# OSAC 2022-S-0036
# Standard Method for the Chemical Testing of Suspected Projectile Impacts for Copper and Lead

Crime Scene Investigation & Reconstruction Subcommittee
Scene Examination Scientific Area Committee (SAC)
Organization of Scientific Area Committees (OSAC) for Forensic Science

**OSAC Proposed Standard**

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**Foreword**

This standard is meant for scene investigators who are responsible for the documentation of a shooting scene and for shooting reconstructionists performing the on-scene documentation. It is recognized that some shooting scenes are processed and documented by practitioners who will not be performing the final reconstructive analysis. However, their work is critical to any subsequent reconstructive efforts. This standard provides guidance for the chemical testing of suspected impact locations for projectile component transfer and the minimum documentation requirements for testing projectile impacts.

All hyperlinks and web addresses shown in this document are current as the publication date of this standard.

**Keywords:** *crime scene, shooting reconstruction, 2-nitroso-1-naphthol test, dithiooxamide test, sodium rhodizonate test, projectile impact, chemical testing*

Table of Contents

# Standard Method for the Chemical Testing of Suspected Projectile Impacts for Copper and Lead

## 1 Scope

This document provides scene investigators and scene reconstructionists with standard methods for the chemical testing of suspected projectile impacts for the presence of copper or lead residues. This standard is specifically meant to address the field processing and documentation of suspected projectile impacts. Collection of an item with a suspected projectile impact for testing in the controlled conditions of a laboratory should be considered when practical and warranted by the circumstances. Chemical processing and enhancement of gunshot residue patterns for the purpose of muzzle-to-target distance determinations or wound ballistics is beyond the scope of this standard. Chemical tests for copper and lead not described in this standard are available and may be used as agency policy allows.

## 2 Normative References

The following references are indispensable for the application of the Standard. For dated references, only the edition cited applies. The latest edition of the referenced document (including any amendments) applies for undated references.

OSAC 2021-N-0015, *Guiding Principles for Scene Investigation and Reconstruction*

OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes*

## 3 Terms and Definitions

For purposes of this document, the following definitions and acronyms apply.

**3.1**
**2-nitroso-1-naphthol test**
**2-NN**
A chemical test for the detection of copper.

**3.2**
**bullet wipe**
The discolored area around the periphery of a projectile entrance is caused by a physical transfer from the surface of a projectile to a target. This transfer can be composed of projectile lubricant, copper, lead, combustion products, bore debris, and/or projectile material. The word bullet in this term is inclusive of all projectiles.

**3.3**
**control**
Material of established origin used to evaluate the performance of a test or comparison. Or a test performed to demonstrate that a test method works correctly and to ensure that data are valid. Positive controls confirm that the procedure will produce the expected result. Negative

controls confirm that the procedure does not produce an unintended result. (ASTM E1732-12, OSAC Lexicon)

**3.4**
**defect**
A generic term for any surface damage. (OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes*)

**3.5**
**dithiooxamide test**
**DTO**
A chemical test for the detection of copper.

**3.6**
**gunshot residue**
**GSR**
The total of all residues resulting from the discharge of a firearm.

Note: Examination of GSR can include chemical analysis to identify the presence of GSR or interpretation of GSR patterns to determine the location or position of a firearm at the time of discharge.

**3.7**
**lead splash**
A deposit made during a projectile impact composed of a coating of lead particles too small to be individually distinguished without magnification. This deposit is observed adjacent to the projectile impact and is often deposited downrange from the impact location.

**3.8**
**projectile**
An object propelled with an initial velocity then acted upon by gravity, air drag, and other outside forces. (OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes*)

**3.9**
**projectile fragment**
Any portion of a projectile that retains characteristics permitting it to be identified as having been part of a projectile. (OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes)*

**3.10**
**projectile impact, *n***
Surface damage determined to have been caused by a projectile. (OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes*)

**3.11**
**sodium rhodizonate test**
**NaRho**
A chemical test for the detection of lead.

**3.12**
**substrate control**
A sample or test of an uncontaminated surface close to the area being tested that appears to share the same composition as the surface bearing the suspected evidence.

