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# Standard Practice for Evaluation of Explosives Vapor Detectors[1]

This standard is issued under the fixed designation F 2069; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice is for the laboratory evaluation and selection of explosives vapor detectors.

## 2. Terminology

2.1 *Definitions:*

2.1.1 *clear down time*—time required for the detector to produce no alarm at the IFMAL after an overload level.

2.1.2 *false negative ratio*—one minus the probability of detection.

2.1.3 *false positive ratio*—ratio of the number of positive alarms to the total number of challenges when no explosives vapor is present, where the number of challenges is large and the instrument is set at the IFMAL.

2.1.4 *interferent*—nonexplosive substance, other than the explosive being detected, that can mask the explosives and produce a false negative decision or is identified as an explosive, producing a false positive decision.

2.1.5 *interferent equivalent response*—positive or negative response caused by a substance other than the explosive being measured, and expressed in explosives equivalent concentration units.

2.1.6 *interferent free minimum alarm level (IFMAL)*—alarm level that provides a 95 % probability of detection at confidence level of 95 %, at that setpoint, and no greater than 5 % false positives, at confidence level of 95 %, when challenged with explosive free air at that setpoint.

2.1.7 *overload level*—that concentration that upon recycle of the detector in the absence of that mass, produces a signal above the minimum alarm level.

2.1.8 *probability of detection*—ratio of the number of alarms to the total number of challenges at a specified explosive vapor concentration, where the number of challenges is 60 or greater and the instrument is set at the IFMAL This probability takes into account other system variables that affect performance, such as sample losses in inlets and preconcentrators.

2.1.9 *response time*—the amount of time required for the detector to analyze the sample and produce a reading that is at least 95 % of the full response for that sample.

2.1.10 *sample throughput*—number of distinguished samples that can be obtained and processed by the detector system in a given time period.

2.1.11 *sample time*—amount of time it takes to obtain a sufficient sample for introduction into the explosives detector.

2.1.12 *span drift*—variance with time of the detector response to the upper calibration concentration level.

2.1.13 *temperature and humidity effects*—effect of temperature and humidity on the stability and drift of the zero and span calibration of the detector.

2.1.14 *total analysis time*—total elapsed time from the sampling start until the system outputs a result. It is the sum of the sample time and response time.

## 3. Significance and Use

3.1 This practice establishes a method for characterizing explosives vapor detectors in the laboratory. The practice does not set performance requirements.

3.2 This practice is intended for use by the manufacturers of explosives vapor detection equipment and any organization that has the facilities and expertise to perform vapor calibrations. This practice relies upon the use of an explosives vapor generator unit to determine the applicable performance levels of the explosives vapor detectors.

3.3 This practice provides a method for evaluation of the following parameters:

3.3.1 Interferent free minimum alarm level,

3.3.2 Probability of detection,

3.3.3 False positive ratio,

3.3.4 False negative ratio,

3.3.5 Interference equivalent,

3.3.6 Temperature and humidity effects,

3.3.7 Sample time,

3.3.8 Response time,

3.3.9 Total analysis time,

3.3.10 Sample throughput, and

3.3.11 Overload level.

3.4 Each user or evaluator may choose to evaluate a detector only for those parameters of interest to them.

## 4. Reference Vapor Generator

4.1 The reference calibrated explosives vapor generator shall be one of the following vapor calibration units: (*1*) the pulsed vapor calibration unit constructed by the Idaho National Engineering Laboratory, Idaho Falls, Idaho, described in detail

[1] This practice is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.60 on Controlled Access Security, Search, and Screening Equipment.

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in Ref (**1**); [2] (*2*) the continuous vapor calibration unit constructed by Sandia National Laboratories, described in Ref (**2**); or (*3*) the continuous vapor calibration unit for higher vapor pressure explosives constructed by the National Research Council Canada described in Ref (**3**).

## 5. Detector Evaluation

5.1 A manufacturer of explosives vapor detectors may construct or purchase a secondary vapor generation device which can be used to measure the parameters of the explosives vapor detectors. Each secondary vapor generation device shall be traceable to one of the calibrated reference explosives vapor generation systems listed in Section 4. At least once a year, each manufacturer's secondary vapor generation source shall be compared to a calibrated reference vapor generator and a calibration curve shall be prepared for the output of the secondary vapor generator.

