



Standard Practice for Verifying Minimum Acceptable Performance of Trace Explosive Detectors¹

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1. Scope

1.1 This practice is primarily intended to assist first responders and security screeners in verifying the minimum acceptable performance of detectors used to identify traces of high explosives such as cyclotrimethylene trinitramine (RDX), pentaerythritol tetranitrate (PETN), and trinitrotoluene (TNT). These explosive detectors may be based on, but are not limited to, ion mobility spectrometry (IMS).

1.2 This practice is used to evaluate the detector response to evaporated residues of low-concentration solutions of explosive compounds placed on test swipes. The solutions used for this evaluation are prepared in a suitable organic solvent and contain a single high explosive.

1.3 This practice does not address or use sampling procedures common to the use of trace explosive detectors. It only tests the response of the detector once a test swipe has been successfully introduced into the explosive detector.

1.4 This practice does not evaluate the effect of contaminants or interferences that may be encountered in sampling for trace explosives in the field.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 Definitions of Terms Specific to This Standard:

2.1.1 *blank solution, n*—semivolatile solvent that does not contain trace explosives to which the detector is sensitive.

2.1.2 *calibration, n*—act of providing the detector with a known substance so that it may be adjusted to identify explosive compounds correctly.

2.1.2.1 *Discussion*—Manufacturers of explosives detectors often provide calibration swipes. In an ion mobility spectrometry (IMS) instrument, calibration allows the instrument to adjust the present values of the mobility (or drift) time of the calibrant to the most current conditions. For explosives detectors based on mass spectrometry (MS), calibration is often called tuning. Some IMS and MS explosives detectors may have built-in materials and software to perform calibration automatically.

2.1.3 *instrument blank swipe, n*—unused swipe freshly removed from the container provided by the manufacturer.

2.1.4 *performance evaluation solution, n*—dilute solution of a single explosive compound dissolved in a semivolatile solvent.

2.1.5 *process blank swipe, n*—sample swipe that has been dosed with the blank solution.

2.1.6 *sample swipe, n*—pads that are made from various types of materials, including fabric and paper, that are offered by the equipment manufacturer to collect particle samples for use in trace explosives detectors.

2.1.6.1 *Discussion*—Also referred to as sample traps by some manufacturers of trace explosives detectors.

2.1.7 *swipe support, n*—holder for the sample swipe that suspends the swipe preventing contact of the back side of the sampling area with any surface that might wick away drops of solution.

2.1.8 *test kit, n*—set of individual solutions of the explosives and a blank solution to be used for the evaluation of explosives detector performance.

2.1.8.1 *Discussion*—The test kit may also include holders used for supporting the sample swipes for solution application.

2.1.9 *test swipe, n*—sample swipe that has been dosed with one of the performance evaluation solutions and dried.

2.1.10 *trace explosives detector, n*—an instrument designed to detect trace amounts (micrograms or less) of explosive compounds.

2.1.10.1 *Discussion*—In the context of this standard practice, a trace explosives detector will require the use of a swipe sample collector. These detectors are commonly based on, but not limited to, ion mobility spectrometry.

2.2 Acronyms:

2.3 *IMS, n*—ion mobility spectrometry

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- 2.4 *MS*, *n*—mass spectrometry
- 2.5 *PETN*, *n*—pentaerythritol tetranitrate
- 2.6 *RDX*, *n*—cyclotrimethylene trinitramine
- 2.7 *TNT*, *n*—trinitrotoluene

3. Significance and Use

3.1 The practice may be used to accomplish several ends: to compare detectors before purchase; as a demonstration by the vendor that the equipment is performing properly to a minimal standard; or for a periodic verification of detector performance after purchase.

3.2 This practice establishes the minimum performance that is required for a detector to be considered effective in the detection of trace explosives. An explosives detector is considered to have “minimum acceptable performance” when it has passed all of the evaluation tests without a failure.

3.3 This practice uses three explosive compounds—RDX, PETN, and TNT—that are used to represent nitro-based compounds having a range of physical and chemical properties. The concentrations of the solutions of explosive have been determined to be sufficient to provide a positive detector alarm signal. In time, other compounds may be added or substituted into this practice as detection priorities dictate.

3.4 This practice was developed using IMS-based trace explosives detectors, but this practice should also be applicable to any explosives detector designed to analyze trace levels of high-explosive compounds collected on swipes.

