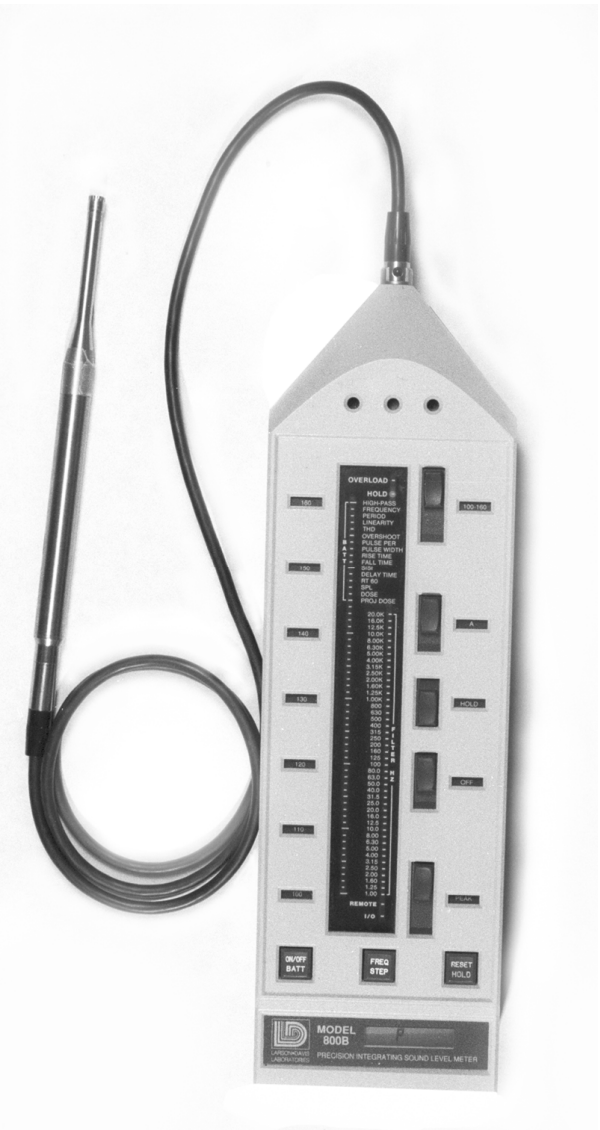
BARREL LENGTH and BORE PRESSURE

We became curious about pressure gradients in the bore throughout the 5.56mm barrel using M855 ammunition.

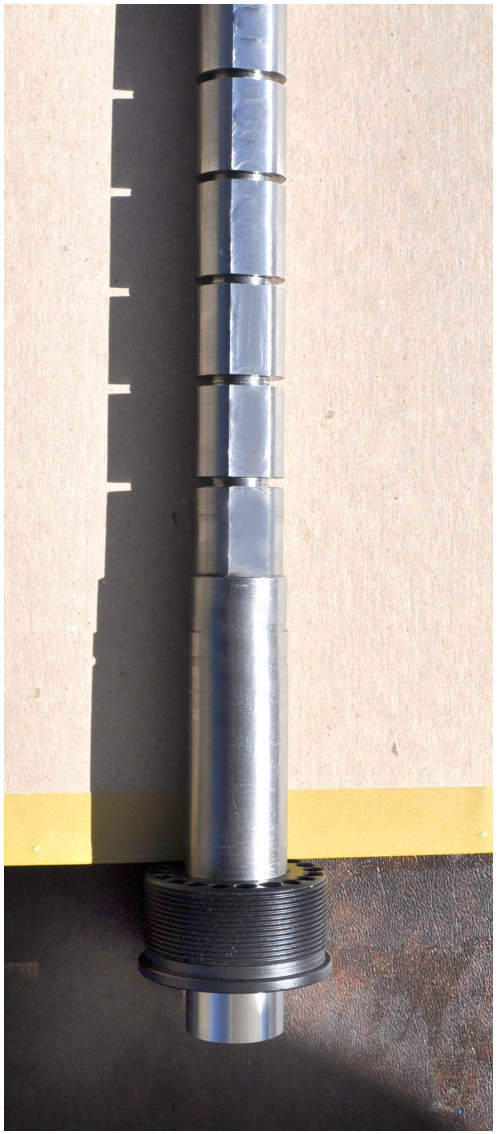
There are numerous studies about temperature gradients, but we could not find any relating to pressure.

BARREL LENGTH and BORE PRESSURE

So we devised our own study. Since we were going to measure bore pressure, we might as well measure velocity and sound pressure levels at the same time.



