Hornady® Superformance™ Technology

A Discussion on Performance, Recoil and Comparative Testing

By Dave Emary, Hornady Senior Ballistician

Superformance ammunition achieves the highest performance of any ammunition on the market today; 100 -200 fps over SAAMI standard, in all calibers, all bullet weights and all bullet types, including monolithic bullets like the Hornady GMX bullet. This performance is achieved by revolutionary new, extremely efficient powders optimized for each load. These powders produce very high performance yet do not produce excessive recoil or compromise accuracy. This performance is achieved because the powder is completely burned prior to the bullet leaving the barrel and imparts as much energy as possible to the bullet. As a result, the muzzle exit pressure is lower and the muzzle gas velocity is dramatically lower than for previous high performance ammunition. This reduces the rocket nozzle effect from the gases leaving the barrel, resulting in lower recoil levels and high levels of accuracy.

Superformance ammunition sets entirely new standards for ammunition performance in all calibers, all bullet weights and all bullet types. Until now centerfire ammunition performance has been based on the IMR series of powders developed in the 1930's and 1940's. It is now possible to achieve 100 – 200 fps higher performance ammunition than standard without paying the price of excessive recoil or finicky accuracy. The heart of Superformance ammunition is revolutionary new 21st Century powders which achieve unprecedented performance and efficiency in small arms. Superformance produces levels of performance that previously could only be achieved by mechanically compacting large amounts of powder in the cartridge case (Light Magnum, High Energy). These performance levels are achieved with powder charges 10-15% lower than those of the compacted ammunition. Powder charge weights are only slightly higher than those of conventional ammunition. Superformance powder design allows loads to be custom tailored to any cartridge, bullet weight and type, achieving unheard of performance levels.

Superformance powders achieve their phenomenal performance because of advances in propellant chemistry and mechanical processing. The design of these powders achieves levels of progressivity greater than anything that has been accomplished in small arms up

to this point. In general, progressivity is a measure of a powder's ability to burn and not exceed a specified maximum pressure and yet be completely burned prior to the bullet leaving the barrel.

In the past, small arms performance has been limited by the powder's ability to completely burn by the time the bullet exits the muzzle. To attempt to get higher performance, high charge weights of a slow burning powder were used to attempt to maximize muzzle velocity. Powders were not progressive enough to allow these heavy charges of slow powder to be completely burned by the time the bullet left the muzzle, especially with lighter weight bullets. The end result was very modest increases in velocity with heavy recoil and many times unacceptable accuracy. Superformance powders solve this problem because of their ability to completely burn by bullet muzzle exit. All loads are designed to fill the cartridge case. Yet, because of the efficient burning characteristics, virtually all the powder is burned by bullet muzzle exit. This results in a much higher percentage of the available powder energy being transferred to the projectile, rather than being blown out the end of the barrel as unburned powder, producing higher velocities with a smaller charge weight. This also results in lower muzzle exit pressure and lower velocity of muzzle gases. A very useful by-product of the highly efficient burning nature of these powders is very small velocity loses with shorter barrel lengths. We tested a 300 Winchester Magnum load by firing it in a barrel that had been shortened to 20 inches. The Superformance ammunition gave up an average of only 18 fps per inch. This is roughly 1/3 to 1/2 the velocity loss per inch of barrel length that would be experienced with conventional powders in a 300 Winchester Magnum.

Superformance propellant design also produces very uniform performance in extreme weather conditions. Most Superformance loads lose very little or no velocity at low temperature and gain very little or no velocity at high temperatures. The performance and point of aim will not change drastically in extreme temperature situations. For a Superformance 30-06 150 gr SST load the performance was as follows; +70 deg F: 3,071 fps @ 56,800 psi; +140 deg F: 3,128 fps @ 61,400 psi; -15 deg F: 3,022 fps @ 58,100 psi. From the African plains to the freezing Arctic, Superformance will deliver consistent performance.

Performance Details

Figure 1. shows a comparison of Chamber Pressure vs. Time for Custom, Superformance and Light Magnum ammunition in 30-06 loaded with a 150 gr SST bullet. As can be seen from the graph all loads produced approximately the same pressure but have widely different charge weights and velocity performance. There is considerably more area under the curve for both Superformance and Light Magnum. This is where the increase in performance comes from. One detail to note is that the Superformance chamber pressure has dropped to at or below that of the Custom ammunition by the time the bullet exits the muzzle. This shows the highly progressive burning characteristics of the powder and its ability to completely burn. As noted above, the charge weights which go along with the different loads and the performance achieved with them are quite different. Custom is loaded with 58.5 grs of powder, Superformance 61.0 grs and Light Magnum 67.0 grs. Superformance ammunition produces significantly higher velocities than Custom with only a small amount more powder and the same velocity as Light Magnum with significantly less powder.

