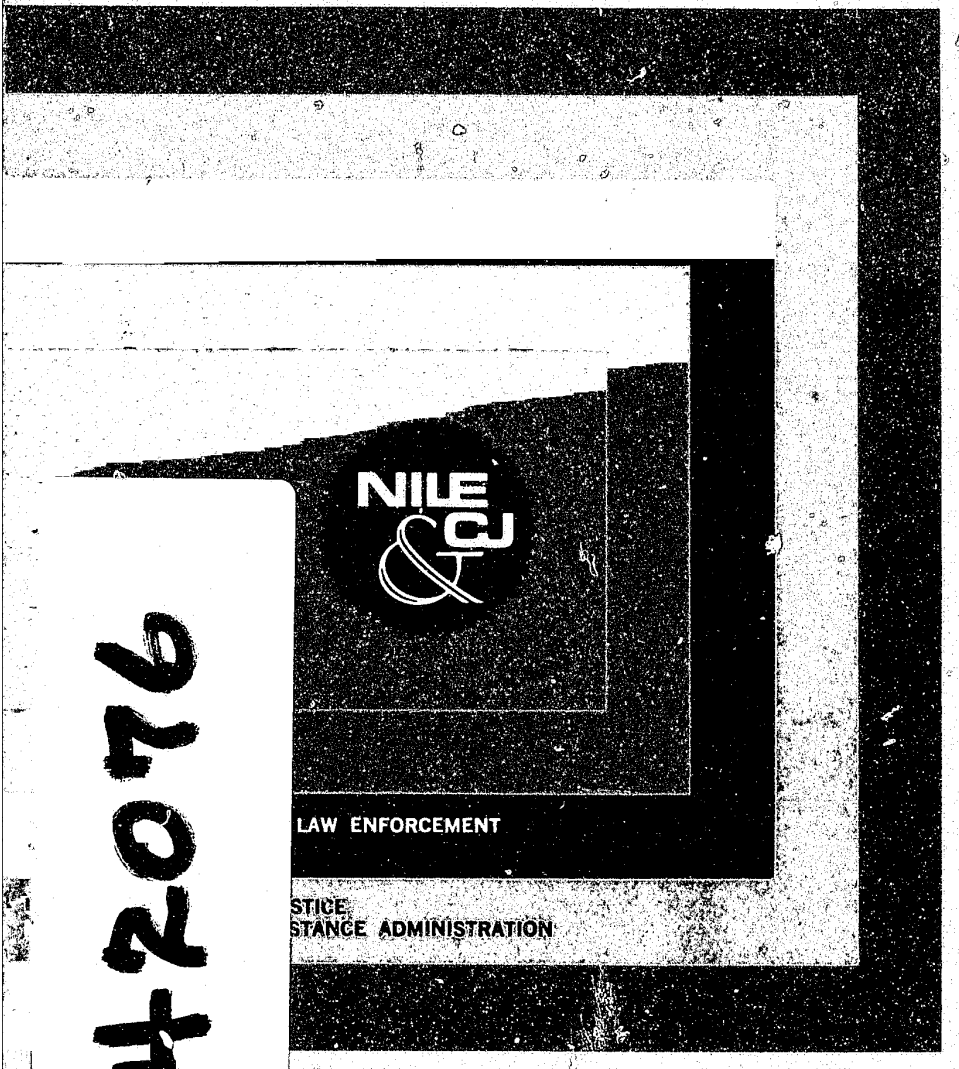
Trace Metal Detection Technique in Law Enforcement



Trace Metal Detection Technique in Law Enforcement

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A manual describing the technique for detecting and identifying traces and specific patterns left on suspects' skin and clothing by weapons, tools and other metal objects.

U.S. DEPARTMENT OF JUSTICE
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I. INTRODUCTION

A difficult problem in Law Enforcement is that of linking weapons (particularly undischarged firearms), tools and like objects to specific individuals. The essential need for such identification in cases involving homicide, suicide, assault, burglary, robbery and civil disorders has resulted in the development of a specific technique which shows whether an individual has been in contact with a particular metallic object. The technique can be conducted by police officers using simple equipment and the procedures described in this manual.

