Ultrasonic Cleaner Validation

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3/12/24
**Purpose**

The purpose of this validation study is to determine if the ultrasonic cleaner will cause any damage to the marking surfaces of a firearm, as well as determine an appropriate length of time to utilize the ultrasonic cleaner in conjunction with Evaporust, Haemo-sol, and Oxi-Clean for the removal of rust and blood.

All data for the ultrasonic cleaner validation can be found at: S:\Crime Lab\Firearms\Validation Studies\Ultrasonic Cleaner Validation.

**Introduction**

The firearms section often receives firearms that have significant amounts of blood or rust on them, sometimes making them inoperable. Currently, rusty firearms are cleaned using Evaporust. This process can sometimes take multiple days and may involve soaking the firearm in Evaporust overnight. This is often effective but very inefficient. In some cases, the Evaporust alone is not enough to make the firearm operational. Using an ultrasonic cleaner would allow for an additional method of rust removal that could increase the likelihood of obtaining test fires from otherwise inoperable firearms. Use of the ultrasonic cleaner would also be a more effective method of removing blood or other biohazardous materials from firearms, which would make test firing them safer for human health. This method of cleaning would be more thorough than the current method of using germicidal wipes and would better protect the technicians and examiners by preventing the spread of potentially dangerous biological hazards within the range caused by discharging firearms.

There is concern when using the ultrasonic cleaner that the high frequency vibrations will cause microscopic changes within the marking surfaces of the firearm including the breechface, firing pin, and barrel. Therefore, a control set of firearms can be used to obtain test fires before placing the firearms in the ultrasonic cleaner and also at specific intervals during use of the ultrasonic cleaner. This would help determine if changes occur in those marking surfaces, if those changes would impact comparison exams, and what length of time utilizing the ultrasonic cleaner would be optimal for preventing microscopic changes.

Ultrasonic cleaners are already being used in conjunction with Evaporust to remove rust from tools and mechanical equipment and components. Ideally, they will also be effective in rust removal from firearms in an attempt to make them operational. Additionally, ultrasonic cleaners are currently used in conjunction with disinfectants to remove biological hazards from medical equipment. This validation will also look at how well rust and blood can be removed from firearms in conjunction with Evaporust, Haemo-sol and Oxi-Clean. Proper PPE was worn while test firing and handling chemicals and potential biohazardous materials throughout the course of the validation study.

**Methods**

**Part 1: Impact of the ultrasonic cleaner on marking surfaces of firearms**
Each of the eight firearms utilized in Part 1 (see table below) was test fired prior to being placed in the ultrasonic cleaner. Initially, the firearms were suspended in water within the ultrasonic cleaner. The heat was turned on while cleaning the firearms. The water was allowed to degas for at least 5 minutes prior to cleaning the firearms. See Figures 1 and 2 for initial cleaning setup. Four of the firearms were placed in the ultrasonic cleaner for 1-minute intervals and four of the firearms were placed in the ultrasonic cleaner for 5-minute intervals. All firearms were cleaned for a total of 20 minutes. After each interval, the exterior, breechface, and barrel were quickly dried with a towel and air compressor and then the firearm was test fired. For each test fire, two cartridges (one brass primer and one nickel primer) were used. Each set of test fired cartridge cases and bullets was placed in a coin envelope labeled with the number assigned to the gun as well as the total length of time the firearm had been in the ultrasonic cleaner when the test fires were obtained. After the firearm was test fired for the final time, it was field stripped and dried using the air compressor, then oiled and reassembled. All sets of test fires were given to an examiner for the purpose of determining whether any changes to marking surfaces occurred.

<table>
<thead>
<tr>
<th>ID #</th>
<th>Make</th>
<th>Model</th>
<th>Caliber</th>
<th>Time Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>Glock</td>
<td>22 Gen4</td>
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<td>5 min</td>
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<td>XD9 3.3</td>
<td>9mm Luger</td>
<td>1 min</td>
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<td>4</td>
<td>S&amp;W</td>
<td>M&amp;P40 Shield</td>
<td>40 S&amp;W</td>
<td>5 min</td>
</tr>
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<td>CF380</td>
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<td>6</td>
<td>Jimenez</td>
<td>J.A. NINE</td>
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<td>5 min</td>
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<tr>
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<td>Lorcin</td>
<td>L380</td>
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<td>1 min</td>
</tr>
<tr>
<td>8</td>
<td>Davis Ind.</td>
<td>P-380</td>
<td>380 Auto</td>
<td>5 min</td>
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Table 1: Firearms used for initial setup

Additionally, a subset of four firearms was selected to test a secondary setup. This setup utilized a secondary tray within the ultrasonic cleaner that contained the cleaning solution. Water was used underneath/around the metal tray. The firearm was laid flat in the secondary interior tray which contained the cleaning solution. The heat was turned on while cleaning the firearms. The
cleaning solution used within the interior tray for Part 1 was water, which was allowed to degas prior to cleaning. See Figure 3 for secondary setup.