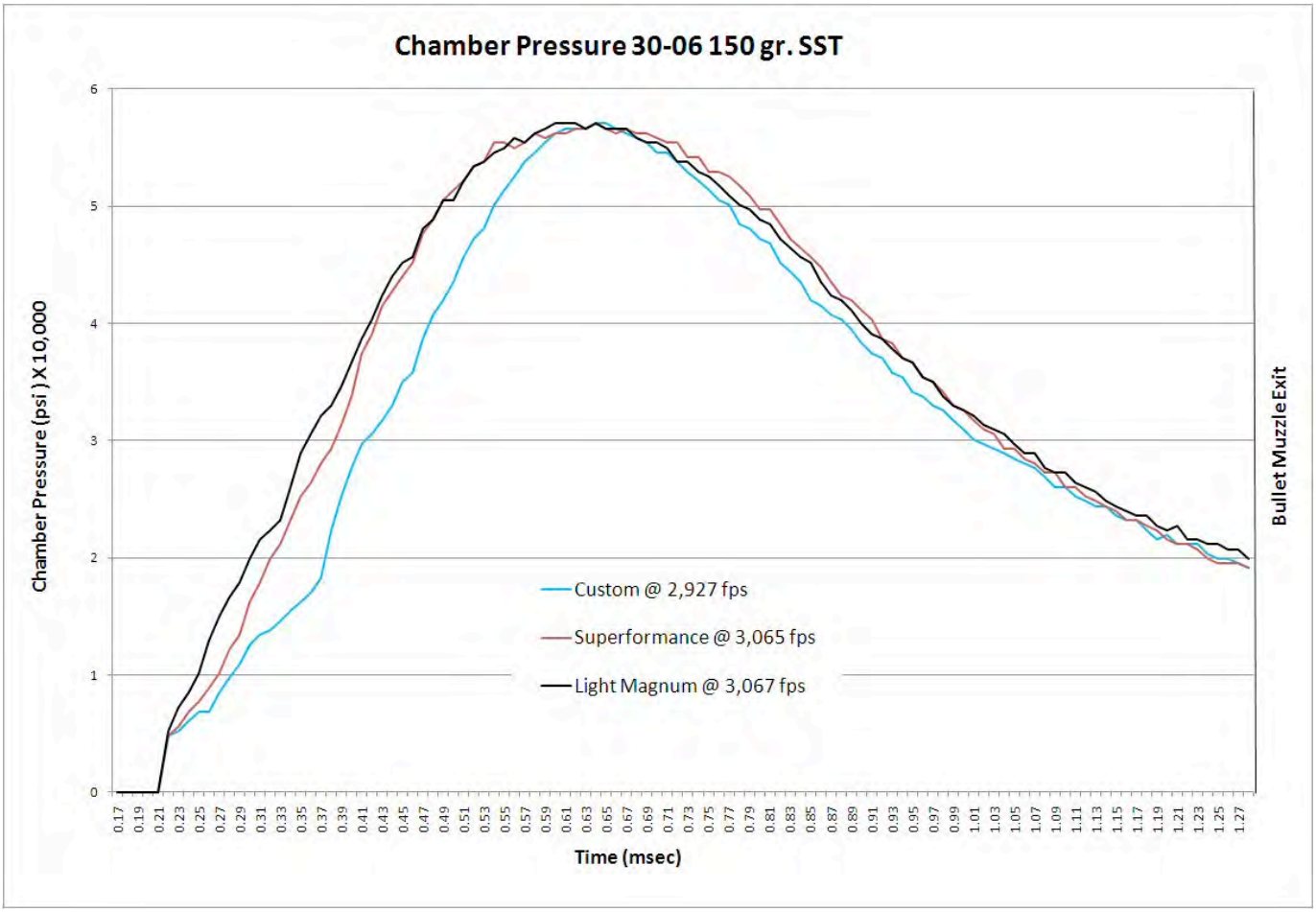

Fig 1.

