State of Idaho
Department of Law Enforcement
Bureau of Forensic Services

FIREARMS & TOOLMARKS TECHNICAL PROCEDURES Manual

Adopted from Washington State Patrol manual

TABLE OF CONTENTS

CONTENTS (continued)

CONTENTS (continued)

APPENDIX C

Sample Worksheets

I. Firearm Worksheet
II. Bullet Worksheet
III. Cartridge Case Worksheet
IV. Photo Work Sheet

INTRODUCTION

INTRODUCTION

The methods and procedures presented in this manual are designed to act as guidelines to **assist** in the proper examination of firearm and toolmark evidence. The examiner is additionally assisted by appropriate technical references as well as private references and communications.

The many variables involved in the examination of firearms- and toolmark-related evidence preclude a "recipe" type manual. Formulas have been included where appropriate in the text and in the appendixes where referenced. Further references or assistance may be obtained by contacting other examiners.

The methods manual is subject to continual review and procedures may be updated or replaced with new methodology.

The forensic scientist responsible for firearm and toolmark examinations will conform to accepted methods and procedures. Proper ethical and professional standards will be maintained as an employee of the Idaho Department of Law Enforcement, Bureau of Forensic Services.

Each procedure in this manual requires certain safety practices. **The examiner is reminded to practice good safety habits at all times.**

Although many of the procedures in this manual are recognized internationally as standard methods, all of them must follow a quality assurance program involving peer review. Peer review is accomplished by subjecting all firearms and toolmarks cases to examination by any other qualified firearms examiner such as Ed Robinson and Stan McGee of the Washington State Patrol Crime Laboratory in Spokane, Washington.

Proficiency testing is recognized as an important adjunct to peer review, and together they function as critical elements of the overall quality assurance program. Each year, every examiner must complete at least one firearm proficiency test and one toolmark proficiency test.

FIREARM EXAMINATION PROCEDURES

FIREARM EXAMINATION PROCEDURES

The procedures in this section require the skills of a trained firearm examiner. To be deemed fully trained, an examiner must have completed an appropriate training program. For each procedure, a fully trained examiner must confirm that the training was completed and that the trainee is able to perform the procedure properly.

To ensure the accuracy and completeness of case documentation, the AFTE glossary should be used for appropriate definitions and appropriate manufacturers' nomenclature for describing firearms parts.

Worksheets should be used to ensure inclusion of all pertinent facts pertaining to the submitted evidence.

The standard method for associating suspect firearms with fired ammunition components is comparison microscopy, using a microscope specifically designed for firearm/toolmark comparison.

Photographs documenting identifications will not normally be taken. Identifications are not made from photography; hence, it is recognized that photography is primarily for recording purposes and generally documents only selected portions of an identification. Photography is inherently limited in its ability to record all of the observed detail.

Firearm/toolmark examiners do not use photographs to make comparisons and reach conclusions because:

1. A photograph is a two-dimensional image of an object that is three-dimensional.
2. Photographs often contain insignificant detail which will confuse people not trained in microscopic comparison.
3. A photograph is still and freezes the cursor (hairline). An actual comparison is very dynamic, and continuous moment of the cursor is an integral part of the examination process.
4. Photographs can be falsified or altered.
5. Photographs provide an incomplete representation of the entire comparison process.
6. Visual data in photographs, particularly when magnified, can be misinterpreted by people not trained in firearm/toolmark examination.

7. The lack of photographic skill by the examiner may affect the resultant image.

8. The incorrect interpretation of a photograph may endanger the accused, particularly on a probable identification

Evidence should be marked for identification by the examiner. Care must be taken to ensure that the evidence is not unnecessarily altered and that firearms are not defaced.

The criteria for identification is an acquired skill based on experience and training in observing patterns of individual and class characteristics which result in the formation of an opinion. The counting of individual characteristics will not be required for an identification.

Examiners are reminded of the importance of quality assurance as discussed in the "Introduction" of this manual. An experienced examiner should peer review all identifications.

SAFE FIREARMS HANDLING IN THE LABORATORY

- **Safety Checks**

Firearm evidence in the laboratory is not dangerous if handled correctly and treated with respect. Occasionally, loaded weapons are received in evidence for a particular examination. These, of course, need very special handling and will be discussed later. **All firearms should be treated as though they are loaded, until the examiner proves they are not!** This rule cannot be overstressed and must be followed at all times, whether it is at the front counter or in the vault, firearms section, range, or court. Safe gun-handling here corresponds exactly with safe gun-handling in general. Prevent accidents by practicing safety at all times.

A rule that needs strict adherence is to keep the muzzle pointed in a safe direction at all times! Some firearms are received containing live ammunition and, therefore, this precaution is extremely important and makes common sense.

The firearms section will provide an examiner to check the "loaded" status of all firearms submitted to the laboratory. In the event an examiner is not available to check, the submitted firearm shall be placed in a box marked substantially as follows:

CAUTION: FIREARM
NEEDS SAFETY/LOADED
CONDITION CHECK

Due to variations in facilities and personnel, the procedure for conducting the safety/loaded check shall be determined in each laboratory by the laboratory manager and the firearms section. The firearms section shall provide special handling for firearms that are unable to be safely unloaded.

A designated area shall be provided within each evidence vault for the safe and proper storage of firearms.

LABORATORY/FIREARMS SECTION SAFETY

- No one will be down range/in front of the examiner while a weapon is being fired.
- Firearms to be test-fired will be loaded and unloaded in the firing area.
- Ear and eye protection must be worn by all persons present during live firing.
- Appropriate notice (i.e., verbal) shall be given prior to test-firing.
- Questions of safety have to be resolved prior to the procedure continuing.

- It is recommended that two people be present in the facility during test-firing.
- When utilizing an outside agency, public or private, existing range rules will be strictly followed.
- After all examinations are completed, no loaded firearm will be placed in the evidence vault or returned to any agency.

PRE-FIRING SAFETY CHECK

It is the responsibility of the firearm examiner to ensure that appropriate safety function checks are performed on a firearm prior to test-firing. Following is a list of safety checks which shall be considered in every case. The examiner should be mindful that individual situations may require more extensive safety checks than that which are listed here. Examiners are reminded to be careful not to lose or destroy trace evidence while performing the safety check.

1. SAFETY CHECKS FOR ALL FIREARMS

a. Is the firearm unloaded? (Check tubular magazines carefully.)

i. General Examinations

ii. Are there any loose or damaged parts?

iii. Are there any dangerous modifications?

iv. Is there a barrel obstruction?

v. Are there any loose or missing screws?

CAUTION: Movement or replacement may make the weapon safer, but may also significantly alter the operational characteristics.

vi. Are there any firearm recall notices that must be considered?

b. Ammunition

i. Are they reloads? As a general policy, they will not be used unless necessary. Remote firing is strongly recommended.

ii. Was the firearm designed for the ammunition to be used (i.e., rechamberings, wildcat cartridges, +P rounds)?

iii. Was the firearm originally designed for black powder loads (i.e., Damascus barrels)?

iv. Are there any ammunition recall notices that must be considered?

2. SAFETY CHECKS FOR REVOLVERS

a. Cylinder

i. Is the cylinder secure when closed?

ii. Do the chambers align with the barrel?

iii. Is the cylinder bulged?

b. Cylinder Rotation

i. Does the cylinder bind?

ii. Does it lock up in both SA and DA?

iii. Does it skip chambers with partial trigger return?

c. Transfer Bar/Hammer Block - Is one present and operational?

d. Trigger

i. Does it return reliably?

ii. Is there a proper pull weight for the revolver model in both SA and DA?

e. Hammer

i. Will it push off?

ii. Will the hammer fall from half cock when the trigger is released?

iii. Are there any false seating positions?

iv. Does the hammer rebound when the trigger is released?

3. SAFETY CHECKS FOR NON-REVOLVER FIREARMS

a. Safeties

i. Do they operate? (Check each safety independently.)

ii. Engage safety, pull and release trigger. Does weapon fire when safety is then disengaged?

b. Disconnector

i. Is one present?

ii. Does it work? (Hold trigger and cycle action.)

c. Lock

i. Does the slide/bolt engage tightly?

ii. Will the weapon fire when the slide/bolt is partially open?

d. Firing pin — Is it free to retract and not binding?

e. Hammer

i. Will it push off?

ii. Does the half cock catch?

iii. Will the hammer fall from half cock when the trigger is pulled?

iv. Are there any false seating positions?

v. Will the hammer/striker release when the bolt is closed quickly?

f. Bolt Action — Will the striker drop when the bolt is closed quickly?

g. Trigger

i. Is the pull weight normal for the type of firearm? (Certified dead weights or calibrated spring tension scales are both acceptable methods.)

ii. If pressure is applied as the action is closed, will the hammer fall?

h. Feeding (Check with dummy ammunition).

*i. Drop/Impact testing is a recognized procedure.

*j. Examination and restoring evidence firearms to safe operating conditions is a recognized procedure.

*k. Examination/Disassembly of damaged/altered firearms for operating condition is recognized procedure.

**AFTE Training Manual, Module 2*

TRACE EVIDENCE

Firearms evidence is often submitted with debris that may cover its characteristics. In order to determine class characteristics or compare individual characteristics of the firearm evidence, this debris may have to be removed. This debris may consist of blood, tissue, paint, fibers, glass, etc. The value of this debris as trace evidence should be considered during this examination. The examiner is cautioned that this type of evidence may present a health hazard. Trace evidence should be collected in compliance with standard laboratory protocol.

In addition to mechanical means, the following list of reagents may be used to clean ammunition evidence:

1. Fifteen percent acetic acid or weaker
2. Methanol
3. Ten percent bleach (AIDS and Hepatitis B)
4. Soap and water

Examiners are reminded that they are responsible for knowing the requirements and safety practices outlined in the Safety Plan. Examiners are also responsible for knowing the health hazards involved in the use of the chemicals named above. These chemicals and their hazards can be found in the Material Safety Data Sheets that are on file in each laboratory.

CASES WITHOUT FIREARMS

The examiner should determine the class characteristics of fired ammunition components. Examples of these class characteristics include but are not limited to:

1. Caliber, weight, type, direction of twist, number of lands and grooves and their widths, extractor/ejector mark locations, unique breech face, and/or manufacture. These characteristics should be compared to appropriate data files and lab data in order to generate a list of possible firearms. When a list of firearms is reported, appropriate qualifying statements should be included to reflect any limitations of the data.

