MELLON INSTITUTE

ADVANCED MATERIALS AND DEVICES
MATERIALS CHARACTERIZATION CENTER

Report on

The Product Evaluation of
Gold Medallion -
A Comparative Study
submitted to

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ABSTRACT

Gold Medallion bore cleaner and conditioner was tested to determine its cleaning characteristics, its propensity to corrode gun steel and if its particle imbed or reside in the bore after cleaning. The product was found to have little or no corrosive effect on gun steel. It was also determined that there was no tendency for the particles to imbed or reside in the bore after following the manufacture's recommended cleaning practices. This study has determined that Gold Medallion improves the character of an as-manufactured gun bore. The effects of this product on a used weapon were not determined.

JOB NO: 8712040
Date: 19 April 1988

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EXHIBIT A

higher magnification; Figure 5c shows noticeable degradation of the surface.

The before and after photos of the Shilen bore immersed in Gold Medallion are shown in Figures 6 and 7. After 72 hrs. in Gold medallion, there is a very slight mottling which shows up at high magnifications. This is indicated by the arrows in Figure 7c. In general though, there is little or no change in the surface quality after soaking in Gold Medallion.

The general condition of the Shilen bore after 1000 cycles with the Hoppes product is shown in Figure 8. The effect of 1000 cycles with Gold Medallion can be seen in Figures 9 and 10. Direct comparison of the before Gold Medallion surface to the after Gold Medallion surface is made in Figure 11a and 11b. Figure 11c is direct comparison of a Shilen segment (S4) cleaned with Hoppes to a Shilen segment (S1) cleaned with Gold Medallion. Similar direct comparisons are made between S2 and S4 in Figure 12a, b and c.

Figure 13b is representative of the entire surface of the Shilen bore cleaned with Gold Medallion. The surface of the bore was scanned with EDX as-received. This spectrum is shown in Figure 14a. Figure 14b is the typical EDX spectrum of the Shilen bore after cleaning with Gold Medallion. This spectrum also is typical of the holes found in the surface as viewed in Figure 13a and 13b.

DISCUSSION

Rifling is put into a barrel by machining operations which are closely related to broaching. Machining operations of this sort remove metal by a shear deformation mechanism. As the shearing occurs at the blade of the tool, a zone of plastically deformed metal of a finite thickness is created. Some of this plastically deformed metal is removed as chips but some remains in the barrel as a disturbed layer on or near the surface of the bore. Within the disturbed layer of metal occur tears, burrs and pushed or smeared metal. The physical properties of the metal in the plastically deformed zone are considerably different than the bulk material. Rather than describe all of the differences it will suffice to say that the integrity of the bulk material is substantial while the integrity of the disturbed zone is sub-standard. This is because the scale of the defects, introduced during manufacturing, approaches the scale of the plastically deformed zone. With many defects localized to a small volume the material in that volume becomes brittle and susceptible to premature wear.

An example of the plastic tearing of metal that occurs during the machining operation is shown in Figure 2c. These tears extend into the surface deeper than they appear. This is because the metal is pushed into and over the tears. The horizontal markings in Figure 2c are the tears. The vertical lines are tool marks left by a microscopically irregular cutting tool. The tears and tool marks are the finer details of the topography. The scale of the fine details is used to describe the roughness of a surface. i.e. the small features have less roughness than would larger details.

The surface finish of the pieces examined were not uniformly the same. With this being so, it is difficult to make consistent comparisons from one piece to another. When comparing the surface qualities of the pre- and post- immersion surfaces for the corrosion study, there is no truly quantitative method for saying that one bore cleaning product corrodes metal more than another. A more proper method for establishing a

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ranking of the corrosive tendency for the products would be to measure the weight gain after extended immersion. In the case of this study, it can only be said that the solutions have a tendency to corrode or not to corrode gun steel. The Hoppes product shows no change in the appearance of the surface after immersion; therefore, it can be said that this product has little or no tendency to corrode the steel. This is illustrated by comparing Figures 2 and 3.

The appearance of pitting (Figure 5b) in the surface of the steel immersed in Shooters Choice indicates that corrosion is occurring. When examined at a high magnification, the corrosion product, which appears as a white powdery substance on the surface of the steel, clearly has changed the quality of the bore surface. This can be seen when comparing Figures 4b and 4c to Figures 5b and 5c.

