Variation of land and groove impressions on fired bullets due to changes in ammunition and condition

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Introduction

The land and groove impressions left on a fired bullet by a rifled barrel can allow an examiner to distinguish it from other bullets and identify a matching firearm. However with the wide range of ammunition available today it is possible to encounter bullets of vastly different types fired from the same firearm. Bullets may vary in weight, design, material, and physical condition. It is understood that this variation in ammunition would in turn create some sort of variation in the widths of the land and groove impressions left on the bullets.

In casework examiners account for variation by including an uncertainty value in all their measurements, but there is currently no basis of knowledge on how much these impressions can vary. This lack of standardization across labs and examiners raises concerns for court testimony.

By analyzing many different samples fired from the same firearms we are able to see the relationship between land and groove widths and different bullet characteristics. From there suitable uncertainty values can be established.

Figure 1. (from top to bottom) Remington 700 (.308 Winchester), Ruger 10/22 (.22 long rifle), Smith & Wesson Model 15-4 (.38 special), Sig Sauer P226 (9mm Luger)

Method

Four common caliber firearms were chosen from the RCMP's collection along with 10 different types of ammunition for each. 20 rounds of each ammunition were fired consecutively into a horizontal water recovery tank. Of these 20, 10 were kept in pristine condition and 10 were pressed in a vice to simulate real world damage.

All lands and grooves on each sample were then measured on the comparison microscope and recorded. The barrels of the firearms were casted using a silicone resin and measured to get the actual land and groove widths as a point of comparison.

Figure 2. Horizontal water recovery tank

Figure 3. .38 special lead semi-wadcutter, pristine (left) vs damaged (right) groove impression

Results

For each sample, all the lands and grooves are averaged together to receive land and groove measurement values representative of the bullet.

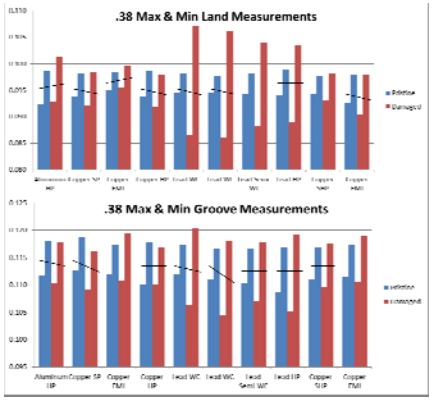

Figure 4. Max, Min, and Average land and groove measurements for each .38s ammo type

Results

The maximum, minimum, and average land and groove measurement for each .38 special ammunition type is shown in figure 4. This figure contains both the pristine and damaged values so we can see how each ammunition type changes with damage.

We can also graph each individual bullets value for land and groove along with the standard deviations to see how close these values are to the true width taken off the barrel casts.

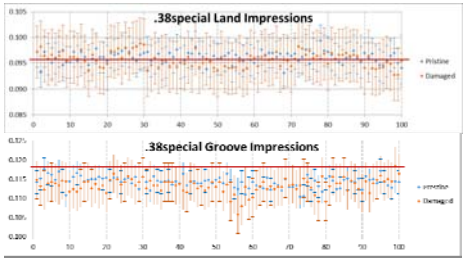

Figure 5. Individual measurements with their standard deviations and true widths

The average values don't vary by more then a few thousandths of an inch across ammunition types but we see a large change in the maximum and minimum measurements. So the individual lands and grooves on a bullet may be drastically different then those of another bullet but the average values provide a much better suited representation. This difference in max and min measurements becomes even more noticeable in the damaged samples.

Impact damage on a bullet distorts its overall shape and skews the measurements. Some lands and grooves will appear larger then their true values and other will be compressed. Surface damage to the bullet can also deface the rifling impressions or remove them entirely.

The material and design of the bullet heavily affect how the bullet receives damage. The unjacketed lead bullets provide very distinct impressions but because of their soft material they have a hard time holding these impressions after damage. Hollow and soft point designs expand on impact which distorts the impressions further.

Conclusions

There are three methods proposed for determining which uncertainty values to use, each with their own benefits and drawbacks. In the first method the examiner determines the condition of the bullet by measuring the smallest and largest diameter and doing a quick calculation $\% = 1 - \frac{d_s}{d_l}$, if this value is under 15% the bullet is considered pristine. Pristine lands, grooves, damaged lands, and grooves receive the following values respectively, ± 0.003", ± 0.004", ± 0.005", ± 0.006".

Conclusions

The second method makes no distinction between damaged or pristine samples to save the examiner time during case work. All lands use the ± 0.005" value and all grooves use ± 0.006". Although this saves time while taking measurements it also widens the range of accepted samples which will create more work later on.

The final method uses one single value of ± 0.008" which is large enough to ensure that every sample from our study meets the actual widths measured off the barrel cast.

To compare all three methods we ran a pristine and damaged sample of each caliber through the AFTE General Rifling Characteristics Database. Every sample was able to correctly identify the make and model of firearm used but each method also provided us with a different amount of possible matches. This information is summarized below along with the error for each method, which is the percentage of samples from our study that didn't meet the actual widths from the cast.

		Number of Entries							
		9mm Luger		38 Special		308 Winchester		22 Long	
Method	Error	Pristine	Damaged	Pristine	Damaged	Pristine	Damaged	Pristine	
1	3.91%	80	100	76	80	9	11	286	
2	1.81%	90	100	87	80	11	11	371	
3	0%	136	141	118	163	17	17	498	

It is up to the examiner to choose which method is more suitable to them, using one value may save time in the lab but it leaves you with a much larger list of possible matches to narrow down. Alternatively you can spend a little more time taking extra measurements and get a small list.

When doing case work an examiner will need to do database searches with their samples or eliminate samples as being fired from the same firearm. In a database search an examiner can use either the max and min value from their sample or the average value. Since we have seen how wildly the max and min values fluctuate across ammunition types it is recommended that examiners use the average land and groove values from their bullet as this is a better representation of the sample.

For elimination cases examiners can compare bullets on a land to land and groove to groove basis or compare the averages. The more accurate method is still using the average values since depending on the condition of the bullet the individual lands and grooves can be drastically different leading to false eliminations.

References

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