Pellet size determination is normally conducted by one or more of the three procedures listed:

1. Direct comparison with known shot sizes.

2. Weighing a specific number of shot in comparison to the same number of known shot sizes, or values established in reference material.

3. Measuring diameter and comparing to known shot sizes or establishing reference material.

Wad gauge determination should be conducted in direct comparison with known standards. The direct comparison method may also be used for brand, type, and design identification.

The expended bullets and cartridge cases in a case submission should be compared in order to determine the number of possible firearms involved.

Expanded hollow point or controlled expansion bullets may have to be straightened/unfolded to observe class and individual characteristics. Documentation should be made of the condition of these bullets prior to straightening/unfolding.

CASES WITH FIREARMS

The examiner should document a case with notes, worksheets, and sketches or photographs noting the condition of the submitted firearm (i.e., safety positions, smoke rings, action position and fired components).

The examiner should perform appropriate safety tests prior to test-firing.

An objective of test-firing is to duplicate as closely as possible the conditions at the time of the shooting incident in a controlled laboratory environment. Prior to test-firing, the examiner should evaluate the need for swabbing the barrel or indexing test ammunition.

The examiner should test fire a minimum of two rounds of ammunition so that the test components are suitable for comparison. These test fires should be permanently retained in the laboratory for reference.

The examiner should be aware of the dangers of firing down-loaded ammunition and the possible change in stria of these bullets.

The examiner should follow these basic procedural techniques in order to facilitate examinations:

1. Ensure that the comparison microscope is properly adjusted for equal magnification at both stages.

2. Directly illuminate the driving edge of the land impressions of bullets during initial examinations.

3. Compare the test-fired components to ensure reproducibility of class and individual characteristics prior to comparing them to the evidence components.

4. Adopt a consistent procedure for the handling and documenting of comparison evidence. As a matter of practice, mount the questioned on the left and the test on the right.

5. During the comparison, documentation of the phase orientation of test-fired and evidence components is recommended.

6. Peer review.

Expanded hollow point or controlled expansions bullets may have to be straightened /unfolded to observe class and individual characteristics. Documentation should be made of the condition of these bullets prior to straightening/unfolding.

SILENCERS (SOUND SUPPRESSORS)

The examiner should evaluate the item as to structure and design, as well as its effectiveness as a silencer. This includes identifying components and structural configurations which indicate an attempt to reduce the noise of discharge.

Prior to testing, the device shall be examined for prior usage and its suitability for safe testing.

In testing silencers, it is recommended that testing equipment (such as an impulse noise level meter) be used in determining sound levels. An audible reduction will satisfy most courts.

Every effort should be made to preserve the device in its original form.

FULL-AUTOMATE FIREARMS AND CONVERSIONS

The examiner should evaluate the design, and test the mechanical function of the firearm or component to determine the possibility of full automatic function.

Extreme caution should be used in the test-firing of any suspected full automatic firearm. Trainees should not be allowed to handle these cases unless closely supervised. Firearms converted to full automatic modes of fire are susceptible to a wide range of malfunctions.

It is recommended that while test-firing for the collection of samples, no more than two rounds of ammunition be loaded into the firearm. Test-firing for the rate of fire should be conducted at a range adequate to accommodate full automatic fire of the caliber being fired.

It is a recognized practice to disassemble full automatic firearms to study the design and to identify any altered internal parts.

BARREL LENGTHS AND OVERALL LENGTHS

Measuring the barrel length and the overall length of a firearm is an easy process. To ensure that all examiners do it the same way, the following rules have been adopted:

1. Barrel Lengths

   a. Revolvers

      Measure the distance from the breech end of the barrel to the muzzle, excluding the cylinder.

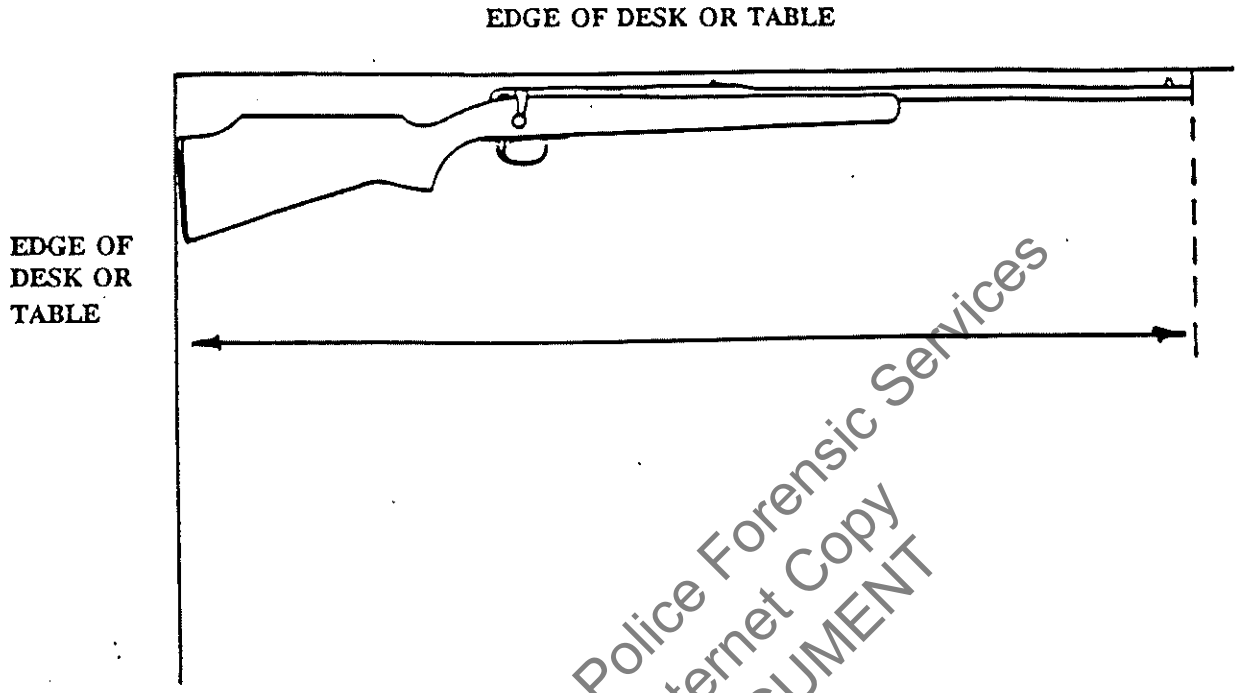
   b. Firearms other than revolvers

      Measure from the breech face in a closed and locked position to the muzzle.

2. Overall Lengths

   Measurements shall be made parallel to the bore and include the longest distance from the butt to the muzzle (see example below).

3. Removable barrel extensions, poly chokes, flash hiders, etc., are not part of the measured barrel lengths or overall lengths.



BORE AND CHAMBER CASTINGS

Occasionally, rifles are received with unknown calibers or calibers that may differ from the designation on the weapon and in the literature. In order to fire test shots that are of correct caliber for a particular firearm, it may be necessary to make a bore or chamber cast. Then, by measuring the cast, the correct cartridge can be determined.

Several methods are available and include casting material (such as low melting point metals and silicone rubber compounds). The specific method will be at the discretion of the examiner.

LAND AND GROOVE MEASUREMENTS

One of the class characteristics used for bullet identification is land and groove measurements. Several instruments are available for making such measurements, and the technique of measurement is approximately the same in each. The critical parameters are the points used for beginning and end of a measurement. Use one or more other methods listed below:

1. Air Gap Method

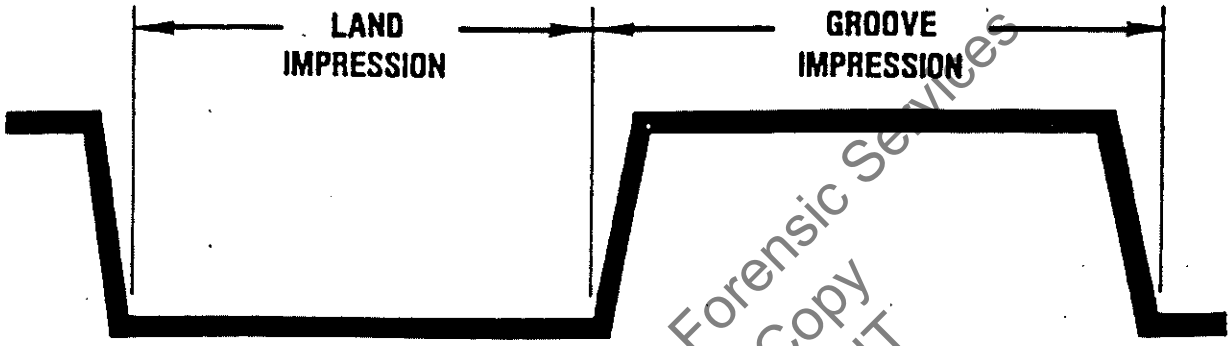
   See AFTE Newsletter, No. 4, December 1969, pp. 28 - 34.

2. Stereozoom microscope with measuring eyepiece or rule.

3. Measuring projector (Unitron Mp 6A or comparable instrument).

LAND IMPRESSION
(BULLET GROOVE)

GROOVE IMPRESSION
(BULLET LAND)



Measure land impression and groove impression as shown above.

TOOLMARK EXAMINATION PROCEDURES

TOOLMARK EXAMINATION PROCEDURES

The completion of the procedures in this section require the skills of a fully trained firearm/toolmark examiner. To be deemed trained in a particular procedure, the examiner must have completed an appropriate and approved training program for the procedure. Additionally, a trained examiner must confirm the training was completed and the trainee is able to perform the procedure satisfactorily.

To ensure the accuracy and completeness of case documentation, it is recommended that the AFTE glossary be used for appropriate definitions and appropriate manufacturers' nomenclature be used for describing tool parts.

The standard method for associating suspect tools with evidence marks is comparison microscopy using a microscope specifically designed for firearm/toolmark comparison.

Photographs documenting identifications will not normally be taken for the reasons outlined in the "Firearm Examination Procedures" of this manual.

Prudence should be exercised in the placement of permanent identification marks on tools and toolmarks so that significant evidence is not altered and the probative value is not lessened.

The criteria for identification is an acquired skill based on experience and training in observing patterns of individual and class characteristics which results in the formation of an opinion. The counting of individual characteristics will not be required for an identification.

All toolmark cases will be peer reviewed by a qualified firearms examiner such as Ed Robinson or Stan McGee of the Washington State Patrol Crime Laboratory in Spokane, Washington.