BARREL LENGTH and BORE PRESSURE

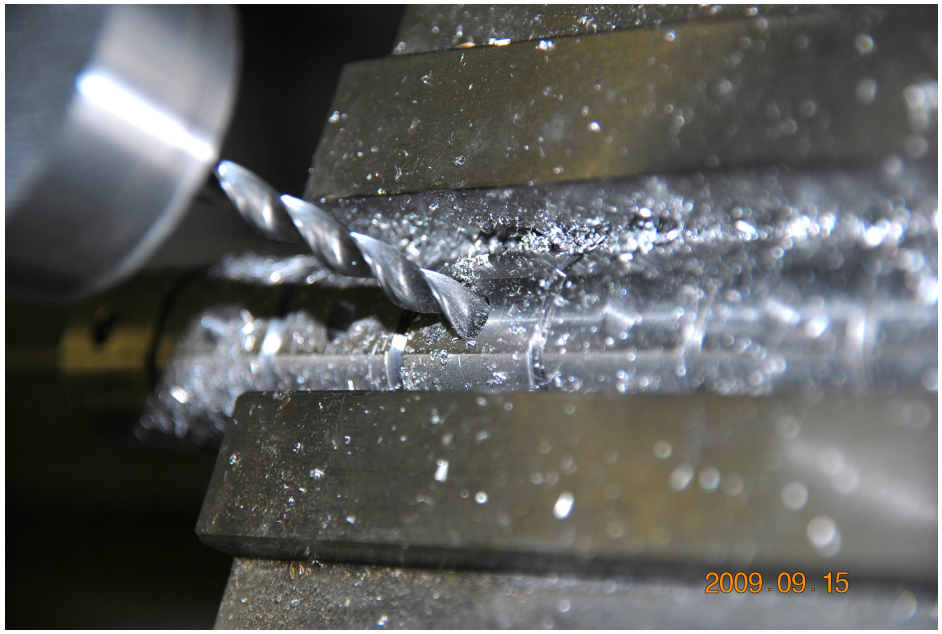


We felt that direct port pressure measurement with a piezoelectric transducer was more accurate than pressures from a strain gauge.

A new 24 inch AR15 barrel was scored at 1 inch intervals down to 5 inches from the bolt face.

We used a barrel without a gas port, making the rifle a single shot weapon

BARREL LENGTH and BORE PRESSURE



If the port and sensor were at the end of the barrel (1/2 inch from the muzzle), the highest pressure measured would be the bore pressure at the moment of bullet exit (uncorking)

A series of 2mm ports were drilled and tapped for pressure measurements.

BARREL LENGTH and BORE PRESSURE

All but the port closest to the muzzle were plugged with a 3/8 inch setscrew.

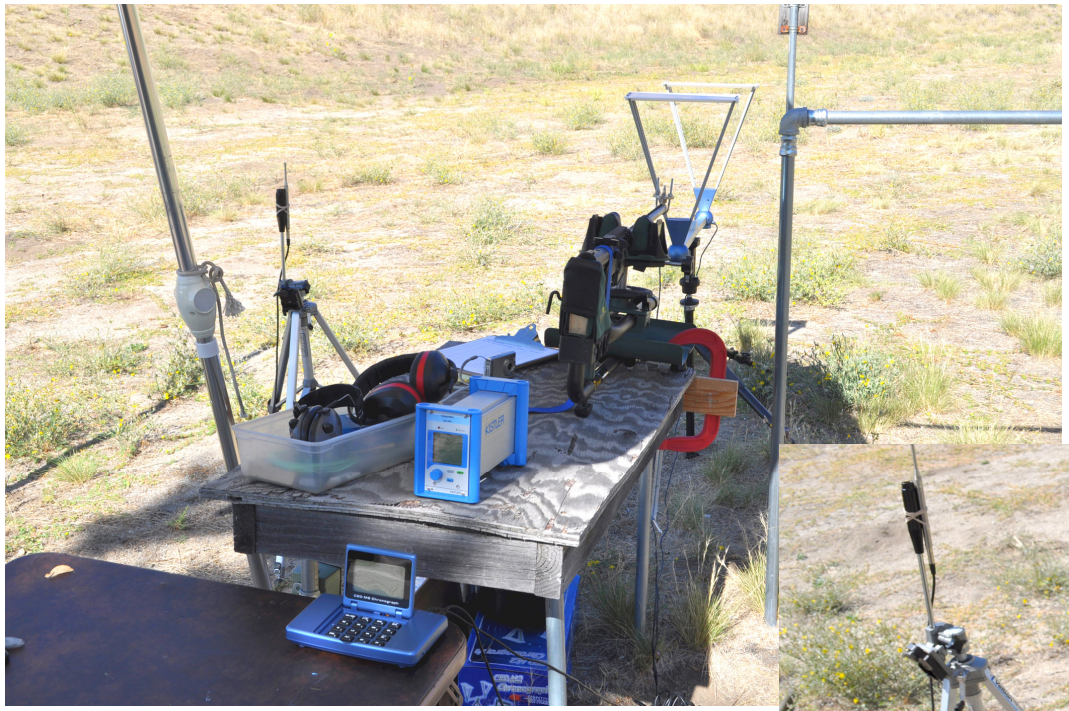
After each test, 1 inch was cut from the barrel and the sensor moved back to the next port.