**3.13**
**target, *n***
Any object struck by a projectile, regardless of whether it was struck intentionally. (OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes*)

## 4 Overview and Objective of Chemical Testing

This standard method is concerned with the testing for copper and lead residues, which are the most common constituents of manufactured projectiles such as lead bullets, copper-jacketed bullets, solid copper bullets, lead bullet cores, lead shot, lead shotgun slugs, and air gun pellets. In this standard, the meaning of the term projectile will be limited to those projectiles that have a copper or lead component.

Projectile impacts are generally identified based on their physical characteristics. However, in some cases, a lack of sufficient physical characteristics and scene context may not support a conclusion of whether a defect was caused by a projectile or some other mechanism. After appropriate documentation, chemical testing for projectile residues may offer additional data that can aid in making that determination.

Projectile residues are often present in or adjacent to a projectile impact due to the forceful interaction of the projectile with a target. This forceful interaction can abrade small amounts of metal or cause particles of metal to be ejected during impact and impinge on downrange surfaces. Sometimes this metal transfer is visible. There are chemical tests that can be used to visualize latent residues.

The presence of some projectile residues can be used to yield other information about the projectile, such as its chemical composition or its direction of travel. Some projectile residues can also provide information about the firearm, such as its orientation relative to the residue deposition.

The chemical tests described below can be used to test for the presence of copper or lead from any source, but those uses are beyond the scope of this standard.

OSAC 2021-N-0015, *Guiding Principles for Scene Investigation and Reconstruction* and OSAC 2021-N-0019, *Standard Practice for Documentation and Processing of Shooting Scenes* shall be used in conjunction with this document. OSAC 2021-N-0015 provides the foundational principles upon which additional specific requirements, such as this document, will be based. OSAC 2021-N-0019 provides standards for the documentation and processing of shooting scenes to include the testing described in this standard.

## 4.1 Considerations Before Chemical Testing

Prior to conducting these chemical tests in the field, the practitioner should consider the following:

**4.1.1** The practitioner should consider consulting with a firearms examiner for guidance. Laboratory testing could include chemical tests beyond the scope of this standard. Field testing should not be used routinely on items such as clothing or fabric that are better suited for analysis in the laboratory.

**4.1.2** If chemical testing is used, it shall be conducted prior to the insertion of trajectory rods into the projectile impacts being examined.

**4.1.3** These tests require the practitioner to be able to differentiate the correct color changes for each reagent. The practitioner's ability to detect the color change and evaluate the testing conditions shall be addressed during training and/or competency testing.

## 4.2 Order of Testing

If testing the impact site for both copper and lead, the order of examination is critical. The sodium rhodizonate test for lead will interfere with the two tests for copper residues. Therefore, when testing for both copper and lead, the copper test(s) shall be conducted before the lead test. Sections 5 and 6 describe detailed materials and methods for conducting chemical tests for the presence of copper and lead residues, respectively.

When more than one test is used, the documentation of the testing shall clearly describe the order in which they were conducted.

## 4.3 Control Testing

The results of all control tests shall be documented in the notes.

### 4.3.1 Substrate Controls

When the practitioner suspects background interference or contamination, a substrate control test shall be conducted away from any potential projectile impacts and in the same manner as described below (Sections 5 and 6). If pre-existing copper or lead is suspected on the target, the target substrate shall be evaluated. Examples of potentially problematic targets include brass doorknobs (containing copper) or surfaces covered in lead-based paint. While not always required, a substrate control may be useful to determine if the background material is causing a positive reaction.

#### 4.3.2 Reagent Controls

To help ensure that the reagents produce reliable results, the use of positive and negative controls is necessary. Reagents shall be tested with positive and negative controls at the time the reagents are prepared and just prior to each test session.

A common practice for controls is to mark a piece of clean filter paper with a known source of copper or lead and to process in the same manner as described below (Sections 5 and 6). The mark is a positive control and should generate the expected color reaction. The surrounding unmarked area is the negative control and should not generate a color reaction. Reagents that do not pass the positive and negative control tests shall not be used.