TRACE EVIDENCE

Toolmark evidence is often submitted with debris adhering to the questioned tool or toolmark. This debris may consist of paint, metallic fragments, glass, wood, etc. The value of this evidence should be evaluated on an individual case basis and, if deemed necessary, collected according to standard laboratory protocol.

TOOLMARK EXAMINATION

The following procedure describes the general methods of working toolmark cases. Because these cases can vary extensively, specificity for any one type is not possible; therefore, this generalization will basically apply to all cases.

The determination of class characteristics (i.e., type of mark, number of marks, size, etc.) is necessary for further comparison or elimination of the suspected tools. While examining for class characteristics, quality of individual characteristics also can be noted, choosing the best ones for the first comparisons. Test marks are made in a suitable material (see "Test Marks," page F/T-15) and marked as to side, edge, or tooth of the tool and then compared to the submitted marks.

The examiner should follow these basic procedural steps to facilitate examinations:

1. Ensure the comparison microscope is properly adjusted for equal magnification at both stages.

2. Adjust the illumination to fully visualize the microscopic details of the toolmarks.

3. Compare the test marks to ensure reproducibility of class and individual characteristics prior to comparing them to the evidence marks.

4. Adopt a consistent procedure for the handling and documenting of comparison evidence. As a matter of practice, mount the questioned on the left and the test on the right.

5. During the comparison, documentation of the phase orientation of test mark and evidence mark is recommended.

6. Peer review.

7. Procedures 2 and 3 will be repeated for every item of evidence requiring this examination.

TEST MARKS

In order to compare an evidence toolmark with a suspected tool, test marks are usually made with the tool. An objective while preparing test marks is to attempt to duplicate the manner in which the tool was used to produce the evidence mark.

The initial test media should be soft enough to prevent alterations to the working surface of the tool. Subsequent test marks may require the use of a harder test material to better reproduce the evidence mark.

A systematic approach should be used for the production of test marks. Consideration should be given to: (a) Areas of recent use, and (b) the indexing of test marks, including test marks of all significant working surfaces.

MAGNESIUM SMOKING

Magnesium smoking is a technique for reducing the glare of a shiny object by lightly coating the surface with fine magnesium smoke. Due to eye and fire hazard, safety is a prime consideration. The use of forceps, proper eye protection, and a leather apron is recommended.

1. This process must be done in a properly ventilated area or under a hood.

2. Cut short pieces of magnesium metal ribbon off the roll and place the remaining roll in a safe place.

3. This technique should be done over a suitable receptacle.

4. **Never look directly at the magnesium flame!** Serious eye damage can occur due to the brilliant white light emitted by the burning magnesium.

5. The magnesium flame is very hot and must be kept away from other combustible/flammable substances. An ABC-type fire extinguisher must be kept nearby at all times.

Examiners are reminded that they are responsible for knowing the requirements and safety practices outlined in the Safety Plan. Examiners are also responsible for knowing the health hazards involved in the use of magnesium. This chemical and its hazards can be found in the Material Safety Data Sheets that are on file in each laboratory.

CASTING OF TOOLMARKS

If an item received for toolmark examination is too large for the microscopie's stage, a cast can be made of the mark or marks. It will also be necessary to cast the test mark so that the comparison will be alike (i.e., negative to negative). No matter what type of casting material is used, the casting procedure is done in a similar manner to all the marks being compared. The casting of toolmarks to facilitate comparison is a recognized practice. In addition, casting may be necessary so that the comparison being made is alike (i.e., negative to negative).

Mikrosil, silicone rubber, and duplicast are similar products used for this process. Follow the manufacturer's mixing instructions for proper usage.

Casting material can also be used for some physical matches where fracture areas need to be compared on the microscopie and the examiner needs to compare two positives or two negatives. This is helpful in cases where the contour is difficult due to one side being the opposite or mirror of the other. Although not always necessary, the examiner should be aware of this material's capability.

SERIAL NUMBER RESTORATION PROCEDURES

SERIAL NUMBER RESTORATION PROCEDURES

Serial numbers on most firearms, as well as many other objects, are usually die-stamped. This process produces a compression of the material in the area immediately surrounding and a short distance below the penetration of the die. Even though the number is obliterated by filing or grinding, restoration may be possible if the removal of the material is not past this compression area. If the obliteration is beyond this area, restoration is impossible for die-stamped, as well as etched or engraved numbers.

The most commonly employed procedure involves the use of an acid-etching solution, usually Heyn's solution. Heyn's solution is good for many steels and when diluted will work well for softer metals such as aluminum. The formula is given below. Other etching solutions used by the Crime Laboratory Division are contained in Appendix 2. Additional methods, reagents and restoration techniques can be found in the Handbook of Methods for the Restoration of Obliterated Serials Numbers[1]

The acid-etching technique is generally the same for all metals, but the reagents differ depending on the type of metal or alloy. The most important step is to thoroughly clean and polish the surface to be restored to a mirror-like finish. (Sometimes this step alone will make part or all of a number visible.) Examination with a low magnification and oblique lighting may also be helpful. Materials other than metal may require another technique.

CAUTION: Because the reagents are etching solutions and contain acids, they are potentially dangerous. They should be used under a fume hood or in a well-ventilated area only by qualified, trained personnel. Storage of these reagents when not in use should be in the appropriate chemical storage area.

- **Heyn's solution for Acid-Etching**

Concentrated hydrochloric acid	12 milliliters
Cupric ammonium chloride	1 gram
Deionized water	12 milliliters

[1]Treptow, Richard S., Handbook of Methods for the Restoration of Obliterated Serial Numbers, NASA, January, 1978. To Order, contact: Stanley G. Young, Project Manager, Materials & Structures Division, NASA Lewis Research Center, Ohio 44135 (Grant NSD 3036 (3030); NASA Contract Report CR-1353)

- **Procedure for Acid-Etching**

1. Make a tape lift (with black fingerprint powder) of the obliterated surface prior to the restoration attempt. This serves to illustrate the original starting condition.

2. Polish the metal surface by hand using a series of aluminum oxide paper from medium to ultra fine grade. It is best to polish in one direction. Deep gouges may require the use of an electric wheel fitted with emery paper or similar polishing compound. Take care not to heat the working surface due to friction.

3. The final polished surface must be mirror-like with cuts and blemishes removed to the extent possible (a single ddep cut may not be completely removed).

4. Clean the surface with acetone.

5. Apply the Heyn's solution with dacron, cotton, or fiberglass swabs (cotton swabs deteriorate more quickly, but they are cheap and they will work just fine). Observe the etching action of the solution carefully.

6. When numbers appear, wipe off the solution, or rinse the solution off with water. Write down the numbers as they appear. Sometimes the numbes can be seen better if the surface is moistened with water, glycerine, or oil.

7. If the numbers are not clear, repolish the surface, and repeat steps 5 and 6. It may take several attempts to adequately restore the entire number. Be careful not to etch beyond the numbers or the compression area. Patience is a virtue in serial number restoration.

8. Once the procedure is completed, lightly oil the restored surface to prevent rust.

It is sometimes desirable to accelerate the etching process. This can be done with DC voltage, using a 6- to 12-volt battery or a toy train transformer. The transformer is best because the voltage can be varied to suit your needs from 0 to about 20 volts DC. Two lengths of 14-gauge wire are each fitted with an alligator clip on one end. The opposite ends of the wires are attached to the positive and negative terminals respectively.

- **Procedure for Accelerated Etching With DC Voltage**

1. Clip the positive wire to the firearm or other item being examined.

2. Attach the negative wire to a Dacron, cotton, or fiberglass swab moistened with Heyn's solution. Make sure that the clip touches the upper portion of the fiber bundle of the swab and is in contact with the solution.

3. Touch the swab to the area being examined and move it back and forth.

4. Watch the area closely and monitor the speed of the reaction. Adjust the voltage up or down as necessary.

5. When the number is visualized, remove the swab, wipe off the solution, or rinse with water. Write down the number.

6. It may be necessary to repeat the process, but be careful not to etch beyond the compression area.

7. Once completed, lightly oil the area to prevent rust.

NOTE: Avoid electrical shocks. Keep the transformer away from water. Make sure the floor is dry. Observe the safety precautions common to electrical appliances.

Examiners are reminded that they are responsible for knowing the requirements and safety practices outlined in the Safety Plan. Examiners are also responsible for knowing the health hazards involved in the use of the chemicals named above. These chemicals and their hazards can be found in the Material Safety Data Sheets that are on file in each laboratory.

PROXIMITY ANALYSIS PROCEDURES

PROXIMITY ANALYSIS PROCEDURES

The completion of the procedures in this section require the skills of a trained examiner. To be considered trained, the examiner must have completed an appropriate and approved training program for the procedures in this section. The training must be verified by another trained examiner.

Training guidelines should include, but should not be limited to, the *Association of Firearms and Toolmarks Examiners (AFTE) Training Manual*, Modules 4 and 6.

To help ensure the accuracy and completeness of case documentation, it is recommended that the AFTE glossary and the FBI gunpowder and primer residues course outline be utilized for appropriate definitions.

Worksheets should be used to ensure evaluation of all pertinent facts pertaining to the submitted evidence.

The procedures in this section should be peer reviewed. They include the following:

1. Bullet Hole and Range Determination
2. Gunshot Residue Examination Sequence
3. Shotgun Range Determination

BULLET HOLE AND RANGE DETERMINATION

The examination of items for projectile holes, impact sites, and subsequent range determination of a firearm-to-target distance can include the evaluation of gunpowder or lead residue patterns, shot patterns, and/or trajectory profiling.

Any deviations from the use of the actual case firearm, ammunition, or target when conducting distance determination tests must be documented in the notes. The procedure should include the examination of the area around any holes for gunshot residues, both visually and microscopically.

"At" or "near contact" ranges may be based on observations of the evidence alone. Ranges greater than "at" or "near contact" must be based on test-firing patterns.

Lacking an obvious visual pattern, at least two techniques from the following list will be conducted:

Microscopic	X-ray
Modified Griess	SEM
Sodium Rhodizonate	Dithiooxamide
Infrared	X-ray Fluorescence

All range determinations for ranges other than contact will be reported using upper and lower limits. Outside factors such as powder deflection, intermediate targets, handling or moving of an article may affect the powder pattern.

It is recommended that *AFTE Training Manual*, Module 4, be utilized as a guideline for training.

- **Chemical Processing of Clothing for Distance Determination**

  This technical supplement is to provide the examiner with a reference for using the Modified Griess and Sodium Rhodizonate Tests. The Modified Griess Test is a specific color test for the nitrite containing compound, produced as a combustion product of smokeless powder. The Griess Test does not chemically interfere with the Sodium Rhodizonate Test for lead residue. The Griess Test must be performed first since the converse is not true.