Figure 2. shows the comparison of Muzzle exit pressure for Custom, Superformance and Light Magnum. The maximum muzzle exit pressure for Superformance falls in between that of Custom and Light Magnum. However, the muzzle exit pressure for Superformance quickly drops to the same level or less than Custom and is always less than Light Magnum. This is caused by the highly progressive burning nature of the Superformance powder and its ability to completely burn. The lower muzzle exit pressure along with the rapidly dropping chamber pressure results in lower velocity gases at the muzzle which reduces the recoil of Superformance ammunition.

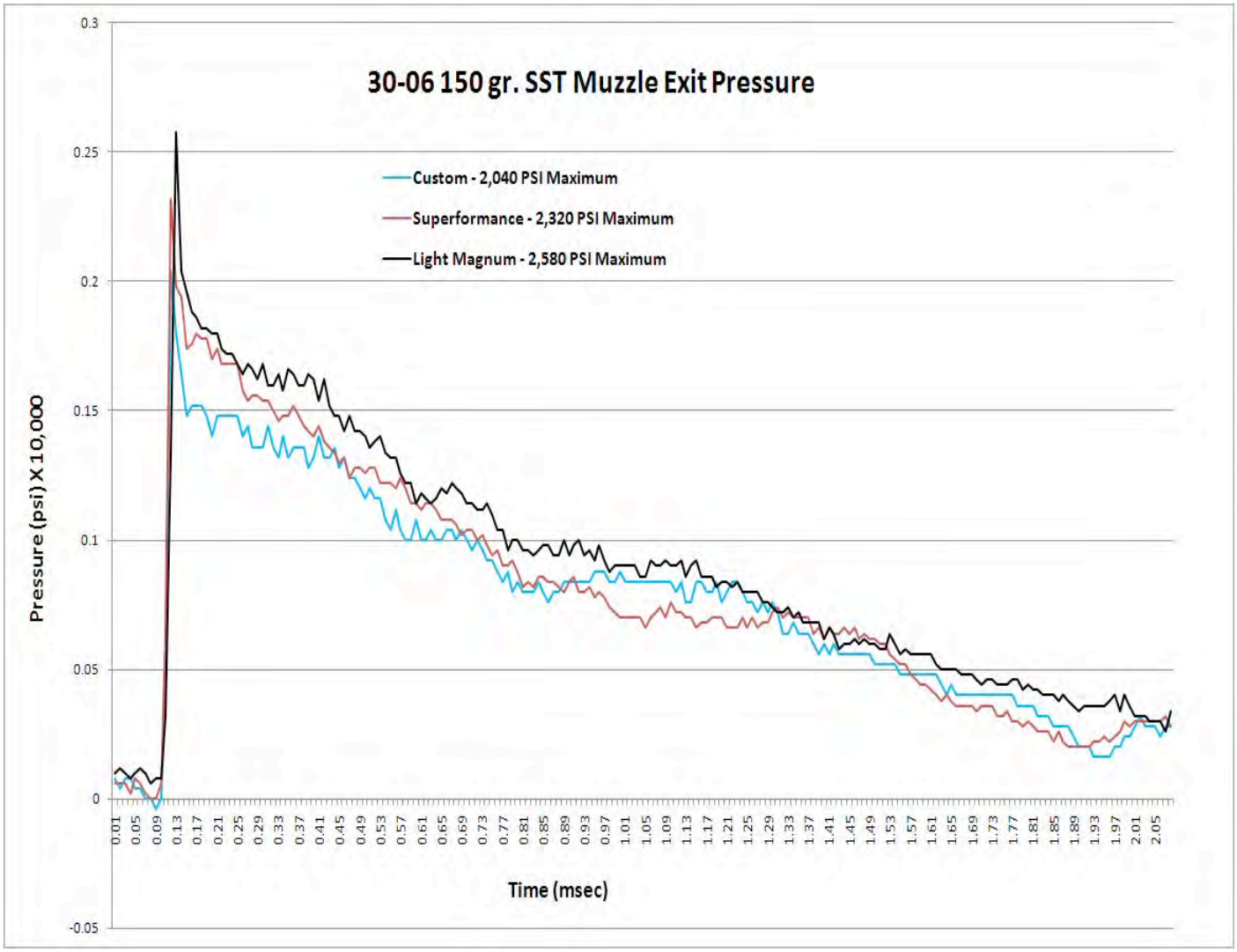

Fig 2.