Research has determined that metal objects leave traces on skin and clothing surfaces in characteristic patterns with intensities proportional to the interaction of weight, friction, or duration of contact with metal objects. The Trace Metal Detection Technique (TMDT) makes such metal trace patterns visible when skin or clothing is treated with a test solution and then is illuminated by ultraviolet light.

Examination by ultraviolet light of the metal trace patterns which appear as fluorescent colors on the hands or clothing of the suspect allows a police officer to determine whether a suspect has been in contact with certain metal objects, the type of metal or metals in the objects; and also to infer what type of weapon or metal object was probably involved. The patterns and fluorescent colors can be analyzed with reference to the circumstances requiring the use of TMDT and with other related information to provide an initial source of evidence. Physical evidence obtained by the use of TMDT, however, should be used as an adjunct to complete investigation.

II. DESCRIPTION OF TMDT

A. Equipment. The TMDT requires the following equipment:

1. TMDT test solution.*
2. Plastic spray-type container (no metal parts).
3. An effective battery-powered, ultraviolet source. (See Section IX, ULTRAVIOLET LIGHT SOURCES, page 10.
4. Material or device for field use to shield area being examined from sources of illumination other than that from the ultraviolet light.

B. Selection of Test Areas. The areas to be examined are selected in relation to the circumstances, the suspect item (handgun, rifle, knife, tools, bludgeon, etc.) and to the normal handling, use, possession, or concealment of the suspect item. For example, if the suspect item is a handgun, in addition to the hands, those areas of clothing which may have been in contact with the weapon and the skin areas directly beneath should be examined. In the latter case, metal traces and patterns are sometimes found to have penetrated clothing to the skin area beneath.

C. Application of the TMDT Test Solution. The area to be examined is completely coated with the TMDT test solution. A spray container is generally the most suitable for this purpose. Whenever possible, the test surface should be in a vertical position while being sprayed to prevent the formation of puddles.

Although the TMDT test solution is non-toxic to skin surfaces, it should not be taken internally. Care should be taken to avoid spraying the solution into the subject's eyes. If spray does get into the eyes, the subject should immediately flush his eyes with water for at least ten minutes and obtain medical aid.

D. Drying the Test Area. The test area is allowed to dry for a period of two or three minutes. The drying time of hands can be shortened by swinging the arms. Sunlight, breeze and hot air also shorten the drying process. Test areas on clothing and other materials should be allowed to dry thoroughly before examination.

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*See page 15.

E. Examination of the Test Area by Ultraviolet Light. The TMDT solution produces a light yellow fluorescence on those parts of the test area that have not been in contact with metal objects. This pale yellow fluorescence provides a background for the metal trace patterns seen on parts of the test area that have been in contact with metal objects. The metal trace patterns will give off fluorescent colors that are unique to types of metals, and appear as silhouettes against the light yellow fluorescent background of the test area. Examples of fluorescent colors produced by various metals are:

Steel-iron	Blackish purple
Brass-copper	Purple
Galvinized iron (tin)	Bright yellow
Aluminum	Mottled dull yellow
Lead	Buff (flesh tone or tannish)

The officer first should identify the types of metal that have been in contact with the test area by the fluorescent colors that appear under the illumination of the ultraviolet light. Essential to the officer's ability to make this identification is his knowledge and experience of what fluorescent colors are produced by metals, such as: steel, brass, copper, lead, aluminum, tin, chromium, iron, nickel, silver, and certain alloys that can be contained in metal objects.

After determining the presence of metal traces in the test area and identifying the metals, the officer can next determine the pattern of the metal traces as revealed by the fluorescent colors. The location, size and shape of metal traces on the hand form patterns that are characteristic of the size and shape, and the normal way in which weapons, tools and other metal objects are handled and used. The recognition of these patterns in conjunction with the determination of what metals left traces on the skin are the basis for identification of metal objects. In this way the officer can ascertain if the pattern is pertinent to a suspect item or to its having been in the possession of a suspect.

F. Detection and Identification of Metal Objects on the Hands. The shape, size and weight of the metal object, the duration of contact, and the use of the metal object, all combine to produce the location and intensity of metal traces and their patterns on the hands.