3.5 This practice does not include procedures to test for compounds that may interfere with detector performance.

3.6 This practice does not test the minimum limit of detection or the dynamic range of the trace explosives detector.

3.7 This practice does not test for compounds other than high explosives.

3.8 This practice only evaluates the response of the detector to traces of pure explosive compounds.

4. Performance Evaluation Materials

4.1 *Test Kit*—One test kit contains:

4.1.1 Test solutions of the specified concentrations of the high explosives that may be in plastic squeeze dropper bottles in which each solution contains a single high explosive labeled with the contents in isobutyl alcohol (2-methyl-1-propanol) or another suitable solvent,

4.1.2 One blank solution containing only alcohol, and

4.1.3 Four swipe supports for holding the test and blank swipes for evaporation.

4.2 *Solution Concentrations*—Solution concentrations of the high explosives for the kit are: RDX concentration: 0.14 mg/L providing ≈ 3 ng per drop; TNT concentration: 1.0 mg/L or ≈ 23 ng per drop; and PETN concentration: 1.7 mg/L or ≈ 40 ng per drop. The volume of solution of explosive delivered by a single drop is based on an average drop volume of 23 μ L dispensed by holding the bottle at approximately a 45°

angle.² A volumetric pipette or syringe may also be used to deliver the 23- μ L volume of the solution of explosives accurately.

5. Procedure

5.1 *Preparation of Workspace:*

5.1.1 Cover table of bench surface with clean, absorbent, disposable material.

5.1.2 Care should be taken not to contaminate sample swipes. Handling the swipes with either unused gloves or clean tweezers is recommended. It is particularly important not to touch the target area of the swipe.

5.1.3 Provide convenient and appropriate means of disposal of used test swipes and other consumables.

5.1.4 Four swipe supports are needed. Each support will provide a means for allowing the alcohol solutions to evaporate completely from the swipe without losses to other surfaces. Label each of the four swipe supports for the identity of the explosive or blank solution to be tested for exclusive use with that solution. This will prevent cross-contamination of the explosives on the holder.

5.1.5 In the case in which the sample and blank swipes are not used immediately, have labeled containers ready to hold the prepared test swipes that are of an appropriate size, are clean, and have covers. Glass or metal containers (including aluminum foil) are appropriate for this task.

5.1.6 The use of chemically resistant nitrile gloves is recommended for handling of test solutions.

5.2 *Preparation of Test Swipes:*

5.2.1 Place the test swipes properly on the labeled swipe supports.

5.2.2 Choose one of the solutions from the test kit, ensure the cap is closed tightly, and shake well to mix.

5.2.3 When the solutions are being dispensed from a squeeze bottle, sacrifice the first drop by opening the cap, holding the bottle at about a 45° angle from horizontal, and squeeze the bottle slowly to deposit one or two drops on a disposable tissue.

5.2.4 Deposit a drop at about a 45° angle from horizontal on the test swipe within the target area for sample deposition as indicated by the instructions provided with the detector. Examples of the target area are provided in NIST IR 7240.² If more than one drop is deposited on the swipe, discard it and begin again with a unused swipe. Alternatively, a 23- μ L drop of the solution from the test kit can be delivered using a volumetric pipette or syringe.

5.2.5 Allow the solvent to evaporate. Wait until the solution is visibly dry on the test swipe and the alcohol smell has dissipated. Drying times vary from approximately 5 to 20 min or longer, depending on the test swipe material and the room temperature. Do not dry the swipes at temperatures above 25°C (77°F). Care should be taken to avoid contaminating the

² Verkouteren, J., Gillen, G., Verkouteren, R. M., Fletcher, R., Etz, E., et al., “IMS-Based Trace Explosives Detectors for First Responders,” *NIST IR 7240, System Assessment and Validation for Emergency Responders*, U.S. Department of Homeland Security, Washington, DC 20528. This document is summarized on the web page <http://saver.tamu.edu/documents.php?fl=336&c=7&s=3&pn=77>.

prepared swipes with each other or with other foreign substances (such as fingerprints, dirt and dust, cardboard, and paper tissues).

5.2.6 Once the test swipe is dry, it should be used immediately or, if necessary, stored individually in the labeled container. Following preparation, test swipes may be stored at room temperature (or refrigerated) for no longer than 4 h. Longer storage may result in significant degradation of the explosive compounds.

5.2.7 Repeat with the remaining performance evaluation and blank solutions to prepare all the test swipes.

5.2.8 Unused sample swipes will be also needed for testing as instrument blank swipes. These should not be removed from the vendor-supplied containers (typically cans) until needed.

5.2.9 For the initial evaluation of the minimal acceptable performance of an explosives detector, a second set of test swipes should be prepared so that all tests may be repeated. For routine performance evaluation, a single set of test swipes should be sufficient.

