8.3 FACTORS OF SIGHTING ERROR

Benchrest shooters have moved to 36 X telescopic sights and sometimes scopes with even higher power. We know (or think we know) that using high powered telescopic sights allows us to shoot smaller groups than when using iron sights. But, and there's almost always a but-there is some suggestion that iron sights can be used to shoot some very small groups.

At the Old Colony Sportsman's Association in Pembroke, MA, there is a Winter League Match shot every Sunday from November to March at 200 yards, offhand, at the military 200 yard target, from a heated shooting house. The black is 13", 10 ring is 7" and the X ring is 3". The categories are Iron Sights, Any Sights, Howes (10# rifle, 3# trigger, flat butt), Over 40 Caliber, Rimfire and Single Shot Rifle. The best target of each category is hung on the wall, so that at any time one may compare the best scores shot with, for example, Irons and Any Sights. By Christmas the scores are in the middle 190's. I have been surprised to see that the Iron Sights categories do not lag the Any Sight = Scope categories by much; sometimes not at all.

In the ASSRA matches, I believe that it was Dick Hughes that shot the first 250 at 200 yards with Iron Sights a few years ago. The 25 ring on the German Ring target is 1 3/4". Several other 250 scores have been shot since. I remember watching Jerry Ventura shoot the first record 250 with a scope on a Model 44 Stevens at Western New York/Alabama Hunt Club, maybe a dozen years ago. So the Irons aren't a great handicap.

And as a last example; I have found that I can shoot surprisingly small bench 100 yard groups with a good peep rear sight and an aperture-or even sometimes a leaf-front.

So-what effect do sights have on potential accuracy?

In The American Rifleman, April 1977, there is the article titled "Factors Of Sighting Error" by L.F. Moore that describes the results of testing conducted at Aberdeen Proving Ground with various sights and conditions. I've read this article many times since 1977, and consider the results very interesting and the article virtually incomprehensible. Since the work was done at Aberdeen, at Government expense, I feel no qualms about using the data from that article. The test was designed to measure the dispersion about the center of the target with various sights.

The tests were done with the sights/rifles in a machine rest, a target at 100 yards that was moved with a synchro-torque transmitter-receiver system, an electrical spark system that marked the target paper on command, and several shooters. The target was moved out of alignment with the sights, the shooter looked through the sight and aligned the target with the sight using knobs for up down and left-right and pressed a button that burned a small hole in the target. This was repeated for a series of "shots", the burned holes in the target forming a "group". These groups were measured and the Mean Radius (MR) was calculated and graphs were constructed using the MR data.

I interpolated the MR data from the graphs in the article. Since MR doesn’t mean much to me, the MR values were turned back into 5 shot 100 yard group sizes that I am familiar with. Jeroen Hogema of the Netherlands found, through some terrifying statistical analyses, that for 5 shot groups, group size = 2.5 X MR, so groups averaging 1" MR would have a group size of 2.5". Thanks again, Jeroen.

The information that I think is of particular interest is shown here in tabular form. The test identification numbers (Test # 7) are from the original article.

TEST #7	TEST #7	TEST # 2	TEST # 2	TEST # 3	TEST # 3	TEST # 5	TEST # 5	TEST #6	TEST #6
		FRONT		REAR				FROM	
	5-SHOT	SIGHT	5-SHOT	SIGHT	5-SHOT	FROM	5-SHOT	FRONT	5-SHOT
	GROUP	APERTURE	GROUP	APERTURE	GROUP	REAR	GROUP	SIGHT	GROUP
SIGHT	DIA.	DIAMETER	DIA.	DIAMETER	DIA.	SIGHT	DIA.	TO EYE	DIA.
TYPE	(INCHES)	(INCHES)	(INCHES)	(INCHES)	(INCHES)	TO EYE	(INCHES)	(INCHES)	(INCHES)
8X Scope	0.125	0.14	0.200	0.03	0.200	1	0.175	50	0.125
2.5 X Scope	0.250	0.135	0.175	0.04	0.150	2	0.125	40	0.125
1 X Scope	0.500	0.125	0.175	0.05	0.175	3	0.125	35	0.125
M1	0.575	0.115	0.175	0.06	0.200	4	0.125	30	0.150
M14	0.625	0.105	0.200			8	0.250	25	0.200
M760	0.700	0.095	0.225			16	0.575	20	0.300
M2	0.850	0.085	0.300					15	0.475
M94	1.175	0.075	0.350					10	0.925
M70	1.200	0.065	0.475						
M99	1.225								
M760	1.275								
M12	1.675								

Notes on these tests:
Test 2, "Effect Of Size Of Front Sight Aperture On Dispersion" Rear Sight .046" aperture

Test 3, "Effect Of Diameter Of Rear Sight Aperture And Dispersion" Front sight .125" aperture.