  In general the chemical reactions that occur in the Griess Test involve converting the nitrite compounds on the garment to an orange dye. These dye pigments are preserved in a medium (desensitized photographic paper) for future side-by-side comparisons with test patterns of known distances.

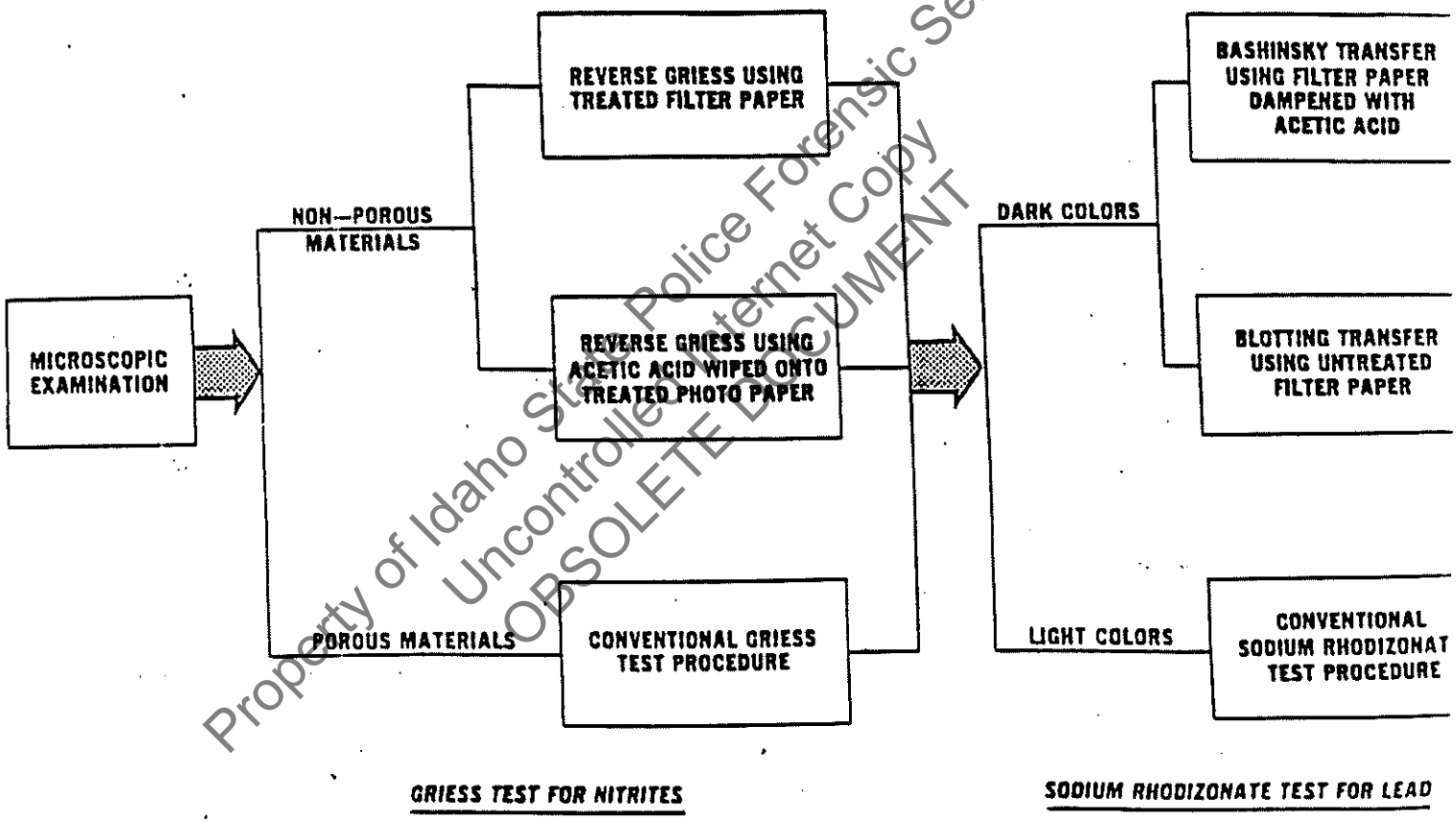
  The process of converting the nitrites is done by exposing the compounds to vaporous acetic acid using an acid solution and heat (dry iron) to form nitrous acid. This nitrous acid then combines with sulfanilic acid in the test media (photographic paper) to form a diazonium salt of sulfanilic acid. The diazonium salt then binds with alpha-naphthol (1-naphthol), also in the test media, to form the orange azo dye.

  The Sodium Rhodizonate Test uses a reagent (sodium rhodizonate) to react with any lead or other heavy metals present on the garment producing a pink color. The specificity for the lead is to apply an additional acid solution (5% hydrochloric acid) to the area. If lead is present then the pink areas will change to a blue-violet color. The chemistry involved is thought to be a chelating of the metal to the rhodizonate molecule and that the blue color is a molecular complex consisting of lead rhodizonate and hydrochloride.

The reagents and test media preparations are outlined in the *FBI Gunpowder and Gunshot Residue Manual* and in the AFTE Journal article, Volume 22, Number 3, pages 243-250 for the Modified Griess Tests; and AFTE Journal article , Volume 22, Number 3, pages 252-256 for the Sodium Rhodizonate Test.

Examiners are reminded that they are responsbile for knowing the requirements and safety practices outlined in the Safety Plan. Examiners are also responsible for knowing the health hazards involved in the use of the chemicals named above. These chemicals and their hazards can be found in the Material Safety Data Sheets that are on file in each laboratory.

- **Gunshot Residue Examination Sequence**



SHOTGUN RANGE DETERMINATION

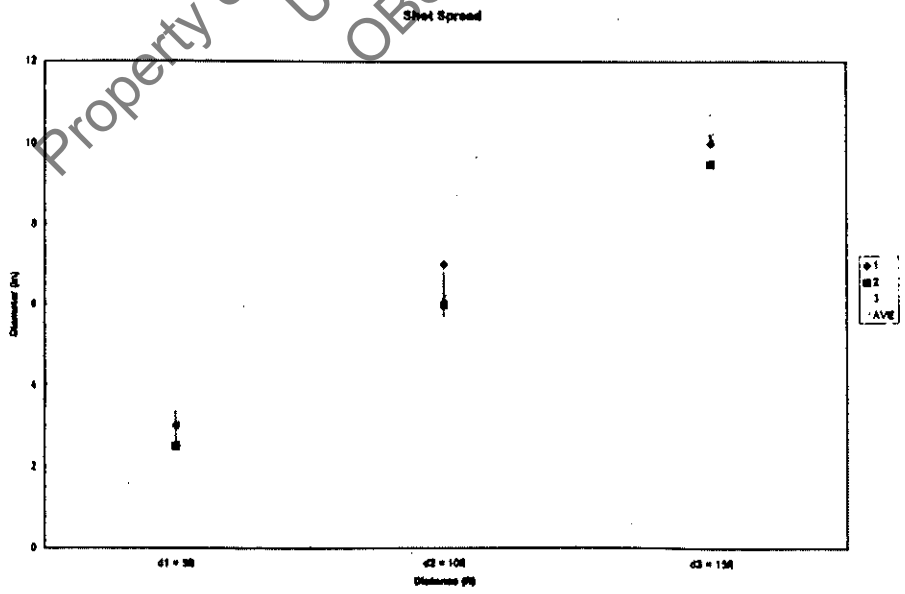
The question of shotgun-firing distance, based on a shot pattern, can be determined by test-firing the suspect shotgun using ammunition like that in the case at targets placed at known distances from the muzzle. Since not all shotgun/shotshell combination will fire exactly the same size pattern repeatedly at a given distance, the "performance envelope" of the shotgun/shotshell combination must be ascertained. This can be done by a graphical analysis of the data collected from the test-firing process.

•Procedure for Shotgun Range Determination

1. Three shots are fired at each distance at suitable targets.
2. The pattern size for each shot is measured in inches.
3. The data is placed into a tabular form as illustrated in the example below:

	d1 = 5 ft	d2 = 10 ft	d3 = 15
1	3.00	7.00	10.00
2	2.50	6.00	9.50
3	3.50	5.50	11.00
Ave	3.00	6.17	10.17
Stdev	0.50	0.76	0.76

4. The data is then plotted on a graph as illustrated below:



5. The mean distance for a given pattern size can be determined from the graph by dropping perpendicular lines from the two extreme curves to the range axis.

- **Conclusion**

Results obtained in this fashion could be reported in the manner suggested below:

The chest area of the item 1 T-shirt was found to exhibit a shot pattern. Using the item 2 shotgun, and ammunition like that in item 3, a similar pattern was produced at an approximate firing distance (or muzzle-to-garment distance) of 5.5 to 7.3 yards (or converted to feet).

REFERENCE STANDARDS

REFERENCE STANDARDS

Reference standards are required to assist the firearm and toolmark examiner to properly accomplish the mission of providing the examination and analysis of submitted evidence. These standards include, but are not limited to, firearm reference collection, ammunition reference collection, technical reference library, security device collection, as well as access to the members of the Association of Firearm and Toolmark Examiners (AFTE). These standards need to be continually updated to keep pace with industry developments and the state-of-the-art in these fields.

WORKSHEETS AND NOTES

Taking proper case notes to support an examiner's conclusion can be facilitated by the use of worksheets. Although there are no standardized worksheets, notes will generally contain the following:

- Information identifying and describing the case and evidence
- Examiner's observations
- Test data and measurements
- Other information pertinent to the case (such as telephone calls, conferences, autopsy reports, etc.)

The report will contain a synopsis of the data which may be of interest to the investigator and any conclusions drawn from the data.

- **General**

Laboratory number
Agency name
Agency case file number
Date received
Date released
Item numbers
Page numbers

- **Firearm**

Firearm make
Firearm model
Firearm country of origin
Firearm serial number and location
Received condition
Caliber
Number of lands and grooves
Direction of twist
Barrel length
Finish
Cartridge capacity
Single- and double-action trigger pulls
Evidence of recent firing and number of times
Number of times test-fired
Ammunition used in test-firing
Mechanical operability (did firearm function normally?)
Trace evidence
Alterations or modifications

- **BULLET**

Caliber
Make
Bullet type
Weight
Design
Number of lands and grooves
Direction of twist
Land impression width
Groove impression width
Trace evidence
Marks of comparison value

- **Cartridge Case**

Caliber
Headstamp
Trace evidence
Marks of comparison value

Samples of worksheets that contain the above-listed information are contained in Appendix 3.