BARREL LENGTH and BORE PRESSURE

The Kistler 6215 direct measuring piezoelectric pressure sensor was screwed into a special fitting that screwed into the threaded holes in the barrel.

Measurements were made using a Kistler 5015 charge meter/amplifier.

BARREL LENGTH and BORE PRESSURE



Rifle was stabilized in a machine rest. Three parameters were recorded in each 5-round string.

1. Bore pressure at uncorking
2. Velocity at 2 meters from muzzle
3. Sound pressure level per MIL-STD-1474D

BARREL LENGTH and BORE PRESSURE

For consistency, ammunition was all LC-2009 M855 ball and from the same lot.

Ambient air temperature varied throughout the day. Ammunition was kept in a cooler until loaded for firing to reduce variability from ammunition temperature.

BARREL LENGTH and BORE PRESSURE

Bore pressure, velocity (at 2 meters), and sound pressure level were recorded for each shot. There was more shot-to-shot variation in pressure and velocity than anticipated.

BARREL LENGTH and BORE PRESSURE

Results in table are 5 (or more) round averages.

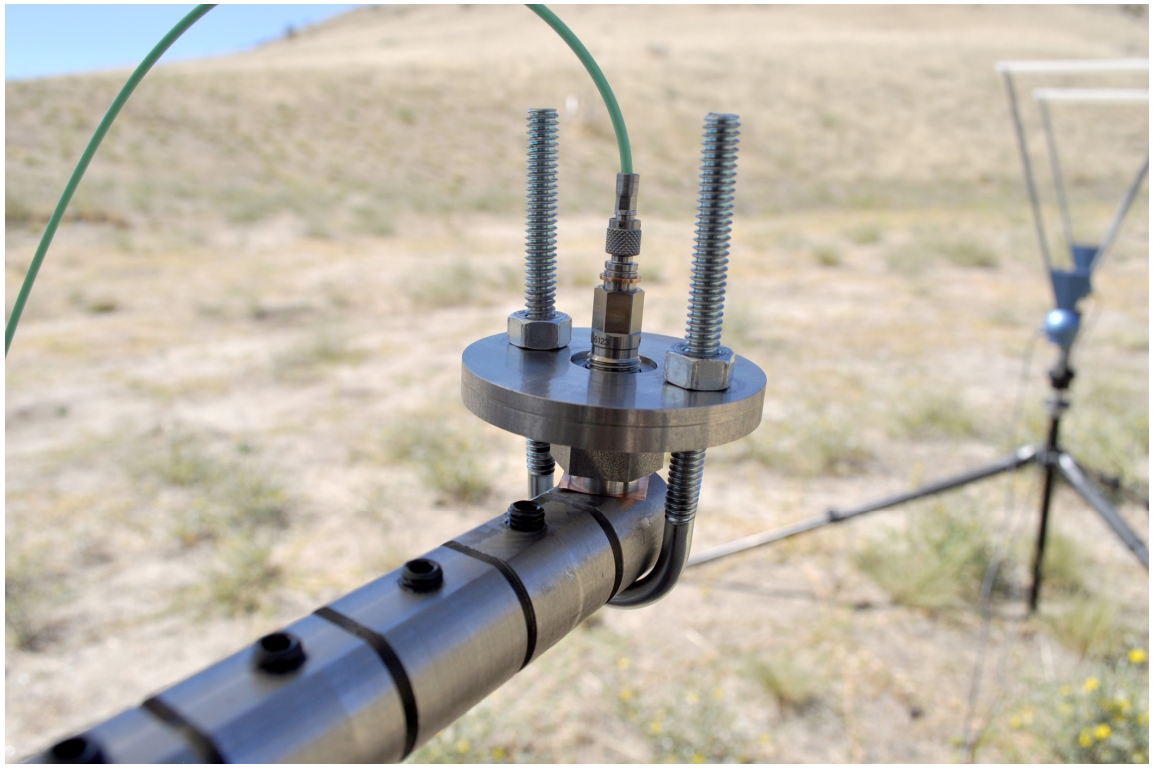
Barrel Length (in)	Pressure (psi)	Velocity (f/s)	SPL [dB(A)]
24	4800	2964	162.5
23	5050	2951	162.7
22	5150	2873	162.7
21	5380	2849	162.7
20	5717	2979	162.9
19	5780	2921	163.1
18	6600	2889	163.1
17	7788	2835	163.6
16	7430	2786	163.3
15	7878	2729	163.4
14	8487	2686	163.6
13	8858	2649	164.0
12	9814	2626	164.6
11	10540	2643	164.2
10	12140	2575	164.3
9	13567	2446	164.7
8	15860	2357	164.7
7	17040	2204	164.8
6	20760	2034	164.5
5	25042	1823	165.1