In comparing the as received bore surface to the surface immersed in Gold Medallion (comparing Figures 6 and 7), it can be said that there appears to be little or no degradation in the surface quality of the bore due to corrosion. There is however, a slight difference in the surface after soaking in Gold Medallion. The arrows in Figure 7c show a mottling of the surface that appears after the extended immersion. This mottling may indicate that some small degree of chemical reaction is occurring on the surface as compared to the Shooters Choice specimen seen in Figure 5c.

The bore cleaning procedures are based on the manufacturers recommendations and the number of cleaning cycles are meant to approximate the number of cleanings that a weapon would experience in an average life time. After 1000 cycles of cleaning with the Hoppes product, examination of the bore with SEM shows that there is little if any difference in the condition of the bore. Comparing Figure 8 to a similar surface shown in

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Figure 4, it can be seen that the burrs and pushed metal are still relatively intact.

Cleaning 1000 cycles with the Gold Medallion has a very noticeable affect on the condition of the bore. Figures 9 and 10 show that most if not all of the burrs have been removed. Also removed is much of the pushed metal that obscured the tears in the plastically deformed layer. The tears are clearly seen in Figures 9b and 10b. The large horizontal machining scars, while still being fairly deep, have had most of the pushed metal cleaned out of them and had the edges of the machining scars rounded off. A contrast of the as-received finish and the as-cleaned finishes for the Gold Medallion and the Hoppes cleaned bores is shown in Figures 11 and 12. The surface finish left by Gold Medallion, shown in Figures 11b and 12b, appears to be less rough than the as-received portion shown in Figures 11a and 12a.

Keeping the images of these two Figures (11 and 12) in mind and examining Table III it is reasonable to see that the barrels that were cleaned with Gold Medallion lost more weight than the barrels cleaned with competing products. Most of the weight loss is assumed to be disturbed metal in the form of burrs, flashing and plastically displaced metal. The material most susceptible to rapid wearing has mostly been removed. This has decreased the roughness and made the properties of the surface and near surface material more like the bulk material. If these barrels were to be cleaned again with Gold Medallion for another 1000 cycles it is expected that the weight loss would be several orders of magnitude lower than the values found for this study.

The SEM-EDX search for particles embedded in the surface of the bore involved scanning the entire portion of the bore that was removed from segments S1 and S2. The portions were scanned at 20X until an area of interest was located. From this region an EDX spectrum was taken. The spectra were very consistent and are well represented by Figure 14b. When compared to the spectrum which is representative of the as received bore, Figure 14a, there is no difference between the two spectra. This was true even in the case of the holes which appear to have foreign material associated with them (similar to the holes seen in Figure10c). The implications of these results are that the particles do not embed in the steel and have little tendency to be caught in the flaws found in the bore surface.

CONCLUSIONS

Gold Medallion improves the integrity of an as manufactured rifled barrel by removing much of the disturbed layer of metal. Despite the fact that cleaning with Gold Medallion caused the largest weight loss it is not apparent that the amount of material removed was excessive. The affect on the bore dimensions after 1000 cycles with Gold Medallion is minor.

Gold Medallion has little tendency to corrode gun steel even after extended immersion.

The particles in Gold Medallion were not found to have any tendency to reside in or imbed the gun bore.

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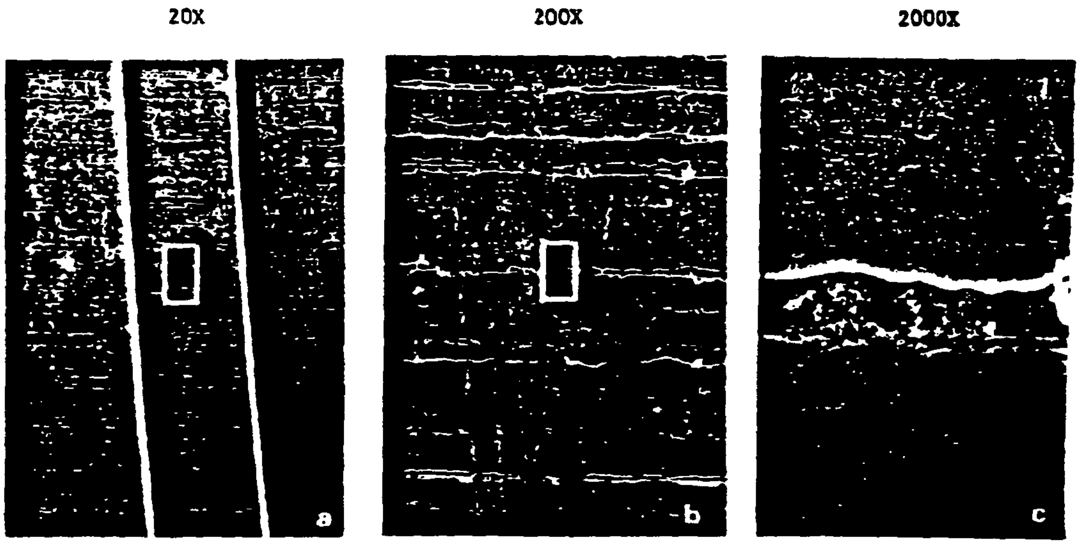