Taking of notes is also essential when examining other related evidence such as clothing for gunshot residue and toolmarks. Due to numerous evidence variations, it is not feasible to generate a list of pertinent information. Several examples of worksheets for recording notes on this type of evidence are also included in Appendix 3.

TRAINING

TRAINING

It is recommended that the training of a firearms examiner be conducted and supervised by an examiner qualified in all of the procedures of this manual.

Training programs and outlines should be flexible and attempt to address the infinite variables involved in modern forensic firearm/toolmark identification.

To ensure the accuracy and completeness of training, the following recommendations are made:

1. The use of the AFTE glossary for appropriate definitions.

2. The use of appropriate manufacturers' nomenclature for describing firearm/tool parts.

3. The use of recognized established training outlines (such as AFTE, Illinois State Police, Oregon State Police, or a combination thereof.)

4. Documentation of completed training to be retained by the laboratory and trainee.

5. Peer review of the training prior to completion by an examiner other than the primary examiner, in a laboratory other than the one being trained in, at regular established intervals with the following goals:

   a. To ensure documentation is completed.

   b. To evaluate strengths and weaknesses in a timely manner.

   c. To evaluate testimony.

   d. To determine if the trainee has reached an acceptable level of performance.

6. The training goals are:

   a. To provide the firearm/toolmark examiner with a high level of confidence in his/her ability to perform the job procedures.

   b. To ensure the laboratory system that the examiner is producing a high quality, verifiable, work product.

   c. That the judicial system benefits from professional, ethical, honest interpretation, and reporting of firearm/toolmark evidence.

APPENDIX

APPENDIX A

GUNSHOT RESIDUE EXAMINATION ARTICLES

THE MODIFIED GRIESS TEST:

A CHEMICALLY SPECIFIC CHROMOPHORIC TEST FOR NITRITE COMPOUNDS IN GUNSHOT RESIDUES

SA John H. Dillon, Jr., FBI Laboratory, Washington, DC

KEY WORDS

Griess, nitrite, range determination, powder pattern, gunshot, gunpowder residue, chromophoric test, Marshall's reagent

ABSTRACT

This article describes the development of the *Modified Griess Test* for detecting nitrites in gunshot residues, the preparation of the reagents, and their recommended utilization.

PURPOSE

The purpose of this paper is to provide the firearms examiner, forensic chemist, or general criminalist with a practical bench reference for use in performing the *Modified Griess Test.* This is a chemically specific chromophoric (color-producing) test for the presence of nitrite compounds, such as produced by the burning of smokeless powder. This test has superseded the standard Griess Test in the FBI Laboratory because it does not involve the use of Marshall's Reagency, a known carcinogen, and does so without loss of chemical specificity. Further, the results of the *Modified Griess Test* are more vivid, the reagent costs are less, and little or no retraining of personnel is required, in that procedures and test media very similar to those of the "old" Griess Test are used.

After completing a study of the material in this paper, the reader will be able to prepare the reagents and test media for the *Modified Griess Test,* perform the test, discusses its chemistry in a general way and note positive results.

DISCUSSION

Smokeless powder, as used in modern cartridge-type ammunition, is essentially cellulose nitrate, an organic compound results from the exposure of a cellulose source (such as cotton or wood fibers) to nitric acid in the presence of sulfuric acid under controlled conditions of temperature and pressure. This process is called "nitration" and simply involves the addition of nitrogen and oxygen atoms to the cellulose molecule. The practical result is a greatly enhanced potential for the release of energy if suitably ignited, as by the spark from the primer of a cartridge. When smokeless powder does burn, or partially burns, various nitrite compounds are formed, and these are detectable by the use of chemically specific chromophoric tests. The safest, cheapest, most adaptable and most practical of these techniques is the *Modified Griess Test.* This method permits an analysis of the size and density of patterns of nitrite residues on a victim's clothing or other objects, and therefore their reproduction at known distances using a suspect weapon and ammunition n combination. It does so with reagents not currently known to be or suspected of being carcinogens. Alpha-naphthylamine as used in the Walker Test, and Marshall's Reagent of the standard Griess Test containing N-1 (1-naphthyl)-ethylenediamine dihydrochloride are avoided, but the chemical specificity of the results is retained.

While it is true that the *Modified Griess Test* makes it possible to detect nitrite residues beyond the capability of the unaided human eye to see, this test is not a substitute for a careful microscopic examination of a questioned surface prior to any chemical testing. The *Modified Griess Test* will not substitute for the necessary visual (1) and microscopic observations regarding the physical characteristics of the gunpowder involved, nor will it detect completely unburned powder (nitrate) particles. The microscope and its careful use by the examiner is the best recourse for these kinds of observations.

THE EVOLUTION OF THE MODIFIED GRIESS TEST

In 1928, Goroncy (a German chemist) proposed the use of alpha-naphthylamine and sulfanilic acid in an acetic acid solution for the detection of nitrite compounds as normally found in the residues of smokeless powder. His test involved cutting out a portion of the victim's clothing and extracting a solution of the residues from the cloth. If a red color was produced upon adding acetic acid to the solution under controlled conditions, the depth of color of the solution could be used as an indication of the approximate distance of the suspect weapon from the garment at the time of discharge. This technique was interesting, certainly, but it gave no indication of the residue distribution or pattern around a suspected bullet hole, and it was destructive in nature.

As early as 1938, Joseph Walker (1) suggested the adaptation of Goroney's chemistry to a mechanically and chemically better approach. He proposed the use of similar reagents, "C" acid (2-naphthylamine-4, 8-disulfonic acid), or "H" acid (alpha-naphthalamine and sulfanilic acid), but instead of adding these reagents to an extract of residues from a victim's garment, he used the reagents to treat a piece of standard emulsion-coated photographic paper which had been desensitized by exposure to a hypo solution. This made the paper light in-sensitive, while becoming chemically sensitive to nitrite compounds under the correct conditions. Walker's technique dictated the formation of a layered "sandwich" which consisted of the treated paper, emulsion side up, the victim's clothing, residue side down, with the bullet hole centered on the treated paper, and layers of toweling containing one layer moistened with an acetic acid solution. The entire package was exposed to heat by simply ironing it for five to ten minutes. Any reddish specks of pigment subsequently found imbedded in the emulsion of the photographic paper were dye pigments produced by the chemical reactions due to the presence of nitrite compounds, and only nitrite compounds. The other benefits of this approach were: (1) that a permanent graphic representation of the nitrite residues present were preserved in the emulsion; (2) that patterns generated this way provided the basis for later comparisons with known-distance patterns fired in the laboratory; and (3) further, the technique was not destructive of the evidence.

The Walker Test was used for many years with great success and with a few minor changes in specific technique and test media, such as the use of a single layer of cheesecloth in lieu of the multiple layers of toweling, However, by the early 1970's, it became known that the chemical alpha-naphthylamine was extremely dangerous—a proven carcinogen. It was necessary to find an alternative chemical or technique. The Firearms/Toolmark Unit and research personnel of the FBI Laboratory then cooperated in a project to find such an alternative. It was determined that the chemistry of one of the spot tests contained in Fritz Fiegl's Spot Tests in Organic Analysis (2) could be adapted to the existing procedures and test media of the Walker Test and still give results which were chemically specific. This spot test, the Griess Test, involved the use of Marshall's Reagent (3), a combination of equal parts of a solution of sulfanilic acid in water and a solution of N-(1-naphthyl)-ethylenediamine dihydrochloride in methyl alcohol. Such a technique was used until the later 1970's, when it then became known that the Marshall's Reagent was a carcinogen, as had been the case with the alpha-naphthylamine in the Walker Test.

A second joint project was then undertaken by the Firearm/Toolmarks Unit and researchers of the FBI Laboratory in order to find a substitute for the Marshall's Reagent which would: (1) still give chemically specific results; (2) which would not be toxic, carcinogenic or otherwise harmful; and (3) which could be integrated with existing techniques. Contacts with the Royal Canadian Mounted Police (RCMP) indicated that their laboratories employed a series of reagents applied directly to victim clothing (5) in order to detect particulate nitrite deposits. The RCMP method is the subject of an AFTE Journal article (3). The reagents were similar to those used in the Griess Test, except that alpha-naphthol or naphthoresorcinol was used in place of the Marshall's Reagent. Further, it was known that neither the alpha-naphthol nor the naphthoresorcinol were carcinogens and that, in fact, both were mild antiseptics. Independent

research confirmed that the RCMP test was indeed specific for nitrite compounds, and that a positive result was indicated by the production of an orange azo dye if alpha-naphthol was used, or a yellow azo dye if naphthoresorcinol was used. In that the orange color was found to be brighter and alpha-naphthol was much more economical, it was decided to attempt to integrate that reagent into current procedures in lieu of Marshall's Reagent. Also, it was believed that the continued use of the photographic paper was preferable to a direct application on victim clothing in that the photographic paper would again provide a means of capturing the size and density of the nitrite pattern for future comparisons. Further, no problems caused by the "masking" effect resulting from the background coloration of red, orange, or yellow victim clothing would be encountered.

Thus the techniques and test media of the Walker/Griess Test were combined with the slightly different chemistry of the RCMP reagents normally applied directly to clothing, producing what is now called the *Modified Griess Test.*

It is noted that the *Modified Griess Test*, as with the previous nitrite tests, does not chemically interfere with the Sodium Rhodizonate Test for lead residues. However, the *Modified Griess Test* must be performed first, because the sodium rhodizonate does interfere with the test for nitrites.

GENERAL CHEMISTRY OF THE MODIFIED GRIESS TEST

In the *Modified Griess Test,* a series of chemical reactions results in the conversion of any nitrite compounds which might be present on an item, such as victim clothing, to a bright orange dye in a chromophoric reaction. These dye pigments are also simultaneously preserved in a suitable test medium (desensitized photographic paper) for later side-by-side comparisons with *Modified Griess Tests* of known-distance firings of similar residue patterns. In specific chemical terms, any nitrite residues which are present are exposed simultaneously to an acetic acid solution and heat to form nitrous acid. This nitrous acid then combines with sulfanilic acid in the test medium to form a diazonium compound of sulfanilic acid. In the final step in the sequence, this diazonium compound couples with the alpha-naphthol, also in the test medium, to form a bright orange water-soluble azo (nitrogen-bearing) dye.