1. Shape and Size of Metal Object. On holding a metal object, depending on the object's shape and size, more or less of the hand comes in contact with the metal surface. For example, on holding objects that are small or narrow in circumference or width, the fingers are bent more and the surface area of the palm is contracted, deepening the creases and lines of the fingers and palm. The surfaces of the hand within the depths of the creases do not contact the metal object, which therefore leaves no metal traces at these points. The larger the diameter and the more uniform the shape of the object, the more likely the creases will be filled with metal traces. Similarly, a heavy object will tend to flatten the creases and lines of the hands to produce a more even and uninterrupted metal trace pattern.

2. Intensity of Metal Traces and Patterns. The intensity of metal traces left on the hands is proportional to the weight and duration of contact with the object. The intensity is also proportional to the actions and forces involved in using a tool, striking blows with weapons and the recoil from the discharge of firearms. In addition, the intensity is increased when a suspect resists action to disarm him.

G. Detection of Metal Objects on Clothing. As noted earlier, metals leave characteristic traces on clothing surfaces. Therefore, the suspect's clothing should be examined by TMDT, in particular: gloves, hats, pockets, linings of coats, shirts, areas used for concealment, and other areas of clothing where the suspect item may have been carried, concealed, or otherwise been in contact.

The spray is applied to the test areas placed in a vertical position whenever possible. Clothing and other materials vary in their absorbency. Therefore,

some of these test areas may require a heavier application of spray, or two or more sprayings to produce the maximum fluorescence and appearance of metal traces and patterns. The maximum appearance is obtained when a repeated spraying does not produce a brighter fluorescence than the previous spraying and drying of the test area.

Metal traces sometimes penetrate clothing to the skin areas beneath. For example, metal traces may be found on the hands even though gloves have been worn while metal objects have been handled. Skin areas directly beneath clothing areas where metal traces have been found should be examined by TMDT. However, it should be noted that plastic, leather and rubber materials are impervious to penetration of metals traces.

III. PROCEDURES FOR THE DETECTION AND IDENTIFICATION OF HANDGUNS BY TMDT

Because of their unique shape and use, handguns leave characteristic patterns and distinct "signatures" on the hands that are specific to types, makes, models and calibres of these weapons.

The police officer, with knowledge and experience in identifying the characteristic patterns and signatures of handguns by TMDT, can determine if a suspect has had a handgun in his possession and the signature of the handgun by the following procedures.

A. Spraying the Hands. The suspect's hands are extended from the sides of the body with the palms in a vertical position and the fingers and thumb separated and extended. The officer should make certain that the entire surface of the front and back of the hands are covered by the spray.

B. Examination of Hands. The officer can next examine the suspect's dry hands by ultraviolet light. He should make a written record of the following observations and analyses of the suspect's hand:

1. First, note and record the fluorescent colors of the metal traces that make up the pattern for the purpose of identifying the metallic content of the gun.

2. Look for the appearance of metal traces (fluorescent colors differing from the light yellow fluorescent color produced by the TMDT test solution) on those parts of the hand that came in contact with the gun: the index finger which rested on the trigger; the remaining fingers and thumb which enclosed the gun; the palm; and the degree of protrusion of the gun into the area between and beyond the junction of the thumb and index finger. (Extensive protrusion of metal traces beyond this area are made by the overhang at the top of the back edge of the handles of automatics, which is common to the design of this type of handgun.)

3. Look for any irregularities or distinguishing marks in the pattern which may have been made by screws, protrusions, ornamentations and other markings on the gun.

4. Look for interruptions in the pattern which may be due to nonmetal parts of the gun. Compare these observations, with the suspect handgun, or if it has not been recovered, with a Catalog of Handgun "Signatures" (see Section IV, page 7). This comparison serves to identify the "signature" of the handgun, or possession thereof by the suspect.

5. Take a photograph of the pattern produced on the suspect's hand under illumination by ultraviolet light. (See Section X, page 11 , Fluorescence Photography.)

6. If the suspect handgun has been recovered before the apprehension of the suspect, or shortly after his arrest (it has been found that detectable metal traces may be found on the hands up to 36-48 hours after contact with metal objects), the pattern of the handgun should be produced on a subject who has not recently handled a gun. The patterns on the subject's and the suspect's hands should be examined side-by-side, under ultraviolet light, to determine whether or not the handgun has been in the possession of the suspect. Photographs should be taken as evidence.