Recoil discussion

Recoil is a complicated discussion that has parts to it that are not commonly understood. The fundamental misunderstanding of recoil is that the recoil is over when the bullet leaves the barrel. In truth, the vast majority of recoil occurs after the projectile exits the barrel. By far the greatest percentage of recoil is produced by the force of the gases and propellant residue/ejecta leaving the barrel. Consider for a moment what is really happening, the mass that existed in the solid propellant before the round was fired doesn't disappear, it is converted into another form of matter, gas. This gas, although you may not be able to see it or touch it, still has mass and energy. The real contribution to recoil from this gas comes from the fact that it is leaving the barrel at velocities on the order of 8,000 – 10,000 fps. The energy in these high velocity gases is what produces the lion's share of recoil. It's easier to picture what is happening if you think of the muzzle as a rocket nozzle. If the amount of gas, gas pressure, and gas velocity, of these exiting gases can be reduced this will reduce the force exerted on the gun by the gases and reduce recoil. This is exactly what has been accomplished with the Superformance propellants and ammunition.

Figure 3. shows the entire recoil process and it's relationship to what is happening inside the barrel. A standard SAAMI test barrel was set up with a chamber pressure and muzzle exit pressure transducer. The test fixture the barrel is mounted in rests on a linear bearing which does not allow the recoiling parts to move in any other direction other than straight back. A force transducer was set up between the recoiling parts and a fixed hard point. All measurements are relative to a common start trigger so that the relative timing of events could be observed. For this test a round of Superformance 30-06 150 gr SST ammunition was used. For the following discussion it is helpful to note that 1 msec is one one-thousandth of a second. The graph shows the projectile exits the barrel very early on, 1.46 msec into the recoil process. From this point on until the muzzle exit pressure drops to zero at 5.68 msec, indicating all the gases have left the barrel, any additional recoil force added to the system is because of the gases leaving the barrel. The recoil force after the muzzle pressure reaches zero is simply the final momentum transfer from the remaining recoil velocity. This graph shows that approximately 85 - 90% of the recoil happens after the projectile has left the barrel. The internal ballistic event lasts 1.46 msec while the recoil event lasts 8 msec!

