18.0 DISTANCE DETERMINATION PROCEDURE

18.1 Scope: Gunshot residues are discharged from a firearm during the firing process. These residues will be in the form of burned, partially burned, and unburned gunpowder particles, vaporous lead, and particulate metals. Muzzle-to-target distance determination is based on gunshot residue examination and/or shot pellet patterning examinations, and the comparison of these patterns to those produced at known distances by the suspect firearm and like ammunition. The comparison of these gunshot residues, along with the morphology of the bullet hole or the size of the pellet pattern, can effectively be used in determining whether an item of evidence/clothing was in the near proximity of a firearm when discharged, and to give a range for the muzzle-to-target distance.

18.2 Precautions/Limitations: The firearm examiner shall handle the evidence as gently as possible, keeping in mind that the residues are very fragile by nature and can be lost if mishandled.

Because of the variations observed between different firearms and ammunition, it is imperative that the suspect firearm and like ammunition be used for producing test patterns. If the firearm is unavailable or unsafe to fire, the same type firearm may be substituted from the Firearms Reference Collection. Care should be taken to ensure the barrel length of the reference firearm is the same as the suspect firearm. Ammunition of the same type and design may be substituted for evidence ammunition when the known components are the same.

At the discretion of the firearm examiner, distance determination examinations may not be conducted until a suspect firearm is confirmed through microscopic comparison of the evidence bullet(s) and/or cartridge case(s) to test fired ammunition components.

18.3 Related Information:

18.3.1 TBI FTIU Chemical/Reagent Manual
18.3.2 TBI FTIU Quality Assurance Procedures
18.3.3 Appendix 1 Worksheets
18.3.4 Appendix 3 Firearms Safety
18.3.5 Appendix 4 Range of Conclusions
18.3.6 Appendix 5 Firearms Reference Collection
18.3.7 Appendix 6 Ammunition Reference Collection
18.3.8 Appendix 8 Verifications and Casework Review

18.4 Instruments:

18.4.1 Stereomicroscope
18.4.2 Keyence Digital Microscope
18.4.3 Digital Camera
18.4.4 Iron

18.4.5 Ruler
18.4.6 Transparent Overlay
18.4.7 Transparent Grid

18.5 Reagents/Materials:

All chemical and reagent preparation information is found in the TBI FTIU Chemical/Reagent Manual.

18.5.1 Reagents and Materials used in Griess Testing
15% Acetic Acid Solution
Griess Solutions
Nitrite Test Swabs
De-sensitized Photographic Paper
Cheesecloth/gauze
Aerosol Sprayers
Spray Bottles

18.5.2 Reagents and Materials used in Sodium Rhodizonate Tests
Tartrate Buffer Solution
Sodium Rhodizonate Solution
Whatman Filter Paper
Aerosol Sprayers
Spray Bottles

18.6 Hazards/Safety:

18.6.1 It is the responsibility of the firearm examiner to employ appropriate safety and health practices. Personal protective equipment shall be worn when handling bio-hazardous evidence. Safe firearm handling procedures shall be strictly followed at all times.

18.6.2 Appropriate hearing and eye protection shall be worn when applicable

18.6.3 Proper caution shall be exercised and the use of personal protective equipment shall be considered to avoid exposure to dangerous chemicals. It is recommended that the firearm examiner consult the appropriate Material Safety Data Sheet (MSDS) for each chemical prior to use.

18.6.4 The firearm examiner should use gloves, and work within a fume hood, when preparing reagents.

18.7 Reference Materials/Controls/Calibration Checks:

18.7.1 Ammunition Reference Collection
18.7.2 Firearm Reference Collection
18.7.3 Positive Lead Control
18.7.4 Nitrite Control Swabs

18.8 Procedures and Methodology:

Prior to performing distance determination examinations on evidence items, a link should be established through microscopic comparison of a bullet(s) and/or cartridge case(s) to a firearm. Additionally, the ammunition manufacturer and type should be determined by comparison to evidence ammunition, or by utilizing the Ammunition Reference Collection.

Prior to microscopic and chemical examination of evidence items for gunshot residues, the items must be thoroughly documented and photographed, including a written description of the evidence item and packaging, the locations of any holes in the items, and a sketch of the item indicating the locations of the holes and other observations (blood, cuts made by medical personnel, etc.). The location of the examiner's markings should be indicated in the notes or sketch. If available, a copy of the autopsy report and diagram of gunshot wounds should be attained and reviewed.

