

Maximizing Precision of Small Caliber Rifle

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EGR 352 Spring 2021

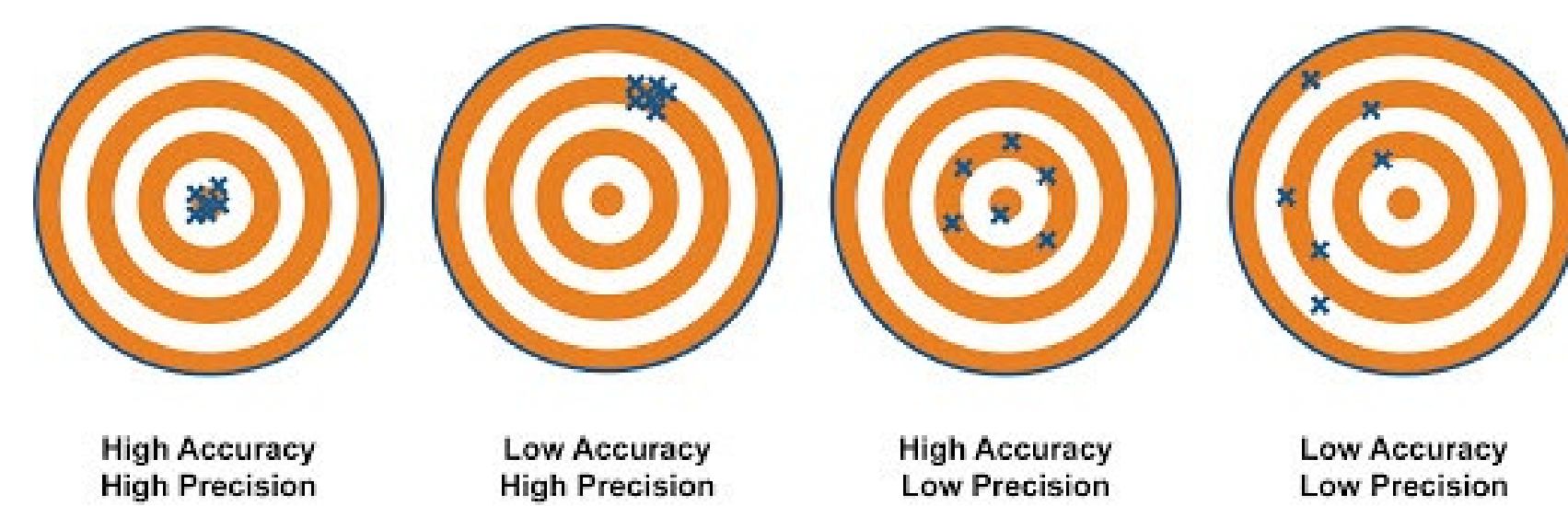
Introduction

Small caliber arms that are affordable and readily available are common to have low levels of precision. This single factor limits the practicality of the competition use of this type of rifle. By varying different parameters of an inexpensive rifle, this experiment seeks to find the factors that can raise the precision to be comparable to a competition rifle. The data will then be analyzed to investigate which factors have the greatest impact on precision.

What is Precision?

Accuracy and precision are often confused. Precision is the ability to repeat the impact point, accuracy is the ability to hit a bull's eye (Figure 1). Accuracy is a function of the shooter, meaning that this aspect is mainly dependent on human input. In contrast, precision is primarily a function of the rifle.

