Miscellaneous Questions #11

This section contains brief discussions of various ballistics and shooting related topics as requested by correspondents. If you have a question you have been trying to find an answer to (keep 'em ballistics and shooting related--see your minister for the mysteries of life) email me by clicking here and I'll do my best to find the answer for you and if it is of general interest, publish it here. If you can contribute additional input to one of the answers I'd would appreciate hearing from you too.

Check back frequently as new topics are always being added.

On this page:

Q. What is +P and +P+ ammunition?

A. "Plus P" and "Plus P Plus" ammunition is simply ammunition loaded to higher than normal SAAMI (Sportings Arms & Ammunition Makers Institute) pressure specifications. "Plus P-ing" was first done with law enforcement pistol ammunition in an effort to wring the last bit of power out of a cartridge. For most rounds the gain in performance is minimal and leads to increased wear and tear on the firearm. The +P+ ammunition is loaded to even higher pressure levels than +P. +P+ loadings are generally limited to "law enforcement sale only." The SAAMI pressures for pistol ammunition are given below. Note that there are no SAAMI specifications for +P+ loads, but by general industry agreement they are about 15 percent greater than +P. Note that there are no SAAMI specifications for +P pistol loads other than those shown below. (The .38 Super is frequently listed as "+P" but that is just to differentiate between the "Super" round and the original .38ACP round.)

The table below gives an idea of what some common +P and +P+ loads do. (Velocity data varies with manufacturer. I have chosen to use the high end figures.) Pressures are given as PSI (piezo transducer).

	Standard Load		+P Load		+P+ Load (Not SAAMI)		Proof Pressure	
	Approximate Velocity	Pressure (PSI) (Max Avg)	Approximate Velocity	Pressure (PSI) (Max Avg)	Approximate Velocity	Pressure (PSI) (Max Avg)	Minimum Allowable PSI	Maximum Allowable PSI
9 mm 115 gr 9 mm 125 gr	1220 1140	35,000	1280 1200	38,500	1335 1250	42,000	52,000	55,000
.38 SPL 125 gr .38 SPL 158 gr	850 780	17,000	945 910	18,500	1000 950	22,000	25,000	27,500
.45 ACP 185 gr .45 ACP 230 gr	960 850	21,000	1140 990	23,000	n/a	n/a	31,000	33,000

257 Roberts 110 gr 257 Roberts 115 gr	2880 2630	54,000	2980 2760	58,000	n/a	n/a	77,500	83,000

Pressure data per SAAMI

Q. What are the current ANSI/SAAMI pressure specifications for ammunition?

A. The tables below give the current maximum average pressure specifications for common commercial cartridges. Note that these specification may differ from previous ones because, unless specified otherwise, they are now based on Piezo transducer PSI measurements and not copper crusher (CUP) measurements. Piezo measurements tend to read slightly higher than copper crusher measurements as they more accurately read pressure peaks. The standards are set in the following SAAMI publications. Not all specifications have been changed to piezo measurement. The standards are available in printed format at the prices below.

#205 ANSI/SAAMI Centerfire Pistol & Revolver, Z.299.3 1993 - $30.00
#206 ANSI/SAAMI Centerfire Rifle, Z.299.4 1992 - $35.00
#208 ANSI/SAAMI Rimfire, Z.299.1 1992 - $20.00
#209 ANSI/SAAMI Shotshell, Z.299.2 1992 - $25.00
#203 ANSI/SAAMI Ammunitions Standard CR-ROM - $90.00 (the complete set)

They can be ordered from

ANSI - SAAMI
11 Mile High Rd
Newton, CT 06470
203-426-1320
Contact Coleen Swayne and ask for the ANSI Ammunition Specification publications.

The tables below were excerpted from those publications.

Under ANSI/SAAMI procedures, for bottlenecked cases the center of the transducer is located .175" behind the shoulder of the case for large diameter (.250") transducers and .150" for small diameter (.194") transducers. For straight cases the center of the transducer is located one-half of the transducer diameter plus .005" behind the base of the seated bullet. Small transducers are used when the case diameter at the point of measurement is less than .35".

The rest of the world uses the Commission Internationale Permanete (CIP) standards for ammunition. Under CIP standards a drilled case is used and the measuring device will be positioned at a distance of 25 mm from the breech face when the length of the cartridge case is between 30 and 40 mm, including limits. When the length of the cartridge case is less than 30 mm, pressure measurement will take place between 5 mm and 25 mm from the base of the case depending on the size of the case. (6.35 mm for the Hornady 17 Mach 2, and 25 mm for most rifle cartridges) The difference in the location of the pressure measurement gives different results than the SAAMI standard

I am currently working on putting together a table of CIP pressure specifications.