BARREL LENGTH and BORE PRESSURE

As an example of the variation in pressures, below are the measured pressures for the 6 rounds used when the barrel was cut to 15 inches.

Note: Sometimes more than 5 rounds were measured because the chronograph may have missed one shot.

7670
8110
7810
7760
8040
7000



The average was 7,878 psi and the standard deviation 396

BARREL LENGTH and BORE PRESSURE

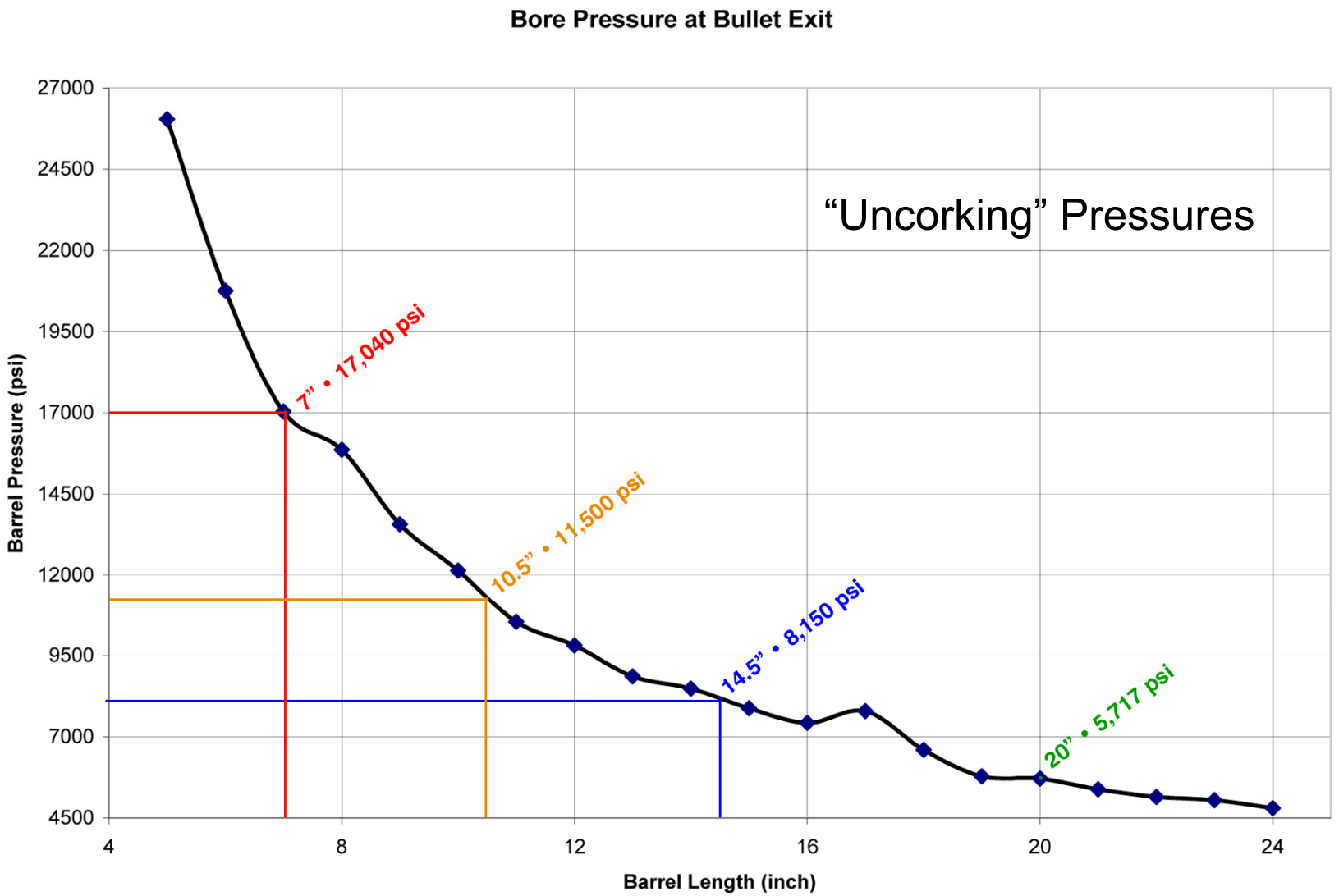
Unable to measure actual chamber pressure, we drilled a 2.5mm port at 3” from the bolt face and measured port pressure.