Figure 1

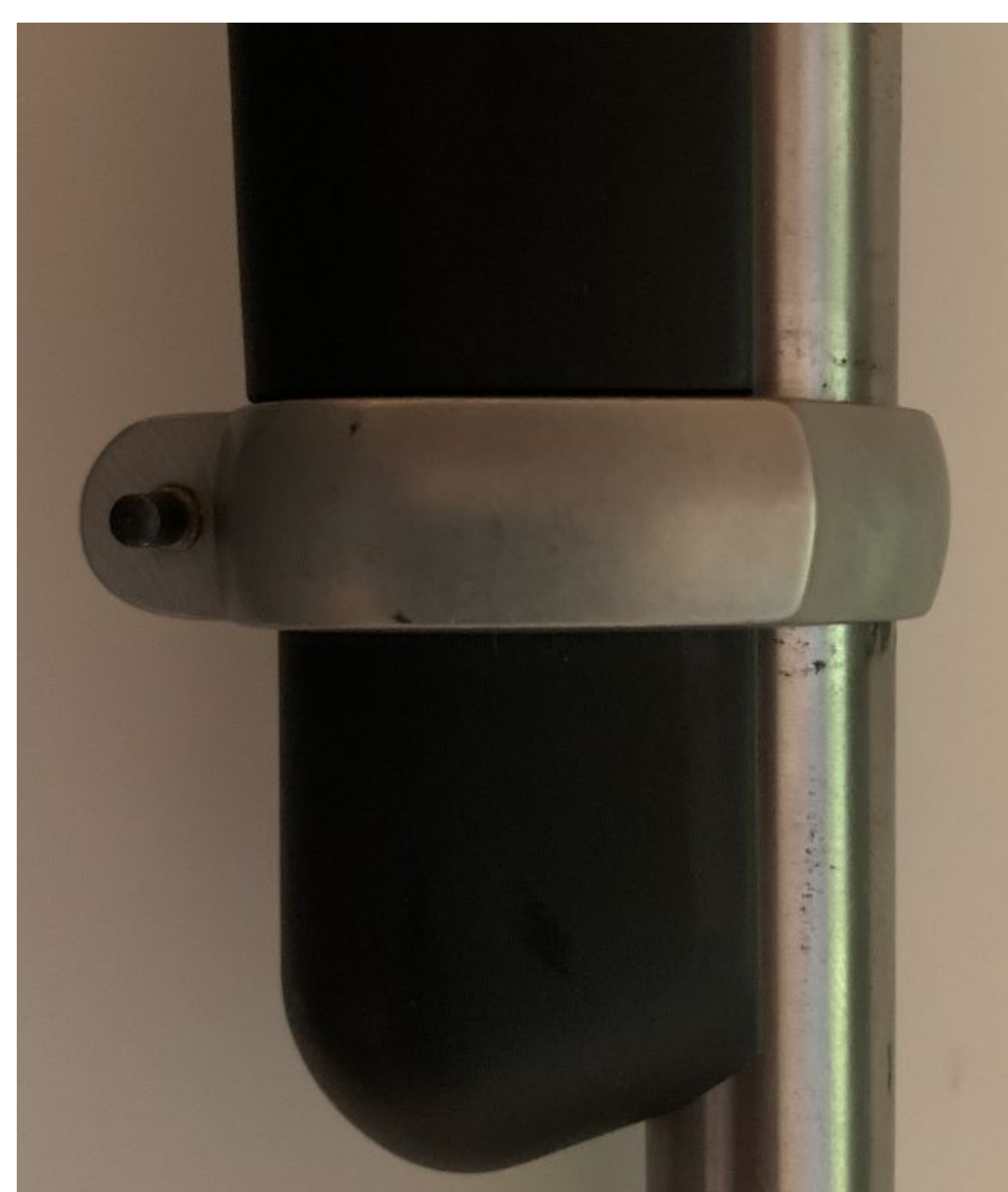


Design of Experiment

For the design of this experiment, four factors, or variables, were chosen that would most likely have the greatest impact on the precision of the rifle. The factors are the torque on the action screw, the quality of the ammunition used, removing the barrel band, and adding tape to the barrel between the barrel and the stock. For this experiment each variable was given two levels, and a full factorial design of experiment was carried out, giving sixteen unique combinations of the variables. For the action screw a high torque of twenty inch-pounds (1) and a low torque of ten inch-pounds (-1) was used. The ammunition used was a competition grade match ammunition from Eley (1), and a lesser expensive target ammunition from Federal American Eagle (-1). The levels for the Barrel band were simply installed (1) or removed (-1), and finally three rounds of black vinyl electrical tape were applied to barrel directly under the band were the stock and barrel meet (1), and tape was removed (-1).



Action screw



Barrel Band (Tape not visible)



Ammunitions used

The Experiment

The equipment used for this experiment was a twenty-two-caliber rifle, a steel shooting bench anchored in the ground, a shooting rest mounted to the top of the table, and a target set up fifty yards from the table. The experiment was conducted at a shooting range with an adequate back stop and far away from any people or residences. Each run was conducted by setting the rifle up according to the values of the factors listed in table 1. Next, the rifle was fired five times at a target. This was repeated three times for each combination to be able average the values.

Run #	Barrel Band	Action screw	Ammunition	Taped Barrel
10	1	1	1	1
2	-1	1	1	1
4	1	-1	1	1
5	-1	-1	1	1
8	1	1	-1	1
15	-1	1	-1	1
3	1	-1	-1	1
12	-1	-1	-1	1
16	1	1	1	-1
1	-1	1	1	-1
6	1	-1	1	-1
11	-1	-1	1	-1
7	1	1	-1	-1
9	-1	1	-1	-1
14	1	-1	-1	-1
13	-1	-1	-1	-1

Table 1

After all the runs were completed, each grouping was measured from center to center of the farthest two holes in the target. The values varied widely from .514 inches to a maximum of 2.636 inches. The data was then analyzed using a normal plot (Figure 2) and a pareto chart (Figure 3).