ANSI/SAAMI Rifle Pressure Specifications (Maximum Average pressure) All Piezo measurements unless specified)			
5 mm RFM	37,000	.30-30 Winchester	42,000
.17 Rem	52,000 cup	.30-06 Springfield	60,000
.22RF Short	21,000	.30-30 Winchester (Saboted)	38,000
.22RF Long & LR	24,000	.300 Savage	47,000
.22WRF	19,000	.300 Weatherby Magnum	65,000
.22WRM	24,000	.300 H&H Mag	54,000 cup
.22 Hornet	43,000 cup	.300 Win Mag	64,000
.218 Bee	40,000 cup	.303 British	49,000
.22-250 Remington	65,000	.307 Win	52,000 cup

220 Swift	54,000cup	.308 Winchester	62,000
.222 Remington	50,000	.308 Winchester (Saboted)	52,000
.222 Rem Mag	50,000 cup	.32 Win Special	42,000
.223 Remington	55,000	.32 Rem	37,000 cup
.243 Winchester	60,000	.32-20	16,000 cup
.25-06 Remington	63,000	.32-40	30,000 cup
.250 Savage	45,000 cup	8mm Mauser	35,000
.256 Win	43,000 cup	8mm Rem Magnum	65,000
.257 Roberts	54,000	.338 Win Mag	64,000
.257 Roberts +P	58,000	.348 Win	40,000 cup
.264 Win Mag	64,000	.35 Remington	33,500
.270 Winchester	65,000	.351 Win SL	45,000 cup
.280 Remington	60,000	.35 Whelan	52,000 cup
.284 Winchester	56,000	.350 Rem Mag	56,200 cup
6mm Remington	65,000	.356 Win	52,000 cup
6 mm BR-REM	52,000 cup	.358 Win	52,000 cup
6.5x55	46,000 cup	.375 H&H	62,000
6.5 Rem Mag	56,200 cup	.375 Win	52,000 cup
7mm BR Rem	52,000 cup	.38-40 Win	14,000 cup
7mm Mauser	51,000	.38-55 Win	30,000 cup
7mm Rem Magnum	61,000	.416 Remington Magnum	65,000
7mm Weatherby Mag	65,000	.444 Marlin	44,000 cup
7mm-08	61,000	.45-70 Government	28,000
7-30 Waters	45,000	.458 Winchester Magnum	53,000 cup
7.62x39	45,000	.470 NE	35,000 cup
.30 Carbine	40,000		
.30-40 Krag	40,000 cup		

ANSI/SAAMI Pistol Pressure Specifications (Maximum Average pressure) All Piezo measurements unless specified)			
Cartridge	Pressure (Max Avg)	Cartridge	Pressure (Max Avg)
.221 Rem Fireball	52,000 cup	.38 Colt	12,000 cup
.22 Jet	40,000 cup	.357 Magnum	35,000
.25 ACP	25,000 cup	.357 Maximum	40,000
.30 Luger	28,000 cup	.40 S&W	35,000
.32 ACP	20,500	10 mm	37,500
.32 S&W Long	15,000	.41 AE	35,000
.32 H&R Mag	21,000 cup	.41 Magnum	36,000
.380 ACP	21,500	.44 Special	15,500
9 mm Luger	35,000	.44-40	13,000 cup
9.mm Luger +P	38,500	.44 Magnum	36,000
9 mm Win Mag	45,000 cup	.45 Auto Rim	15,000 cup
.38 Auto	26,500	.45 ACP	21,000
.38 S&W	14,500	.45 ACP +P	23,000
.38 Special	17,000	.45 Colt	14,000
.38 Special +P	18,500	.45 Colt (Ruger)	25,000 cup
.38-40	14,000 cup	.45 Win Mag	40,000 cup
.38 Super +P	36,500	.454 Casull	50,000 cup
.38 S&W	13,000 cup	.50 AE	35,000

ANSI/SAAMI Shotgun Pressure Specifications (Maximum Average Pressure in PSI) All Piezo measurements unless specified)	
Cartridge	Maximum Average pressure
10 gauge	11,000 (all)
12 gauge	11,5000 (all but 3 1/2" mag)
12 gauge 3 1/2" mag	14,000
16 gauge	(11,500 (all)
20 Gauge	12,000 (all)

28 gauge	12,500 (all)
.410 Bore 2 1/2"	12,500
.410 Bore 3"	13,500

New statistical data analysis suggests that for *most* cartridges ANSI/SAAMI Maximum Average Piezo (PSI) and Maximum Average copper crusher (CUP) can be related by the following formula which has an R^2 value (a statistical measurement of certainty) of .927.

(1.51586 * CUP) - 17902.0 = PSI

While the relationship is generally within 3Kpsi (it assumes that the CUP was determined using ANSI/ SAAMI standards) one should not rely on this conversion for absolute maximum loads. This conversion is only applicable to rifle ammunition.

