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DISPERSION VERSUS CYCLIC RATE TEST OF 4.32MM CARTRIDGE

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An adjustable brake compensator was used to control, and minimize, round-to-round dispersion of three rounds fired serially in a burst from a rifle. Two weapons, an M16 and a SPIW, were rebarreled to fire 4.32mm ammunition. The impulse levels during the test were on the order of 0.57 pound-seconds. Only the SPIW was further modified to permit external control of firing rate. Ten subject soldiers fired the M16 from the prone and standing positions at its natural rate, and the SPIW from the standing position at 1500 and 800 rounds per minute (rpm). The mean extreme spread (MES) for the SPIW was 10.1 mils at 1500 rpm and 13.1 mils at 800 rpm. For the M16

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prone position the MES was 10.2 mils, and 14.7 mils for the standing. It was concluded that a tunable brake compensator will reduce dispersion; however, the gain in reduced MES is not proportional to the reduction of impulse levels.

Technical Note 8-74

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INTRODUCTION

As part of the Future Rifle System (FRS) Program, the U. S. Army Human Engineering Laboratory (HEL) conducted a field experiment to determine whether the dispersion requirements of FRS could be met by a rifle firing a 4.32mm cartridge, in three-round bursts, at cyclic rates between 800 and 1600 rounds per minute (RPM). The weapons used in this test fired a 4.32mm cartridge. The impulse level, depending on the adjustment of the muzzle brake-compensator, ranged from approximately 0.5 to 0.8 pound per second.

METHOD

Subjects

Eleven U. S. Army enlisted men, grades E2 through E6, served as subjects. Each subject had received Army Basic and Advanced Individual Training and had qualified with the M16 rifle. The average height of the subjects was 5 feet 10 inches and the average weight was 164 pounds. All subjects were right-handed.

Apparatus

The experiment was conducted at the Bullet-Trap Range, Aberdeen Proving Ground, MD, from 22 July through 2 August 1974.

The targets were a series of numbered 1-inch bulls spaced about 4 feet apart on a roll of white Kraft paper 4 feet wide. The roll was mounted on a frame 25 meters from the firing point and remotely unrolled to expose one target bull at a time. Only one trigger pull was fired at each bull. The rounds were color-coded by coating the cartridge projectile with printer's ink. The first round was not colored; the second was colored green; the third red.

HEL designed and built a cylindrical muzzle brake-compensator with adjustable double-slit openings on half (top) of the circumference, and set screw holes along the opposite half-side of the cylinder (Fig. 1). The front plate had only a small opening large enough to permit the projectile to exit. Weight of the device was approximately 7-1/2 ounces. Opening the double slot or screw holes varied the amount and direction of firing gas deflection. Thus the device could be set (tuned) to provide needed compensation and braking to minimize dispersion.

Two weapons were used during the test. The first was a SPIW rifle, modified to fire the 4.32mm cartridge. The modifications also included provisions for electronically controlling the firing rate. Simply, the sear release was controlled by a solenoid which responded to selected pulse rates initiated by external electronics when a microswitch was activated by pulling the rifle trigger. The second weapon was an M16, modified to fire the 4.32mm cartridge. No provisions were made to vary the firing rate. Both weapons were fired in the automatic mode.