Figure 2

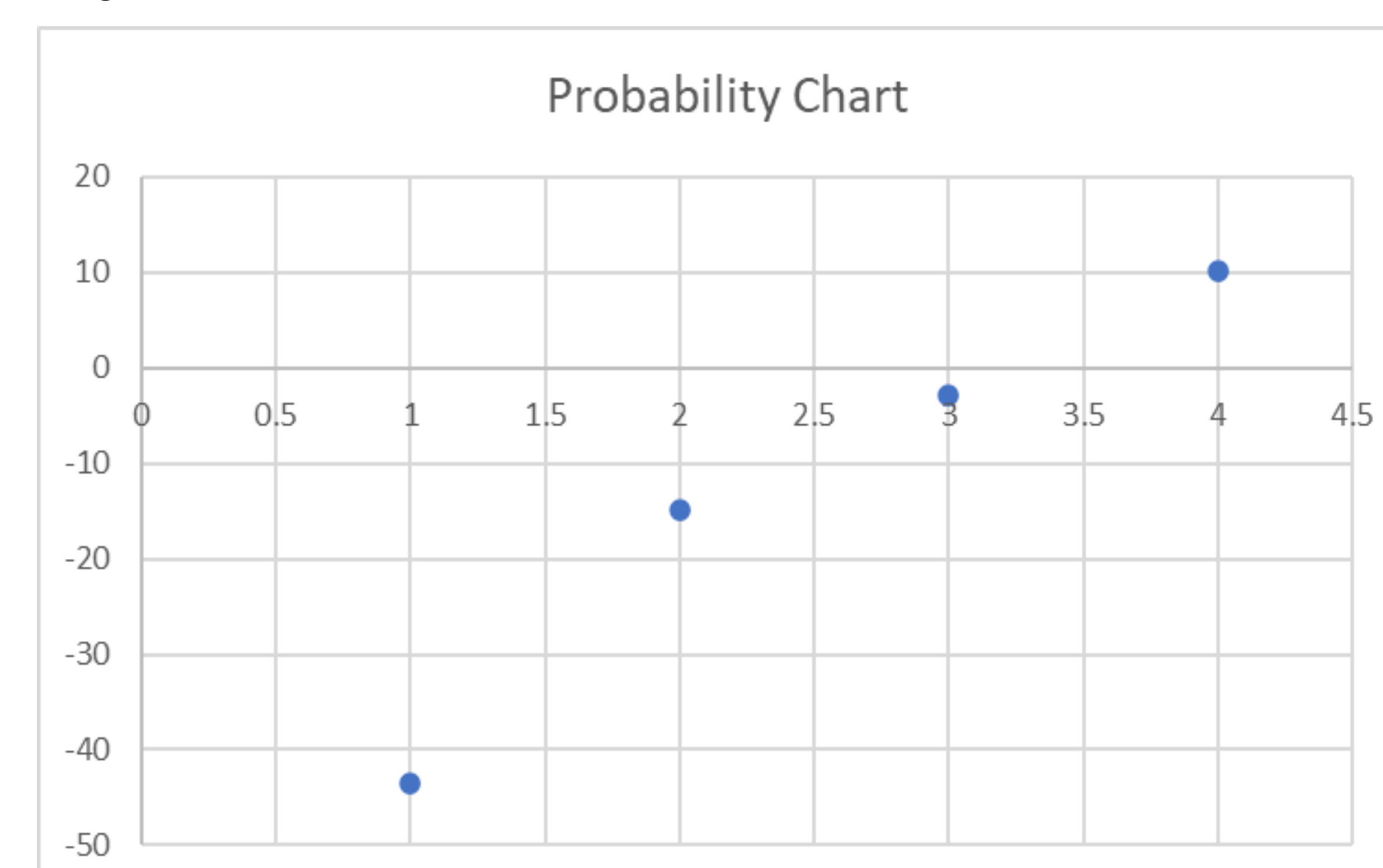
