

BACKGROUND DOCUMENT

REPORT ON REVISIONS TO 5TH EDITION AP-42 CHAPTER 15 - ORDNANCE DETONATION

EMISSION FACTORS DEVELOPED BASED ON FIRING POINT EMISSION STUDY PHASE II
SERIES 2 TESTING CONDUCTED AT ABERDEEN PROVING GROUND, MARYLAND

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NOTICE

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1.0 INTRODUCTION

Due to the lack of credible data concerning emissions from training ordnance when used in their tactical configurations, the U.S. Army Environmental Center (USAEC) established a program to quantify emissions from the detonation of ordnance. This document presents background information concerning the development of air emission factors for two ordnance types used during training exercises at U.S. Army installations. The air emission factors were developed from test data collected by USAEC. Ordnance for which emission factors have been developed and their corresponding AP-42 sections are identified in Table 1. To help readers easily find those emission factors of interest, the ordnance are organized according to their Department of Defense Identification Code (DODIC).

TABLE 1 ORDNANCE FOR WHICH EMISSION FACTORS WERE DEVELOPED

DODIC	Ordnance Description	AP-42 Section
B519	M781 40-mm Practice Cartridge	15.2.2
B584	M918 40-mm Practice Cartridge	15.2.7

It should be noted that the air emission factors documented herein are only representative of emissions associated with the use of the propelling cartridge. Emissions associated with the impact and/or explosion of the propelled projectile are addressed elsewhere.

The emission factors described in this document are based on data obtained during testing conducted at Aberdeen Proving Ground, Maryland, as presented in the final test report titled *Report No. 2 for the Firing Point Emission Study Phase II*¹ and the document titled *Detailed Test Plan No. 2 for the Firing Point Emission Study Phase II*.² These documents were supplemented by additional data provided by the testing contractor.³ It should be noted that Reference 1 indicates that DODIC B592 was tested rather than DODIC B584 as identified in Table 1. However, based on data obtained from Reference 3, the test report is incorrect and the actual ordnance tested was DODIC B584.

For each ordnance, two test runs were conducted. In order to generate measurable quantities of emissions, fourteen M781 cartridges were fired per test run and twenty M918 cartridges were fired per test run. Source test protocols were developed by USAEC before any testing was conducted and they were reviewed by the U.S. Environmental Protection Agency's (EPA's) Emission Measurement Center. The tests were conducted between August 30 and September 15, 1999.

The compounds that were measured included carbon monoxide (CO), carbon dioxide (CO₂), oxides of nitrogen (NO_x), sulfur dioxide (SO₂), ammonia (NH₃), methane (CH₄), total suspended particulate (TSP), particulate matter with an aerodynamic diameter less than or equal to 10 microns (PM-10), particulate matter with an aerodynamic diameter less than or equal to 2.5 microns (PM-2.5), metals, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), dioxin and furan compounds, acid gases, hydrogen cyanide (HCN), aldehydes and carbonyl compounds, hydrocarbons, polycyclic aromatic hydrocarbons (PAH), and energetic materials. Within each of the AP-42 sections, only emission factors for criteria pollutants, carbon dioxide, hazardous air pollutants (as defined by §112(b)(1) of the *Clean Air Act* [CAA]), and toxic chemicals (as defined by §313 of the *Emergency Planning and Community Right-to-Know Act* [EPCRA]) are presented.

The emission factors were developed on a "per item" basis and on a "per net explosive weight (NEW)" basis. Users should choose the appropriate emission factor to estimate emissions based upon the data available; either factor is equally valid. The NEW of each ordnance tested is provided in the corresponding AP-42 section and in Table 2.

TABLE 2 ORDNANCE NET EXPLOSIVE WEIGHT

DODIC	Ordnance Description	NEW (lb/item) ^a
B519	M781 40-mm Target Practice Charge	8.00 E-04
B584	M918 40-mm Target Practice Charge	1.03 E-02

^a NEW values were obtained from Reference 3.

This document includes five sections in addition to this Introduction. Section 2 of this document identifies the compounds measured during the test program and describes the emission measurement methods used. Section 3 includes a discussion of the emission factor final test report and ratings for the test data contained therein. Section 4 describes the calculations and methodologies used to develop emission factors for each type of compound measured. Section 5 describes the methodology used to rate the emission factors and provides emission factor ratings for each type of compound measured. Section 6 includes a complete list of the references cited in this document.

There are two appendices included with this document. Appendix A identifies, by ordnance type, all of the compounds for which analyses were performed and the emission factors that were developed. [Note: Compounds present in the method blank at greater than 50 percent of test levels are excluded from Appendix A.] Appendix A also identifies the minimum detection levels associated with all compounds that were not detected. Emission factors and minimum detection levels presented in Appendix A were determined from the most accurate method if two sampling or analytical methods were used to measure one compound. Appendix B presents the new AP-42 sections for the two ordnance that were tested.

In addition to this document, there are electronic databases available on the web (<http://www.epa.gov/ttn/chief/ap42/index.html>) that contain the data used in the development of the emission factors. The general procedures that were followed to develop these emission factors can be found at the same web address under the title *Procedures for Preparing Emission Factor Documents*.⁴

2.0 COMPOUNDS MEASURED AND EMISSION MEASUREMENT METHODS

The USAEC Firing Point Series 2 testing was conducted in the Emission Characterization Chamber (ECC) located at the Aberdeen Test Center (ATC), Maryland. The ECC is a 3/8-inch thick steel cylinder with parabolic caps welded to each end. The chamber is approximately 7 feet in diameter and 15 feet long with a high-solids epoxy coating on all interior and exterior surfaces. A personnel access door and remotely operated firing port door are integrated into the rear and front parabolic caps, respectively. The firing port door allows the projectile to exit the chamber and then closes to maintain the seal required for emissions characterization.

Fans inside the ECC ensure even distribution of the sulfur hexafluoride (SF₆) tracer gas and weapon emission products. A series of 12 ports are located along the sides and top of the chamber to accommodate instrumentation. A separate instrumentation and test control building is part of the facility and instrumentation and firing of the weapon are controlled remotely from this location. Instrumentation and equipment are in place to collect emission product data.

A removable interior partition, located between the second and third instrumentation ports, allows the test volume of the facility to be adjusted to approximately 213 cubic feet, 307 cubic feet, or 520 cubic feet, depending on the size of the weapon tested and expected quantity of emissions. An optional weapon box, which attaches to the partition and is approximately 28 inches wide by 28 inches high by 60 inches

long, increases the smallest test volume to approximately 240 cubic feet. For tests of large weapons where the smallest test volume is desired, the weapon may be mounted in the box, which allows the muzzle of the weapon to be moved away from the firing port door, minimizing the escape of emission products. The box also permits manual firing of the weapon, while maintaining separation of the operator from the weapon emissions.

DODIC B584 was tested using the largest chamber volume of 520 cubic feet. DODIC B519 was tested using the smallest volume, increased to 240 cubic feet using the optional weapon box. Because of the small volume of the test chamber in which DODIC B519 was sampled, four partially instrumented trials were required to obtain data for two complete test runs.

A number of different test methods were employed to collect and analyze the emission data that were used to develop emission factors for firing of ordnance. Table 3 identifies each emission test method used; bracketed information identifies the purpose of using the method. The emissions data were collected using EPA test methods published in Title 40 of the Code of Federal Regulations, Part 50 (40 CFR 50); 40 CFR 60; 40 CFR 63; and in *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*.⁵ Some of the sample analytical procedures used were from EPA Office of Solid Waste (OSW) publication SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*⁶ and the *National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods (NMAM), Fourth Edition*.⁷ Additional sampling and analytical procedures were taken from Internal Operating Procedures (IOP) developed by the ATC Chemistry Team and from Standard Operating Procedures (SOP) developed by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Directorate of Laboratory Sciences (DLS). Where necessary, the test methods were adapted to reflect application to the unique testing of ordnance firing in the ECC.

TABLE 3 EMISSION TEST METHODS USED

Compound	Test Method
CO	40 CFR 60, Appendix A, EPA Method 10 - <i>Determination of Carbon Monoxide Emissions from Stationary Sources</i> [sampling and analysis]
CO ₂	40 CFR 60, Appendix A, EPA Method 3A - <i>Measurement of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources</i> [sampling and analysis]
NO _x	40 CFR 60, Appendix A, EPA Method 7E - <i>Measurement of Nitrogen Oxides Emissions from Stationary Sources</i> [sampling and analysis]
SO ₂	40 CFR 60, Appendix A, EPA Method 6C - <i>Measurement of Sulfur Dioxide Emissions from Stationary Sources</i> [sampling and analysis]
SF ₆ , NH ₃ , CO, CO ₂ , and CH ₄	40 CFR 63, Appendix A, EPA Proposed Method 320 - <i>Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy</i> [sampling and analysis]
TSP	40 CFR 60, Appendix A, EPA Method 17 - <i>Determination of Particulate Emissions from Stationary Sources (In-Stack Filtration Method)</i> [sampling] 40 CFR 50, Appendix B - <i>Reference Method for the Determination of Suspended Particulate Matter as in the Atmosphere (High Volume Method)</i> [analysis]
PM-10 and PM-2.5	40 CFR 50, Appendix J - <i>Reference Method for the Determination of Particulate Matter as PM-10 in the Atmosphere</i> [sampling and analysis]

TABLE 3 (cont.)

Compound	Test Method
Metals	Metal sample was obtained from TSP sample [sampling] 40 CFR 50, Appendix G - <i>Reference Method for Determination of Lead in Suspended Particulate Matter Collected from Ambient Air</i> [analysis]
VOC	EPA Compendium Method TO-14A - <i>Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography</i> [sampling and analysis]
PAH	EPA Compendium Method TO-13A - <i>Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)</i> [sampling] EPA Compendium Method TO-13 - <i>Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)</i> [analysis]
SVOC	EPA Compendium Method TO-13A - <i>Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)</i> [sampling] SW-846 Method 8270 Modified (SW8270M) - <i>Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)</i> [analysis]
Dioxins and Furans	EPA Compendium Method TO-9A - <i>Determination of Polychlorinated, Polybrominated, and Brominated/ Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air</i> [sampling and analysis]
Acid Gases	NIOSH Method 7903 - <i>Inorganic Acids</i> [sampling and analysis]
Hydrogen Cyanide	NIOSH Method 7904 - <i>Aerosol and Gas Cyanides</i> [sampling and analysis]
Aldehydes and Carbonyls	EPA Compendium Method TO-11A - <i>Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography (HPLC)</i> [sampling and analysis]
Hydrocarbons and n-Hexane	40 CFR 60, Appendix A, EPA Method 18 - <i>Measurement of Gaseous Organic Compounds by Gas Chromatography</i> [sampling and analysis]
SF ₆	40 CFR 60, Appendix A, EPA Method 18 - <i>Measurement of Gaseous Organic Compounds by Gas Chromatography</i> [sampling] Gas chromatography with electron capture detection (GC/ECD) [analysis]
Energetic Materials	EPA Compendium Method TO-13A - <i>Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)</i> [sampling] USACHPPM-DLS SOP CAD 26.1 - <i>Procedure For Analysis of Explosives in Ambient Air</i> [analysis]

The following sections identify and briefly describe the test methods used to measure each compound or group of compounds. Additional information regarding the operation of the ECC and the test methods used is presented in Reference 2. EPA-approved methods were used by the laboratories that provided sampling and analysis data.