Figure 8: Shilen segment after 1000 cleaning cycles with Hoppes No. 9

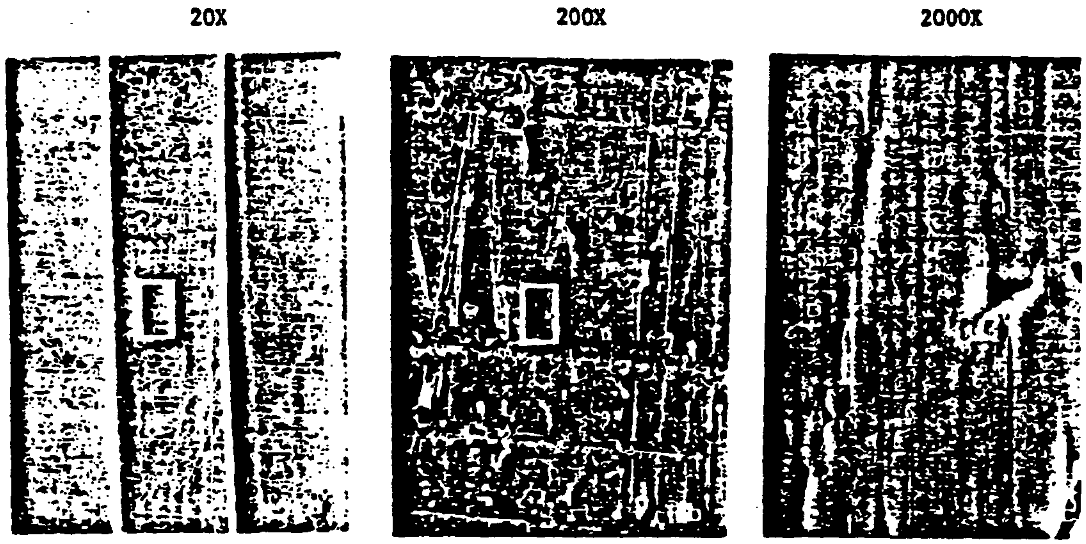

Figure 9: Shilen segment after 1000 cleaning cycles with Gold Medallion (Land)

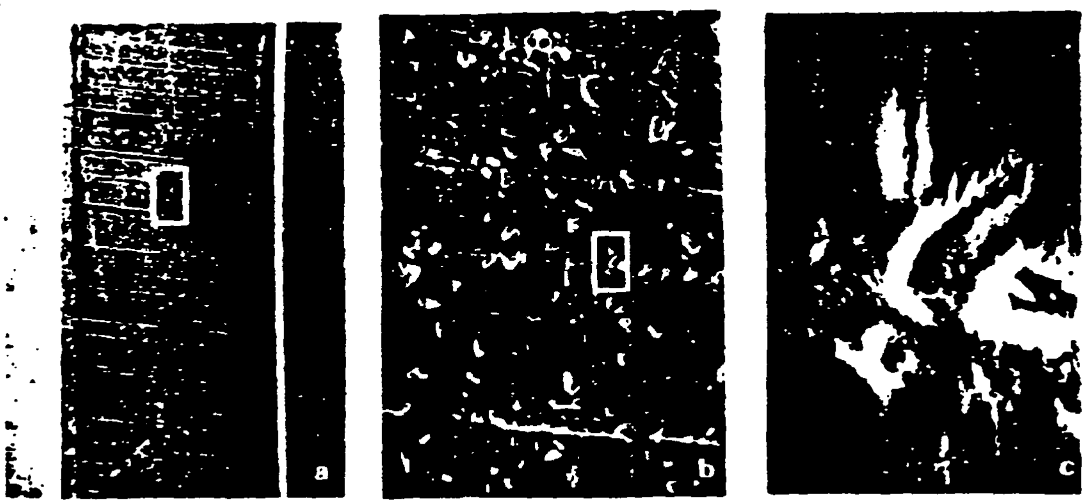

Figure 10: Shilen segment after 1000 cleaning cycles with Gold Medallion (Groove)