The SAAMI maximum chamber pressure for commercial .223 is listed as 55,000 psi.

The 3 inch port pressure we measured was 55,744 psi using M855 (average of 9 rounds).

The measurements varied from a low of 52,500 psi to a high of 57,600 psi

BARREL LENGTH and BORE PRESSURE



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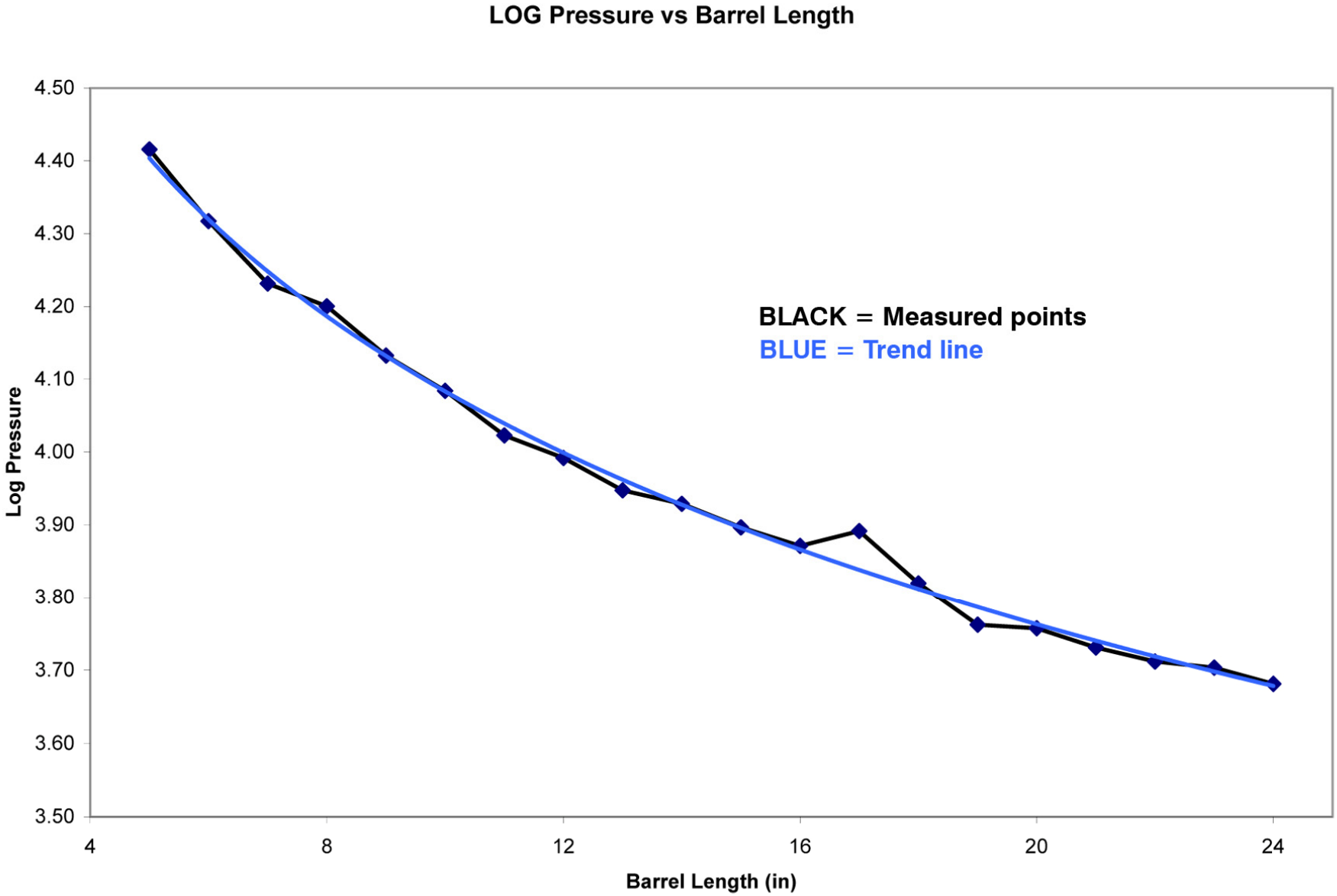
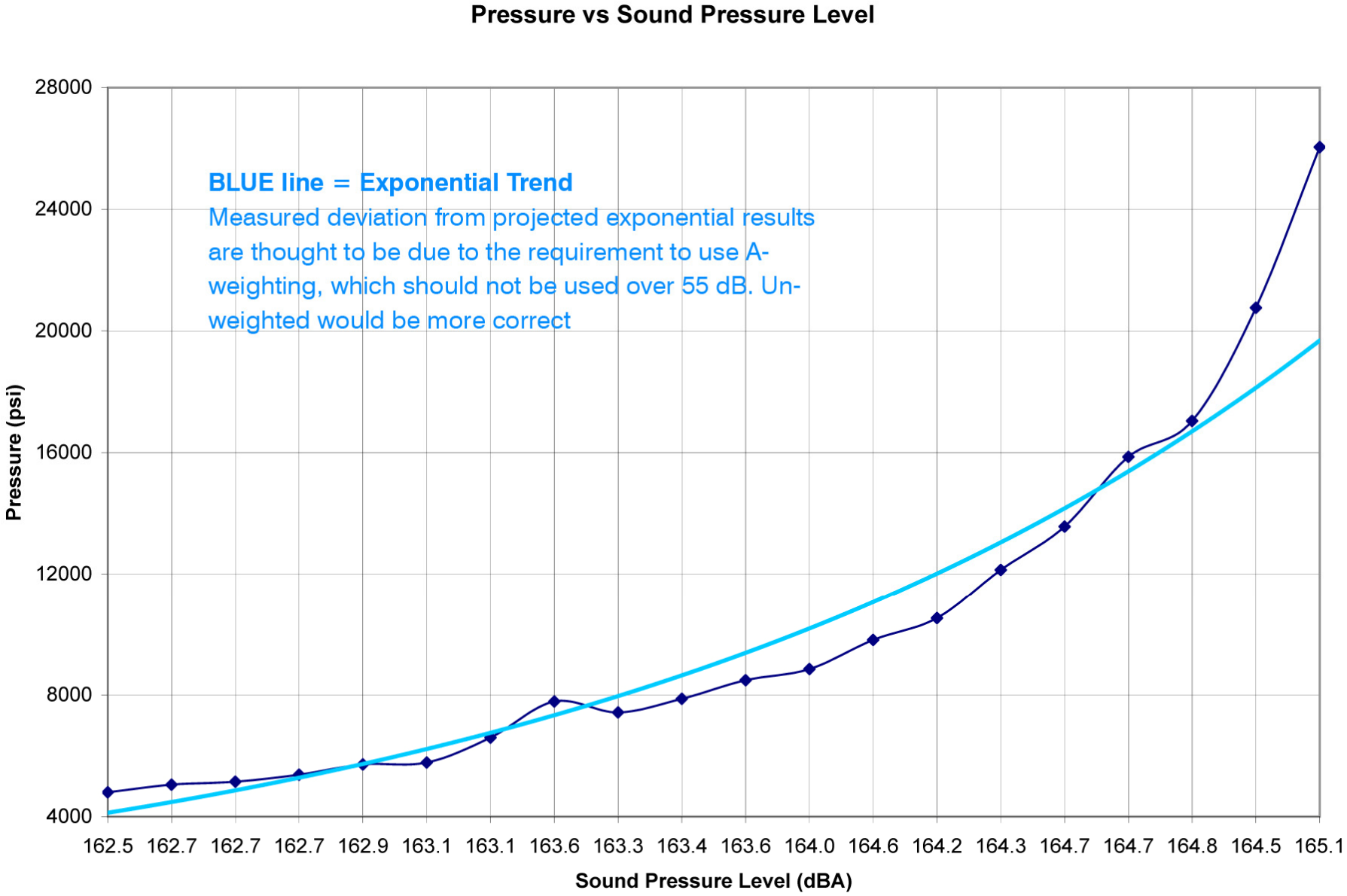
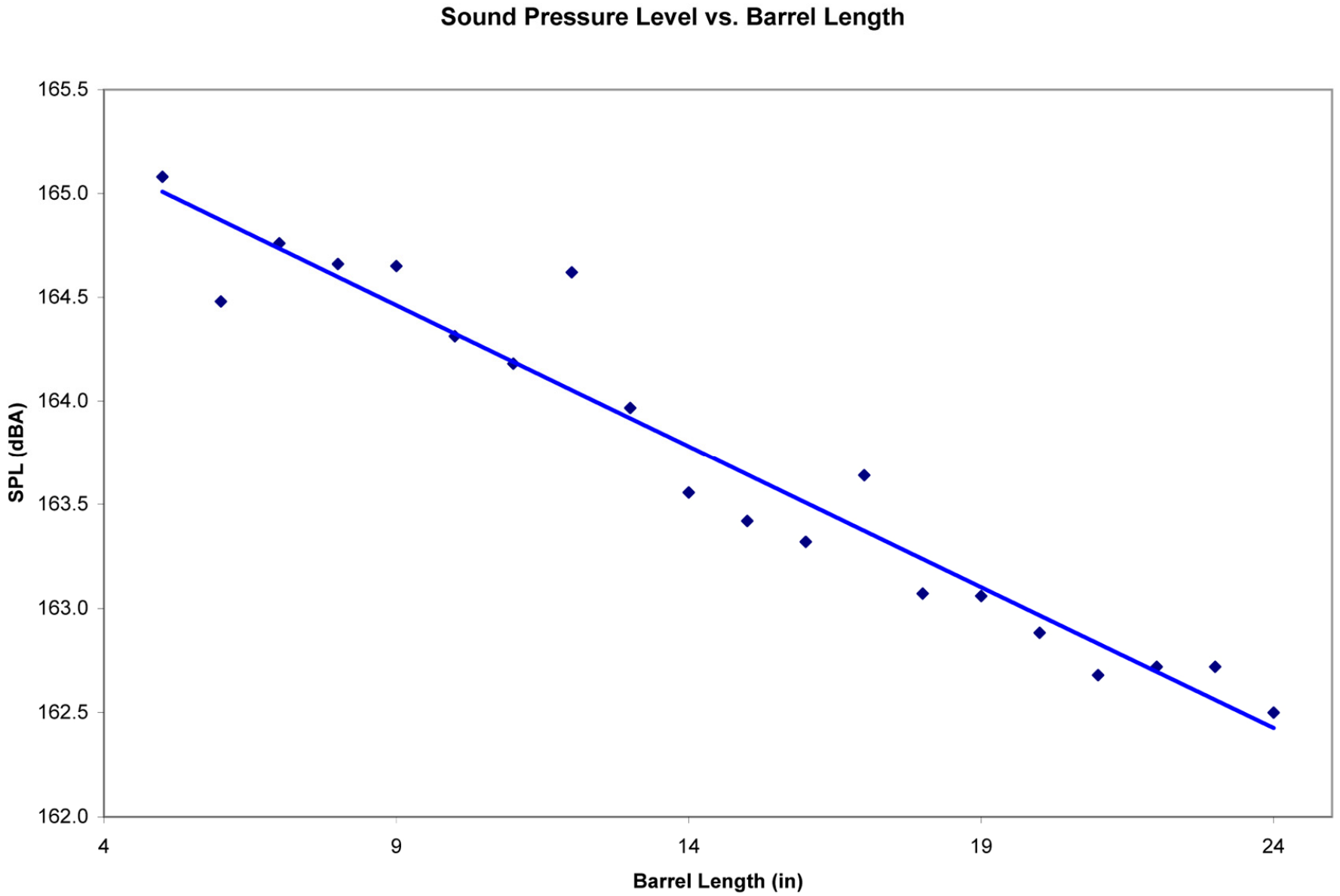