2.1 Carbon Monoxide, Carbon Dioxide, Oxides of Nitrogen, and Sulfur Dioxide

Real-time concentrations of CO, CO₂, NO_x, and SO₂ that resulted from the firing of ordnance in the ECC were measured using a continuous emissions measurement system (CEMS). The final test report¹ states that the compounds were measured using EPA reference methods as described in the following paragraph. Although the report does include results for some quality control checks, due to a lack of calibration data, conformance with the stated methodologies could not be confirmed.

CO sampling and analysis was conducted in accordance with 40 CFR Part 60, Appendix A, Method 10 - *Determination of Carbon Monoxide Emissions from Stationary Sources*, with a Thermo Environmental Instruments, Inc. (TEI) nondispersive infrared analyzer. CO₂ sampling and analysis was conducted in accordance with 40 CFR Part 60, Appendix A, Method 3A - *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*, with a TEI nondispersive infrared analyzer. NO_x sampling and analysis was conducted in accordance with 40 CFR Part 60, Appendix A, Method 7E - *Determination of Nitrogen Oxides Emissions from Stationary Sources*, with a TEI model No. 10AR chemiluminescent analyzer. SO₂ sampling and analysis was conducted in accordance with 40 CFR Part 60, Appendix A, Method 6C - *Determination of Sulfur Dioxide Emissions from Stationary Sources*, with a TEI 43H pulsed fluorescent analyzer.

Each analyzer channel sampled at approximately 4 liters per minute (lpm) through Teflon-lined polyethylene tubing with Mine Safety Appliance (MSA) ultra type H cartridge filters used to control particulate. An inline Balston filter was used to trap condensation. Due to the ambient condition of the samples, no heated probes or sample lines were used. Data was collected four times per second.

2.2 Sulfur Hexafluoride, Ammonia, Carbon Monoxide, Carbon Dioxide, and Methane

Extractive Fourier Transform Infrared (FTIR) spectroscopy was used to measure real-time concentrations of the SF₆ tracer gas, NH₃, CO, CO₂, and CH₄ as well as to identify qualitatively the presence of other permanent gas species using protocols modified from procedures in 40 CFR 63, Appendix A, EPA Proposed Method 320 - *Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy*. Samples were drawn continuously from the ECC at a nominal rate of 0.5 cubic feet per minute (ft³/min) using a Teflon-lined polyethylene tube and an Alcatel Pascal[®] rotary vane-type pump, for a minimum of 20 minutes. The FTIR spectra were collected and stored at a minimum of every 20 seconds.

2.3 Total Suspended Particulate

The TSP concentration that resulted from the firing of ordnance in the ECC was determined using a modified sampling and analysis procedure based on 40 CFR 60, Appendix A, Reference Method 17 - *Determination of Particulate Emissions from Stationary Sources (In-Stack Filtration Method)*. A Graseby[®] Model PS-1 ambient air sampling module equipped with a quartz fiber filter was connected by a flex line to the Method 17 metering system. The metering system extracted test chamber air through a Whatman[®] filter at a nominal rate of 1 ft³/min for a target minimum sampling time of 20 minutes. The TSP concentration was computed, in accordance with 40 CFR 50, Appendix B - *Reference Method for the Determination of Suspended Particulate Matter as in the Atmosphere*, by dividing the mass of TSP collected by the volume of air sampled, corrected to standard conditions.

2.4 Particulate Matter with an Aerodynamic Diameter Less than or Equal to 10 or 2.5 Microns

The PM-10 and PM-2.5 concentrations that resulted from the firing of ordnance in the ECC were determined using a modified sampling and analysis procedure based on 40 CFR 50, Appendix J -

Reference Method for the Determination of Particulate Matter as PM-10 in the Atmosphere. An ambient sampler with a Graseby No. G24B dichotomous PM-10 size selective inlet head was used to collect the PM-10 and smaller particulate at a sampling rate of 16.7 lpm for 20 minutes. The PM-10 fraction was then passed through a virtual impactor to separate the particulate larger than PM-2.5. The PM-10 and PM-2.5 concentrations were computed by dividing the mass of PM-10 and PM-2.5 collected by the respective volumes of air sampled, corrected to standard conditions.

2.5 Metals

Metal concentrations that resulted from the firing of ordnance in the ECC were determined using particulate matter from the TSP samples collected as described in Section 2.3. The analyses followed the procedures of 40 CFR 50, Appendix G - *Reference Method for Determination of Lead in Suspended Particulate Matter Collected from Ambient Air.* The method was modified to use inductively coupled plasma (ICP) spectroscopy for analysis and to include additional metals. Concentrations of target metals were computed by dividing the mass of metal collected by the volume of air sampled, corrected to standard conditions.

2.6 Volatile Organic Compounds

VOC concentrations that resulted from the firing of ordnance in the ECC were determined using procedures from the *Second Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, Method TO-14A - *Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canister with Subsequent Analysis by Gas Chromatography.* Air samples were collected for 20 minutes using a Scientific Instrument Specialists Inc., pressurized canister sampler and 6-liter silicon-lined SUMMA canister that was certified VOC free prior to use. An analysis by gas chromatography/mass spectrometry in full scan mode (GC/MS/SCAN) followed. Unknown compounds were tentatively identified using computerized mass spectral matching techniques.

2.7 Semivolatile Organic Compounds and Polycyclic Aromatic Hydrocarbons

SVOC and PAH concentrations that resulted from the firing of ordnance in the ECC were determined based on procedures found in Method TO-13A - *Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS).* During each run, samples were collected using a PS-1 sampler equipped with a quartz fiber filter and XAD-2 adsorbent resin cartridges. The PS-1 sampling module was used to sample for 20 minutes at 1 ft³/min. Following sampling, the filters and resin cartridges underwent solvent extraction and analysis by GC/MS analysis in selected ion monitoring (SIM) mode. The sample extracts were reanalyzed in scan mode following modified procedures in SW-846 Method 8270 - *Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS).* Modifications are described in the USACHPPM SOP SV 72.4. Unknown compounds were tentatively identified using computerized mass spectral matching techniques.

2.8 Dioxin and Furan Compounds

Polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofuran (PCDF) compound concentrations that resulted from the firing of ordnance in the ECC were determined based on procedures found in Method TO-9A - *Determination of Polychlorinated, Polybrominated, and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air.* Samples were collected using modified PS-1 samplers with quartz fiber particulate filters and polyurethane foam (PUF) packed cartridges. The PS-1 sampling module was connected to a stack source airflow metering system with a

flex line and used to sample for 20 minutes at a nominal rate of 1 ft³/min. After sampling, the filters and adsorbent cartridges underwent extraction and analysis by GC/High Resolution Mass Spectroscopy according to Method TO-9A.

2.9 Acid Gases

Acid gas concentrations that resulted from the firing of ordnance in the ECC were determined based on procedures found in NIOSH Method 7903 - *Inorganic Acids*. Acid gases were collected by using silica gel sorbent tubes (ORBO-53) and a sampling pump. Sample gases were passed through the sorbent tubes for about 20 minutes at a nominal rate of 0.5 lpm. Analysis was performed according to NIOSH Method 7903-Inorganic Acids, by ion chromatography as detailed in ATC IOP 372 – *Anion Analysis using the AS14 Column*.

2.10 Hydrogen Cyanide

HCN concentrations that resulted from the firing of ordnance in the ECC were determined using NIOSH Method 7904 - *Aerosol and Gas Cyanides*, but utilizing modified sampling and analytical procedures. The sample gas was drawn through an 0.8 micrometer PVC filter and an impinger containing 0.1 normal potassium hydroxide (KOH) for 20 minutes at a nominal rate of 0.5 lpm. The impinger solution and extracted filter were analyzed by ion selective electrode using procedures described in Galson Laboratories SOP IC-N7904.R01.

2.11 Aldehydes and Carbonyl Compounds

Aldehyde and carbonyl compound concentrations that resulted from firing of ordnance in the ECC were determined using EPA Compendium Method TO-11A - *Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography (HPLC)*, but utilizing modified sampling and analytical procedures. Dinitrophenylhydrazine (DNPH) laden cartridge tubes were used as a direct probe to trap and derivatize aldehyde and carbonyl compounds. Sample gases were extracted for 20 minutes (nominal) from the test chamber through ozone denuders at a rate of 1 to 2 lpm using a rotary vane pump, manifold, critical orifice, and needle valve. Analysis was by reverse-phase HPLC with ultraviolet (UV) detection using Compendium Method TO-11A modified as detailed in ATC IOP 227 Rev. 3.0 – *Analysis of Formaldehyde and Other Carbonyl Compounds by High Performance Liquid Chromatography*.

2.12 Hydrocarbons, n-Hexane, and Sulfur Hexafluoride

Hydrocarbon, n-hexane, and SF₆ concentrations that resulted from the firing of ordnance in the ECC were sampled using 40 CFR 60, Appendix A, EPA Method 18 - *Measurement of Gaseous Organic Compounds by Gas Chromatography*. The samples were collected at a nominal rate of 1 lpm for 20 minutes. Analysis for the light hydrocarbons was by gas chromatography/flame ionization detector (GC/FID) in accordance with 40 CFR 60, Appendix A, EPA Method 18. SF₆ was analyzed by gas chromatography with electron capture detection (GC/ECD). This measurement served as a backup to the FTIR measurement of SF₆.

2.13 Energetic Materials

Energetic compound concentrations that resulted from the firing of ordnance in the ECC were determined based on procedures found in EPA Compendium Method TO-13A - *Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)*. Samples were collected using a PS-1 sampler equipped with a quartz fiber

particulate filter and XAD-2 adsorbent resin cartridges. The PS-1 sampling module was used to sample for 20 minutes at approximately 1 ft³/min. Analyses followed procedures outlined in USACHPPM, Directorate of Laboratory Sciences, Chromatographic Analysis Division - *Procedure for Analysis of Explosives in Air*, Standard Operating Procedure CAD 26.1. This method specifically addresses the analysis of 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2,4,6-trinitrotoluene, and RDX by impinger/XAD-2 resin sampling, followed by isoamyl acetate extraction and GC/ECD analysis.

3.0 TEST DATA ANALYSIS AND RATING

3.1 EPA Guidance Regarding Test Data Quality Ratings

Prior to inclusion of emission factors in AP-42, the reliability of the underlying emission test data must be appraised in accordance with the rating system specified in Reference 4. Under this rating system, test data are assigned a rating from A to D, where an “A” rating is assigned to the highest quality data. The criteria used to assign a specific data quality rating are summarized below.