### 4.4 Recording Reagent Lot Numbers

Any chemical reagents or precursors used in their preparation that are used on evidence or at a scene shall be traceable to the specific manufacturer and lot number used. Manufacturer and lot numbers or agency-issued tracking number shall be recorded in the case notes.

### 4.5 Chemical Safety

Safe handling and preparation of chemical reagents are beyond the scope of this standard. Personnel preparing or using these reagents shall understand basic safety when working with these chemicals and review their safety data sheets (SDS) prior to their use. When spraying reagents, respiratory protection or proper ventilation shall be used.

## 5 Chemical Testing for Copper Residues

### 5.1 2-Nitroso-1-Naphthol (2-NN) and Dithiooxamide (DTO) Tests

#### 5.1.1 Overview and Theory

When a copper-bearing projectile impacts a surface, trace residual copper may be transferred at the contact point. There are two different chemical tests for copper: 2-nitroso-1-naphthol (2-NN) and dithiooxamide (DTO). The practitioner may choose which of these two tests to use. Because each reagent has its own color reaction (pink for 2-NN and dark green for DTO), consideration of the color of the substrate can help the examiner decide which reagent to use. The copper test selected should be whichever one provides the best color contrast against the substrate background color.

Prepared solutions of 2-NN and DTO have a limited shelf life and should be prepared at the time of use. Reagents prepared in advance may be used, but the reactivity of any reagent shall be confirmed with controls prior to use.

See Appendices A and B for recommended materials and reagent preparation.

### 5.2 Protocol for Copper Testing of Suspected Projectile Impacts

#### 5.2.1 Pre-testing procedures

All prepared solutions shall be control tested, both at the time the reagents are prepared and just prior to each test session. If loss of potency is suspected, additional control tests may be appropriate.

The results shall be recorded in the case notes. If reagents fail a control test, they shall not be used.

Visual assessments, notes, and photographs of the suspected impact shall be conducted prior to the chemical testing. Any potentially probative biological or trace evidence shall be collected prior to chemical testing. Trajectory analysis tools shall not be inserted into a defect prior to chemical testing. Any prior physical contact with the defect shall be documented and considered as a potential source of contamination.

**5.2.2** Transfer/Lift Method

The following test method shall be followed with any deviations documented in the notes:

a) Cut a section of filter paper (or equivalent) larger than the area of interest.
b) Moisten the filter paper with the 2:5 ammonium hydroxide solution,
c) Without rubbing, firmly press and hold the moistened filter paper onto the surface to be examined. Ensure that the filter paper is in contact with the entire area of interest (e.g., bent car metal with a suspected impact that has caused a deep defect).
d) Place reference marks to record the orientation on the filter paper. It is recommended to use a pencil for the reference marks to avoid bleeding of the marks when reagents are applied. Remove the filter paper and examine for any color transfer that could mask the color reaction of 2-NN or DTO. If a color transfer is present, choose the best reagent to visualize the reaction.
    i) If background material has been transferred that inhibits the observation of a positive reaction, the test paper shall be documented with color photography and recorded in the notes. If the practitioner attempts the test, the interference of the transferred color shall be considered in the interpretation of the results as described in Section 8 (Limitations).
e) Lightly apply the 2-NN or DTO solution onto the filter paper.
    i) A positive result for copper with the 2-NN solution will result in an immediate pink color change.
    ii) A positive result for copper with the DTO solution will result in an immediate dark green color change.
    iii) No color change indicates a negative test result.
f) Positive results shall be photographed in color with a scale.
    i) In some instances, the shape and position of a positive reaction can be useful for a shooting reconstructionist.

g) Once the reaction has been documented, the filter paper may be preserved or discarded, at the discretion of the practitioner.

**5.2.3** Direct Application Method

Prior to applying the reagents, the area of interest shall be examined and photographed to identify pre-existing background colors. If the area of interest is on a relatively porous material and the responses of the reagents can be visualized over the background colors, the direct application method can be used to lightly spray the reagents directly onto the suspected impact area in the same order as described above in 5.2.2.

Spraying an excessive volume of liquid reagents should be avoided during the direct application method can dilute or wash away the color reaction. The transfer/lift method can allow better visualization when the background color masks the reaction color. The direct application method may be performed after the lifting method is attempted.