7. If the suspect handgun has not been recovered, the pattern on the suspect's hand should be compared with the photographs of handgun patterns entered in a Catalog of Handgun "Signatures". A photograph of the pattern on the subject's hand should also be taken, and compared with those in the catalog to aid in the possible identification of the type of gun the suspect has had in his possession.

IV. CATALOG OF HANDGUN "SIGNATURES"

It has been noted earlier that handguns leave distinct patterns or "signatures" which are specific to types, makes, models and calibres of these weapons. It is important that police officers develop a thorough knowledge and a permanent record of these signatures. For this purpose, a catalog of signatures should be prepared of as many types, models, makes and calibres of specimen-handguns that can possibly be obtained. The signatures of these handguns can be produced on the hands of subjects and examined under ultraviolet light, as described in Section III, above. A photograph of each signature is then entered in the catalog along with a record of the observations made under ultraviolet light and the type, make, model and calibre of the specimen-handgun.

V. DETECTION OF TOOLS AND OTHER METAL OBJECTS

Some tools and other metal objects leave patterns that are characteristic of their shape, normal handling and use, for example: pliers, wrenches, shears, scissors, etc; while other tools and metal objects may leave patterns that are similar because they are alike in shape and diameter; for example: crowbars, pipes, metal bars, etc.

Accurate analysis and determination of patterns on suspects' hands depend upon relating the above factors to circumstances, information and evidence of the case, and upon the technician's experience and

skill in using TMDT. Again, as an aid in obtaining such experience and skill the technician should prepare a catalog of patterns and metal traces produced by tools and other metal objects.

VI. FACTORS THAT AFFECT THE USE AND RESULTS OF TMDT

A. Contact With Non-Significant Metal Objects. The hands of individuals may have metal traces from contact with metal objects such as handles, door knobs, keys, etc. The intensities of the traces will be proportional to the force and duration of contact with these metal objects. In some cases, the metal traces will be faint because of momentary and light contact with the objects. But in other cases, the traces from non-significant metal objects may have sufficient intensity to mask the metal traces and distort the patterns of significant metal objects.

B. Disassembly or Assembly of a Handgun. If the suspect has handled a handgun for these purposes, metal traces will be left on the hands which do not form the pattern ordinarily produced by the weapon. However, if the suspect has held the weapon in the usual way for a period of time, the technician may be able to detect the specific pattern left by the handgun. (It should be noted that gun oils give off a mother-of-pearl appearance under ultraviolet light.)

C. Similar Patterns of Metal Objects. Some metal objects may leave metal traces and patterns that are similar, but not identical to the metal traces and patterns of the significant object. The officer should be mindful of such potential "false positives" and learn to discriminate accordingly.

D. Exposure of Hands to Soap and Water. Exposure to water after contact with metal objects does not affect an examination of the hands. Repeated handwashings with abrasive soap or rubbing with dirt after contact with metals will reduce the amount of traces deposited on the skin in a deliberate attempt to remove

metal traces. However, it has been found that metal trace patterns may be found on the hands up to 36 to 48 hours after contact when the suspect has followed a normal routine of daily handwashings.

E. Fluorescence Brightness of Metal Traces and Patterns. The maximum fluorescence brightness of metal traces and patterns that can be obtained in a TMDT examination depends, not only upon the amount of metal that has been deposited on a skin or clothing surface, but also upon the following factors:

1. Adequate application and coverage of the TMDT test solution.
2. A strong source of ultraviolet illumination.
3. Exclusion of all other illumination from the test area.
4. The proximity of the ultraviolet light to the test area.

VII. USE OF TMDT IN THE FIELD AND FOR GROUP SCREENING

The successful use of TMDT in the field for checking on a suspect or screening a group of individuals for previous possession of weapons or other significant metal objects depends on whether the circumstances and conditions are suitable for such examinations. The acquiescence or subjugation of the suspect must be obtained to perform the examination. Sources of environmental light must be greatly reduced or eliminated in order to produce adequate fluorescence by ultraviolet light. And, finally, field personnel must have sufficient experience and skill to ascertain whether an individual has been in contact with a weapon or significant metal object; and whether an individual should be held for further detailed examination by TMDT. Studies should be carried out by police officers to determine the conditions and circumstances that prevent or are conducive to valid use and results of TMDT in the field.