- A** Tests are performed by using an EPA reference test method, or when not applicable, a sound methodology. Tests are reported in enough detail for adequate validation and raw data are provided that can be used to duplicate the emission results presented in the report.
- B** Tests are performed by a generally sound methodology, but lacking enough detail for adequate validation. Data are insufficient to completely duplicate the emission result presented in the report.
- C** Tests are based on an unproven or new methodology, or are lacking a significant amount of background information.
- D** Tests are based on a generally unacceptable method, but the method may provide an order-of-magnitude value for the source.

Four specific criteria are identified in Reference 4 for consideration to assist in the assignment of a test data quality rating. These four criteria are:

1. Source operation. If the manner in which the source was operated is well documented in the report and the source was operating within typical parameters during the test, an “A” rating should be assigned. If the report stated parameters that were typical, but lacked detailed information, a “B” rating should be assigned. If there is reason to believe the operation was not typical, a “C” or “D” rating should be assigned.
2. Test methods and sampling procedures. In developing the ratings, the estimated accuracy and precision of the test method as well as the adequacy of the documentation should be considered. In general, if a current EPA reference test method, appropriate for the source, was followed, the rating should be higher (“A” or “B”). If other methods were used, an assessment should be made of their validity. If it is judged that the method was likely to be inaccurate or biased, a lower rating (“C” or “D”) should be given. A complete report should indicate whether any procedures deviated from standard methods and explain any deviations. If deviations were reported, an evaluation should be made of whether these were likely to influence the test results.
3. Process information. During testing, many variations in the process can occur without warning and sometimes without being noticed. Such variations can induce wide deviations in sampling results. If a large variation between test run results cannot be explained by information contained in the site final test report or from test reports of other sources, the data are suspect and should be given a lower rating or excluded. However, it should be recognized that a process may have

highly variable emissions and a lower rating may not be appropriate solely on the basis of wide deviations in sampling results.

4. Analysis and calculations. Ideally, final test reports should contain original raw data sheets and other documentation such as gas parameters (dry cubic feet per minute, oxygen percentage), calculation sheets, or example calculations describing how the calculated emission results were obtained. If there are data sheets, the nomenclature and equations used should be compared to those specified by EPA to establish equivalency. The depth of review of the calculations should be dictated by the reviewers' confidence in the ability and conscientiousness of the tester, based on such factors as consistency of results and completeness of other areas of the final test report. Reports may indicate that raw data sheets were available, but were not included. If the final test report is of high quality based on the other criteria, the quality rating should not be lowered due to a lack of data sheets.

An overall test data quality rating should be assigned based upon the ratings assigned for each of the four criteria.

3.2 Analysis of Test Data

Data included in the final test report,¹ the detailed test plan,² and in the analytical data supporting the test report were rated in accordance with the rating system described above. Results for each of the four criteria described above are presented in the following sections.

3.2.1 Source Operations

The manner by which the ordnance were deployed (i.e., used) is documented in the final test report. Each ordnance that was tested was deployed in a manner similar to that which would occur in the field. The tests appear to have replicated typical ordnance operating parameters; consequently, the test data should be assigned an "A" rating based on this criterion.

3.2.2 Test Methods and Sampling Procedures

The test methods and sampling procedures were evaluated as being appropriate and consistent with EPA test methods or sound methodology. Except as noted below, no problems of any significance were identified; consequently, the test data should be assigned an "A" rating based on this criterion.

3.2.2.1 CEMS-Measured Data

CEMS raw data were provided for the tests,³ but not for the pre- and post-test quality control (QC) activities. CEMS QC measures specified under 40 CFR 60, Appendix A, EPA Methods 3A, 7E, and 6C were not followed. Furthermore, none of the calibration gas certifications were supplied. There was no evidence of bias in the data; however, based on the issues noted above, the test data for the CEMS-measured compounds (i.e., CO, CO₂, NO_x, and SO₂) should be assigned a "B" rating based on this criterion.

3.2.2.2 Compounds Sampled or Analyzed Using More than One Test Method or Analytical Method

Thirty-six compounds were either sampled or analyzed using two methods; these compounds are identified in Table 4. For each of these compounds, emission factors were calculated based upon the data measured using the more appropriate test or analytical method; data obtained using the less appropriate

method were ignored. The more appropriate method was identified by reviewing the methods and the target compound lists associated with each method. If a specific compound appeared on the target compound list for one method but not the other, the method targeting the compound was selected. If a specific compound appeared on the target compound lists for both methods, the method judged to provide the most accurate data was selected.

If a compound was analyzed using both the SW8270M (SVOC) and TO-14A (VOC) methods, the TO-14A method analysis was judged to be more accurate and was therefore selected. For compounds analyzed using both the SW8270M (SVOC) and TO-13 (PAH) methods, the TO-13 value was selected because TO-13 allowed quantification of compounds at lower levels than SW8270M. For compounds sampled using a CEMS and FTIR spectroscopy, the CEMS measurements were judged to be more accurate. For compounds analyzed using both SW8270M (SVOC) and SOP CAD 26.1 (energetic materials), the SOP CAD 26.1 data were selected because SOP CAD 26.1 allows detection of compounds at lower levels than SW8270M. If a compound analyzed using both the TO-11A (aldehydes) and TO-14A (VOC) methods, the TO-11A method analysis was judged to be more accurate and was therefore selected. For compounds analyzed using both Method 18 (hydrocarbons) and TO-14A (VOC), and for which the compounds appeared on both target compound lists, the Method 18 analysis was judged to be more accurate and was selected. For compounds analyzed using both Method 18 (hydrocarbons) and FTIR spectroscopy, the Method 18 analysis was judged to be more accurate and was selected.

If a compound sampled under two methods had poor precision between test runs for the sampling method that would have been more accurate under normal circumstances, data from the other method were used to calculate emission factors. These cases are also noted in the footnotes for Table 4.

TABLE 4 COMPOUNDS MEASURED USING MORE THAN ONE TEST OR ANALYTICAL METHOD

Compound	Selected Method	Other Method Employed
Carbon Dioxide	40 CFR 60, Method 3A (CEMS)	40 CFR 63, Method 320 (FTIR)
Carbon Monoxide	40 CFR 60, Method 10 (CEMS)	40 CFR 63, Method 320 (FTIR)
Methane	40 CFR 60, Method 18 (Hydrocarbons)	40 CFR 63, Method 320 (FTIR)
Acenaphthene	TO-13 (PAH)	SW8270M (SVOC)
Acenaphthylene	TO-13 (PAH)	SW8270M (SVOC)
Acrolein	TO-11A (Aldehydes)	TO-14A (VOC)
Anthracene	TO-13 (PAH)	SW8270M (SVOC)
Benzo[a]anthracene	TO-13 (PAH)	SW8270M (SVOC)
Benzo[b]fluoranthene	TO-13 (PAH)	SW8270M (SVOC)
Benzo[k]fluoranthene ^a	TO-13 (PAH)	SW8270M (SVOC)
Benzo[g,h,i]perylene	TO-13 (PAH)	SW8270M (SVOC)
Benzo[a]pyrene	TO-13 (PAH)	SW8270M (SVOC)
1,3-Butadiene	40 CFR 60, Method 18 (Hydrocarbons)	TO-14A (VOC)
Chrysene ^b	TO-13 (PAH)	SW8270M (SVOC)
Dibenz[a,h]anthracene ^c	TO-13 (PAH)	SW8270M (SVOC)

TABLE 4 (cont.)

Compound	Selected Method	Other Method Employed
Dibutyl phthalate	SOP CAD 26.1 (Energetics)	SW8270M (SVOC)
1,2-Dichlorobenzene	TO-14A (VOC)	SW8270M (SVOC)
1,3-dichlorobenzene	TO-14A (VOC)	SW8270M (SVOC)
1,4-Dichlorobenzene	TO-14A (VOC)	SW8270M (SVOC)
2,4-Dinitrotoluene	SOP CAD 26.1 (Energetics)	SW8270M (SVOC)
2,6-dinitrotoluene	SOP CAD 26.1 (Energetics)	SW8270M (SVOC)
Di-sec-octyl phthalate	SOP CAD 26.1 (Energetics)	SW8270M (SVOC)
Fluoranthene	TO-13 (PAH)	SW8270M (SVOC)
Fluorene	TO-13 (PAH)	SW8270M (SVOC)
Hexachlorobutadiene	TO-14A (VOC)	SW8270M (SVOC)
Hexachloroethane	TO-14A (VOC)	SW8270M (SVOC)
Hexane	40 CFR 60, Method 18 (Hydrocarbons)	TO-14A (VOC)
Indeno[1,2,3-cd]pyrene	TO-13 (PAH)	SW8270M (SVOC)
Naphthalene	TO-13 (PAH)	SW8270M (SVOC)
Nitrobenzene	SOP CAD 26.1 (Energetics)	SW8270M (SVOC)
Phenanthrene	TO-13 (PAH)	SW8270M (SVOC)
Propylene ^c	40 CFR 60, Method 18 (Hydrocarbons)	TO-14A (VOC)
Pyrene	TO-13 (PAH)	SW8270M (SVOC)
1,2,4-Trichlorobenzene	TO-14A (VOC)	SW8270M (SVOC)
Acetone ^d	TO-11A (Aldehydes)	TO-14A (VOC)
Pentane	40 CFR 60, Method 18 (Hydrocarbons)	TO-14A (VOC)

^a SW8270M data were used to develop the benzo[k]fluoranthene and dibenz[a,h]anthracene emission factors for DODIC B519 because samples measured using the TO-13 method had a relative percent difference greater than 100 percent, indicating poor precision.

^b SW8270M data were used to develop the chrysene emission factors for DODIC B584 because samples measured using the TO-13 method had a relative percent difference greater than 100 percent, indicating poor precision.

^c TO-14A data were used to develop the propylene emission factors for DODIC B584 because samples measured using Method 18 had a relative percent difference greater than 100 percent, indicating poor precision.

^d TO-14A data were used to develop the acetone emission factors for DODIC B584 because samples measured using the TO-11A method had a relative percent difference greater than 100 percent, indicating poor precision.

3.2.2.3 Tentatively Identified Compounds

During the analysis of the SVOC data, the 15 highest nontarget “peaks” from each test run were tentatively identified using computerized mass spectral matching techniques. Similarly, during the analysis of the VOC data, the 10 highest nontarget “peaks” were tentatively identified. Emission factors were developed for these tentatively identified compounds (TICs) if all of the following criteria were met.

1. The TIC corresponded to a unique compound (e.g., ethylbenzene). Emission factors were not developed if the TIC corresponded to a class of compounds (e.g., unknown alcohol).
2. The TIC was not identified using another analysis method that provided higher confidence data. Emission factors were developed based upon the higher confidence analysis method if such data were available.
3. The TIC was not present in the method blank. Emission factors were not developed if the TIC was found in the corresponding method blank.

For DODIC 519, 10 SVOC and 12 VOC were tentatively identified as unique compounds. [Note: Because 2 test runs were conducted, the total number of VOC TICs identified exceeded 10.] Four SVOC and nine VOC were tentatively identified as unique compounds for DODIC B584. None of these compounds were identified using a higher confidence method or were present in the method blank; therefore, emission factors were developed for all of the TICs that were identified as unique compounds. Because of the uncertainty in the true identity of the TICs, the test data were assigned a “C” rating.