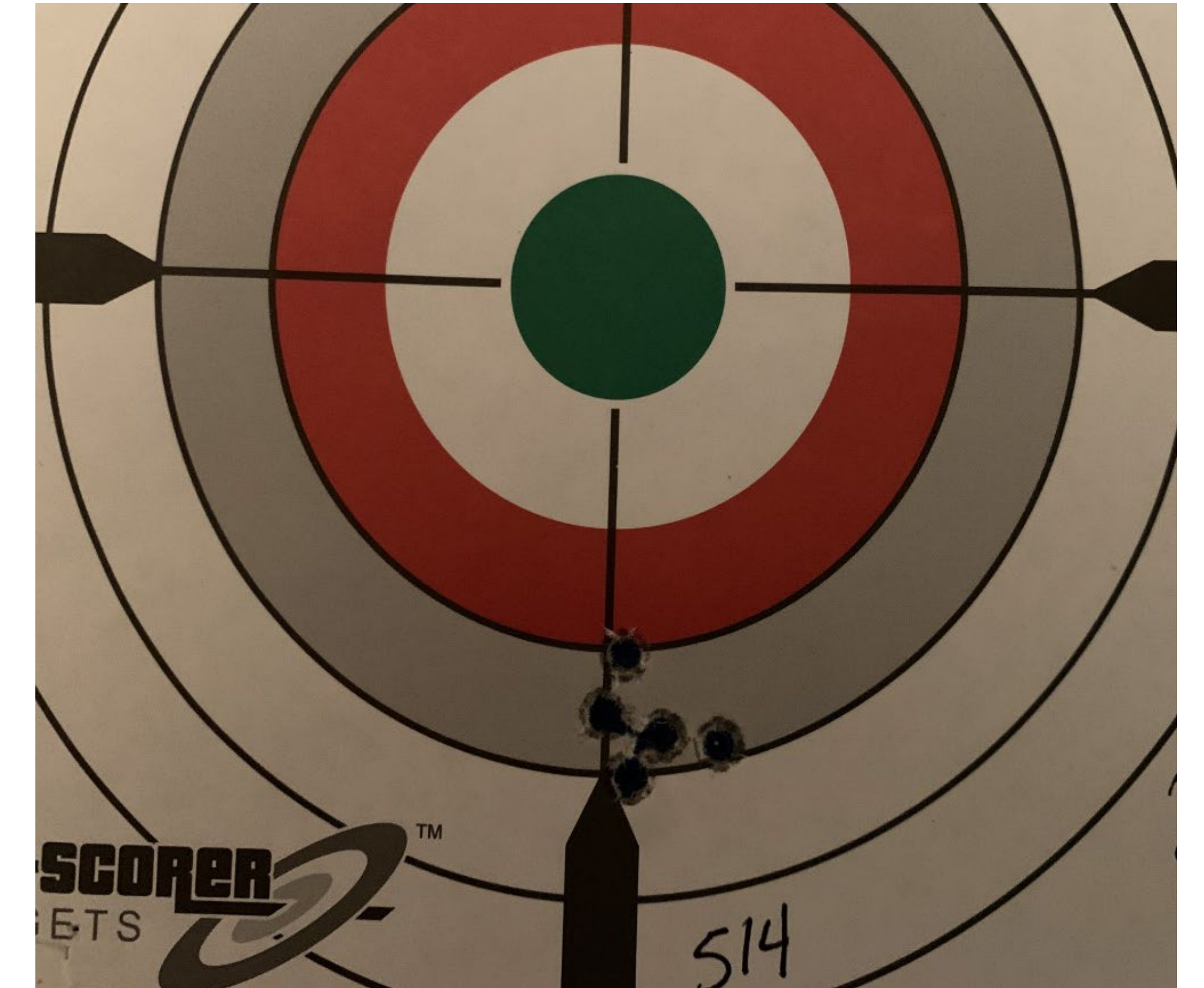
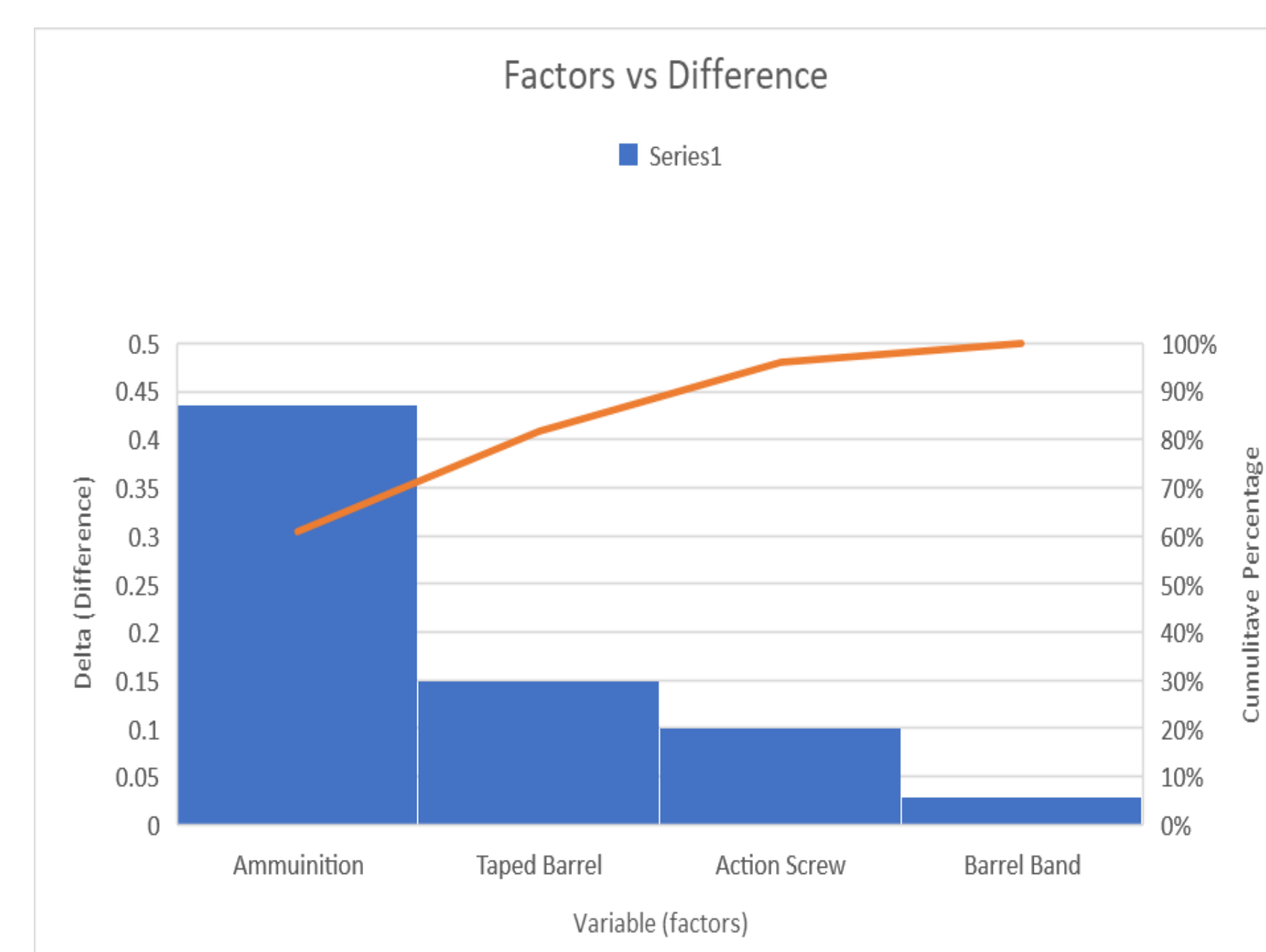