5.2 *Secondary Explosive Vapor Generator Unit*—Each manufacturer's secondary vapor generator shall have the following characteristics:

5.2.1 The output flow of the secondary vapor generator unit shall be at least equal to the required flow for the sampling device, but no greater than 1.25 times the flow of the sampling device. If the flow of the generator is greater than the flow of the sampling device, then the input diameter of the sampling device shall be no greater than one half the output diameter of the vapor generator. Additionally, the output of the generator and inlet of the sampling device should be coaxial, and at a distance not to exceed one-half the output diameter of the vapor generator.

5.2.2 The test atmosphere delivery system shall be designed and constructed so that no explosives vapor shall be allowed to collect on the walls of the delivery system.

5.2.3 The output of the test atmosphere generation system shall be sufficiently constant in flow and concentration to obtain a stable response during the required test measurements. The concentration of each test atmosphere shall be established by calibration of the secondary explosives vapor generator with the reference explosives vapor generator. This is accomplished by taking the secondary vapor generator to the reference vapor generator and measuring the output of the secondary generator using the same analytical techniques used to calibrate the reference vapor generator. The method used to calibrate the reference generator is to be used to measure the response of the secondary vapor generator.

5.2.4 All diluent air shall be free of explosives and potential interferents.

5.2.5 The accuracy of all flow measurements used to calculate the test atmosphere concentrations shall be documented.

5.2.6 The concentration output of a secondary vapor generator is determined by the calibration curve determined during the calibration of the reference vapor generation unit.

5.2.7 In order to obtain reproducible results when measuring the output concentration of a secondary vapor generator, a fixture shall be used to reproducibly hold the sampling device at the same position with respect to the output flow of the vapor generator. Additionally, for a batch type analyzer the sampling device shall be operated in a mode to ensure that for each analysis point, the sampling device is used the identical amount of time. All test performed in Section 6 are to be performed using the sampling device as the means of introducing the explosives and potential interferents into the sample analysis stream of the detector.

## 6. Measurement of Detector Parameters

6.1 Each explosives vapor detector shall be setup and adjusted to the manufacturers recommended specifications. Adjustments for "special" or unusual performance are not permitted. In conducting these measurements, the manufacturer shall take a random instrument from his production line and set it up according to the instructions in the detector's operating instruction booklet. No special research instruments or special instruments are to be used to determine these operating parameters.

6.2 *Equipment Required*:

6.2.1 Explosive vapor detector under test.

6.2.2 Environmental chamber capable of controlling temperature between the lowest and the highest operating temperature expected for the unit.

6.2.3 Secondary vapor generator capable of generating the required concentration levels of explosives for the performance testing.

6.2.4 Constant voltage transformer, sufficient for powering the unit followed by a variac, to allow for generation of constant voltages between the test voltages. The unit shall be operated in the voltage window specified by the manufacturer.

6.2.5 A power generator of the same frequency as specified for the unit tested.

6.2.6 The appropriate device to record the output, which may be manual recording.

6.3 *Test Conditions*:

6.3.1 Set-up and start-up shall be in strict accordance with the operating instruction manual supplied with the unit. Allow adequate warm-up or stabilization time as indicated in the manual before beginning any of the testing.

6.3.2 Evaluation of the detector shall be performed in strict accordance with the users manual. A response curve (see 6.4) shall be generated by introducing at least three different concentrations of explosives vapors and one free of explosives vapor for each explosive type tested, and noting the instant response for units with a quantitative output of signal strength. A plot shall be prepared of the output. The log of the concentration may be used.

6.3.3 *Recalibration and Maintenance*— No recalibration shall be performed once the test sequence has begun, unless the recalibration is explicitly called for in the users manual. Once the unit has been calibrated and set-up, and the tests started, manual adjustments or normal periodic maintenance are permitted only in accordance with the manufactures recommended schedule. Replacement of consumables are permitted in accordance with the manufacturers operation manual. Automatic adjustments which the unit performs by itself are permitted at any time. Records should be kept of all manual adjustments and periodic maintenance procedures.



[2] The boldface numbers in parentheses refer to the list of references at the end of this practice.

6.3.4 *Malfunctions*—If a malfunction occurs during the performance testing, that entire test shall be repeated. A detailed explanation of the malfunction and the remedial action taken shall be included in the test report. If more than one malfunction occurs, all performance test procedures for all parameters shall be repeated.