**5.2.4** Documentation of Results

The positive color reactions can fade quickly. Documenting the reaction shall occur immediately after the application of the reagent. Positive reactions shall be documented with color photography using a scale and recorded in the notes.

Negative reactions shall be recorded in the notes and may be photographed.

## 6 Chemical Testing for Lead Residues

**6.1** Sodium Rhodizonate (NaRho) Test

**6.1.1** Overview and Theory

When a projectile, whether jacketed or not, impacts a target surface, it can leave trace amounts of lead at or around an impact site. By partially dissolving lead in an acidic buffer (such as pH 2.8 tartrate or 15% acetic acid), the impact site can be tested with sodium rhodizonate solution. (Note: Other validated acidic buffers can also work in this reaction and may be substituted if agency protocols allow.) Upon application of the sodium rhodizonate reagent, a pink color change will occur when lead is present. A follow-up test with 5% hydrochloric acid (HCl) will change a positive pink color to purple-blue color, further supporting the presence of lead. The tartrate buffer solution and dilute HCl solution may be stored for extended periods of time at room temperature, in an airtight container, and out of strong light. The sodium rhodizonate solution should be made, and control tested just prior to use. Reagents prepared in advance may be used, but their reactivity shall first be confirmed with controls.

See Appendices A and B for recommended materials and reagent preparation.

### 6.2 Protocol for Lead Testing of Suspected Projectile Impacts

**6.2.1** Pre-testing procedures

All prepared solutions shall be control tested, both at the time the reagents are prepared and just prior to each test session. If loss of potency is suspected, additional control tests may be appropriate. The results shall be recorded in the case notes. If reagents fail a control test, they shall not be used.

Visual assessments, notes, and photographs of the suspected impact shall be conducted prior to the chemical testing. Any potentially probative biological or trace evidence shall be collected prior to chemical testing. Trajectory analysis tools shall not be inserted into a defect prior to chemical testing. Any prior physical contact with the defect shall be documented and considered as a potential source of contamination.

**6.2.2** Transfer/Lift Method

The following test method shall be followed with any deviations documented in the notes:

a) Cut a section of filter paper (or equivalent) larger than the area of interest.
b) Moisten the filter paper with tartrate buffer solution. Another validated acidic buffer may be substituted if agency protocols allow.
c) Without rubbing, firmly press and hold the moistened filter paper onto the surface to be tested. Ensure that the paper is in contact with the entire area of interest (e.g., bent car metal with a suspected impact that has caused a deep defect).
d) After placing any reference or orientation marks on the paper, remove it and examine for any color transfer.
    i) If background material has been transferred that inhibits the observation of a positive reaction, the test paper shall be documented with color photography and recorded in the notes. If the practitioner attempts the test, the interference of the transferred color shall be considered in the interpretation of the results as described in Section 8 (Limitations).
e) Apply sodium rhodizonate solution onto the filter paper.
    i) A positive result for lead will produce an immediate pink color change. To neutralize the background color from sodium rhodizonate application, the 5% HCl application may be used. A purple-blue color change further supports the presence of lead.
    ii) No color change indicates a negative test result.
f)
g) Positive results shall be photographed in color with a scale.
    i) In some instances, the shape and position of a positive reaction can be useful for a shooting reconstructionist.

h) Once the reaction has been documented, the filter paper may be discarded.

**6.2.3** Direct Application Method

Prior to applying the reagents, the area of interest shall be examined and photographed to identify pre-existing background colors. If the area of interest is on a relatively porous material and the responses of the reagents can be visualized over the background colors, the direct application method can be used to lightly spray the reagents directly onto the suspected impact area in the same order as described above in 6.2.2.

Spraying an excessive volume of liquid reagents should be avoided during the direct application method can dilute or wash away the color reaction. The transfer/lift method can allow better visualization when the background color masks the reaction color. The direct application method may be performed after the lifting method is attempted.

**6.2.4** Documentation of Results

The positive color reactions can fade quickly. Documenting the reaction shall occur immediately after the application of the sodium rhodizonate and again if the HCl overspray step is conducted. Positive reactions shall be documented with color photography using a scale and recorded in the notes.