3.2.3 Process Information

Ordnance are manufactured to tight tolerances and are expected to deploy in a very repeatable fashion. Consequently, the test data should be assigned an “A” rating based upon this criterion. However, large relative percent differences (i.e., greater than 100 percent) between test runs were noted for several compounds. Specific instances in which these differences were noted included the measurement of 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin, 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin, 1,1,1-trichloroethane, and diethylphthalate during the DODIC B519 test runs and the measurement of acetaldehyde, t-butyl alcohol, ethylene, formaldehyde, 1,2,3,6,7,8-hexachlorodibenzofuran, acetylene, ethane, n-heptane, and pentane during the DODIC B584 test runs. The equation below illustrates calculation of relative percent difference:

$$\text{relative percent difference} = \frac{\text{test 1 concentration} - \text{test 2 concentration}}{\text{average of test 1 and test 2 concentrations}} \times 100\%$$

Due to the large relative percent differences between test samples, the test data specifically identified above were assigned a “C” rating. The remainder of the data should be assigned an “A” rating based on this criterion.

3.2.4 Analysis and Calculations

The test report,¹ detailed test plan,² and analytical data supporting the test report³ were reviewed to determine whether they contained all of the original raw data, other documentation, and example calculations. Although the test report did not contain raw field data, the data were made available upon request. The test report also lacked certain calibration data. However, the missing information was judged insufficient to result in a downgrade of the test data quality rating.

The raw data and sample calculations presented in the final test report, detailed test plan and analytical data supporting the test report were reviewed to determine if the emission factors presented in the report could be duplicated. Where differences were found between the emission factors calculated using the Excel spreadsheets and those presented in the test report, an examination was made to determine the reason for the differences.

Several minor errors were noted in the calculation of the emission factors within the test report, particularly with respect to correcting the sample volumes to standard conditions and the incorporation of analytical detection limits into the emission factors (see Section 4.2 for a discussion of the methodology). The emission factors presented in AP-42 are based upon the corrected spreadsheets. Based upon the raw data, other documentation, and the Excel spreadsheet calculations, the test data should be assigned an “A” rating.

Emission factors developed for compounds present in the method blank at levels of 20 to 50 percent of test values were assumed to be biased high. One compound, 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin, met this criterion for both ordnance tested. For this compound, the test data were assigned a “B” rating.

When compounds were found in the method blank at levels greater than 50 percent of test values, the data were assumed to be suspect and no emission factors were developed. No compounds in this test series met this criterion.

On two occasions, the analytical method for the hydrocarbons, 40 CFR 60, Appendix A, Method 18, was unable to distinguish between two similar compounds. In these instances, the laboratory reported analytical data for combinations of compounds. Because it was impossible to tell the concentration of each individual compound, no emission factors were developed for the two combinations (i.e., 1-butene/isobutylene and 1-butyne/cis-butene).

3.3 Test Data Quality Ratings

Upon completing the analysis described in the preceding section of this document, the test data quality ratings assigned as a result of the four criteria were reviewed. This review led to a downgrading of some of the test data from an “A” rating to either a “B” rating or a “C” rating. Table 5 identifies the data quality ratings for all compounds that did not receive an “A” rating.

TABLE 5 DOWNGRADED DATA QUALITY RATINGS

Compound or Class of Compounds	Data Quality Rating	Applicable DODIC
Carbon dioxide	B	B519 and B584
Carbon monoxide	B	B519 and B584
Oxides of nitrogen	B	B519 and B584
Sulfur dioxide	B	B519 and B584
Acetaldehyde	C	B584
Acetophenone	C	B519
t-Butyl alcohol	C	B584

TABLE 5 (cont.)

Compound	Data Quality Rating	Applicable DODIC
1-Chloro-1,1-difluoroethane	C	B584
Ethylene	C	B584
Formaldehyde	C	B584
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	C	B519
1,2,3,6,7,8-Hexachlorodibenzofuran	C	B584
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	C	B519
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	B	B584
1,1,1-Trichloroethane	C	B519
Acetylene	C	B584
Benzene, 1-ethyl-2-methyl-	C	B519
Benzene, 1,2,3-trimethyl-	C	B519
Benzonitrile	C	B519
1-Buten-3-yne	C	B519 and B584
Cyclohexane, hexyl-	C	B519
Cyclohexasiloxane, dodecamethyl	C	B519 and B584
Cyclopropane, ethyl-	C	B584
Decanedionic acid, bis(2-ethylhexyl) ester	C	B584
Diethylphthalate	C	B519
2,6-Dimethyldecane	C	B519
Dodecane	C	B519
Dodecanoic acid	C	B519
Ethane	C	B584
Ethanol	C	B519
Furan	C	B519 and B584
Heptane	C	B584
Hexadecanoic acid	C	B519 and B584
1-Hexene	C	B584
Methyl 4-hydroxybenzoate	C	B519
Octadecanoic acid	C	B584
Pentane	C	B584
1-Pentene, 2,4,4-trimethyl-	C	B584
Phthalic acid diisohexyl ester	C	B519
1,2-Propadiene	C	B584

TABLE 5 (cont.)

Compound	Data Quality Rating	Applicable DODIC
1-Propene, 2-methyl-	C	B519
Tetrakis(trimethylsiloxy)silane	C	B519
Thiirane	C	B519
Thiirane, 2,3-dimethyl-, trans-	C	B584
Thiophene	C	B519
Undecane	C	B519
Undecane, 2,6-dimethyl-	C	B519
Undecane, 3-methyl-	C	B519

4.0 EMISSION FACTOR CALCULATIONS

The methodologies and procedures that were used to develop emission factors from the test data are described in this section. A similar approach was used to calculate emission factors for TSP, PM-10, PM-2.5, metals, SVOC, PAH, and energetic materials. The calculation steps that were performed for each sample and each run are summarized below.

1. The sample volumes associated with the background and test runs were corrected to the EPA Stationary Source Program standard temperature and pressure (i.e., 68°F and 29.92 inches of mercury).
2. For compounds for which more than one test sample was obtained, analytical detection limits were incorporated into the test data.
3. The background compound concentration was calculated by dividing the mass of compound detected during the background run by the background run sample volume corrected to standard conditions.
4. The test compound concentration was calculated by dividing the mass of compound detected during the test run by the test run sample volume corrected to standard conditions.
5. A background-corrected concentration was calculated by subtracting the background concentration from the test concentration.
6. A dilution-corrected concentration was calculated by dividing the background-corrected concentration by the test's dilution correction factor.
7. The mass of compound released during the test run was calculated by multiplying the dilution-corrected concentration by the volume of the ECC.
8. Emission factors for each sample and test run were calculated by dividing the mass of compound released by the number of ordnance detonated during the test run or by the NEW detonated during the test run, as appropriate.
9. Average emission factors were calculated for each compound.

Because concentration data (i.e., milligrams per cubic meter [mg/m^3], parts per million by volume [ppmv], or parts per billion by volume [ppbv]) were recorded for VOC, hydrocarbons, FTIR- measured compounds, and CEMS-measured compounds, it was not necessary to calculate a corrected sample volume as described in step 1 or to calculate background and test concentrations as described in steps 3 and 4. Detection limits were applied directly to test compound concentrations of VOC, hydrocarbons, FTIR- measured compounds, and CEMS-measured compounds, as described in step 2. Where present, ppmv and ppbv values were converted to mg/m^3 . Emission factors for VOC and hydrocarbons were then estimated in accordance with steps 5 through 9 described above. FTIR- and CEMS-measured compounds were estimated in accordance with steps 5 through 9 described above, except that step 6, the dilution correction, was not required. FTIR- and CEMS-measured concentrations were determined from initial steady-state points that occurred prior to significant dilution.

Test and background concentrations of acid gases, hydrogen cyanide, aldehydes, and dioxin/furan compounds were provided by the laboratory. The laboratory calculated the concentrations based upon the sample volumes as measured at actual conditions. Concentration data received from the laboratory were corrected for volume at Stationary Source Program standard conditions and analytical detection limits were incorporated as described in step 2. Emission factors for acid gases, hydrogen cyanide, aldehydes, and dioxin/furan compounds were then estimated in accordance with steps 5 through 9 described above.

The following sections describe each of the nine emission factor calculation steps listed above in more detail.

4.1 Correction of Sample Volume to Standard Conditions

Because sample volumes were initially reported at actual conditions, calculations to correct the sample volumes to the EPA Stationary Source Program standard temperature of 68°F and pressure of 29.92 inches of Hg (20°C and 760 mm Hg) were performed. To obtain the sample volume at EPA Stationary Source Program standard conditions (V_{stat}), the sample volume at actual conditions (V_{act}) was multiplied by the ratio of pressure at actual conditions (P_{act}) to temperature at actual conditions (T_{act}) and by the ratio of temperature at Stationary Source Program standard conditions (T_{stat}) to pressure at Stationary Source Program standard conditions (P_{stat}). This calculation is illustrated by the following equation:

$$V_{\text{stat}} = V_{\text{act}} \times \frac{P_{\text{act}}}{T_{\text{act}}} \times \frac{T_{\text{stat}}}{P_{\text{stat}}}$$

4.2 Incorporation of Analytical Detection Limits to the Test Data

In most cases, more than one test sample was obtained for a specific compound (i.e., more than one test run was conducted). When multiple samples were obtained for the same compound, a comparison was made of all the sample data collected. Based upon the results of the comparison, the following adjustments were made to the test data:

1. If all of the samples indicated that a compound was “not detected,” the sample data were not adjusted.
2. If all of the samples indicated that a compound was detected, the sample data were not adjusted.
3. If one or more of the samples indicated that a compound was detected and one or more of the samples indicated that a compound was not detected, the “not detected” values were replaced with a value equal to one half of the compound’s analytical detection limit. The assumption inherent to this adjustment was that the measured presence of a compound in one or more

samples was indicative of the compound's presence in all samples. The analytical detection limits for each sample were obtained from the analytical data supporting the test report.

4.3 Determination of Background Concentration

For TSP, PM-10, PM-2.5, metals, SVOC, and PAH, the background compound concentration (BC) was calculated by dividing the mass of compound detected during the background run (Bkgd mass) by the background run sample volume corrected to EPA Stationary Source Program standard conditions (Bkgd V_{stat}). The background concentration calculation is illustrated by the following equation:

$$BC = \frac{Bkgd\ mass}{Bkgd\ V_{stat}}$$

The background compound concentrations of acid gases, hydrogen cyanide, aldehydes, and dioxin/furan compounds provided by the lab were calculated using the sample volume at actual conditions (V_{act}). In order to correct the concentrations to EPA Stationary Source Program standard conditions (V_{stat}), the uncorrected concentrations (UC) were multiplied by the ratio of volume at actual conditions to volume at standard conditions. This calculation is illustrated by the following equation:

$$BC = UC \times \frac{V_{act}}{V_{stat}}$$

FTIR- and CEMS-measured compounds were not sampled for during the background runs. However, background data were recorded for each test run between the time the FTIR and CEMS began sampling and the time of detonation. The only FTIR- or CEMS-measured compound for which significant background concentrations were recorded was CO₂. The CO₂ background concentration was assumed to equal a representative value over the sampling period. Background concentrations for the other FTIR- and CEMS-measured compounds were assumed to be zero.