Based on the above chemistry, it can be readily stated that this test is not appropriate for the detection of purely nitrate compounds, such as unburned smokeless powder. A practical reality, however, is that unburned powder particles (nitrates) are commonly coated with burned powder residues (nitrites) and positive reactions take place.

REAGENT AND TEST MEDIA PREPARATION

The following instructions are self-explanatory and are usable by both chemists and non-chemists alike in the preparation of the reagents and test media for use in the *Modified Griess Test* for nitrite residues. As always, good laboratory practice dictates the use of appropriate precautions to preclude inhalation, ingestion or skin contact with chemicals, whether in the preparation or use of reagents and test media. Ventilation, protective gloves, and hand-washing are definitely required. Storage of prepared chemicals and test media should be such that no outside contamination or intercontamination is possible. Storage containers should be kept sealed until the contents are needed.

It is noted that the desensitized photo paper mentioned below is simply photographic print paper which as been exposed to a hypo solution and thus no longer bears light sensitive silver salts in its surface emulsion.

1. Processing of previously desensitized photographic paper —

   a. Prepare a solution of 7.7 grains (0.5 grams) of sulfanilic acid in 100 milliliters of distilled water.

   b. Prepare a solution of 4.3 grains (0.28 grams) of alpha-naphthol in 100 milliliters of methanol.

   c. Combine the equal volumes of the above solutions.

   d. Pour the combined solutions into a nonreactive photo-processing tray and briefly dip pre-cut sheets of the desensitized photographic paper into the tray. Simply submerge the sheets completely and remove them.

   e. Set the sheets aside to dry on an uncontaminated surface.

   f. Place the remaining solution in an uncontaminated storage container and seal.

   g. **NOTE:** In lieu of desensitized photographic paper, ordinary laboratory filter paper may be processed in the same manner for use in the *Modified Griess Test.* Economy may dictate that this alternative be used. (See the suggested method in the specific test procedure which follows.)

   h. Shelf life for this reagent is known through experience to be at least two months and probably a great deal longer.

2. Preparation of nitrite test swabs —

   a. Prepare a solution of 9.3 grains (0.6 grams) of sodium nitrite in 100 milliliters of distilled water.

   b. Soak the cotton-tipped ends of a package of six-inch swabs (typically, one hundred/package) in the solution.

   c. Set the swabs aside to dry. Store in a sealed container.

3. Preparation of a 15% acetic acid solution —

   a. Combine 150 milliliters of glacial acetic acid with 850 milliliters of distilled water. Remember to gently pour the acid into the water to preclude the potential spattering of undiluted acid.

   b. Store in an appropriate uncontaminated sealed container.

SPECIFIC TEST PROCEDURES FOR QUESTIONED (EVIDENCE) ITEMS OR KNOWN-DISTANCE TEST-FIRINGS

1. Procedure for a *Modified Griess Test* —

   a. Test the four corners of the emulsion-coated side of the desensitized and chemically treated photographic paper for sensitivity to nitrite compounds. This is easily accomplished by saturating a nitrite test swab in a small amount of 15% acetic acid solution and dabbing the four corners. An orange color should appear at each corner, confirming such sensitivity before going further. Being able to testify to this sensitivity in court could turn out to be a critical issue.

   b. Place the evidence or known-distance test questioned side down on the emulsion-coated side of the treated photographic paper. Index seams, buttons, button holes, rips, pockets, suspected bullet holes, tears, cuts, etc., for possible future reference in court by marking with a lead pencil. DO NOT USE INK at this point because it may transfer back onto the tested item.

c. Soak a piece of nitrite-free cheesecloth in the 15% acetic acid solution (in a large beaker) and wring it out. Place the cheesecloth on the questioned item or known-distance test as the third layer of the "sandwich". Press the "sandwich" with a hot iron. On many irons, the setting for "cotton" is appropriate. (Note that nitrite-contaminate cheesecloth will cause a generalized orange background coloration. Although undesirable, this is not a fatal flaw as long as individual point reactions are still visible against the background.)

EDITOR'S NOTE: Jeff Doyle (4) describes a method that eliminates the cheesecloth. He added the dilute acetic acid to a steam iron and it is dispensed when heating and pressing. His method seems to work efficiently and have merit.

d. Discard the cheesecloth and separate the questioned item or known-distance test-firings from the photographic paper. Any orange indications on the paper are the result of a chromophoric reaction chemically specific for the presence of nitrite residues. Note that such reactions for nitrite residues may indicate visible nitrite sources (partially burned gunpowder), nitrite deposits which cannot be visually observed, even during a microscopic examination, or nitrite-coated unburned powder particles. While it is also possible that in a given case, a spurious source of nitrite residues (not firearms-related) could be introduced, it is unlikely that it would alter the meaning of the total array of point reactions around a suspected bullet hole. Often, such spurious nitrite sources are manifested as background haze in the test media as opposed to an array of point reactions. In view of these factors, it is normally not productive and often not possible to attempt to relate a given positive point reaction on the test medium to a corresponding visible point source on evidence items.

e. Retain any photographic paper showing positive results as a part of the raw data for inclusion in your notes. When dry, the photographic paper should be marked appropriately in ink with your symbol and case/file number. Test media relating to negative results need not be retained. In areas of the country with a constant high temperature and humidity, it may be advisable to spray positive results with a coating of Krylon clear plastic to inhibit any fading of the orange pigment.

2. An alternative procedure for a *Modified Griess Test* using treated filter paper instead of the more expensive photographic paper —

   a. Treat the filter paper in the same solutions used for treating the photographic paper. Allow it to dry.

   b. Place the filter paper on the questioned surface. Test for nitrite sensitivity using the test swabs.

c. Saturate a piece of nitrite-free cheesecloth in the 15% acetic acid solution and wring it out. Place the cheesecloth over the filter paper and apply a hot iron.

OR

d. Spray the filter paper with the 15% acetic solution until very damp. Cover with two or three additional layers of filter paper and iron until dry.

e. Separate the test media and check for positive results.

3. Procedure for a reverse *Modified Griess Test* for thick or otherwise nonporous materials through which the acetic acid solution "steam" will not penetrate—

a. Tape a piece of filter paper or other appropriate nitrite-free substitute to the back of a piece of desensitized and treated photographic paper. Test as usual, using nitrite test swabs.

b. Place the photographic paper emulsion side down on the questioned surface and use a pencil to index seams, buttons, suspected bullet holes, pockets, rips, tears, cuts, etc., for possible future courtroom reference.

c. Wipe the emulsion-coated side of the photographic paper with a piece of cheesecloth saturated with a 15% acetic acid solution. Apply the solution to the entire surface, but lightly. Too much will cause indistinct or hazy results due to pigment migration.

d. Immediately place the photographic paper emulsion side down on the questioned surface. Apply a hot iron to the back of the photographic paper. Note that the back was previously covered by filter paper or an appropriate substitute, otherwise the paper may stick to the iron.

e. Separate the photographic paper and the questioned item. Any orange indications on the photographic paper are the result of a chromophoric reaction chemically specific for the presence of nitrite residues.

f. When dry, mark and preserve any positive results for retention as in the previously described normal *Modified Griess Test.*

EDITOR'S NOTE: Monty Lutz and Reginald Templin (5) point out that some disinfectants can cause positive reactions to the Griess Test. Also M. James Kreiser (6) notes that marijuana can cause a positive reaction to the Griess Test.

BIBLIOGRAPHY

1. Anonymous (1970). "Gunshot Residues and Shot Patterns Tests," FBI Law Enforcement Bulletin; 39:9:7-11 (revised 2/79).

2. Barnes, F. C. and Helson, R. A. (1974). "An Empirical Study of Gunpowder Residue Patterns", J. Forensic Sci., 19:448-462.

REFERENCES

1. Walker, J. T., (1940). "Bullet Holes and Chemical Residues in Shooting Cases", Journal of American Institute of Criminal Law and Criminology; 31:497-521.

2. Fiegl, F. (1966). Spot Tests in Organic Analysis. 7th ed., Elsevier Publishing Co., New York.

3. Watson, D. J., (1979). "Nitrites Examination in Propellant Powder Residue". AFTE Journal, 11:1:32.

4. Doyle, Jeffrey S., "Griess Test Modification", AFTE Journal, Vol. 19, No. 2, p. 165.

5. Lutz, Monty C., and Templin, Reginald H., "Some Disinfectants Cause Positive Reaction to Griess Test", AFTE Journal, Vol. 15, No. 4, p.35.

6. Kreiser, M. James, "A Potential 'False' Reaction With the Griess Test". AFTE Journal, Vol. 16, No. 3, p.9.

THE SODIUM RHODIZONATE TEST:

A CHEMICALLY SPECIFIC CHROMOPHORIC TEST FOR LEAD IN GUNSHOT RESIDUES

SA John H. Dillon, Jr., FBI Laboratory, Washington, DC

KEY WORDS

sodium rhodizonate, lead residue, gunshot residue, distance determination

ABSTRACT

Lead residue in gunshot cases can be identified using the sodium rhodizonate test as defined by this procedure. This article describes the source of the lead, preliminary examinations, reagent preparation and testing, and test procedure. If lead is present, this test is specific for it.

PURPOSE

A purpose of this paper is to provide the firearms examiner, forensic chemist, or general criminalist with a practical bench reference for use in performing the *Sodium Rhodizonate Test* on shooting victim garments or other surfaces for the detection of lead residues. Equally as important, this reference will provide a means for forensic laboratory personnel to rapidly refresh their recollection in regard to the various aspects of this test prior to court testimony. Knowledge and the self-assurance and confidence it produces form the foundation for credible expert testimony. This paper is directed toward supporting such an end.

After completing a study of the material in this paper, the reader will be able to prepare the reagents and test media for the *Sodium Rhodizonate Test,* perform the test, discuss its chemistry in a general way, and note positive results.

DISCUSSION

When firearms discharge, more than simply a projectile leaves the weapon. In addition to the bullet (or shot pellets) and unburned and partially burned powder, various forms of lead residue typical of the discharge of a weapon can be ejected. The most notable type of lead residue is the very visible vaporous lead or "smoke" produced by the high velocity turbulence of expanding muzzle gases at closer ranges. This phenomenon deposits minute lead particulate on victim garments or other objects, including possibly the shooter's own garments and a large variety of other possible surfaces. These deposits are primarily due to the lead compounds typically found in cartridge primer mixtures. However, significant amounts of this easily observed deposit can result fro the friction generated by the bullet/barrel interaction and from surface erosion of the bases of bullets, including open-based jacketed bullets. In the case of a revolver, lead residues, among other types of residues, can also escape through the cylinder gap between barrel and cylinder, and to a much lesser degree, from the ejection port of an autoloading weapon.