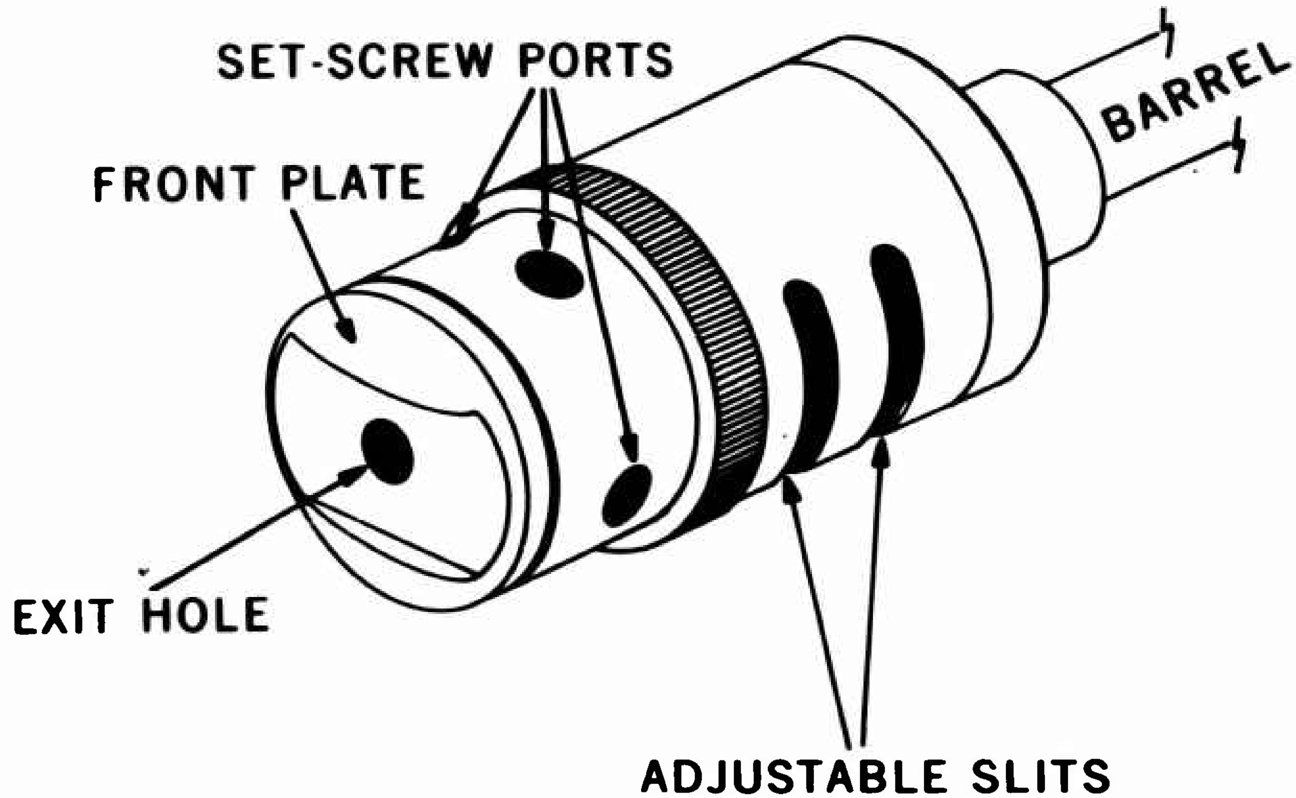

Fig. 1. Cylindrical muzzle brake compensator

Procedure

The muzzle device was tuned to minimize dispersion for each firing rate and firing position. The subjects fired in rotation and adjustments were made to the muzzle device until the average dispersion was minimized for the 10 subjects. Once a minimum average dispersion was visually found, the muzzle device was secured for record firings. All the firings with the SPIW weapon were done from the standing position. The subjects fired in rotation, one trigger pull, until 10 trigger pulls were obtained from each subject at the selected firing rate. Similar tuning procedures were used to tune the M16; however, the device was tuned separately for the standing and unsupported prone positions. Furthermore, the subjects fired only five successive trigger pulls (at a time) in rotation, for 10 trigger pulls per subject.

Each target was manually scored to obtain first, second, and third round hit coordinates. Measurements were made to the nearest tenth of an inch with respect to the aiming point. The data were analyzed to obtain dispersions, centers of impact, and mean extreme spreads.

RESULTS

The impulse levels were measured by firing the modified SPIW rifle from a five-string ballistic pendulum. With all the control ports of the muzzle device open and the front plate in place (maximum use of firing gas for braking), the impulse level was 0.50 pound-seconds. With the front plate removed (equivalent to no muzzle device), the impulse level was 0.84 pound-seconds. The average impulse level during testing was 0.57 pound-seconds.