18.8.1 Visual and Microscopic Examination

Evidence items will be visually examined for observable physical characteristics of gunshot residues. This examination should be performed in an uncontaminated area using a variable power stereomicroscope with adequate lighting. During the visual examination, the examiner will look for physical effects that are indicative of, or consistent with, the discharge of a firearm. These effects include:

- Any holes in the item, or a pattern of pellet holes.
- Stellate, or star-shaped, tearing of the item (consistent with contact gunshots).
- Vaporous lead (smoke).
- Soot.
- Particulate metals (shavings of lead, copper, brass).
- Unburned or partially burned gunpowder particles.
- Melted adhering gunpowder.
- Burned and/or singed fibers, or melted artificial fibers.
- A visible ring around the perimeter of the hole(s).

Other observations may include:

- The location of all holes, tears, missing buttons, etc.
- The presence of any possible masking effects (blood, mud, etc).
- The direction of artifacts surrounding the hole.

All observations regarding these physical effects and visible residues shall be included in the firearm examiners notes, sketch, or appropriate worksheet. Photographic documentation of these effects may aid in the documentation. Transparent overlays may be useful in documenting partially burned and unburned gunpowder particles, and their locations relative to the bullet hole(s). The Keyence digital microscope may be used when photographing gunpowder particles.

18.8.2 Chemical Examination Procedures

18.8.2.1 Modified Griess Test Procedure

The Modified Griess Test utilizes a chemically-specific chromophoric (color-producing) reaction to help detect and distinguish obscure or faint gunpowder patterns. This test detects nitrites, a product of the incomplete burning of gunpowder, by reacting with Acetic Acid to form nitrous acid. The nitrous acid combines with Sulfanilic Acid and then Alpha-Naphthol to produce an orange-red color reaction.

It is at the discretion of the examiner to conduct a Modified Griess Test when physical effects indicate a contact gunshot or shot pattern. All other distance determination examinations require a Modified Griess test.

See the TBI FTIU Chemical/Reagent Manual for preparing the chemicals necessary to perform the Modified Griess Test, and for necessary controls.

The Modified Griess Test will be performed in an uncontaminated fume hood using a clean iron. The following steps will be followed when conducting a Modified Griess Test:

18.8.2.1.1 Place the evidence item questioned side down on the emulsion-coated side of the treated photographic paper. Using a pencil or other marking device, index suspected bullet/pellet holes.

18.8.2.1.2 Soak a piece of cheesecloth/gauze in a solution of 15% Acetic Acid and wring it out. Place the cheesecloth/gauze on the questioned item as the third layer.

18.8.2.1.3 Using a hot iron, press the cheesecloth/gauze forcing the Acetic Acid solution through the evidence item. The iron should be dry, and direct pressure should be applied without movement of the iron, until the produced steam subsides.

18.8.2.1.4 Carefully remove and discard the cheesecloth/gauze. Carefully separate the evidence item from the photographic paper.

18.8.2.1.5 Examine the photographic paper for a pattern of spots of orange reactions. Any orange indications on the photographic paper are the result of a chromophoric reaction chemically specific for the presence of nitrite residues.

18.8.2.1.6 Record the results of this test in notes, on worksheets, or photographically. The photographic paper should be retained in the designated area of the FTIU.

18.8.2.2 The Reverse Modified Griess Test Procedure

The Reverse Modified Griess Test is used for non-porous evidence items, which would interfere with the penetration of the Acetic Acid solution through the item.

See the TBI FTIU Chemical/Reagent Manual for preparing the chemicals necessary to perform the (Reverse) Modified Griess test, and for necessary controls.

The following steps will be followed when conducting a Reverse Modified Griess Test:

18.8.2.2.1 Spray or wipe the emulsion-coated side of the photographic paper with the 15%

Acetic Acid solution.

18.8.2.2.2 Immediately place the photographic paper emulsion side down on the questioned surface. Apply a hot iron to the back of the photographic paper. The iron should be dry, and direct pressure should be applied without movement of the iron. Note: Placing filter paper, cotton twill jean, or cheesecloth/gauze between the iron and the photographic paper can help prevent the photographic paper from sticking to the iron.

18.8.2.2.3 Separate the photographic paper from the evidence item. Any orange indications on the photographic paper are the result of a chromophoric reaction chemically specific for the presence of nitrite residues.

18.8.2.2.4 Record the results of this test in notes, on worksheets, or photographically. The photographic paper should be retained in the appropriate area of the FTIU.

18.8.2.3 Sodium Rhodizonate Test Procedure

The Sodium Rhodizonate Test is a chemically-specific chromophoric (color-producing) test to detect the presence of lead. This test can effectively be used to determine if a hole is consistent with the passage of a projectile, differentiate between entrance and exit holes, or to detect lead vapor. This test will be conducted on all distance determination examinations where holes appearing to be bullet/projectile holes are located, and is always performed after the Modified Griess Test or the Reverse Modified Griess Test.