6. Analysis of Test Swipes

6.1 *Power On*—Ensure that the trace explosives detector is powered on and completes the warmup period according to the instructions provided with the detector. This may require 15 min or more.

6.2 *Calibration*—If the detector requires manual calibration before evaluating samples, insert the calibration swipe provided by the manufacturer according to the instructions provided in the detector manual. Confirm proper calibration and that the instrument is ready to accept samples. For many detectors, a “ready” signal will be displayed. If the instrument provides automatic calibration, verify that the instrument is “ready” to accept samples.

6.3 *Analyze Instrument Blank Swipe*—Before testing with the prepared swipes, place the instrument blank swipe into the detector according to the manufacturer’s instructions. Confirm that the detector does not provide an alarm signal for any of the explosive compounds. This constitutes a “pass” of this test. If the detector provides an alarm signal, this constitutes a “fail” in this test. Reinsert an instrument blank swipe and reanalyze. If the detector continues to provide an alarm with repeated testing, maintenance may be required, such as cleaning of the inlet.

6.4 *Analyze Process Blank Swipe*—Place the process blank swipe into the detector. If a positive alarm for any explosive occurs, there is a problem with this test result and it is a “fail.”

A fresh process blank swipe should be prepared and tested. If no alarm is found, then proceed to the next test. If the detector continues to provide an alarm with repeated testing, there may be a problem with the integrity of the solutions or with the performance of the detector.

6.5 *Analyze Test Swipes*—Analyze each of the test swipes in turn, each followed by the analysis of an instrument blank swipe (see 6.3). If the explosives detector provides a positive alarm on each test swipe and correctly identifies the explosive, then the detector has given a “pass” on each test. If the explosive detector fails to provide the correct positive alarm for any of the test swipes, the test was a “fail.” Upon failure, prepare additional test swipes and repeat the test.

6.6 *Reevaluation of Instrument Blank Swipes*—Following the evaluation of each test swipe, evaluate an instrument blank swipe. If the explosive detector provides a negative test, this test is a “pass.” If the explosives detector provides a positive alarm, the detector has failed the test and this test is a “fail.”

6.7 *Repeat Steps in 6.3-6.6*—The detector is considered to have minimum acceptable performance when all blank swipes provide a negative test and all test swipes provide a positive alarm with the correct identification of the explosive being tested. If the explosives detector fails any these tests, it should not be used for explosives detection. Upon failure of any one of these tests, the source of the problem with the detector or the test materials or both should be investigated and corrected.

6.8 *Document the Results of All of These Tests in the Checklist in Fig. 1*—Upon failure of any of the steps in the checklist in Fig. 1, the detector evaluation has failed. It is recommended that the testing be interrupted and the source of the problem with the detector or the test materials or both be investigated and corrected before testing is continued. The source of the failure should be noted in the checklist in Fig. 1 under comments.

6.9 *Routine Testing*—For periodic reevaluation of detector performance, analyzing a second set of swipes is not required. Applying the tests outlined in 6.1-6.6 is sufficient to verify the minimum acceptable performance of an explosives detector that has previously passed the steps outlined in 6.1-6.8. The sections in the checklist in Fig. 1 entitled “Evaluation 2” should be marked with a large X.

7. Keywords

7.1 explosive; IMS; ion mobility spectrometry; PETN; RDX; sample matrix; swipe; test kits; TNT

Instrument Manufacturer and Model Number _____

Serial Number _____

Test Kit Identification Number _____

Instruction	Evaluation 1		Evaluation 2	
	pass	fail	pass	fail
1. Power on as described in 6.1.				
2. Preparation of work area is completed (5.1).				
3. Preparation of test swipes have been completed and are ready for evaluation as described in 5.2.				
4. Analyze instrument blank swipe as described in 6.3. To pass this test, there should be no explosives alarm signal.				
5. Analyze process blank swipe as described in 6.4. To pass this test, there should be no explosives alarm signal.				
6. Analyze test swipes as described in 6.5. To pass this test, the correct alarm signal should be observed for each corresponding test swipe (that is, a TNT alarm was observed for a TNT-dosed test swipe).				
• TNT				
• RDX				
• PETN				
7. Analyze instrument blank swipe as described in 6.6. To pass this test, there should be no explosives alarm signal.				
• Following TNT test swipe				
• Following RDX test swipe				
• Following PETN test swipe				

Test Operator Name (Print) _____

Test Operator Signature _____ Date _____

Test Operator Comments _____

FIG. 1 Explosives Detector Performance Checklist

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