The four firearms used for this setup were previously utilized with the original setup. Two of the firearms were placed in the ultrasonic cleaner using the new setup for 1-minute intervals and two of the firearms were placed in the ultrasonic cleaner for 5-minute intervals. All four firearms were cleaned in the new setup for a total time of 20 minutes. The firearms were test fired using two cartridges (one brass primer and one nickel primer) after each cleaning interval. The procedure for drying and test firing after each cleaning interval was the same as during the testing of the initial setup. All sets of test fires were given to an examiner for the purpose of determining whether any changes to marking surfaces occurred.

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<td>5 min</td>
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<tr>
<td>4</td>
<td>S&amp;W</td>
<td>M&amp;P40 Shield</td>
<td>40 S&amp;W</td>
<td>1 min</td>
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<td>1 min</td>
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<tr>
<td>8</td>
<td>Davis Ind.</td>
<td>P-380</td>
<td>380 Auto</td>
<td>5 min</td>
</tr>
</tbody>
</table>

Table 2: Firearms used for secondary setup

Figure 3: Secondary setup

**Part 2: Effectiveness of ultrasonic cleaner in removing rust from firearms**

For this portion of the study, the secondary setup from Part 1 was used. Evaporust was used as the cleaning solution within the interior tray of the ultrasonic cleaner. The heat was again turned on when cleaning the firearms. The Evaporust within the metal tray and the water surrounding the metal tray were allowed to degas for at least 5 minutes prior to cleaning the firearms. Some of the firearms used were able to be test fired prior to cleaning and some were too rusty to test fire. The variability in amount of rust and initial functionality is representative of the spectrum of firearms that would be encountered in casework. Initial photos were taken of each firearm before being placed in the ultrasonic cleaner. Additional photos were taken after each cleaning interval.
Firearms were cleaned in 1-minute intervals initially, then the interval was increased once significant progress was made in removing rust from the firearm. Each firearm was cleaned for a total of 20 minutes regardless of functionality. At the point where each firearm became operational, it was test fired, then test fired again after each cleaning interval using two cartridges (one brass primer and one nickel primer). After the final test fire, the operational firearms were able to be disassembled, dried, and oiled. The firearms that were not operational were dried as much as possible for storage, to prevent further damage to the firearm. All sets of test fires were given to an examiner for the purpose of determining whether any changes to the marking surfaces occurred.

<table>
<thead>
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<th>Time Interval</th>
</tr>
</thead>
<tbody>
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<td>Security-9</td>
<td>9mm</td>
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<tr>
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<td>Ruger-57</td>
<td>5.7x28mm</td>
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<td>38 Special</td>
<td>5 x 1 min, 3 x 5 min</td>
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<td>12</td>
<td>Glock</td>
<td>30S</td>
<td>45 Auto</td>
<td>10 x 1 min, 2 x 5 min</td>
</tr>
<tr>
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<td>40 S&amp;W</td>
<td>20 x 1 min</td>
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<td>14</td>
<td>Unknown Revolver</td>
<td>Unknown</td>
<td>Unknown</td>
<td>20 x 1 min</td>
</tr>
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</table>

Table 3: Firearms used for Part 2

Part 3: Effectiveness of ultrasonic cleaner in removing blood from firearms

For this portion of the study, the secondary setup from Part 1 was used, again with the heat turned on. Two different cleaning solutions were used, Haemo-sol and Oxi-Clean. Seven of the eight firearms from Part 1 were utilized again in this portion of the study, as well as an additional firearm, Firearm 15. To preserve resources, a smaller plastic container with the cleaning solution was placed inside the metal tray, which was filled with water. See photo below for setup.

The preparation guidelines on the Oxi-Clean and Haemo-sol packaging were followed to make each cleaning solution. To prepare the Oxi-Clean solution, approximately 2800mL of water was placed into the plastic container and the scoop that came with the Oxi-Clean powder was filled to the line marked “2”. To prepare the Haemo-sol solution, 1900mL of water was placed into the plastic container and the scoop provided with the Haemo-sol was filled to the line marked “1 tablespoon”. The cleaning solution and water in and around the metal tub were allowed to degas before cleaning the firearms.