Figure 3



Example of a grouping. This was the smallest group achieved.

Analysis

The normal plot, or probability chart shows the probability of a factor impacting the group size of the rifle. The farther away from the x-axis, the greater the impact. The data is then used to generate a pareto chart, which confirms the findings and shows the factors that have the greatest impact on the results of the experiment.

This type of experiment is valuable for testing large numbers of variables or factors and then allows the engineer to find which factors to focus on. By only focusing on the factors that have the greatest impact, the scope of the testing can be greatly reduced, resulting in considerable cost and time savings.

Conclusion

The results show that the ammunition quality has the greatest impact on the precision of this particular rifle. Taping the barrel had the second largest impact, while having the barrel band installed or removed had very little impact. The expected result was for the action screw and ammunition to be the two greatest factors. This goes to show that analyzing the data is one of the most important parts of any experiment.

This results of this experiment tell us what factors to focus on in the future to further improve the precision of this rifle. This can be accomplished by adding more levels to the two largest factors, which are the type of ammunition and taping the barrel, and then repeating an experiment with these.

After analyzing all the data, a Bergara BXR rifle was used to compare the best groups to. This rifle is a highly upgraded version of the inexpensive rifle used for the experiment. The same high-quality ammunition from Eley was used. The average of the three groups for the Bergara was .842 inches. The cheap rifle barely beat this with run number five averaging .829 inches.

Acknowledgements

- Donald Pitman (Landowner)
- Lindsey Sanders (Shooter)
- Jimmy Loyd (Setup help)