In addition, other types of lead residues can leave a weapon and be deposited on victim garments or other surfaces. Lead-coated smokeless powder particles, small lead shavings, or other grosser lead particulate (such as small solidified lead droplets) are often observed. Further, visible or invisible lead residues may be left on a surface due to the passage of a bullet. This "bullet wipe" is found on the immediate perimeter of a bullet hole, even in the case of a fully-jacketed bullet which still carries traces of lead from the combustion products of primer compounds in a cartridge and/or barrel residue from previous firings.

One implication generated by the above is that a careful microscopic examination may supply a considerable amount of preliminary data concerning the lead residues that may be present around a suspected bullet hole. Obviously, such a preliminary examination emphasizes the physical characteristics of those lead residues which are present and visible. However, it is possible and advisable to proceed further and with greater specificity than to simply note physical characteristics. This can be done by a chemical test which can both corroborate the preliminary findings in regard to visible lead deposits and also detect lead residues not visible to the unaided eye. This is accomplished by the use of a chemically specific chromophoric (color-producing) test for lead, the *Sodium Rhodizonate Test.*

CHEMISTRY OF THE SODIUM RHODIZONATE TEST

The *Sodium Rhodizonate Test* is a procedure in which a succession of previously prepared reagent solutions is applied to a surface, such as a victim's garment, in an attempt to detect any type of lead residue present. It is always performed after the Modified Griess Test (1) in order to preclude chemical interference and, thus, invalid results.

EDITOR'S NOTE: See the article by the same author on the Modified Griess Test as part of this series.

The initial step in the test sequence is to spray the questioned area with a saturated solution of sodium rhodizonate in distilled water. This is followed by spraying with a buffer solution (pH2.8) consisting of sodium bitartrate and tartaric acid in distilled water. Any pink reaction which results may be lead, but in order to be objective, it must be confirmed in an additional procedure which is chemically specific for lead. At this point, it should again be noted that the test is chromophoric (color-producing) and that these colors are dependent on the metals present and the degree of acidity. In order to test specially for the presence of lead, a third reagent is applied by spraying with a dilute solution of hydrochloric acid. This spray changes the color of the pink areas to a blue-violet color if lead is present, and only if it is present.

It should be noted at this point that while chemists do not entirely understand the reaction of sodium rhodizonate and lead in turning from pink to blue, a plausible explanation is that the increased acidity causes the formation of a blue complex product consisting of lead rhodizonate and hydrochloric acid (2).

REAGENT PREPARATION

The following instructions are self-explanatory and usable by both chemists and nonchemists alike in the preparation of the reagents and test media for use in the *Sodium Rhodizonate Test.* As always, good laboratory practice dictates the use of appropriate precautions to preclude inhalation, ingestion, or skin contact with chemicals, whether in the preparation or use of reagents and test media. Ventilation, protective gloves, and hand-washing are definitely indicated. Storage of prepared chemicals and test media should be such that no outside contamination or inter-contamination is possible. Storage containers should be kept sealed until the contents are needed.

Each reagent solution is treated separately below, and helpful hints in the preparation of each are also included. Fractions or multiples of the weights and volumes indicated may be used as appropriate to the amount of work to be done.

1. Preparation of the Sodium Rhodizonate Solution

   a. Place a small amount of sodium rhodizonate in a small beaker and add sufficient water to make a saturated solution approximately the color of strong tea. The solution is saturated if a slight sediment is noted on the bottom of the beaker after stirring with a clean glass stirring rod.

   b. Make only enough solution for immediate use and do not store the solution. Shelf life is currently unknown.

2. Preparation of 2.8 pH Buffer Solution

   a. Dissolve 29.3 grains (1.9 grams) of sodium bitartrate and 23.1 grains (1.5 grams) of tartaric acid per 100 milliliters of distilled water. This usually requires both heat and agitation to complete in a reasonable period of time. A combination hot plate/magnetic stirrer is convenient for this and saves a great deal of time and effort.

   b. Store the solution in an uncontaminated and sealed container. Contaminate containers and water, or simply containers left open to the air, can allow the formation of what appear to be microscopic life forms which cloud the solution. While these do not interfere with the specificity or reliability of the test, they do tend to clog up reagent spraying equipment. Allow such material to settle before spraying.

3. Preparation of the Dilute (5%)[1] Hydrochloric Acid Solution

   a. Combine 5 milliliters of concentrated acid with 95 milliliters of distilled water. Remember to gently pour the acid into the water to preclude potential spattering of undiluted acid.

   b. Store the solution in an uncontaminated and sealed bottle.

SPECIFIC TEST PROCEDURES

Many of the procedures which follow involve spraying of reagents in an aerosol form. This can be done using cans of compressed gas (Spra-Tool, etc) or, what is much more cost-effective in the long run, a combination of air brush and air compressor. All spraying should be done in a chemical fume hood that has sufficient air flow to prevent back-flow of the reagents into the work area.

1. Direct Application to an Item of Evidence

   a. Spray the appropriate area of the questioned item with a previously prepared saturated solution of sodium rhodizonate in water.

   b. Spray the same area of the questioned item with the previously prepared tartaric acid/sodium bitartrate buffer solution. This solution will eliminate the general yellow background color caused by the sodium rhodizonate, will establish a local pH or 2.8, and turn any lead and a few other metals which may be present to a pink color.

[1] EDITOR'S NOTE: Since concentrated hydrochloric acid is only 36% - 38% HCl, the diluted acid is actually about 2% HCl or 0.64 Normal.

c. Spray the same area with the previously prepared dilute hydrochloric acid solution. The presence of lead is specifically determined wherever the previous pink color fades out and leaves a blue-violet color in its place. This indicates lead and only lead. Be very aware of the fact that a positive (blue-violet) result may abruptly fade out. Take good notes immediately after applying the dilute hydrochloric acid solution.

2. The Bashinski transfer method (3,4) for dark-colored items which would mask the blue-violet coloration of a positive test result.

a. Place a piece of filter paper over the appropriate area of the questioned item.

EDITOR'S NOTE: Monty Lutz (5) pointed out that one batch of sodium rhodizonate from Fisher Scientific Co. did not react to show lead residue. His recommendation is to verify that the reagent is working to be sure that a negative is a negative! A small piece of lead acetate paper or a cotton-tipped swab rubbed vigorously on a piece of lead can be used to verify that the sodium rhodizonate reagent is working. Also, Doug Branch (6) cautioned that false positives can occur if the iron, previously used for the Griess Test, is not cleaned prior to using it with the *Sodium Rhodizonate Test.*

REFERENCES

1. Anonymous, (1970), "Gunshot Residues and Shot Pattern Test", FBI Law Enforcement Bulletin, Vol. 39, N. 9, pp. 7-11. (revised 2/79)

2. Fiegl, F. and Anger, V., (1972). Spot Tests in Inorganic Analysis, 6th Ed., Elsevier Publishing Co., New York.

3. Bashinski, J. S., Davis, J. E. and Young, C., (1974): "Detection of Gunshot Residues on Targets Using the Sodium Rhodizonate Test". Paper presented at the spring meeting of the California Association of Criminalists, Long Beach, California.

4. Bashinski, J. S. (1974). "The Evaluation of Gunshot Residues - the Sodium Rhodizonate Test". Paper presented at the fall meeting of the California Association of Criminalists, Berkeley, California.

5. Lutz, Monty C., "Problems with Sodium Rhodizonate". AFTE Journal, Vol. 19, No. 1, p. 15.

6. Branch, Doug, "Possible Griess Test Contaminant", AFTE Journal, Vol. 14, No. 3, p. 11.

APPENDIX B

SERIAL NUMBER RESTORATION INFORMATION AND FORMULAS

SERIAL NUMBER RESTORATION INFORMATION AND FORMULAS

SERIAL NUMBER RESTORATION SOLUTIONS FOR ACID ETCHING

- **Steel**

  Heyn's Solution

Cupric ammonium chloride	1 grams
Con. hydrochloric acid	12 milliliters
Deionized water	12 milliliters

Cupric chloride	5 grams
Ethanol	25 milliliters
Con. hydrochloric acid	40 milliliters
Deionized water	30 milliliters

Cupric chloride	90 grams
Con. hydrochloric acid	120 milliliters
Deionized water	100 milliliters

Ferric chloride	6 grams
Deionized water	100 milliliters

- **Cast Iron**

  Heyn's Solution (as above)

  Ammonium persulfate (as above)

- **Stainless Steel**

Ferric chloride	5 grams
Con. hydrochloric acid	50 milliliters
Deionized water	100 milliliters

- **Zinc Alloys**

Solution #1

Phosphoric acid (85%)	98 milliliters
Con. nitric acid	2 milliliters

Solution #2

Con. nitric acid	5 milliliters
Water	95 milliliters

Solution #1 is applied for 10 seconds, then wiped off. Solution #2 is then applied and the number should appear within 30 seconds. See the AFTE article written by Mike Knowles of ATF following this page.

- **Aluminum**

Sodium hydroxide	5 grams
Deionized water	100 milliliters
Heyn's solution (as above)	1 part
Deionized water	5 parts

- **Copper Alloys**

Nitric acid from concentrated to various dilutions with water.
(Depends on the rate of reaction for the particular alloy.)

- **Nickel Alloys**

Con. nitric acid	5 milliliters
Deionized water	95 milliliters

Accelerated by DC voltage

- **Brass**

Sodium sulfate	1.5 grams
Chromic acid	20 grams
Deionized water	100 milliliters

- **Lead Alloys**

Molybdic acid	100 grams
Ammonium hydroxide	140 milliliters
Deionized water	240 milliliters
filter then add	
Con. nitric acid	60 milliliters

INSTANT RECOVERY OF OBLITERATED SERIAL NUMBERS

Mike Knowles

Many of the firearms received in the lab for serial number restoration are made of a cheap zinc alloy. Such handguns as RG and Clerke and the Raven (Model MP-25) are made from this alloy. Therefore, a fast and reliable method of restoring the serial numbers on these guns would be of benefit.

In the Atlanta Lab, the most commonly used reagent for this alloy is a ten percent solution of ammonium persulfate. In the literature, I have found chromic acid recommended. I have found that ammonium persulfate, when it works at all, is very slow and requires constant attention since it tends to form crystals on the metal surface which discolor the metal and obscure the number. Chromic acid solution etches very rapidly even in low concentrations, causing pitting of the surface and a black coating is formed which obscures the number.