4.4 Determination of Test Compound Concentration

For TSP, PM-10, PM-2.5, metals, SVOC, PAH, and energetic materials, the test compound concentration (TC) was calculated by dividing the mass of compound detected during the test run (Test mass) by the test run sample volume corrected to EPA Stationary Source Program standard conditions (Test V_{stat}). The test compound concentration calculation is illustrated by the following equation:

$$TC = \frac{Test\ mass}{Test\ V_{stat}}$$

Test compound concentrations of acid gases, hydrogen cyanide, aldehydes, and dioxin/furan compounds provided by the lab were calculated using the sample volume at actual conditions. In order to correct the concentrations to EPA Stationary Source Program standard conditions, the uncorrected concentrations (UC) were multiplied by the ratio of the volume at actual conditions (V_{act}) to the volume at EPA Stationary Source Program standard conditions (V_{stat}). This calculation is illustrated by the following equation:

$$TC = UC \times \frac{V_{act}}{V_{stat}}$$

For VOC, hydrocarbons, FTIR- measured compounds, and CEMS-measured compounds, sample volume correction was not required. VOC and hydrocarbon test concentration values were used directly. Test concentrations of CEMS- and FTIR-measured compounds were determined based upon the initial

steady-state values reached after detonation. The time at which a compound's concentration reached an initial steady state was determined by visually inspecting plots of the concentration data versus time. The initial steady state corresponds to the time at which a compound was well mixed within the ECC, but before the compound's concentration began to decrease at a steady rate due to dilution.

4.5 Determination of Background-Corrected Concentration

For all compounds, the calculation of the background-corrected concentration (BCC) was dependent on whether the background (BC) and test concentrations (TC) were detected and whether they were less than, equal to, or greater than one another. The procedures used to calculate the background-corrected concentration for each sampling train and compound are described below and are displayed graphically in Figure 1.

1. If the test concentration was not detected (ND), the background-corrected concentration equaled ND.
2. If the test concentration was detected and the background concentration was not detected, the background-corrected concentration equaled the test concentration.
3. If the test and background concentrations were detected and the test concentration was less than or equal to the background concentration, the background-corrected concentration equaled 0.
4. If the test and background concentrations were detected and the background concentration was less than the test concentration, the background concentration was subtracted from the test concentration. This calculation is illustrated by the following equation:

$$BCC = TC - BC$$

4.6 Determination of Dilution-Corrected Concentration

The dilution-corrected concentration (DCC) was calculated by dividing the background-corrected concentration by the applicable dilution correction factor (DCF). This calculation is illustrated by the following equation:

$$DCC = \frac{BCC}{DCF}$$

With the exception of CEMS- and FTIR-measured compounds, dilution correction factors were obtained from the test contractor.³ Because the test concentrations of CEMS- and FTIR-measured compounds were obtained prior to dilution, it was not necessary to calculate a dilution corrected concentration for these compounds.

4.7 Determination of Mass of Compound Released

The mass of compound released was calculated by multiplying the dilution-corrected concentration by the volume of the ECC. This calculation is illustrated by the following equation:

$$\text{Mass compound released} = DCC \times \text{ECC volume}$$

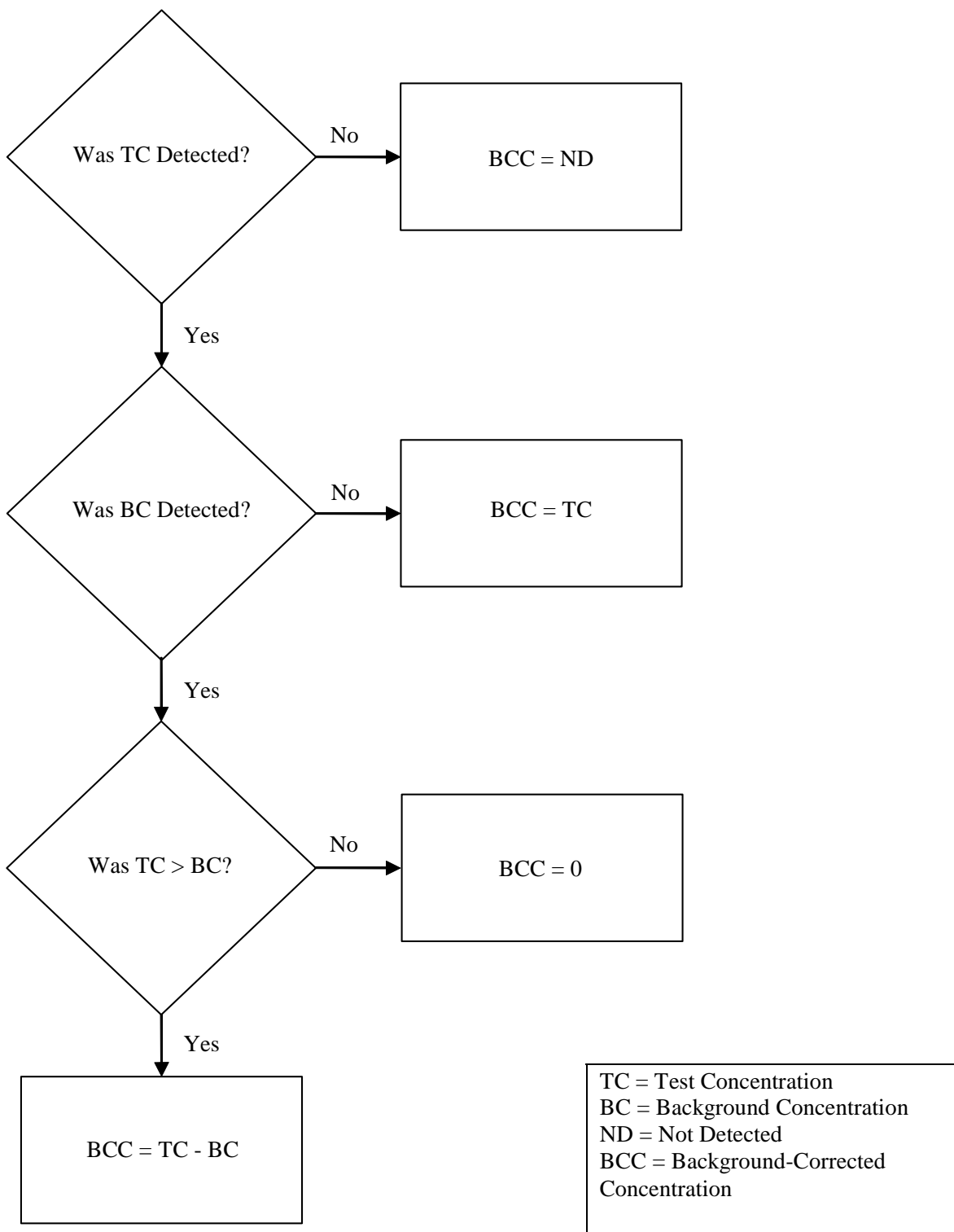


Figure 1 Calculation of background-corrected concentration.

4.8 Determination of Emission Factors

Once the mass of compound released was calculated, two emission factors were developed for each sample and for each test run: the mass of compound released per item (i.e., per single ordnance) and the mass of compound released per pound NEW. The NEW for all ordnance were determined from Reference 1.

4.9 Determination of Average Emission Factors

Steps 1 through 8, as described in Sections 4.1 through 4.8, are applicable to individual samples within individual test runs. The final step in the emission factor calculation process was to calculate average emission factors for each compound in terms of mass released per item and mass released per pound NEW. The average emission factors for each compound were calculated as the arithmetic mean of the individual samples associated with the compound. If all samples indicated that the compound was not detected (ND), then the average emission factor was assigned a value of ND. [Note: The minimum detection levels associated with the compounds that were not detected are presented in Appendix A.] Total dioxin/furan emission factors were calculated by summing the average emission factors of all dioxin/furan compounds.

5.0 EMISSION FACTOR RATINGS

The emission factors were appraised in accordance with the rating system specified in Reference 4. Under this rating system, emission factors are assigned a rating from A to E, where an “A” rating is assigned to the highest quality factors. The criteria used to assign a specific emission factor rating are summarized below.

- A** Excellent. The emission factor was developed primarily from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population was sufficiently specific to minimize variability.
- B** Above average. The emission factor was developed primarily from A- or B-rated test data from a moderate number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industry. As with the “A” rating, the source category population was sufficiently specific to minimize variability.
- C** Average. The emission factor was developed primarily from A-, B-, and/or C-rated test data from a reasonable number of facilities. Although no specific bias was evident, it was not clear if the facilities tested represented a random sample of the industry. As with the “A” rating, the source category population was sufficiently specific to minimize variability.
- D** Below average. The emission factor was developed primarily from A-, B-, and C-rated test data from a small number of facilities, and there may have been reason to suspect that these facilities did not represent a random sample of the industry. There also may have been evidence of variability within the source category population.
- E** Poor. The emission factor was developed from C- and D-rated test data from a very limited number of facilities, and there may have been reason to suspect that the facilities tested did not represent a random sample of the industry. There also may have been evidence of variability within the source category population.

Two analyses were conducted to assign ratings to the ordnance emission factors. First, an analysis was conducted on an ordnance-specific basis. Second, an analysis was conducted using all

available ordnance emission factor data. The second analysis was conducted to determine whether a sufficient correlation existed between emission factors for different but similar ordnance to allow the number of test data points to be increased to the point that higher emission factor ratings could be assigned than were possible when using the ordnance-specific approach. Both analyses are described below.

5.1 Emission Factor Ratings Assigned – Based on Ordnance-Specific Test Data

As previously described, emission factor ratings are dependent upon the test data quality, the number of test data points, the amount of variability present within a source category population, and the randomness of the source category sample. The following test data facts pertain to these rating criteria:

1. As described in Section 3 of this Background Document, the ordnance test data was primarily rated A or B. The test data for a few compounds was rated C.
2. Only two tests were conducted per ordnance.
3. Ordnance are manufactured to very tight tolerance levels so there is little variability within a specific type of ordnance.
4. There was no evidence that suggested the tested items within each type of ordnance were specially selected.

Emission factor ratings were assigned based upon these facts. The rationale used to accept or reject specific emission factor ratings follow.

- A: Rejected. The number of test data points was deemed to be insufficient to assign an A emission factor rating.
- B: Rejected. The number of test data points was deemed to be insufficient to assign a B emission factor rating.
- C: Accepted for most ordnance. The emission factors were developed using A- and B-rated test data, there is little variability among items, and there was no evidence that suggested the tested items were specially selected. Because of the limited number of data points, a C rating was deemed appropriate for this set of circumstances.
- D: Accepted for some ordnance. The emission factors were developed using C-rated test data, there is little variability among items, and there was no evidence that suggested the tested items were specially selected. Because of the limited number of data points, a D rating was deemed appropriate for this set of circumstances.
- E: Rejected. The ordnance described in this report were developed primarily using A- and B-rated test data rather than C- or D-rated data, there is little variability among items, and there was no evidence that suggested the tested items were specially selected. Therefore, an E emission factor rating was deemed inappropriate.