Negative reactions shall be recorded in the notes and may be photographed.

## 7 Commercial Projectile Impact Test Kits

A variety of commercial kits are marketed for the testing of suspected projectile impacts for the detection of copper and lead residues. Such kits may be used if the kit instructions are followed.

The practitioner shall know which chemical test(s) are in the kits they use. If not expressly described in the kit instructions, this information might be present in the safety data sheets (SDS) for the product.

Commercial kits can use different reagents and protocols that are beyond the scope of this standard. If the commercial kit does use the reagents described above, the chemical safety, control testing, pre-testing procedures, and documentation of results from this standard shall apply. The limitations and interpretations (Sections 8 and 9) shall also apply to the results of a commercial kit.

## 8 Considerations and Cautions

### 8.1 Negative Results

Before eliminating a suspected projectile impact due to a negative result, the following possibilities shall be considered.

**8.1.1** Projectile residues are regularly but not always transferred during impact. For that reason, negative results must be carefully interpreted.

**8.1.2** When projectiles impact materials, the substance that is physically contacted can be removed (e.g., glass, asphalt). This can yield a negative result, even if the defect was actually a projectile impact.

**8.1.3** While lead and copper are the most commonly encountered projectile metals, in rare instances, projectiles can be made of other materials. Chemical tests for copper or lead will not detect uncommon projectile materials. This can yield a negative result, even if the defect was actually a projectile impact.

**8.1.4** The trace amounts of projectile residues transferred at a projectile impact site can be further reduced by environmental factors or poor handling, resulting in mechanical loss of those projectile residues.

**8.1.5** Because of the sensitivity of the tests discussed in this standard, the amount of material transferred during a projectile impact is generally more than the detection limit of the reagents. The wide variety of target materials and projectile types has a greater influence on the results than the detection limits of the reagents.

**8.1.6** The prepared reagent solutions can degrade over time. This limitation can be mitigated by control testing prior to and after a test session.

**8.1.7** Physical interferents that can mask the results of chemical testing at projectile impacts include target color, target cleanliness, and the presence of biological materials.

**8.1.8** The chemical makeup of the target material should be considered as it can prevent or detract from the reagent's effectiveness. For example, alkaline substances like concrete blocks can neutralize acidic solvents such as acetic and tartaric acids, thereby influencing the test results.

### 8.2 Positive Results

Before accepting a positive result as supporting a conclusion that the projectile was composed of copper or lead, the following possibilities shall be considered.

**8.2.1** Manufactured projectiles that are not made of copper or lead can still be contaminated with those elements from primer residues and pre-existing barrel residues. Therefore, those elements can be transferred to an impact and yield a positive test result for copper or lead.

**8.2.2** The target material could contain copper or lead that would produce a positive reaction.

## 9 Results and Interpretation

### 9.1 Chemical Test Results

Chemical test results for copper or lead should be considered together with the observed physical characteristics of a projectile impact to help support a conclusion that a defect is consistent with a projectile impact.

**9.1.1** A positive reaction for copper and observed physical characteristics on a suspected projectile impact using either the 2-NN or DTO test supports the conclusion of an impact from a source of copper.

**9.1.2** A positive reaction for lead and observed physical characteristics on a suspected projectile impact using the sodium rhodizonate test supports the conclusion of an impact from a source of lead.

**9.1.3** A negative result for either test means that copper or lead was not detected.

### 9.2 Interpretation

**9.2.1** Positive results, after considering the limitations as discussed above in section 8, are supportive of the opinion that a defect was caused by a projectile impact when other physical characteristics, location, and scene context are present.

**9.2.2** Negative results do not necessarily eliminate a defect as having been caused by a projectile impact and shall be interpreted considering physical characteristics, location, and scene context. The presence or absence of limitations (as discussed in section 8) shall be considered and documented for all negative results.