VIII. ADDITIONAL USE OF TMDT

Another possible use of TMDT is the determination that a metal object has rested on another, nonmetal object. For example, research experiments involving the successful application of this use determined that: 1) a pair of scissors, no longer present, had rested on the paper lining in a drawer and; 2) coins, no longer present, had rested on a paper document in the buttom of a storage container. In the latter case, the duration of contact of the undisturbed coins was sufficient to show which side of each coin had rested on the document.

Since friction is not involved, results depend on the weight and duration of the contact of the metal object with the surface on which it rests. When consideration is given to the use of TMDT for this type of detection, the officer should conduct a test to determine if trace metal deposits can be produced on the surface in question.

IX. ULTRAVIOLET LIGHT SOURCES

Battery-powered, short-wave ultraviolet light units are commercially available. Since the battery life of these units is 45 to 60 minutes, it is advisable to have on hand spare batteries and a battery charger which are available as accessories to the units.

Another commercial source of short-wave ultraviolet light is the tubular type that can be obtained from electrical supply companies (General Electric, Sylvania and Westinghouse). Tubes can be purchased in various lengths, up to 48 inches, at reasonable cost, that fit into and operate in standard fluorescent light fixtures.

The selection of ultraviolet sources should be based upon a number of factors, such as: the required illumination, intensity, convenience, availability, cost of replacement of lamps, batteries and accessories, areas to be illuminated, and working distance (the distance from the light source to the work surface that

will permit examining and photographing hands and clothing and will not appreciably reduce the intensity of fluorescence).

PRECAUTIONS

Short-wave ultraviolet light is injurious to the eyes. Do not look directly into the light or shine the light into an individual's eyes. Protective goggles are commercially available that prevent the passage of short-wave ultraviolet light but transmit the visible fluorescent light, which is not injurious to the eyes.

X. FLUORESCENCE PHOTOGRAPHY

It is commonly believed that ultraviolet photography is also fluorescence photography. Actually two types of photography are involved.

The main purpose of ultraviolet photography is to record information about objects that have the property of either absorbing or reflecting ultraviolet light, or about objects in which two or more of its elements will absorb or reflect ultraviolet light to different degrees. These effects can be recorded photographically to show differences between objects or between areas of the same object. Whether or not the object emits fluorescence does not enter into the purposes of ultraviolet photography.

If a source of ultraviolet light is used to excite fluorescence in an object, photographing the fluorescent object is known as fluorescence photography. This type of photography is used for recording fluorescent metal trace patterns produced by TMDT.

A. Photographic Techniques. The following factors should be considered in photographing fluorescent objects:

1. Illumination. Efficient sources of ultraviolet light, placed as close to the subject as is practical, should be used to excite the maximum fluorescence brightness of the object. The incidence of illumination on the object should be at an angle of about 45 degrees. Two sources (one on each side of the object) will provide twice as much light and prove more practical in photographing three-dimensional objects.

2. Exciter Filter. This filter is placed between the subject and the source of illumination to transmit the ultraviolet light necessary to excite fluorescence and to absorb all other radiation which, if higher in brightness, may mask the fluorescence. Corning Glass No. 9863 (Filter No. CS 7-54) transmits ultraviolet in the long, medium, and short wave regions. This glass filter can be placed in front of the ultraviolet source as an exciter filter.

3. Barrier Filter. This filter is placed in front of the camera lens to absorb the ultraviolet light radiation transmitted by the exciter filter and to transmit only the fluorescent light given off by the object. An efficient barrier filter is Kodak Wratten Filter No. 2A, if the exciter filter transmits ultraviolet light only.