5.2 Emission Factor Ratings Assigned – Based on All Available Test Data

The proceeding sections of this Background Document concern the emission measurement methods, data analysis, and calculations used to develop emission factors for specific ordnance. However, USAEC's ordnance emission factor development program includes more than 200 ordnance that have been tested under more than 25 separate test series. Because many of these ordnance are similar in size and/or chemical composition, a statistical analysis was conducted to assess the similarity of the

emission factors developed for similar ordnance. The results of this analysis were used to reevaluate the emission factor ratings assigned on an ordnance-specific basis.

USAEC characterized individual ordnance as falling into one of 17 separate categories, depending upon the size and/or chemical composition of the ordnance. The ordnance and their respective categories are identified in Table 6 along with a comment field describing the number of data points.

TABLE 6 ORDNANCE CATEGORIZATION FOR EMISSION FACTOR CORRELATION ASSESSMENT

Category	DODIC	Ordnance Description	Test Series	Comment
CS	G963 ^a	M73A CS Riot Control Agent Hand Grenade	DPG VI	Data not yet available
	K765 ^a	CS Riot Control Agent Capsule	DPG VI	
Demolition	G900	TH3 AN-M14 Incendiary Grenade	EO5	20+ data points
	G911	MK3A2 Offensive Hand Grenade	EO2	
	G911	MK3A2 Offensive Hand Grenade	EO6	
	K010	M4 Field Incendiary Burster	EO5	
	K145	M18A1 Antipersonnel Mine	EO2	
	M023	M112 Demolition Block Charge	EO1	
	M030	1/4-Pound Demolition Block Charge	EO1	
	M030	1/4-Pound Demolition Block Charge	EO3	
	M031	1/2-Pound Demolition Block Charge	DPG IVA	
	M032	1-Pound Demolition Block Charge	EO2	
	M032	1-Pound Demolition Block Charge	EO3	
	M130 ^a	M6 Electric Blasting Cap	DPG VII	
	M130 ^a	M6 Electric Blasting Cap	EO7	
	M131 ^a	M7 Blasting Cap	EO7	
	M241	M10 High Explosive Universal Destructor	DPG IVB	
	M456	PETN Type 1 Detonating Cord	DPG IVA	
	M500 ^a	M21 REEF Line Cutter	FP10	
	M591	M1 Military Dynamite Demolition Block Charge	EO1	
	M913	M58A3 Linear Demolition Charge	EO3	
	ML05 ^a	MK24 High Explosive Cutter	EO11	
ML09	Linear Demolition Charge, Shaped 20 gr/ft	DPG IVA		
ML15	Linear Demolition Charge, Shaped 225 gr/ft	DPG IVA		
ML47 ^a	M11 Blasting Cap	EO7		

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Demolition, continued	MM50 ^a	M221 Shaped Charge	EO11	20+ data points
	MN02 ^a	M12 Blasting Cap	EO7	
	MN03 ^a	M13 Blasting Cap	EO7	
	MN06 ^a	M14 Blasting Cap	EO7	
	MN07 ^a	M15 Delay Blasting Cap	EO11	
	MN08 ^a	M81 Igniter	EO9	
	MN68 ^a	M151 Booster Demolition Charge	DPG VIII	
	None	PAX-11, Granular Powder Burn	EO4	
	None	PAX-11, Molded Pellet Detonation	EO4	
Fuze	G878 ^a	M228 Practice Hand Grenade Fuse	DPG VI	<10 data points
	K051	M604 Anti-Tank Practice Mine Fuze	EO6	
	N278 ^a	M564 MTSQ Fuze	EO11	
	N285 ^a	M577 Fuze	EO9	
	N286 ^a	M582 Fuze	EO7	
	N335	M557 Point Detonating Fuze	EO5	
	N340	M739A1 Point Detonating Fuze	EO5	
	N464 ^a	M732 Fuze	EO9	
Grenade	G881	M67 Fragmentation Grenade	EO1	<10 data points
	G978	M82 Smoke Simulant Screening Grenade Launcher	DPG V	
	G982	Terephthalic Acid Smoke Hand Grenade	DPG V	
	GG09 ^a	M84 Non-Lethal Stun Hand Grenade	EO12	
Illumination	B535	M583A1 40-mm White Star Parachute Cartridge	DPG IVB	20+ data points
	B536	M585 40-mm White Star Cluster Cartridge	DPG IVB	
	B627	M83A3, M83A2, & M83A1 60-mm Illuminating Cartridge with Fuze	DPG V	
	D505	M485A2 155-mm Illumination Round (projectile)	DPG I	
	L305	M195 Green Star Parachute Signal Flare	DPG I	
	L306	M158 Red Star Cluster Signal Illumination	DPG II	
	L307	M159 White Star Cluster Signal Illumination	DPG II	
	L311	M126A1 Red Star Parachute Signal Flare	DPG II	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Illumination, continued	L312	M127A1 White Star Parachute Signal Flare	DPG I	20+ data points
	L314	M125A1 Green Star Cluster Signal Flare	DPG I	
	L367 ^a	M22 Anti-Tank, Guided Missile, and Rocket Launching Simulator	DPG VI	
	L410 ^a	M206 Aircraft Countermeasure Flare	DPG VI	
Inert	HA11 ^a	Rocket, 2.75-inch Flechette with M255A1 Warhead	DPG VIII	Data not yet available
Large	C511	M490 105-mm Target Practice Tracer Cartridge (tracer)	EO6	Only 1 data point yet available
	C784 ^a	M831 120-mm Target Practice Tracer Cartridge	EO12	
	C785 ^a	M865 120-mm Target Practice Discarding Sabot Tracer Cartridge	EO12	
Medium	BA11 ^a	M1001 40-mm HVCC Cartridge	EO12	Data not yet available
	BA15 ^a	M769 60-mm FRP Cartridge	EO12	
Medium-FP	A652	M220 20-mm TP-T Cartridge	FP9	10+ data points
	A940	M910 25-mm Target Practice Discarding Sabot Tracer Cartridge	FP8	
	A976	M793 25-mm Target Practice Tracer Cartridge	FP8	
	B129 ^a	M789 30 mm CTG	EO9	
	B519	M781 40-mm Practice Cartridge	FP2	
	B584	M918 40-mm Practice Cartridge	FP2	
	B505 ^a	M662 40-mm Red Star Parachute Cartridge	DPG VIII	
Mine	K042 ^a	M88 Volcano Practice Canister Mine	DPG VIII	Data not yet available
Mortar	CA03	XM929 120 mm Smoke Cartridge with M7334A1 Fuze	DPG V	Only 1 data point
Projectile	B542	M430 40-mm High Explosive Dual Purpose (HEDP) Cartridge (projectile)	EO3	10+ data points
	B571	M383 40-mm High Explosive Cartridge (projectile)	EO3	
	B632	M49A4 60-mm High Explosive Cartridge (projectile)	EO3	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Projectile, continued	B642	M720 60-mm High Explosive Cartridge (projectile)	EO6	10+ data points
	BZ-13 ^a	M888 60-mm Cartridge with M935 PD Fuze	EO11	
	C995	M136 AT4 Recoilless Rifle, 84-mm Cartridge (projectile)	EO3	
	H557	M72A3 66-mm High Explosive Antitank Rocket (warhead)	EO1	
	H708 ^a	M73 35-mm Subcaliber Practice Rocket	DPG VIII	
	None ^a	PAX-21, 60-mm Mortar	EO8	
	PJ02	FIM-92A Stinger-Basic Guided Missile (warhead)	EO6	
Propellant	B642	M720 60-mm High Explosive Cartridge (propelling charge)	FP4	20+ data points
	B653 ^a	M766 60-mm Short Range Practice Mortar Cartridge	FP10	
	C226	M301A3 81-mm Illuminating Cartridge (propelling charge)	FP4	
	C379	M934 120-mm High Explosive Cartridge (Zone 1 - propelling charge)	FP8	
	C511	M490 105-mm Target Practice Tracer Cartridge (propelling charge)	FP5	
	C784	M831 120-mm Target Practice Tracer Cartridge (propelling charge)	FP5	
	C785	M865 120-mm Target Practice Discarding Sabot Tracer Cartridge (propelling charge)	FP5	
	C868	M821 81-mm High Explosive Cartridge (propelling charge)	FP4	
	C876	M880 81-mm Target Practice Short Range Cartridge (propelling charge)	FP4	
	CA09	M931 120-mm Full Range Practice Cartridge (Zone 1 - propelling charge)	FP8	
	CA09	M931 120-mm Full Range Practice Cartridge (Zone 4 - propelling charge)	FP8	
	D533	M119A2 155-mm Propelling Charge (Zone 7)	FP5	
	D540	M3 155-mm Propelling Charge (Zone 3, M199 Cannon)	FP1	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Propellant, continued	D540	M3 155-mm Propelling Charge (Zone 3, M199 Cannon)	FP5	20+ data points
	D540	M3 155-mm Propelling Charge (Zone 3, M284 Cannon)	FP1	
	D540	M3 155-mm Propelling Charge (Zone 5, M199 Cannon)	FP1	
	D540	M3A1 155-mm Propelling Charge (Zone 3, M199 Cannon)	FP1	
	D540	M3A1 155-mm Propelling Charge (Zone 3, M284 Cannon)	FP1	
	D541	M4A2 155-mm Propelling Charge (Zone 7)	FP5	
	H557	M72A3 66-mm High Explosive Antitank Rocket (propelling rocket)	FP7	
	M174 ^a	MK209 Impulse Cartridge	FP10	
	M842 ^a	M1 Squib	EO7	
	M842 ^a	M79 Igniter	EO9	
	MD73 ^a	M796 Impulse Cartridge	FP10	
	PJ02	FIM-92A Stinger-Basic Guided Missile (flight motor)	FP7	
	PJ02	FIM-92A Stinger-Basic Guided Missile (launch motor)	EO5	
Pyrotechnic	H975 ^a	M274 2.75-inch Signature Smoke with H872 Warhead	DPG VIII	10+ data points
	L366	M74A1 Projectile Air Burst Simulator	DPG IVB	
	L495	M49A1 Surface Trip Flare	DPG II	
	L508 ^a	M72 Red Railroad Warning Fuse	DPG VI	
	L592	TOW Blast Simulator	DPG V	
	L594	M115A2 Ground Burst Simulator	DPG I	
	L595 ^a	M9 Liquid Projectile Air Burst Simulator	EO12	
	L596	M110 Flash Artillery Simulator	DPG I	
	L598	M117 Flash Booby Trap Simulator	DPG I	
	L599	M118 Illuminating Booby Trap Simulator	DPG II	
	L600	M119 Whistling Booby Trap Simulator	DPG II	
	L601	M116A1 Hand Grenade Simulator	DPG I	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Pyrotechnic, continued	L602	M21 Artillery Flash Simulator	DPG IVB	10+ data points
	L709	M25 Target Hit Simulator	EO2	
	L709	XM25 Target Hit Simulator	DPG V	
	L720	M26 Target Kill Simulator	EO6	
	M327 ^a	Coupling Base Firing Device	FP10	
	M448 ^a	M2 Percussion Detonator	EO11	
	M626 ^a	M1 Push Igniter	EO9	
	M627 ^a	M5 Pressure Release Igniter	FP10	
	M630	M1 Pull Igniter	DPG V	
	M630 ^a	M1 Pull Igniter	EO9	
	M670 ^a	M700 Blasting Fuse	EO11	
	M766 ^a	M60 Igniter	EO9	
	ML03 ^a	M142 Firing Device	EO11	
Rocket/Missile	H459	Rocket, 2.75-inch Flechette, MK40 Mod 3 Motor (propelling rocket)	FP7	<10 data points
	H557	M72A3 66-mm High Explosive Antitank Rocket (propelling rocket)	FP4	
	H708	M73 35-mm Subcaliber Practice Rocket Motor	FP9	
	H974	Rocket, 2.75-inch M267 Practice Warhead, MK66 Mod 3 Motor (propelling rocket)	FP7	
Small Arm-FP	A010	M220 10 Gage Blank/Subcaliber Salute Cartridge	FP9	20+ data points
	A011	12 Gage #00 Shot Cartridge	FP9	
	A017 ^a	12 Gage #9 Shot Cartridge	FP10	
	A059	M855 5.56-mm Ball Cartridge (fired from the M16A1 Rifle)	FP3	
	A059	M855 5.56-mm Ball Cartridge (fired from the M16A2 Rifle)	FP3	
	A059	M855 5.56-mm Ball Cartridge (No-Lead)	FP4	
	A063	M856 5.56-mm Tracer Cartridge	FP3	
	A065	M862 5.56-mm Practice Ball Cartridge	FP3	
	A066	M193 5.56-mm Ball Cartridge	FP6	
	A068	M196 5.56-mm Tracer Cartridge	FP6	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Small Arm-FP, continued	A080	M200 5.56-mm Blank Cartridge	FP3	20+ data points
	A086	.22 Caliber Long Rifle Ball Cartridge	FP4	
	A106	.22 Caliber Standard Velocity Long Rifle Ball Cartridge	FP4	
	A111	M82 7.62-mm Blank Cartridge	FP3	
	A131	M62 7.62-mm Tracer Cartridge	FP6	
	A136	M118 7.62-mm Ball Match Cartridge	FP6	
	A143	M80 7.62-mm Ball Cartridge	FP3	
	A171	M852 7.62-mm Ball Match Cartridge	FP6	
	A182	M1 .30 Caliber Ball Cartridge	FP6	
	A212	M2 .30 Caliber Ball Cartridge	FP6	
	A218	M25 .30 Caliber Tracer Cartridge	FP9	
	A247	M72 .30 Caliber Ball Match Cartridge	FP6	
	A363	M882 9-mm Ball Cartridge	FP3	
	A365	M181 14.5-mm Trainer-Spotter Cartridge with 3-sec Delay (Artillery)	DPG V	
	A366 ^a	M182 14.5-mm Cartridge	EO11	
	A400	M41 .38 Caliber Special Ball Cartridge	FP9	
	A403	.38 Caliber Special Blank Cartridge	FP9	
	A475	M1911 .45 Caliber Ball Cartridge	FP3	
	A518	M903 .50 Caliber SLAP Cartridge	FP9	
	A518 ^a	M962 .50 Caliber SLAP/T	FP10	
A525	M2 .50 Caliber Armor Piercing Cartridge	FP8		
A557	M17 .50 Caliber Tracer Cartridge	FP3		
A557	M33 .50 Caliber Ball Cartridge	FP3		
A598	M1A1 .50 Caliber Blank Cartridge	FP3		
Smoke	C870 ^a	M819 (IUK) 81-mm Red Phosphorous Smoke	DPG VII	10+ data points
	G815 ^a	Red Phosphorous Smoke Screening Grenade Launcher (UK)	DPG VII	
	G930	Hexachloroethane Smoke Grenade	DPG V	
	G940	M18 Green Smoke Hand Grenade	DPG III	
	G945	M18 Yellow Smoke Hand Grenade	DPG III	