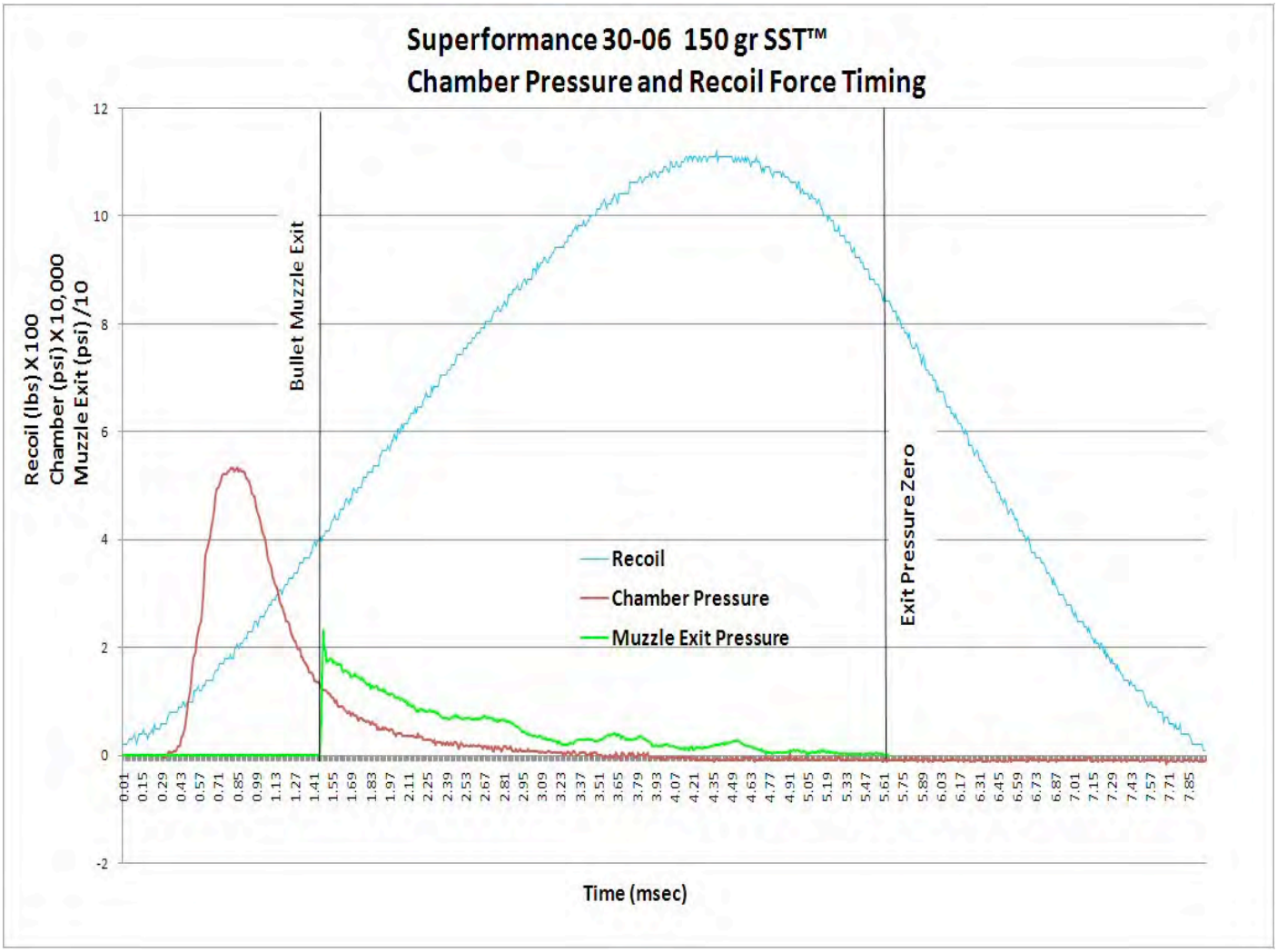

Fig 3.

Figure 4. shows a graph of the recoil force for Custom, Superformance and Light Magnum. Although Superformance produces more recoil than Custom it rapidly drops to at or below Custom recoil levels on the back side of the curve, showing it's efficient burn out characteristics. Superformance produces significantly less maximum and total recoil impulse than Light Magnum yet produces the same velocity. You have to shoot Superformance ammunition to appreciate how much more comfortable it is to shoot than previous high performance ammunition.