Initially, four of the firearms were cleaned in the ultrasonic cleaner for a total of 20 minutes with the cleaning solution only and test fired after each 1-minute interval in order to determine if the cleaning solutions have an impact on the marking surfaces of the firearm. Two cartridges (one brass primer and one nickel primer) were test fired after each cleaning interval. Firearms 1 and 15 were cleaned in Oxi-Clean and firearms 3 and 4 were cleaned with Haemo-sol. After the firearm was test fired for the final time, it was field stripped and dried using the air compressor, then oiled and reassembled. All sets of test fires were given to an examiner for the purpose of determining whether any changes to marking surfaces occurred.
Table 4: Firearms used for initial testing of Oxi-Clean and Haemo-sol

After blood was applied, the firearms were cleaned using both cleaning solutions in order to determine the effectiveness and how long each solution needed to be used to remove blood from the firearms. Four firearms were cleaned in the ultrasonic cleaner with Oxi-Clean and four were cleaned in the ultrasonic cleaner with Haemo-sol. After application, the blood was allowed to dry for 48-72 hours. Then, the firearms were placed in the ultrasonic cleaner for 1-minute intervals until the blood had been visibly removed from the firearm. During the cleaning process, once the blood on the exterior of the firearm was removed, the firearms that were able, were locked open and cleaned in that configuration as well. The firearms were photographed before cleaning and after each 1-minute interval. A final test fire was obtained after cleaning was complete using two cartridges (one brass primer and one nickel primer). After the firearm was test fired, it was field stripped and dried using the air compressor, then oiled and reassembled. All test fires were given to an examiner for the purpose of determining whether any changes to marking surfaces occurred.

Table 5: Firearms cleaned with Oxi-Clean

Table 6: Firearms cleaned with Haemo-sol
Results

Part 1: Impact of the ultrasonic cleaner on marking surfaces of firearms

Although, some variation is expected between two cartridge cases fired from the same firearm, the examiner was looking for significant changes in breechface markings and markings within the firing pin impression that would indicate that the marking surfaces were damaged or changed by the ultrasonic cleaner during the cleaning process. For any changes to be considered “significant”, it meant that they were too a degree such that a false-positive or false-negative error would be more likely to occur (assuming one did not know the origin). To aid in this determination for all parts of the study, the examiner used a Leeds Forensic Systems Olympus SZX16 dual-stage comparison microscope and representative comparison photos were capture using an Olympus DP74 Camera with Stream Start software v2.2.

For both setups, there were no significant changes observed to any marking surfaces between the initial test fired cartridge cases and those taken up to five minutes in the ultrasonic cleaner for any of the firearms. There were no significant changes to any of the breechface or aperture shear markings for any of the firearms during the total 20 minutes in the ultrasonic cleaner. There were changes observed to the firing pin impression for Gun 1 between 7-8 minutes and changes to the firing pin impression for Gun 6 between 5-10 minutes. See representative photos below of changes to marking surfaces observed on the test fired cartridge cases for Guns 1 and 6.
Additionally, gun oil had to be applied to Gun 7 several times during the cleaning process so that the slide was able to be manipulated in order to test fire. In addition to removing unwanted substances from the firearm, the ultrasonic cleaner also removed oil from surfaces that need lubrication to work effectively.

**Part 2: Effectiveness of ultrasonic cleaner in removing rust from firearms**

Regardless of whether or not the firearm was able to be made functional again, the ultrasonic cleaner was successful in removing rust from the firearms. It was also observed that the ultrasonic cleaner removed the finish from metallic portions of the firearm.

Firearms 9-11 were initially operational but had some rust on various portions of the firearm. A majority of the rust was removed from each of these firearms during the first 10 minutes of cleaning.
Firearm 9 Photos:
Firearm 10 Photos:
For Guns 9-11, there was some decline in breechface and aperture shear markings after 10 minutes in the ultrasonic cleaner. There was also an increase in extraneous markings for Gun 9 towards the end of the cleaning process. It is possible that residual debris in the cleaning solution impacted the marking surfaces during the latter portion of the cleaning process.
Firearm 12 was initially stuck in the open position, but the slide catch was not holding the slide rearward. The slide appeared to be held open by rust and debris within the firearm. After being in the ultrasonic cleaner for a total of 4 minutes, the slide was able to be closed using force. After a total of 6 minutes, Firearm 12 was able to be field stripped. At that time, it was discovered that the recoil spring was broken. A recoil spring from a reference collection firearm was placed inside Firearm 12 and the pistol was able to be test fired, however a mallet had to be used to close the slide. Even though test fires were obtained, the firearm was placed back in the ultrasonic cleaner for 1-minute intervals up to a total of 10 minutes, then 5-minute intervals up to 20 minutes. After 7 minutes, the slide catch was functional and after 8 minutes the firearm was completing all the cycle of fire steps, however, the slide still had to be closed with a mallet intermittently.
Photos of Firearm 12:

Due to the heavier rust on Gun 12, the breechface markings continued to improve with more time in the ultrasonic cleaner. Those markings were optimal around 15 minutes for Gun 12.
Firearm 13 was also initially stuck in the open position, again, being held open by rust and debris as opposed to the slide catch. The frame was cracked and it appeared that the firearm had been damaged potentially by being crushed. After 10 minutes in the ultrasonic cleaner, the slide was able to be closed by force and the take down pin was removed, however the firearm was still unable to be field stripped. After 12 total minutes, the magazine body, that was previously stuck in the magazine well of Firearm 13, was able to be removed. After each minute, from 13-15 total minutes, an attempt was made to remove the firing pin through the rear of the slide. It was thought that if the firing pin was broken, it might be preventing the slide from separating from the frame. After 16 total minutes, the slide was able to be removed from the frame. At that point, only the slide was placed in the ultrasonic cleaner. After 18 total minutes, the firing pin was able to be removed from the slide. The firing pin channel was cleaned with a brush and lubricated, and the slide was placed back in the ultrasonic cleaner for two additional minutes, however the firing pin was never able to be inserted back into the firing pin channel. The firing pin from Firearm 13 was able to be inserted into the slide of a reference firearm, however, the reference firing pin was not able to be inserted into the slide of Firearm 13. It is possible that the damage to Firearm 13 possibly impacted the diameter of the firing pin channel. In a casework scenario, the firing pin and barrel from Firearm 13 could be used in a reference firearm in order to obtain test fires, however, that was not deemed necessary for the purpose of the validation study.
Photos of Firearm 13:
Firearm 14 was severely rusted and the cylinder was stuck in the open position. After 3 minutes in the ultrasonic cleaner, the cylinder was able to be moved slightly and after 9 minutes, the cylinder was able to be moved in completely. The hammer began to move after 11 minutes in the ultrasonic cleaner and began to move in conjunction with the trigger after 16 minutes. The cylinder release was also functional after 14 minutes in the ultrasonic cleaner. Firearm 14 was never made operational; however, several mechanical parts were made functional and a significant amount of rust was removed from the firearm.

**Photos of Firearm 14:**

![Photos of Firearm 14](image-url)
Part 3: Effectiveness of ultrasonic cleaner in removing blood from firearms

Prior to applying blood to the firearms, the cleaning solutions were tested to determine if they negatively impacted the marking surfaces. The only change noted was a change in the prominence of aperture shear markings for Gun 15 in the Oxi-Clean solution after 8 minutes in the ultrasonic cleaner.

![Figure 10: Gun 15 breechface pre-cleaning and after 8 minutes](image)

![Figure 11: Gun 15 breechface pre-cleaning and after 20 minutes](image)

The ultrasonic cleaner was effective in removing blood from firearms while utilizing either Oxi-Clean or Haemo-sol. Both cleaning solutions assisted in the removal of blood, however the firearms that were cleaned using Haemo-sol took less time to remove visible blood from the firearm. Additionally, when the firearms were disassembled after cleaning and test firing, the firearms that were cleaned with Oxi-Clean had some residual blood within the slide. The firearms cleaned with Haemo-sol did not have any residual blood within the slide when disassembled. Most of the blood was removed from the exterior of the firearm in the first minute when using Haemo-sol.
Photos of Firearm 1 (Oxi-Clean):
Photos of Gun 5 (Oxi-Clean):
Photos of Gun 6 (Oxi-Clean):
Photos of Gun 15 (Oxi-Clean):
Photos of Gun 3 (Haemo-sol):
Photos of Gun 4 (Haemo-sol):
Photos of Gun 7 (Haemo-sol):
Opinions and Limitations