Comparison of Pressure Specifications Between Copper Crusher and Piezo ANSI/ SAAMI Specifications for .308 Win.			
	Max Average Pressure	Max Probable Lot Mean	Max Probable Sample Mean
Copper Units of pressure (CUP)	52,000	53,300	55,300
PSI (Piezo)	62,000	63,600	66,000
PSI Converted from CUP	60,922	-	-

Interestingly the correlation between the European CIP CUP measurements and Piezo measurements has an even better correlation with an R^2 of .997. The formula for the CIP conversion is

(1.20911 * CIPCUP) - 2806.88

The same warning about using this conversion for maximum load work and its being applicable to rifle ammunition only applies to this formula. too

For a detailed analysis of the origin of these formulas see the article "Correlating CUP and PSI" on RSI's Tech Information Page at www.shootingsoftware.com.

Q. How are proof pressures determined?

A. US commercial proof pressures are set by SAAMI specifications. The current standards for proof pressures are shown below. Military proof load standards are set by the arsenals and government specification and may or may not be the same as SAAMI.

	Multiply Max Probable Lot Mean Pressure by*	
Cartridge Class	Minimum Proof*	Maximum Proof**
Shotshell	1.55	1.70
Centerfire Rifle	1.30	1.40
Centerfire Pistol 15,000 psi or less	1.40	1.55
Centerfire Pistol 15,100 - 18,000 psi	1.35	1.50
Centerfire Pistol 18,100 - 21,000 psi	1.30	1.45
Centerfire Pistol 21,100 psi or greater	1.30	1.40
Rimfire	1.25	1.40

* Max Probable Lot Mean is calculated by adding two standard errors to the Max Average pressure. The "standard error is calculated by the standard deviation of the sample by the square root of the size of the sample. **For all intents and purposed just use the Max Avg Pressure.**

* Min Proof values rounded UP to nearest 500 psi.

** Max Proof values rounded DOWN to nearest 500 psi.

Q. What is the Hatcher Formula?

A. The Hatcher Formula is a mathematical formula use to evaluate the approximate effectiveness of pistol ammunition in incapacitating a person shot with it. It was developed by Gen. Julian Hatcher in the 1930s and uses the bullet momentum, bullet frontal area, velocity, and a form or shape factor. It was derived from his observations of the effects of pistol ammunition on cadavers and steers. While it does not take into consideration bullet penetration or expansion and is basically an approximation, it is still a good formula to use to give one an idea of how a given round will stack up as a fight stopper.

The original formula was somewhat cumbersome to use and the formula was:

$$RSP = M_B * A * F$$

where

RSP = Relative Stopping Power Index
M_B = Momentum of the bullet in pound feet - $(W_B/450240) * V$
(If you know the kinetic energy and the velocity you can divide the KE by the velocity to get the momentum.)
A = Area of the bullet in in^2
F = Form factor derived from the chart below.

Note: In the text of Textbook of Pistols and Revolvers the original formula given in the text contained an error in math (he used 240,125 or 1/2 the correct number as the divisor and thus if the text is followed you will get values double the correct ones. The table for the momentum calculations is, however, correct in the book.

A more convenient variation of the original formula which eliminate working with big numbers is:

$$RSP = (W_B * V * A * F) / 1000$$

where

RSP = Relative Stopping Power Index
W_B = the bullet weight in grains
A = Area of the bullet in in^2
V = the bullet velocity in feet per second (f/s)
F = Form factor derived from the chart below.

In the form factor table below the entries in red are recent approximations for bullet types not originally listed by Hatcher. **For Hatcher's original formula the numbers below should be multiplied by 1000 before using.**

Bullet Type	"F"		Bullet Type	"F"
Fully Jacketed Pointed	.7		Lead Flat Point (Large Flat)	1.1 - 1.2
Fully Jacketed Round Nose	.9		Jacketed Softpoint (unexpanded)	1 - 1.1
Fully Jacketed Flat Point	1.05		Jacketed Softpoint (expanded)	1.35
Fully Jacketed Flat Point (Large flat)	1.1		Lead Semi-wadcutter	1.25
Lead Round Nose	1		Hollow Point (unexpanded)	1.1
Lead Flat Point	1.05		Hollow Point (expanded)	1.35

Note that the results obtained by this "short form" are not numerically equal to the original formula (they are about half the old formula numbers) but the the comparisons between different cartridges are still valid. With this short form a value of about 14 is considered barely adequate and about 25 or greater highly desirable. With the original formula a value of 30 was considered barely adequate and 50 or greater highly desirable.

There are several "modern" variations of this formula floating around. One variation sometimes

seen is to multiple the results by 0.9 if penetration in test media is less than 10" and by 1.1 if penetration is greater than 10". Another one uses the average area of the "expanded" bullet (area of minimum expanded diameter + area of maximum expanded diameter) / 2, as the bullet diameter and no form factor is used.

For your enjoyment the table below lists the frontal area of common pistol calibers.

Bullet Caliber	Area (in^2)
.22	.039
.25	.052
.30	.074
.32	.076
9 mm	.099
.38 / .357	.101
.40 / 10 mm	.125
.41	.132
.44	.146
.45 ACP	.160
.45 Colt	.161

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