See the TBI FTIU Chemical/Reagent Manual for preparing the chemicals necessary to perform the Sodium Rhodizonate Test, and for necessary controls.

The following steps will be followed when conducting a Sodium Rhodizonate Test:

18.8.2.3.1 Spray the questioned area of the clothing with the buffer solution.

18.8.2.3.2 Spray the same area with a saturated solution of Sodium Rhodizonate. The presence of lead will be indicated by a pink reaction. Record the results of this test in notes, worksheets, and/or photographically. A piece of Whatman filter paper may be used as a transfer medium to visualize the positive reaction (pink coloration) on dark colored evidence items, or the Bashinsky Transfer Method may be used.

18.8.2.4 Sodium Rhodizonate Bashinsky Transfer Test Procedure

The Bashinsky Transfer Method of Sodium Rhodizonate Testing is used to test dark-colored items which would mask the colors of the chromophoric reaction.

The following steps will be followed when conducting a Sodium Rhodizonate Bashinsky Transfer Test:

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

18.8.2.4.2 Using a pencil or other marking device, index the suspected bullet/pellet holes.

18.8.2.4.3 Uniformly dampen the filter paper while on the questioned item by spraying with a 15% solution of Acetic Acid.

18.8.2.4.4 Cover the dampened filter paper with several layers of dry filter paper. Apply a hot iron to the filter papers and iron it until the damp paper is dry.

18.8.2.4.5 Remove the filter paper which was in direct contact with the evidence item, and process it as in the direct application method. Note: Any positive reactions are a mirror image of the deposition of the questioned item.

18.8.2.4.6 Record the results of this testing in notes, on worksheet, and/or photographically.

18.8.3 Shot Pellet Pattern Procedure

Shot patterns in evidence items and clothing may also be examined microscopically and chemically tested for nitrites and lead residues. This process may detect any possible bullet hole(s) or other residues within the shot pellet pattern.

The main basis for distance determination utilizing shot pellet patterns is simply the size and density of the shot pattern and the production of similar size patterns with the suspect firearm and similar ammunition for comparison.

Documentation of shot pellet patterns will include:

- The overall size of the pattern, including dimensional descriptions and measurements. A transparent grid may aid in the documentation and measurement of shot pellet patterns.

  Some pellet patterns may be elongated in shape due to the angles involved at the instance of firing. In the cases where elongated patterns are present, the narrower dimension of the elongated shot pellet pattern is the significant dimension and the basis of comparison with the diameter of test pellet patterns.

- The examiner can visually eliminate flyers, or holes which deviate from a roughly circular pattern.

- The examiner may need to examine the pellet pattern microscopically to detect fine plastic particulate, or filler material. Filler material may assist in identifying or corroborating the type of ammunition involved and is, in itself, indicative of the discharge of a shotgun.

A direct side-by-side comparison of the evidence pattern with test patterns produced with the suspect firearm and like ammunition, at known distances, is necessary to determine a muzzle-to-target range. The size and the density of the patterns must be taken into consideration before arriving at a conclusion. The examiner must also conclude that the shot pellet pattern is complete, and not a partial pattern. Care should be exercised when examining clothing items, as the body is a rounded object capable of many orientations, which must be accounted for when providing a muzzle-to-target distance bracket.

Note: A shot pellet pattern is not necessarily the product of a shotgun having been fired. There are numerous handgun loads by various manufacturers that fire shot pellets, especially in the smaller shot sizes (rat shot).

Care must be taken when conducting a shot pellet pattern analysis when the evidence indicates

a buckshot load was fired. Due to the limited number of pellets in buckshot loads, this type of ammunition rarely produces a circular pattern with a regular distribution of pellet holes.

18.8.4 Production of Test Patterns:

18.8.4.1 Gunshot Residues Test Pattern Procedure

- Attach pieces of cotton/twill jean material, or a piece of material similar to the evidence, to a cardboard backing board. The test medium shall be marked with the muzzle-to-target distance of the test fire.
- It is essential that the suspect firearm and ammunition like that represented by the evidence be utilized for these tests. The evidence bullet(s) and cartridge case(s) should have been previously linked to the suspect firearm. If the exact firearm and ammunition is not available, samples may be used from the Firearm and/or Ammunition Reference Collections.
- Test patterns shall be produced at known distances to establish the range of gunshot residue produced by the suspect firearm and like ammunition.
- One test should be produced per piece of target media.
- Process the test media according to the procedures outlined above.
- Record all observations in notes.