The offsets of the centers of impact of the first rounds about the bull and second and third rounds about the first rounds are given in Table 1. The radial dispersions of the first rounds about the bull, second and third rounds about first rounds, and third rounds about second rounds are shown in Table 2. Also shown in Table 2 are the mean extreme spreads (MES) for the different rates of fire and firing positions.

It should be noted that the modified SPIW weapon was found to be unserviceable after six trigger pulls per subject at 800 rpm. Therefore, all the 800 rpm modified SPIW data are based on six trigger pulls rather than the 10 in all other cases.

Tables 3 through 6 show the mean extreme spreads (MES) of each subject, and the high and low values about each mean. Also shown are the percent of times that each subject was within ±25 percent of his MES value.

It was decided to modify the data by subtracting the center of impacts of the second and third rounds from the raw data of the second and third round, respectively, and recalculating the radial dispersions and MES. In effect, this was similar to (numerically) obtaining a perfect average tuning of the muzzle device. The modified results are shown in Table 7.

TABLE 1

Center of Impact and Linear Standard Deviations, in Inches, of First Rounds, and Second and Third Rounds About the First Rounds

Center of Impact		SPIW Standing 1500 rpm x	SPIW Standing 1500 rpm y	SPIW Standing 800 rpm x	SPIW Standing 800 rpm y	M16 Standing Natural x	M16 Standing Natural y	M16 Prone Natural x	M16 Prone Natural y
1st about bull	Mean	1.9	-0.4	0.6	0.6	0.6	0.1	2.6	0.5
	S.D.	2.1	2.9	2.1	3.5	2.4	2.9	1.7	4.9
2d about 1st	Mean	2.7	-3.6	0.8	-5.5	-3.0	-1.3	1.4	4.8
	S.D.	2.5	3.2	4.3	4.0	6.1	4.8	3.5	4.2
3d about 1st	Mean	6.1	-1.7	2.2	-8.8	-1.1	-4.3	0.2	2.7
	S.D.	5.2	6.4	8.2	6.9	13.1	9.5	7.1	7.4

TABLE 2

Radial Error of First Round, Second and Third Rounds About First, and Third Rounds About Second

Radial Error of Rounds	SPIW Standing 1500 rpm Mean	SPIW Standing 1500 rpm S.D.	SPIW Standing 800 rpm Mean	SPIW Standing 800 rpm S.D.	M16 Standing Natural Mean	M16 Standing Natural S.D.	M16 Prone Natural Mean	M16 Prone Natural S.D.
1st about bull	3.5	2.2	3.5	2.4	3.4	2.1	4.3	4.0
2d about 1st	5.4	2.7	7.2	3.6	7.1	4.5	6.8	3.0
3d about 1st	9.2	4.7	12.5	6.2	14.0	9.0	9.1	5.2
3d about 2d	7.1	3.4	8.2	3.9	9.9	5.7	6.5	4.4
Mean Extreme Spread	10.1	4.2	13.1	5.5	14.7	8.6	10.2	4.7

TABLE 3

Mean Extreme Spreads (ES) and Range of ES, by Subjects, for the Modified SPIW Weapon Fired at 1500 Rounds Per Minute

Subject No.	Mean ES	Range of MES High	Range of MES Low	Percent of MES Within ± 25%
1	8.5	18.2	3.7	30
2	10.0	18.3	4.3	30
3	12.3	19.2	6.7	60
4	9.6	13.9	4.7	80
5A	14.9	19.7	10.5	80
5B	-	-	-	-
6	9.4	16.9	4.7	60
7	9.2	15.6	3.7	30
8	10.4	16.4	7.7	50
9	6.8	11.6	3.5	60
10	10.0	16.7	3.1	40

TABLE 4

Mean Extreme Spreads (ES) and Range of ES, by Subjects, for the Modified SPIW Weapon Fired at 800 Rounds Per Minute