**Annex A**

(informative)

**Materials**

The following materials are needed to perform the chemical tests for copper and lead. Chemical safety is addressed in Section 4.5.

a) Small sprayers or dropper bottles
b) Sheets of clean, white filter paper (or equivalent)
c) Latex or nitrile gloves
d) Eye protection
e) Copper source for positive control
f) Lead source for positive control
g) Graduated cylinder/beaker
h) Scale/Balance
i) Reagents/chemicals
   i) 2-nitroso-1-naphthol (2-NN) and/or dithiooxamide
   ii) 95-100% (reagent-grade) ethanol
   iii) 28-30% ammonium hydroxide ($NH_4OH$)
   iv) sodium bitartrate
   v) tartaric acid (powdered)
   vi) glacial acetic acid
   vii) distilled water
   viii) concentrated hydrochloric acid (HCl) or 5% HCl
   ix) sodium rhodizonate (powder)

## Annex B
(informative)

### Reagent Preparation

The following list of materials and mixing instructions are used for reagent preparation. Chemical safety is addressed in Section 4.5. Always use appropriate personal protective equipment when mixing chemicals.

**B.1 2-NN solution**

0.2 g of 2-nitroso-1-naphthol in 100 ml of reagent-grade ethanol

Pour 0.2 grams of the dry powder of 2-nitroso-1-naphthol into a beaker and add 100 milliliters of ethanol. Swirl the container to allow the powder to dissolve. The reagent will be a dark color after mixing. Transfer the liquid reagent into the appropriate spray bottle or dropper.

**B.2 DTO solution**

0.2 g of dithiooxamide in 100 ml of reagent-grade ethanol

Pour 0.2 grams of the dry powder of dithiooxamide into a beaker and add 100 milliliters of ethanol. Swirl the container to allow the powder to dissolve. The reagent will be a dark color after mixing. Transfer the liquid reagent into the appropriate spray bottle or dropper.

**B.3 2:5 dilution factor of ammonium hydroxide**

20 ml of ammonium hydroxide ($NH_4OH$) in 30 ml of distilled water

To obtain the 2:5 dilution factor, measure 30 ml of distilled water and slowly add 20 ml of concentrated ammonium hydroxide ($NH_4OH$). Transfer the liquid reagent into the appropriate spray bottle or dropper. Ammonium hydroxide is a strong base, and the concentrated liquid can cause chemical burns.

**B.4 pH 2.8 tartrate buffer solution**

1.9 g of sodium bitartrate and 1.5 g of tartaric acid in 100 ml of distilled water

Weigh out the powder sodium bitartrate and tartaric acid and combine in a glass container. Add 100 ml of warm distilled water and stir until the powder has completely dissolved. Transfer the liquid reagent into the appropriate spray bottle or dropper. The preservative benzalkonium chloride and/or refrigeration prevents the growth of mold in the solution, if this solution is to be stored.

**B.5 15% acetic acid**

15 ml glacial acetic acid in 85 ml distilled water

Measure 85 ml of distilled water and slowly add 15 ml of glacial acetic acid. Transfer the liquid reagent into the appropriate spray bottle or dropper. Glacial acetic acid is a strong acid, and the concentrated liquid can cause chemical burns.

**B.6 0.2% sodium rhodizonate solution**

0.2 g of sodium rhodizonate in 100 ml of distilled water (a saturated solution)

Mixing 0.2 g of sodium rhodizonate powder in 100 ml of distilled water will create a saturated solution., The solution may also be prepared by adding enough sodium rhodizonate powder to distilled water until a small amount of undissolved powder remains at the bottom of the container (a saturated solution). Transfer the liquid reagent into the appropriate spray bottle or dropper.

**B.7 Dilute (5%) hydrochloric acid (HCl) for follow-up testing**

5 ml concentrated HCl diluted to in 95 ml of distilled water

Measure 95 ml of distilled water and slowly add the 5 ml of concentrated HCl. Transfer the liquid reagent into the appropriate spray bottle or dropper. Concentrated HCl is a strong acid, and the concentrated liquid can cause chemical burns.

**Annex C**
(informative)

**Bibliography**

This is not meant to be an all-inclusive list, as the group recognizes other publications on this subject may exist. At the time this document was drafted, these were the publications available for reference. Additionally, any mention of a particular software tool or vendor as part of this bibliography is purely incidental, and any inclusion does not imply endorsement.

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