TABLE 6 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Smoke, continued	G950	M18 Red Smoke Hand Grenade	DPG III	10+ data points
	G950	M18 Red Smoke Hand Grenade (new formulation)	DPG V	
	G955	M18 Violet Smoke Hand Grenade	DPG III	
	G955	M18 Violet Smoke Hand Grenade (new formulation)	DPG V	
	K866 ^a	ABC-M5 HC Ground Smoke Pot (MILES)	DPG VII	
	K867 ^a	M4A2 Floating Smoke Pot	DPG VII	

^a Although testing may have been completed, emission factors for this ordnance have not yet been analyzed for inclusion in AP-42; therefore, these data were not included when the data correlation was assessed.

Within each of the 17 ordnance categories identified by USAEC, emission factors for each compound were compared. To allow the comparison of emission factors for ordnance with similar constituents but significant differences in net explosive weight, the comparison was made using the normalized emission factor units of mass of compound released per pound NEW. Based upon information provided by EPA,⁸ the following procedures were used to assess the data correlation:

1. The relative standard deviation, defined as the standard deviation divided by the mean, was calculated for each compound within each ordnance category.
2. If the relative standard deviation was less than 1.0, the evaluated emission factors were considered to demonstrate good correlation. As such, the rating for these emission factors could be elevated to a maximum of an A, depending on the number of data points within the evaluated ordnance category.
3. If the relative standard deviation was between 1.0 and 2.0, the evaluated emission factors were considered to demonstrate fair correlation. As such, the rating for these emission factors could be elevated to a maximum of a B, depending on the number of data points within the evaluated ordnance category.
4. If the relative standard deviation was greater than 2.0, the evaluated emission factors were considered to demonstrate poor correlation. As such, the emission factor rating could not be elevated, regardless of the amount of data available.

A poor correlation between emission factors was not necessarily construed as being indicative of poor test data. Rather, a poor correlation was more likely to indicate that the ordnance included in the category were not as similar in nature as anticipated by USAEC when the ordnance categories were defined.

In addition to assessing the data correlation, an assessment was made of the number of test data points available within each of the 17 ordnance categories. Because each ordnance test consisted of two test data points (i.e., two test runs per ordnance or two independent sampling trains were used during an ordnance test), the number of test data points available in each of the ordnance categories varied from 2 to 68. Based upon information provided by EPA,⁸ the following assumptions were used to assess whether sufficient category-specific test data points were available to justify elevating the emission factor ratings based on ordnance-specific data only:

1. If 20 or more data points were available, the emission factor rating could be elevated to a maximum of an A, provided that the data also demonstrated a good correlation.
2. If at least 10 but less than 20 data points were available, the emission factor rating could be elevated to a maximum of a B, provided that the data also demonstrated a good correlation.
3. If less than 10 data points were available, the emission factor rating could not be elevated, regardless of the data correlation.
4. If the data demonstrated a fair correlation and 20 or more data points were available, the emission factor rating could be elevated to a maximum of a B.
5. If the data demonstrated a fair correlation and at least 10 but less than 20 data points were available, the emission factor rating could be elevated to a maximum of a C.

Using the criteria specified above, the emission factor ratings assigned to ordnance in each of the 17 ordnance categories were reevaluated. This evaluation indicated that some of the emission factor ratings associated with ordnance included in eight categories could be elevated from a C or D rating to an A or B rating. These eight categories are:

1. Demolition
2. Illumination
3. Medium – Firing Point
4. Projectiles
5. Propellants
6. Pyrotechnics
7. Small Arms – Firing Point
8. Smokes

A final assessment was made as to the emission factor rating assigned based on ordnance-specific test data only. If the original emission factor data rating assigned was a C, then the emission factor rating was elevated to an A or B, as appropriate, based upon the data for the whole ordnance category. If the original emission factor data rating assigned was a D, then the emission factor rating was elevated to a B or C, as appropriate, based upon the data for the whole ordnance category. The analysis is documented in an Excel spreadsheet that is located on the EPA website at:

<http://www.epa.gov/ttn/chief/ap42/index.html>.

Both ordnance within the current test series were included in the Medium-FP category, which included more than 20 test data points. As a result, some emission factor ratings associated with these ordnance were elevated. The emission factor ratings assigned are presented in Appendix A.

6.0 REFERENCES

1. *Report No. 2 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, October 2001.
2. *Detailed Test Plan No.2 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, October, 2001.

3. Supporting information including Excel spreadsheets, analytical results, field notes, and case summaries supplied upon request by the Applied Science Test Team — Chemistry Unit, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, October 2004.
4. *Procedures for Preparing Emission Factor Documents*, EPA-454/R-95-015, U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1997.
5. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, Second Supplement, EPA/600/4-89/018, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1988.
6. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)*, U.S. Environmental Protection Agency, <http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm>.
7. *National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods (NMAM), Fourth Edition*, National Institute for Occupational Safety and Health, Cincinnati, OH.
8. Information regarding the relationship between emission factor data correlation, the number of data points available, and the resulting emission factor rating assigned supplied upon request by Mr. Ron Myers, Measurement Policy Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 2006.

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APPENDIX A

**COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR ORDNANCE
INCLUDED IN FIRING POINT EMISSION STUDY PHASE II SERIES 2 TESTING,
ABERDEEN PROVING GROUND, MARYLAND**

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TABLE A1 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR
DODIC B519, M781 40-MM PRACTICE CARTRIDGE

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Criteria Pollutants, Methane, and Total Suspended Particulate				
124-38-9	Carbon dioxide ^f	2.6 E-04	3.2 E-01	--
630-08-0	Carbon monoxide ^f	3.5 E-04	4.4 E-01	--
7439-92-1	Lead	6.7 E-06	8.3 E-03	--
74-82-8	Methane ^f	3.7 E-06	4.6 E-03	--
--	Oxides of nitrogen	3.6 E-05	4.5 E-02	--
--	PM-2.5 ^f	2.3 E-05	2.9 E-02	--
--	PM-10 ^f	2.6 E-05	3.3 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^f	2.3 E-05	2.9 E-02	--
Hazardous Air Pollutants and Toxic Chemicals				
83-32-9	Acenaphthene	1.1 E-10	1.4 E-07	--
208-96-8	Acenaphthylene	2.1 E-09	2.7 E-06	--
75-07-0	Acetaldehyde	6.8 E-08	8.4 E-05	--
75-05-8	Acetonitrile ^f	6.0 E-08	7.5 E-05	--
98-86-2	Acetophenone ^g	4.4 E-08	5.5 E-05	--
107-02-8	Acrolein	ND	ND	2.4 E-02
107-13-1	Acrylonitrile	9.5 E-08	1.2 E-04	--
107-05-1	Allyl chloride	ND	ND	3.2 E-03
7664-41-7	Ammonia	ND	ND	2.1
120-12-7	Anthracene ^f	6.0 E-11	7.5 E-08	--
7440-36-0	Antimony	1.2 E-06	1.5 E-03	--
7440-38-2	Arsenic	ND	ND	1.2 E-03
7440-39-3	Barium	6.7 E-07	8.3 E-04	--
71-43-2	Benzene	6.8 E-07	8.5 E-04	--
56-55-3	Benzo[a]anthracene	1.8 E-11	2.2 E-08	--
205-99-2	Benzo[b]fluoranthene	1.1 E-10	1.4 E-07	--
207-08-9	Benzo[k]fluoranthene	ND	ND	1.8 E-02
191-24-2	Benzo[g,h,i]perylene	2.2 E-10	2.7 E-07	--
50-32-8	Benzo[a]pyrene	8.0 E-11	1.0 E-07	--
100-44-7	Benzyl chloride	ND	ND	5.3 E-03
7440-41-7	Beryllium	ND	ND	4.6 E-04
75-25-2	Bromoform	ND	ND	1.1 E-02
74-83-9	Bromomethane	ND	ND	3.9 E-03