Subject No.	Mean ES	Range of MES High	Range of MES Low	Percent of MES Within ± 25%
1	11.7	19.9	9.3	67
2	12.8	18.0	8.7	50
3	19.3	19.9	18.6	100
4	9.8	16.8	4.1	33
5A	18.0	31.9	6.3	33
5B	-	-	-	-
6	11.3	17.1	8.8	67
7	13.2	20.2	6.5	50
8	14.9	20.5	6.9	50
9	11.2	16.8	6.1	33
10	9.3	12.2	6.7	50

TABLE 5

Mean Extreme Spread (ES) and Range of ES, by Subjects, for the Modified M16 Fired from the Standing Position

Subject No.	Mean ES	Range of MES High	Range of MES Low	Percent of MES Within ± 25%
1	30.2	42.7	16.1	70
2	8.5	12.5	4.7	60
3	18.3	29.9	9.1	50
4	10.1	17.0	5.0	60
5A	-	-	-	-
5B	12.9	30.2	4.1	50
6	11.1	14.9	6.9	60
7	9.6	16.5	4.6	30
8	12.1	26.0	5.1	30
9	15.3	31.6	2.7	40
10	19.2	31.2	5.6	40

TABLE 6

Mean Extreme Spread (ES) and Range of ES, by Subjects, for the Modified M16 Fired from the Prone Position

Subject No.	Mean ES	Range of MES High	Range of MES Low	Percent of MES Within ± 25%
1	13.7	26.2	9.6	40
2	9.8	28.8	4.9	50
3	8.2	12.9	5.3	50
4	8.1	15.9	4.3	80
5A	-	-	-	-
5B	9.9	21.1	3.5	30
6	12.4	17.2	7.5	60
7	11.2	18.4	1.8	60
8	11.0	17.1	3.9	50
9	11.0	19.4	7.3	70
10	11.5	14.3	2.4	10

TABLE 7

Modified, for Perfect Tuning, Radial Error of First Round, Second and Third Rounds About First, and Third Rounds About Second

Radial Error of Rounds	SPIW Standing 1500 rpm		SPIW Standing 800 rpm		M16 Standing Natural		M16 Prone Natural	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1st about bull	3.5	2.2	3.5	2.4	3.4	2.1	4.3	4.0
2d about 1st	3.4	2.1	4.9	3.2	6.6	4.1	4.8	2.5
3d about 1st	7.3	3.8	9.3	5.2	13.6	8.6	8.8	5.2
3d about 2d	6.0	3.6	7.3	3.9	9.3	5.5	6.3	4.0
Mean Extreme Spread	7.9	3.6	9.9	4.9	14.2	8.1	9.3	4.9

DISCUSSION

It must be remembered that neither weapon used in testing was zeroed. Therefore, the data for the first round is not representative of firing capability of subjects or of system performance. The modified results show that there was almost a 3 inch reduction of the MES for both SPIW rates of fire. On the other hand, the M16 MES was not greatly affected by the modification. It is suspected that, for the SPIW firings, the muzzle device was not as well tuned as it could have been. However, the modified MES shows that values on the order of 8 (at 1500 rpm) and 10 (at 800 rpm) may be expected with the impulse level on the order of 0.6 pound per second.

The radial dispersion and MES values for the M16 were higher than the SPIWs. It is felt that the addition of the 7-ounce muzzle device tended to aggravate the barrel-whip of the rifle.

It is interesting to compare the M16 results obtained in this study with those reported in a previous study [1]. In the previous report, the M16A1 fired its standard 5.56mm cartridge with an impulse level of approximately 1.2 pounds per second. The MES for a compensated rifle was 12.6 prone and 17.6 standing. Thus, with an approximate 50 percent reduction of impulse level, the MES was reduced approximately 18 percent.

CONCLUSION

The tunable muzzle brake compensator did reduce the dispersion. However, the gain in the reduction of MES was not proportional, and was less than, the associated reduction of impulse level.

[1] Webster, R. L., Jr., Final report of military potential test of two and three round burst control devices with and without compensator for M16A1 rifle. USAIB Project No. 3367, U. S. Army Infantry Board, Fort Benning, GA, October 1972.