6.3.5 Tests for all performance parameters shall be completed on the same explosives vapor detector.

6.4 *Interferent Free Minimum Alarm Level*—Determine the lowest explosive vapor concentration that can be reliably detected. This would be the lowest concentration that would produce 60 responses out of 60 challenges. Each challenge with explosives vapor shall be followed by a successful challenge (that is, no alarm) with explosives free air. The resulting concentration is the interferent free minimum alarm level (IFMAL). The alarm level guarantees a 95 % probability of detection with a confidence level of 95 % at that setpoint and no greater than 5 % false positives with a confidence level of 95 % when challenged with explosive free air at that setpoint. Once the interferent free minimum alarm level has been determined, it is to be set at the beginning of the test protocol. Once the level is set, it is not to be changed during the test protocol.

6.5 *Detector Response Curve*—The detector response shall be determined according to the instructions in the users manual. This test can be performed with either a calibrated reference or a calibrated secondary vapor generator. If the test detector does not identify the explosive, then rigorous documentation shall be available to certify the purity of the materials used in the generator. Additionally, the test protocol shall ensure that cross contamination has not occurred. This shall be documented by independent analytical chemistry tests which check the purity of the generator output. This shall be carried out before, during, and at the end of each test. One simple test to ensure that the system has not been contaminated is to vary the temperature of the generator and ensure that the change in instrument response agrees with the known vapor pressure variation of the explosive with temperature.

6.5.1 Adjust the sample concentration of the secondary vapor generator to supply at least four concentrations of each of the different explosives. One point shall be zero, the second point shall be the expected interferent free minimum alarm level (IFMAL, see 6.4), the third point about 20-50 times the interferent free minimum alarm level, and the fourth point about 1 % of the equilibrium vapor pressure of the test explosive at 25 °C. For the case where the test instrument has an extremely low IFMAL, which is difficult to generate, the lower point for the calibration curve can lie at any convenient point between 20 times the IFMAL and 10 % of the higher calibration point. For the case where the detector has a high IFMAL where 20 to 50 times the IFMAL is close to 1 % of the equilibrium vapor pressure at 25 °C, only two points and zero need be taken.

6.5.2 Note the detector response for each explosive type. Plot the detector response versus concentration output (or log of concentration) for each explosive type using statistical methods to obtain the response curve. This plot shall be used for the rest of the testing protocol to translate the reported output of the detector into actual concentration units for each explosive. Include the instrument response curve as part of the test report.

6.6 *Interference Equivalent*—The following tests are designed to show interferences problems:

6.6.1 The test detector shall be tested for all substances likely to be encountered in typical use which may cause a detectable response. A list of interferents is contained in Table 1.

6.6.2 The test detector shall be challenged 20 times with each interferent agent specified in Table 1. The effect of the interference is positive if the test detector's response is increased or negative is the response is decreased by the presence of the interferent. The tests shall be performed in the following manner: The interferent compound shall be placed inside a 45 mm inside diameter, disposable aluminum weighing dish. If the interferent is a liquid, 1.0 mL of the liquid shall be placed onto a filter paper (Whatman 42.5 mm diameter) placed in the weighing dish. If the interferent is dissolved in a solvent, 1.0 mL of this solution shall be placed onto the filter paper. In this later case, 5 min shall be allowed for the solvent to evaporate before testing. One gram of the solid samples shall be placed directly onto the aluminum weighing dish. A new weighing dish and filter paper shall be used for each test.

6.6.3 Cigarette smoke shall be sampled by lighting a cigarette, placing it 5 cm from the detector inlet and sampling the



**TABLE 1 Interferent Equivalent Levels**

| Interferent | Interferent Equivalent Level | Units |
|---|---|---|
| Dibutyl Phthalate Plasticizer | | g/L |
| Formaldehyde | | g/L |
| Cigarette Smoke | | g/L |
| Dry Cleaning Solvent (Trichloroethylene) | | g/L |
| Coty Wild Musk Perfume | | g/L |
| Ethyl Alcohol | | g/L |
| Skoal Wintergreen Smokeless Tobacco | | g/L |
| McCormick Ground Cloves | | g/L |
| Kiwi Black Shoe Polish | | g/L |
| Lysol Spray Disinfectant | | g/L |
| Pinesol Cleaner | | g/L |
| Chloraseptic Mouthwash | | g/L |
| Solarcaine Sunburn Spray | | g/L |
| Mothballs, Naphthalene | | g/L |
| Mothballs, p-Dichlorobenzene | | g/L |
| WD-40 Penetrating Oil | | g/L |
| Armorall Vinyl Cleaner | | g/L |