4. Exposure Determination. Because of the very low brightness of fluorescence the proper exposures for photographing fluorescent metal trace patterns will have to be determined by tests. The beginner should take a number of photographs of subjects at various exposures. At a fixed lense aperture, exposure time should be increased by a factor of 2, in successive steps, over a wide range of decreasing shutter speeds. A record of all exposure conditions should be made, including: subject, ultraviolet source and its distance from the subject, filters, film, shutter speed and lens opening. With a record of such data and the experience acquired in such tests, the police officer can develop the know-how and skill in estimating the exposures for photographing subjects.

An extremely sensitive exposure meter can be used for determining exposures. However, its cell should

be covered with a barrier filter to absorb ultraviolet light reflected from the subject which, if higher in brightness than the fluorescence of the subject, will give erroneous exposure settings on the camera. If the case of an exposure meter is feasible, the tests described above may not be needed to determine exposures.

B. Black-and-White Films. The black-and-white films used in fluorescence photography should have panchromatic sensitivity and high speed. The Eastman Kodak Company in its publication, Ultraviolet and Fluorescence Photography, makes the following recommendations:

> When a 35mm film is indicated, Kodak Tri-X Pan Film is recommended. It has very fine grain and high speed (ASA 400). If extremely high speed is desirable, and some graininess can be tolerated, Kodak 2475 Recording Film (Estar-AH Base) is suggested. It is available in 36-exposure magazines (RE 135-36). Information about this film is contained in Kodak Pamphlet No. P-95, available on request. By selected development it can be processed to achieve speeds up to about 4000. If sheet film is needed, there are many Kodak Films on Estar Thick Base from which to choose. In order of decreasing granularity, they are: Royal-X Pan (ASA 1250), RS Pan (ASA 650), Royal Pan (ASA 400), and Tri-X Pan Professional (ASA 320).

Black-and-White films produced by other film manufacturers such as, E. I. DuPont de Nemours and Co., General Aniline and Film Corporation Polaroid Co., etc., should also be considered for use. Information on the types and characteristics of films can be obtained from the manufacturers.

Examples of black-and-white photographs taken of fluorescent metal trace patterns, produced on subjects' hands by treatment with TMDT solution after holding handguns, are shown in Figures 1 and 2, page 16. Following is the photographic data:

Figure	Weapon	Film Type	Exposures
1	.38 Special Revolver (held for 15 minutes)	Royal-X Pan	4 sec. at f/4.7
2	.25 Auto Pistol (held for 15 minutes)	Royal-X Pan	4 sec. at f/4.7

Illumination was by two 115-volt Mineralight UVS 11 lamps made by Ultra-Violet Products, Inc., San Gabriel, California. The light sources were held about eight inches from the hand at an angle of about 30 degrees from the camera optical axis. A Kodak 2-A filter was used over the camera lens. The pictures were taken with a Polaroid MP-3 Camera, with a 127mm lens, and a lens to subject distance of 19 inches. The film was developed in HC-110 dilution "A" rated at an E.I. of 1250.

C. Color Films. The advantages of using color films to record fluorescent metal trace patterns are obvious. The patterns are produced in fluorescence colors which are examined and analyzed as such. Photographing the patterns with color film records their actual appearance; whereas black-and-white films record the patterns, interruptions in the patterns, and incomplete coverage by the TMDT solution as varying shades of gray. In addition, many persons cannot distinguish shades of gray as easily as they can distinguish different colors.

These advantages of using color films, however, are offset by their lower ASA speeds. Kodak recommends High-Speed Ektachrome Films, Daylight Type and Type B, and Ektachrome-X Film. Their ASA speed ratings are 160, 125 and 64, respectively. With a time adjustment in Kodak Process E-4, it is possible to use these films at higher-than-normal speed ratings which allows for shorter exposure times with these films. Again, as in the case with

black-and-white films, the beginner should conduct tests to determine exposures using these films and those of other film manufacturers.

The Kodak Technical Publication, M-27, Ultraviolet and Fluorescence Photography, published by the Eastman Kodak Company, is an excellent source of information on the technique and equipment used in fluorescence photography. It covers such topics as, illumination, filters, films, reciprocity effects, exposures and procedures; and includes an appendix.

TMDT TEST SOLUTION

0.1–0.2% solution of 8-Hydroxyquinoline in isopropanol (CP grade only).

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Figure 1. .38 Special Revolver.

Figure 2. .25 Auto Pistol

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