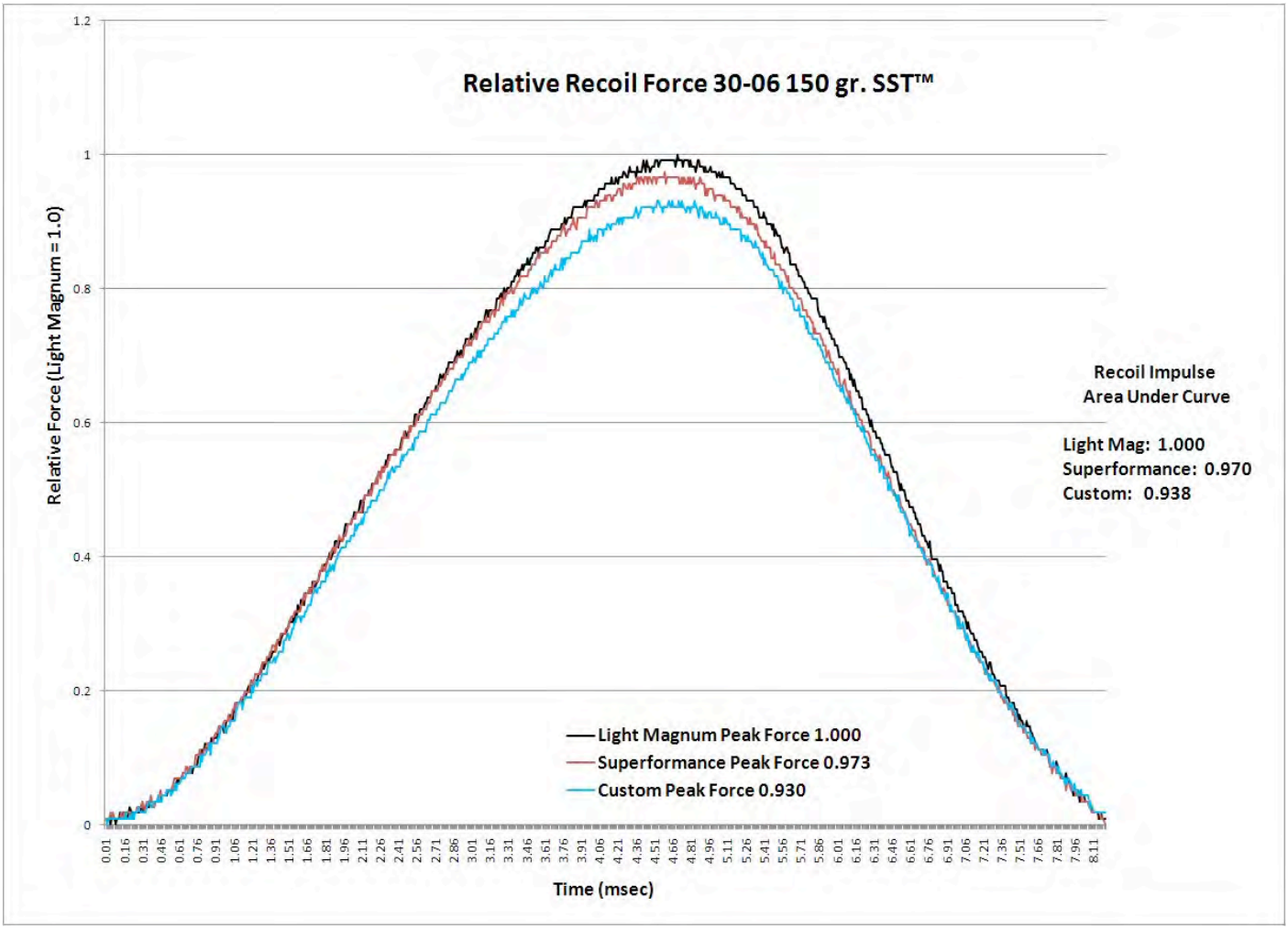

Fig. 4

Comparative testing

Table 1. diplays a comparative test between several types, calibers and manufacturers of ammunition to Superformance. All testing was done in SAAMI specification test barrels per SAAMI procedures. All velocities listed are measured at 15 feet from the muzzle of the barrel. All pressures listed are measured per the SAAMI conformal chamber pressure method. All test barrels were calibrated with SAAMI reference ammunition prior to testing. All other brands of ammunition were purchased at local retail outlets. **SAAMI MAP** is the SAAMI Maximum Average Pressure specification for each cartridge listed.

	SAAMI MAP	BULLET WT	PRESSURE	INST VEL	BULLET
243 WINCHESTER	60,000				
HORNADY		**80**	**57,300**	**3,397**	**GMX**
WINCHESTER		80	61,000	3,448	SP
FEDERAL		85	60,400	3,263	TRIPLE SHOK
HORNADY		**95**	**55,700**	**3,178**	**SST**
WINCHESTER		95	55,500	3,097	BALLISTIC S.T.
270 WINCHESTER	63,000				
HORNADY		**130**	**59,700**	**3,188**	**SST**
REMINGTON		130	59,500	3,007	CORE LOKT
WINCHESTER		130	57,700	3,030	S.P.
FEDERAL		130	60,700	3,068	TRIPLE SHOK
HORNADY		**130**	**61,000**	**3,182**	**GMX**
30-06 SPRINGFIELD	60,000				
HORNADY		**165**	**58,000**	**2,938**	**SST**
REMINGTON		165	59,200	2,781	CORE LOKT
REMINGTON		165	59,900	2,800	ACCU TIP
WINCHESTER		165	58,100	2,788	FAIL SAFE
FEDERAL		165	58,100	2,780	TRIPLE SHOK
HORNADY		**165**	**58,100**	**2,920**	**GMX**
300 WIN MAG	64,000				
HORNADY		**150**	**61,200**	**3,400**	**GMX**
REMINGTON		150	57,700	3,232	CORE LOKT
FEDERAL		165	63,200	3139	TRIPLE SHOK
HORNADY		**165**	**60,700**	**3,240**	**GMX**
FEDERAL		180	61,500	3,001	HOT CORE
HORNADY		**180**	**59,600**	**3,112**	**SST**
WINCHESTER		180	54,400	2,934	POWER PT.

Table 1.

Table 2. displays the complete Superformance line of ammunition for 2010.