18.8.4.2 Shot Pellet Test Pattern Procedure

- The test media for shot pellet test patterns is a large piece of filter paper or an appropriately sized cardboard target backing board.
- It is essential that the suspect firearm and appropriate ammunition be utilized for these test patterns. Care should be taken to ensure the shotshells used to produce test patterns are the same type as the evidence in the case. This includes manufacturer, gauge, shotshell length, load type, pellet size, pellet composition, total weight of shot, and type of shot wads. If the exact shotshells are not available, it is at the examiner's discretion to decide which type of ammunition will best represent the evidence when producing test patterns.
- Test patterns shall be produced at known distances to establish the shot pellet patterns produced by the suspect firearm and like ammunition.
- Record all observations in notes.

18.9 Records: The firearm examiner shall document their findings in the form of handwritten notes, computer generated notes, or by utilizing gunshot residue worksheets. If possible, the firearm examiner should consider photographing the evidence items before and after processing. The Griess paper and test patterns will be sealed, appropriately labeled, and retained indefinitely in the designated storage area.

18.10 Interpretations of Results:

18.10.1 Results consistent with the Discharge of a Firearm:

- Vaporous lead (smoke).

- Lead bullet wipe.
- Particulate metals (shavings of lead, copper, brass).
- Partially burned and unburned gunpowder.
- Stellate tearing.
- Shot pellet pattern.
- Presence of buffer material.

18.10.2 Results consistent with the Passage of a Bullet:

- A hole in the item with a visible ring around the perimeter of the hole(s).
- A hole in the item with a positive Sodium Rhodizonate reaction immediately surrounding the hole(s).

18.10.3 Indications consistent with a Contact Shot:

- Ripping or tearing (stellate).
- Burning or singeing.
- Melted artificial fibers.
- Heavy vaporous lead residues.
- An absence of gunpowder particles.

18.10.4 Possible Masking Effects

- Dark background color.
- Blood staining.
- An intervening object.

18.10.5 If the observations on the evidence item/clothing support the findings of a “contact shot”, no production or comparison to test patterns is necessary.

18.10.6 If the observations do not support a “contact shot” finding, a muzzle-to-target distance must be interpreted by comparison of the patterns on the evidence item/clothing to test patterns produced at known distances, using the suspect firearm and ammunition like that represented by the evidence. The results should include a range of distances that bracket the pattern of residues found on the evidence item/clothing.

18.10.7 The absence of gunshot residues on an item of evidence precludes the determination of a muzzle-to-target distance. In this instance, it may be useful to determine the maximum distance at which the suspect firearm and similar ammunition leave a pattern of residues. However, it must be emphasized that other factors (blood, intervening object, extensive or rough handling, etc.) may have affected the results of the testing.

18.10.8 For shot pellet patterns, a muzzle-to-target distance must be interpreted by comparison of the shot pellet pattern on the evidence item/clothing to test

shot pellet patterns produced at known distances, using the suspect firearm and ammunition like that represented by the evidence. The results should include a range of distances that bracket the shot pellet pattern size and density found on the evidence item/clothing.

18.11 Report Writing: Most distance determination report writing can be found in Appendix 4 Range of Conclusions. The Official Firearms Report should indicate if the submitted evidence ammunition was used for producing test patterns, or reference ammunition was substituted from the Ammunition Reference Collection. It should be clearly stated if a reference firearm was substituted for the suspect firearm, or if no firearm was submitted.

18.12 References:

Association of Firearms and Toolmark Examiners Training Manual, March 3, 2001

Association of Firearms and Toolmark Examiners Procedures Manual, July 9, 2001

Association of Firearms and Toolmark Examiners Glossary, 5th Edition, 2007

Dillon, John, H., "A Protocol for Gunshot Residue Examinations in Muzzle-To-Target Distance Determinations", AFTE Journal, July 1990, Vol.22, No.3, pgs. 243-274.

F.B.I., "Gunpowder and Gunshot Residue", Training Manual, 2000 Edition.

Nichols, Ronald G., "Shotgun Proximity Testing: A review of the Literature Regarding Muzzle-to-Target Distance Determinations Involving Shotguns", AFTE Journal, Summer 2006, Vol. 38, No. 3, pgs. 192-203.

Rathman, Garry, "Gunpowder/Gunshot Residue Deposition Barrel Length vs. Powder Type", AFTE Journal, July 1990, Vol.22, No.3, pgs. 318-327.

Rawls, Donald D. and John P. Ryan, Jr., "Modified Feigl Test for Lead", AFTE Journal, Summer 2006, Vol. 38, No. 3, pgs. 213-222.