Use of the ultrasonic cleaner in conjunction with the tested cleaning solutions can assist in making firearms operational or safer to test fire. The ultrasonic cleaner is easy to setup and use and does not have significant negative impacts on the firearm being cleaned when used for short periods of time.
When using the ultrasonic cleaner to remove rust or blood from firearms in casework, additional tools can be used to aid cleaning such as brushes, rinsing with water, and wiping off the firearm. It is also possible that gun oil will need to be applied to the firearms prior to test firing. These are all methods that are already being utilized in case work and could assist in shortening the amount of time that the firearm spends in the ultrasonic cleaner. Due to changes observed in the marking surfaces of some firearms during the validation study, it is recommended to only utilize the ultrasonic cleaner for up to five minutes when the goal is simply to clean the firearm. Additionally, if firearms can be locked open during cleaning so that interior areas are exposed that is beneficial in ensuring that blood or other substances are removed from interior areas as well.

For rusty firearms that are initially not operational, the examiner must weigh the potential damage to marking surfaces against the benefits of further cleaning the breechface when determining how long to clean the firearm. It is recommended to test fire the firearm as soon as it is operational, and then if additional cleaning is necessary, the firearm can be placed back in the ultrasonic cleaner and then test fired again. It is likely that some rusty firearms might require more than five minutes in the ultrasonic cleaner, however, an effort should be made to minimize the amount of time. The condition of the cleaning solution should also be monitored, and when necessary, the cleaning solution can be replenished or replaced to reduce the amount of debris in the cleaning solution that could interact with the firearm.

The use of the ultrasonic cleaner and related cleaning solutions will have little to no impact on other sections within the laboratory since this type of testing is only conducted once other sections have done their testing or have decided testing is not necessary. Similarly, it is likely not to impact the rest of the department. However, it should be made clear that putting a firearm or related components into the ultrasonic cleaner increases the chances of contamination of the evidence so that no further biological or latent processing could occur.

**Potential Areas of Non-Conforming Testing**

Potential areas of non-conforming testing primarily include improperly preparing cleaning solutions and incorrect use of the ultrasonic cleaner. Manufacturer recommendations for cleaning solution preparation were followed during the validation study. Additionally, the manufacturer recommendations for using the ultrasonic cleaner were followed as well. Important notes from the ultrasonic cleaner manual include using enough water to fill the ultrasonic cleaner to the recommended level for operation, not placing items directly in the bottom of the ultrasonic cleaner, and degassing the water and cleaning solution.

**QA/QC Guidelines**

When using the ultrasonic cleaner, all manufacturer recommendations should be followed (including use of heat). Additionally, the setups validated in this study should be used to ensure that firearms are not damaged by being placed in the ultrasonic cleaner. A procedure regarding the use of the ultrasonic cleaner will be added to the Firearms Section Procedure Manual. In addition, all examiners and technicians will be trained in the proper general use of the ultrasonic cleaner as well as the approved setup configurations and suggestions for cleaning solutions.
When using cleaning solutions that need to be prepared by the user, manufacturer recommendations for preparation should be followed. The amount of water and Haemo-Sol/Oxi-Clean powder that should be used will be posted near the ultrasonic cleaner for ease of use.

An important consideration when using the ultrasonic cleaner is balancing the length of time spent in the ultrasonic cleaner with the anticipated benefits. Firearms should be cleaned to a safe and operational state but should not be left in the ultrasonic cleaner longer than necessary.

At the conclusion of testing, an effort should be made to prevent any further damage to firearm by thoroughly rinsing free of chemicals, drying, and oiling the firearm. This preserves the firearm for return to the owner as well as for potential future testing.

**Interpretations**

Since the ultrasonic cleaner did not damage marking surfaces when utilized for short durations (less than five minutes) it is recommended for use for removal of rust and blood from firearms.

Additionally, the ultrasonic cleaner was successful in removing blood from firearms and it is recommended for use in conjunction with Haemo-Sol and Oxi-Clean for firearms that pose a biological hazard. Furthermore, Haemo-sol is recommended over Oxi-Clean for instances where blood or other biological hazards have penetrated the interior areas of the firearm.

Since the ultrasonic cleaner was successful in removing rust from firearms it is recommended for use in conjunction with Evaporust for firearms that are inoperable due to rust/corrosion. It is important to remember that marking surfaces and the finish on metallic surfaces can be damaged by the ultrasonic cleaner when used for longer periods of time. That potential damage should be weighed against the benefit of removing rust from the firearm. However, it is acceptable to place firearms in the ultrasonic cleaner for longer than the recommended five minutes at the discretion of the examiner/technician in order to maximize visibility of markings for comparison and NIBIN entry.

**References**