Test 5, "Effect Of Location Of Rear Sight And Dispersion".
Rear sight aperture varied to suit, front sight .125" aperture

Test 6, "Effect Of Location Of Front Sight On Dispersion" Rear sight .042" aperture, front sight 13 MOA aperture. Note that this test measures the effect of the distance between sights on dispersion. After 25", which with 2" from rear sight to eye leaves 23" between sights, the reduction in dispersion is minor.

Test 7, Effectiveness Of Various Types Of Sights
First Telescopic sights; then the M1, M14, M760 and M2 Carbine sights are aperture rear and post/bead front; the M94, M70, M99 and M760 are "open" sights, and the M12 had a shotgun bead front only.

The other tests:
Test 1 "Effect Of Learning On Dispersion" showed that dispersion was reduced as the number of trials increased. But not much, from .312" group diameter at the first try, down to .15" group diameter after 40 tries.

Test 4 "Effect of Target Type On Dispersion" showed dispersion varying from .15" group diameter on the NRA Smallbore Rifle Target to .375" group diameter on the "Game" target; with .042" aperture rear and .125" aperture front - 34" between sights.

Test 8 "Effect Of Illumination On Dispersion" showed that in almost-darkness, with an M1 rifle, dispersion is large - about 1.5" group diameter; and with a 2.5 X telescope it is only .325" group diameter. Given some light, from about 2 candles per square foot to 30 candles per square foot, The M1 rifle dispersion is about .55"-.675" group diameter, and the 2.5 X telescope dispersion is pretty flat at .175" group diameter.
This test shows that we can't aim very well in the dark, that with a little light we can aim pretty well, and that we can aim more precisely with a telescope than with iron sights. Few surprises.

Test 9 "Effect Of Target Type On Dispersion" First, with an M1 rifle, dispersion varied from .70" group diameter to .95" group diameter as target type varied from NRA Smallbore Rifle to "Game". Then, with an 8X Telescope, dispersion was .15" group diameter on the NRA Smallbore Rifle target, and .20" group diameter on the "Game" target. The author points out that *"The smallest dispersion with match-type aperture front and rear sights was obtained with a round aiming point, approaching the small dispersion obtained on the same target with the 8X telescope, and actually surpassing the performance of the 2.5X telescope"*

Test 10 showed no difference in dispersion as sight finish was changed on an M1 rifle-normal finish or no finish on the sights, then sights blackened with a carbide lamp, and then with a red translucent front sight.

Test 11 is hard to follow, but seems to show that tight fit between the stock and the shooter's face reduces dispersion.

Test 12 "Effect Of Mirage On Dispersion" shows dispersion varying from .075" group diameter with a 20X Lyman STS telescope to .175" group diameter in heavy mirage with target iron sights.

There are several factors affecting accuracy, and the relationship between these factors is slightly complex. Let's say that there are rifle, ammunition and sight factors affecting accuracy. Then group size is the square root of the sum of the squares of the dispersion due to these factors. For example:

with a perfect rifle and ammunition the sights would cause a 2" group
with a perfect rifle and sights the ammunition would cause a 2" group
with perfect sights and ammunition the rifle would cause a 2" group

Expected group size = the square root of (2"X2" ammunition)+(2"X2" rifle)+(2"X2" sights)
= the square root of (4+4+4) = 3.46"
Now let the sights error fall to zero. Expected group size = the square root of (4+4)= 2.82"

This, at least for me, isn't intuitive or expected, but it seems to be true. I first read it in Harold Vaughn's book, and have encountered this relationship several other places since.

I got my copy of the original article from Rudi Prusok, ASSRA archivist. He can supply copies.

The work on MR and group size done by Jeroen Hogema is too frightening for this article.