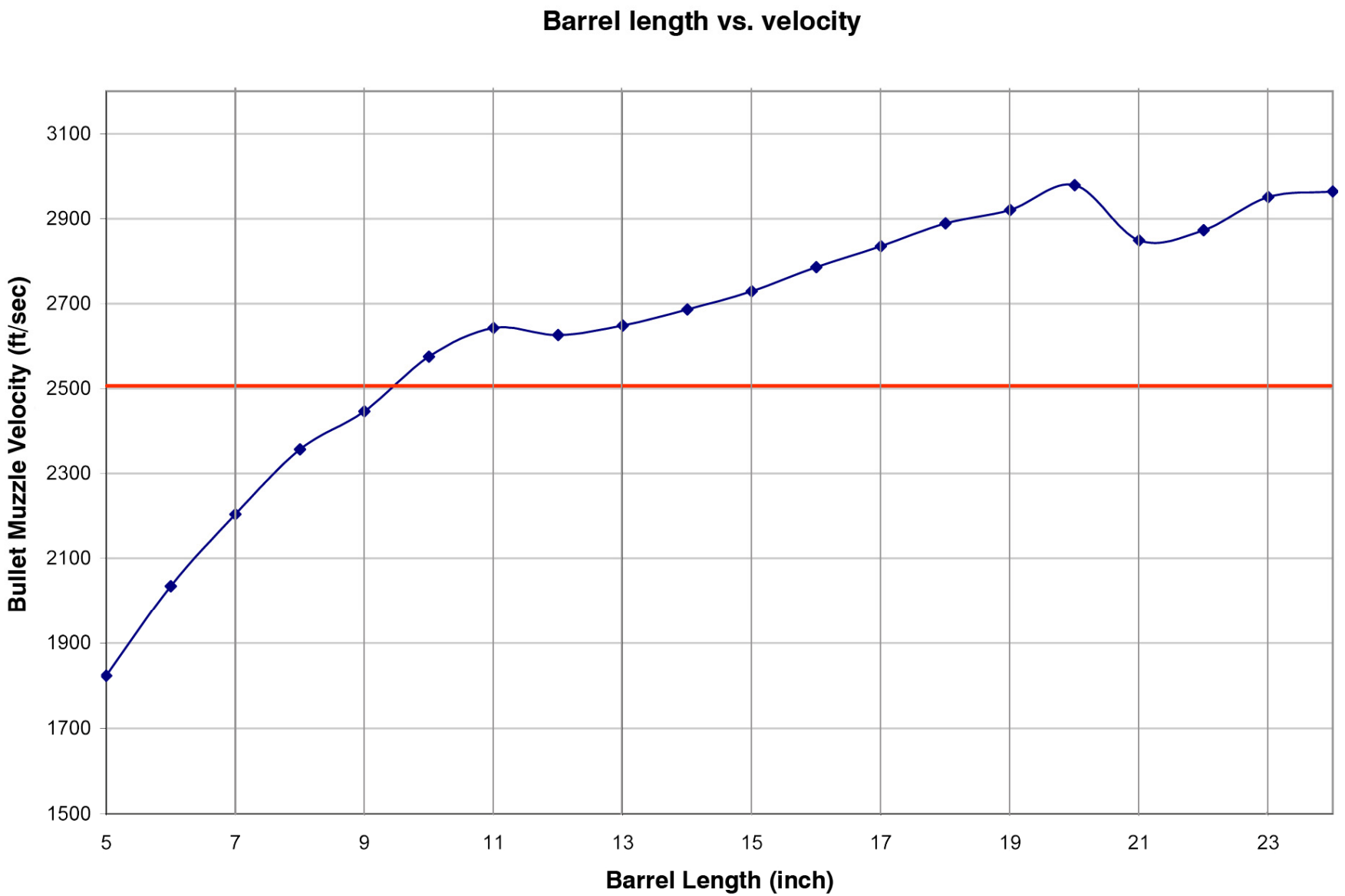
BORE PRESSURE and S.P.L.



S.P.L. and BARREL LENGTH



BARREL LENGTH and VELOCITY



CONCLUSIONS

1. Pressure in the bore (uncorking pressure) increases exponentially with decreasing barrel length.
2. Non-suppressed sound pressure level increases exponentially with decreasing barrel length.
3. Pressure in a suppressor's entrance chamber appears to increase proportionately with uncorking bore pressure (based on previous studies).
4. Maximum velocity is in a 20 inch barrel. Barrels at or less than 10 inches may not have adequate velocity (2,500 ft/sec) for a lethal wound channel at other than point-blank range with M855 ammunition.