By applying two solutions alternately to the obliterated area, it is possible to see the number within seconds every time. One solution is ninety-eight mls. of eighty-five percent phosphoric acid to two mls. of concentrated nitric acid. The other solution is dilute nitric acid. The phosphoric acid cleans the surface and etches the area slightly, the nitric acid then turns the background grey, as in the spot test for zinc, leaving the number standing out in white. I have not known this method to fail, though of course, if the number is ground off deeply enough, it cannot be recovered. The complete procedure can be accomplished in three or four minutes.

First, the obliterated area is smoothed off, using a small rotary grinder with a mandrel and 400-grit emery paper. It is necessary to remove any prominent scratches, but if they are deep, it is best to try the solutions first before grinding too deeply, though you can grind some more if necessary.

Next, the phosphoric acid is applied with a cotton swab, enough to thoroughly wet the surface. This will foam furiously and eat the cotton swab, but don't worry, it etches very slowly and smoothly. After about ten seconds, wipe the surface off and apply the dilute nitric. The number will be visible within thirty seconds. If not, add more phosphoric acid and wait about thirty seconds, then wipe off the area and reapply the weak nitric. Deeply grooved areas may need more smoothing off before good results can be obtained. In most cases, this yields clearly visible numbers within one minute and legible numbers in all cases so far.

The strength of the nitric acid doesn't seem to matter much, but five to ten percent is strong enough. Wool-tipped swabs will last longer, the phosphoric actually dissolves the cotton in about two minutes. The swabbing action seems important to make the nitric work, but the phosphoric can just be put on and left to work a few seconds. Only a few milliliters of reagent is used for each gun, so two hundred milliliters will last a long time.

Recently, eighty-five such guns were brought into the Atlanta Lab for recovery of serial numbers. The results were needed for a trial the next week. These had been ground off using an electric drill with a very coarse stone, and were all badly grooved, yet recovery was instant in all cases. All eight-five were recovered in about eight man-hours.

In short, this method is fast and well-proven, superior by far to any others I have found.

****

ATF Atlanta Field Laboratory, Atlanta, Georgia 30370

Mike Knowles
Physical Science Technician
ATF Atlanta Field Laboratory
PO Box 2994
Atlanta GA 30370

APPENDIX C

SAMPLE WORKSHEETS

BUREAU OF FORENSIC SERVICES **Lab #** **Date**

FIREARMS IDENTIFICATION WORK SHEET

Type CAL Manuf Model Chamber #

#Location(s) Overall Length TWT & LAG #BBL's BBL Lgth

Choke

Other Marks & Locations

Safeties & Position as Received:

Type of Action & Extraction:

Exterior Color & Condition of Metal Of Grips

Conditon of Bore/Rifling

Powder Residues: BBL's Chamber #

Rifling/Bore Mfg. Method

Test Bullet Av. L. Impr Width G. Impr. Width

(Groove)Diam: Av. & Range Av. & Range

Barrel Av. L. Width G. Width

(Bore) Diam: Av. & Range Av. & Range

Trigger Pull &

Dry Firings: S/A ( ) D/A ( )

Operating Condtion

Type Magazine/Clip

Capacity & Contents:

BOB BBL Breech

Extractor = EXT FPN And

Ejector = EJR Finish:

Firing Pin = FPN

EXT or EJR Slot = ES BOB And

Breech or Bolt Striae = BOB Finish:

Impressions = I

Prep of Bore for Tests	
Test #	
Make & Cal	
Bullet Wt. & Type	
Ammunition Source	
Chamber #'s Used	
Ej. Characteristics	

Cylinder (Draw in): Chambers and assigned numbers; Dir. Of Cyl Rota.; Halos/Flares

Chamber Contents:

Misc. Notes:

BUREAU OF FORENSIC SERVICES **Lab #** **Date**

BULLET WORK SHEET

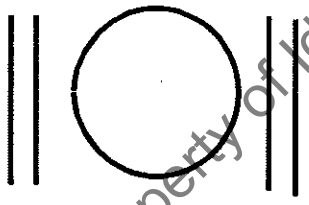
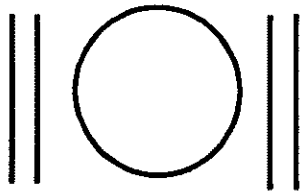
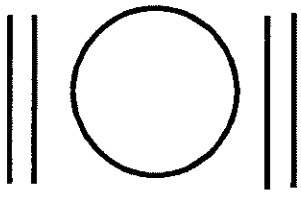
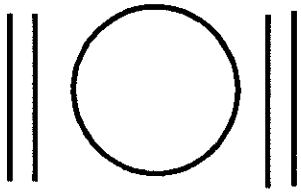
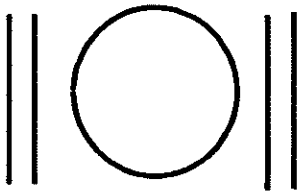
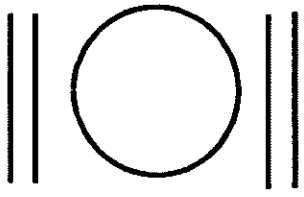
Item #						
Item Source						
Nominal Cal. & Wt.						
Sketch (undamaged)						
Composition						
Probable Mfg.						
Sketch (actual)						
Actual Wt.: Grain/Gram						
TWT & # LAG						
# LAG for comparison						
Potential for ID						
L. Imp. Width (range)						
G. Imp. Width (range)						
Impressions on Base						
Impressions on Nose						
Trace evidence						
Examiner ID marks						

Comparisons	Class	Individual	Conclusion	Remarks
T- /T-				
T- /T-				
T- /T-				
T- /Ev				
T- /Ev				
T- /Ev				

BUREAU OF FORENSIC SERVICES **Lab #** **Date**

CARTRIDGE WORK SHEET

Item #						
Item Source						
Cartridge Type						
Bullet Wt/Style						
Fired/Unfired/Misfired						
Case Composition						
Headstamp/Manuf						
Trace Evidence						
Damage						
Examiner's ID Marks						

Firing Pin = FPI: Extractor = EXT: Ejector = EJR: Breech or Bolt = BOB: Clip = CL: Mgazine = MA: Chamber Mark = CM:

BUREAU OF FORENSIC SERVICES **Lab #** **Date**

PHOTO WORK SHEET

Photo #:_____Photographer_____Date_____
Subject_____
Time_____f/_____Exposure Settings_____
Lighting_____Distance from Subject_____
Room Lights on/off Film_____Lens_____ASA___
Bellows extension_____Back Reflection Yes/No
Eyepieces___Objectives___Magnification_____
Comments_____
_____
_____

Photo #:_____Photographer_____Date_____
Subject_____
Time_____f/_____Exposure Settings_____
Lighting_____Distance from Subject_____
Room Lights on/off Film_____Lens_____ASA___
Bellows extension_____Back Reflection Yes/No
Eyepieces___Objectives___Magnification_____
Comments_____
_____
_____

1.5.4. Repeat these measurements until at least two measurements for each condition (will fire, and will not fire) agree within one quarter to one half pound of force.

1.5.5. Record results

1.5.6. Repeat steps 1.5.1 through 1.5.5 for double action mode.

1.6. QUALITY MEASURES

1.6.1. Weights used should be checked on a balance that has been calibrated and checked in accordance the appropriate procedure for that balance.

1.7. REPORTING RESULTS

1.7.1. Resultant trigger pulls should be recorded on an appropriate worksheet or other notes. These results may be included in a final report.

1.8. REFERENCES

AFTE GLOSSARY

Revision #	Issue Date	History
0		This is an original procedure offered 06/02

Approval

Technical Leader: Chester A. Park **Date:** 6-13-02

Chester A. Park

Issuance

QC Manager: Richard D. Groff **Date:** 6-13-02

Richard D. Groff

Properly reviewed; Validation not required; Appropriate detail

Idaho State Police
Forensic Services
Firearms/Toolmarks

Procedure for measuring trigger pull on firearms

1.1. BACKGROUND

The amount of force that must be applied to the trigger of a firearm to cause the sear to release and discharge the firearm.

1.2. SCOPE

During the course of examining a firearm, prior to test firing, measuring trigger pull is useful for safety reasons and as an aid in determining the likelihood of accidental discharge.

1.3. PRIN

Uss 1/23/06
Repl 1/10/07

ce of gravity on known weights applied to a
onfiguration while the muzzle is pointed
pplied force. The usual configuration
ith the muzzle vertical to the floor.

1.4. EQUIP

The equipment used is a standard device with which weights in varying amounts can be applied to a rod constructed so that it can be hooked over a trigger without touching any other part of the firearm.

1.5. STANDARDS

Standards consist of weights that can be combined for a cumulative effect.

1.6. PROCEDURE

1.6.1. Make sure no live ammunition is in the weapon

1.6.2. In single action mode, apply weights to the trigger using the described trigger pull equipment so that the force is applied parallel to the barrel until the firearm will fire (WF).

1.6.3 Remove weights (applied parallel to the barrel) until the firearm will not fire (WNF).

1.6.4. Repeat these measurements until at least two measurements for each condition (will fire, and will not fire) agree within one quarter to one half pound of force.

1.6.5. Record results

1.6.6. Repeat steps 1.6.1 through 1.6.5 for double action mode.

1.7. QUALITY MEASURES

1.7.1 The weights need to be checked and documented upon initial use, annually, and whenever there is reason to believe the weights may have changed. The balance used to check the weights will be calibrated and checked in accordance the appropriate procedure for that balance.

1.8. REPORTING RESULTS

Resultant trigger pulls should be recorded on an appropriate worksheet or other notes. These results may be included in a final report.

1.9. SAFETY PRECAUTIONS

All guns must be checked to ensure they are not loaded before performing examination.

REFERENCES

AFTE GLOSSARY

Idaho State Police
Forensic Services
Firearms Section
Trigger pull

Revision #	Issue Date	History
0	06-13-02	This is an original procedure offered
1	01-23-06	Moved part of 1.4 to 1.6.1 and now requires annual check of weights. Changed 1.6.1 should to shall re-worded 1.6.1 to clarify no substantive changes. Moved part of the background to the scope. Added scope section. Re-numbered the sections after Scope was added. Safety pre-caution added

Approval

Technical Leader: Dwight D. VanHorn Date: 01/30/06
Dwight VanHorn

Issuance

QC Manager: Richard D. Groff Date: Jan 24 2006
Richard D. Groff