CARTRIDGE	BULLET WT	SAAMI M.V.	LT MAG M.V.	MUZ VEL	BULLET
243 WIN	80	3335	N/A	3425	GMX
	95	3060	3100	3185	SST
6 mm REM	95	N/A	N/A	3235	SST
257 RBTS +P	117	2770	2940	2945	SST
25-06 REM	100	3220	N/A	TBD	GMX
	117	2985	3110	3110	SST
6.5 CREEDMOOR	120	N/A	N/A	TBD	GMX
	129	N/A	N/A	2950	SST
270 WIN	130	3060	3215	3200	SST
	130	3060		3190	GMX
	140	2960	3100	3090	SST
7 X 57	139	2660	2830	2760	SST
	139	2660	N/A	2740	GMX
7 - 08 REM	139	2855	2990	2960	SST
	139	2855	NA	2920	GMX
280 REM	139	2995	3110	3100	SST
	139	2995		3080	GMX
7 mm MAG	139	3160	3250	3240	SST
	139		N/A	3190	GMX
	154	3045	N/A	3100	SST
	162	2950	N/A	3030	SST
308 WIN	150	2810	3000	3000	SST
	150	2810	2810	2940	GMX
	165	2680	2880	2840	SST
	165	2680	2680	2750	GMX
30 TC	150	3000	N/A	3000	SST
	165	2850	N/A	2850	SST
30-06	150	2910	3100	3085	SST
	150	2910	NA	3085	GMX
	165	2800	3015	2965	SST
	165	2800	NA	2945	GMX
	180	2700	2880	2825	SST

CARTRIDGE	BULLET WT	SAAMI MV	LT MAG M.V.	MUZ VEL	BULLET
300 RCM (20")	150	3170	N/A	3220	SST
	150	3065	N/A	3175	GMX
	165	3030	N/A	3090	SST
	165	3030	N/A	3040	GMX
	180	2900	N/A	2950	SST
300 RCM (24")	150	3300	N/A	3310	SST
	150	3200	N/A	3265	GMX
	165	3140	N/A	3185	SST
	165	N/A	N/A	3130	GMX
	180	3000	N/A	3040	SST
300 WIN MAG	150	3285	N/A	3400	GMX
	165	3120	N/A	3170	IB
	165	3120	N/A	3260	GMX
	180	2960	3100	3130	SST
338 RCM (20")	185	N/A	N/A	2880	GMX
	200	2850	N/A	2850	SST
	225	2680	N/A	2680	SST
338 RCM (24")	185	N/A	N/A	2980	GMX
	200	2950	N/A	2950	SST
	225	2745	N/A	2745	SST
338 WIN MAG	185	N/A	N/A	3085	GMX
	200	2950	N/A	3030	SST
	200	2950	N/A	TBD	GMX
	225	2780	2950	2845	SST
375 H&H	270	2690	2870	2800	SP-RP
	300	2525	N/A	2670	DGS
	300	2525	N/A	2685	DGX
375 RUGER	270	2840	N/A	2840	SP-RP
	300	2660	N/A	2660	DGS
	300	2660	N/A	2660	DGX
458 WIN MAG	500	2020	2140	2140	DGS
	500	2020	2140	2140	DGX

Table 2.

At this point it is necessary to caution that you may not get the same results shown in the table above. These are factory ballistics for 24", unless otherwise noted, SAAMI **minimum** specification test barrels. Production firearms do not necessarily have minimum specification bore and groove dimensions nor chambers. This is because of the need to have dimensional tolerances in mass production and to maximize tool life. Tolerances will vary between manufacturers. The tolerance range for a specific manufacturer will allow the actual dimensions from rifle to rifle to be different. If the chamber, and bore and groove dimensions of a rifle are near SAAMI **maximum** the velocities it produces will be appreciably slower than those listed in **Table 2**.

As an illustration of this, **Table 3** lists the 15 foot instrumental velocity of the 30-06 165 gr SST Superformance load in 5 different rifles across four different manufacturers. Notice even the barrel lengths are different.

Manufacturer/Model	**Barrel Length (in)**	**15" velocity (fps)**
Mossberg / 4 x 4	24	2,955
Savage / 116	22	2,943
Thompson Center / ICON	24	2,953
Thompson Center / ICON	24	2,938
Winchester / M70	24	2,893

Table 3.

To properly evaluate ammunition performance in your rifle you should compare your current ammunition's performance to Superformance in your rifle. Although we have tested rifles that gave lower velocities they consistently produced the velocity differences between SAAMI standard and Superformance in **Table 2.**

Superformance ammunition is the only ammunition that truly produces 21st Century performance.