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
101-55-3	4-Bromophenylphenylether	ND	ND	1.8 E-02
106-99-0	1,3-Butadiene	ND	ND	4.5 E-02
75-65-0	t-Butyl alcohol	0	0	--
85-68-7	Butylbenzylphthalate	ND	ND	1.8 E-02
123-72-8	Butyraldehyde	ND	ND	3.1 E-02
7440-43-9	Cadmium	ND	ND	1.2 E-03
75-15-0	Carbon disulfide	1.3 E-07	1.7 E-04	--
56-23-5	Carbon tetrachloride	2.7 E-09	3.3 E-06	--
106-47-8	4-Chloroaniline	ND	ND	3.6 E-02
108-90-7	Chlorobenzene	ND	ND	4.7 E-03
75-45-6	Chlorodifluoromethane	ND	ND	3.6 E-03
75-00-3	Chloroethane	ND	ND	2.7 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	1.8 E-02
111-44-4	bis(2-Chloroethyl)ether	ND	ND	1.8 E-02
67-66-3	Chloroform	ND	ND	5.0 E-03
74-87-3	Chloromethane	0	0	--
91-58-7	2-Chloronaphthalene	ND	ND	1.8 E-02
95-57-8	2-Chlorophenol	ND	ND	1.8 E-02
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	1.8 E-02
7440-47-3	Chromium	1.5 E-08	1.8 E-05	--
218-01-9	Chrysene	4.0 E-11	5.0 E-08	--
7440-48-4	Cobalt	ND	ND	4.6 E-04
7440-50-8	Copper	7.2 E-08	8.9 E-05	--
106-44-5	p-Cresol	ND	ND	1.8 E-02
4170-30-3	Crotonaldehyde	ND	ND	3.0 E-02
98-82-8	Cumene	3.6 E-09	4.5 E-06	--
57-12-5	Particulate cyanide	ND	ND	1.0 E-01
53-70-3	Dibenz[a,h]anthracene	ND	ND	1.8 E-02
132-64-9	Dibenzofuran	ND	ND	1.8 E-02
106-93-4	1,2-Dibromoethane	ND	ND	7.8 E-03
84-74-2	Dibutyl phthalate	ND	ND	1.8 E-01
95-50-1	1,2-Dichlorobenzene	ND	ND	6.1 E-03
541-73-1	1,3-Dichlorobenzene	ND	ND	6.1 E-03
106-46-7	1,4-Dichlorobenzene	ND	ND	6.1 E-03

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
91-94-1	3,3'-Dichlorobenzidine	ND	ND	3.6 E-02
75-27-4	Dichlorobromomethane	ND	ND	6.8 E-03
75-71-8	Dichlorodifluoromethane	0	0	--
75-34-3	1,1-Dichloroethane	ND	ND	4.1 E-03
107-06-2	1,2-Dichloroethane	9.8 E-09	1.2 E-05	--
75-43-4	Dichlorofluoromethane	ND	ND	4.3 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	1.8 E-02
78-87-5	1,2-Dichloropropane	ND	ND	4.7 E-03
10061-02-6	trans-1,3-Dichloropropene	ND	ND	4.6 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	7.1 E-03
105-67-9	2,4-Dimethylphenol	ND	ND	1.8 E-02
131-11-3	Dimethyl phthalate	ND	ND	1.8 E-02
99-65-0	1,3-Dinitrobenzene	ND	ND	3.6 E-03
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	3.6 E-02
51-28-5	2,4-Dinitrophenol	ND	ND	3.6 E-02
121-14-2	2,4-Dinitrotoluene	ND	ND	3.6 E-03
606-20-2	2,6-Dinitrotoluene	ND	ND	3.6 E-03
122-39-4	Diphenyl amine	ND	ND	8.9 E-02
123-91-1	1,4-Dioxane	ND	ND	3.7 E-03
--	Total dioxin/furan compounds	2.0 E-13	2.5 E-10	--
140-88-5	Ethyl acrylate	ND	ND	4.2 E-03
100-41-4	Ethylbenzene	2.1 E-08	2.6 E-05	--
74-85-1	Ethylene	1.7 E-06	2.2 E-03	--
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	1.8 E-01
206-44-0	Fluoranthene	1.0 E-10	1.3 E-07	--
86-73-7	Fluorene	2.7 E-10	3.3 E-07	--
50-00-0	Formaldehyde	9.2 E-08	1.2 E-04	--
76-13-1	Freon 113	ND	ND	7.8 E-03
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin ^g	2.4 E-14	3.0 E-11	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	ND	ND	2.5 E-09
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND	ND	3.7 E-09
118-74-1	Hexachlorobenzene	ND	ND	1.8 E-02

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
87-68-3	Hexachlorobutadiene	ND	ND	1.1 E-02
77-47-4	Hexachlorocyclopentadiene	ND	ND	1.8 E-02
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.9 E-15	2.4 E-12	--
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	2.1 E-09
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND	ND	5.5 E-09
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	ND	ND	2.7 E-09
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	ND	ND	1.5 E-09
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	4.8 E-09
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	2.7 E-09
67-72-1	Hexachloroethane	ND	ND	9.8 E-03
110-54-3	Hexane	ND	ND	7.2 E-02
7647-01-0	Hydrochloric acid	ND	ND	5.1 E-02
74-90-8	Hydrogen cyanide ^f	6.1 E-07	7.6 E-04	--
7664-39-3	Hydrogen fluoride	ND	ND	2.2 E-01
193-39-5	Indeno[1,2,3-cd]pyrene	1.2 E-10	1.4 E-07	--
78-59-1	Isophorone	ND	ND	1.8 E-02
7439-96-5	Manganese	1.1 E-09	1.4 E-06	--
96-33-3	Methyl acrylate	ND	ND	3.6 E-03
74-95-3	Methylene bromide	ND	ND	7.2 E-03
75-09-2	Methylene chloride	3.2 E-07	4.0 E-04	--
78-93-3	Methyl ethyl ketone	5.4 E-09	6.7 E-06	--
74-88-4	Methyl iodide	ND	ND	5.9 E-03
108-10-1	Methyl isobutyl ketone	ND	ND	4.2 E-03
80-62-6	Methyl methacrylate	ND	ND	4.2 E-03
91-57-6	2-Methylnaphthalene	ND	ND	1.8 E-02
95-48-7	2-Methylphenol	ND	ND	1.8 E-02
1634-04-4	Methyl tert-butyl ether	ND	ND	3.7 E-03
91-20-3	Naphthalene	1.2 E-08	1.5 E-05	--
7440-02-0	Nickel	ND	ND	1.2 E-03
7697-37-2	Nitric acid	4.0 E-07	5.0 E-04	--
100-01-6	4-Nitroaniline	ND	ND	3.6 E-02
98-95-3	Nitrobenzene	ND	ND	3.6 E-03

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
55-63-0	Nitroglycerin	ND	ND	3.6 E-03
88-75-5	2-Nitrophenol	ND	ND	1.8 E-02
100-02-7	4-Nitrophenol	ND	ND	3.6 E-02
62-75-9	n-Nitrosodimethylamine	ND	ND	1.8 E-02
86-30-6	n-Nitrosodiphenylamine	ND	ND	1.8 E-02
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	1.8 E-02
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	1.7 E-13	2.2 E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	ND	ND	5.7 E-09
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND	ND	4.8 E-09
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	2.2 E-09
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	ND	ND	9.4 E-10
87-86-5	Pentachlorophenol	ND	ND	3.6 E-02
85-01-8	Phenanthrene	3.2 E-10	4.0 E-07	--
108-95-2	Phenol	ND	ND	1.8 E-02
123-38-6	Propionaldehyde	ND	ND	2.5 E-02
115-07-1	Propylene	1.6 E-07	2.0 E-04	--
129-00-0	Pyrene ^f	1.1 E-10	1.3 E-07	--
7782-49-2	Selenium	ND	ND	2.3 E-03
7440-22-4	Silver	ND	ND	4.6 E-04
100-42-5	Styrene	2.4 E-07	3.0 E-04	--
7664-93-9	Sulfuric acid	ND	ND	2.0 E-02
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND	ND	3.0 E-09
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	ND	ND	2.6 E-09
630-20-6	1,1,1,2-Tetrachloroethane	ND	ND	7.0 E-03
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	7.0 E-03
127-18-4	Tetrachloroethylene	ND	ND	6.9 E-03
7440-28-0	Thallium	ND	ND	1.2 E-03
108-88-3	Toluene	8.6 E-08	1.1 E-04	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	7.5 E-03
71-55-6	1,1,1-Trichloroethane ^g	1.2 E-07	1.4 E-04	--
79-00-5	1,1,2-Trichloroethane	ND	ND	5.5 E-03
75-69-4	Trichlorofluoromethane ^f	0	0	--

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
95-95-4	2,4,5-Trichlorophenol	ND	ND	1.8 E-02
88-06-2	2,4,6-Trichlorophenol	ND	ND	1.8 E-02
96-18-4	1,2,3-Trichloropropane	ND	ND	6.1 E-03
95-63-6	1,2,4-Trimethylbenzene	5.1 E-08	6.3 E-05	--
540-84-1	2,2,4-Trimethylpentane	ND	ND	4.8 E-03
108-05-4	Vinyl acetate	ND	ND	3.6 E-03
75-01-4	Vinyl chloride	ND	ND	2.6 E-03
75-35-4	Vinylidene chloride	ND	ND	4.1 E-03
106-42-3, 108-38-3	m-Xylene, p-Xylene	7.4 E-08	9.2 E-05	--
95-47-6	o-Xylene	5.3 E-08	6.6 E-05	--
7440-66-6	Zinc	4.2 E-06	5.2 E-03	--
Other Pollutants				
67-64-1	Acetone	1.5 E-08	1.9 E-05	--
74-86-2	Acetylene	1.4 E-06	1.8 E-03	--
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	3.6 E-03
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	3.6 E-03
100-52-7	Benzaldehyde	ND	ND	4.5 E-02
611-14-3	Benzene, 1-ethyl-2-methyl- ^g	3.6 E-08	4.5 E-05	--
526-73-8	Benzene, 1,2,3-trimethyl- ^g	4.8 E-08	6.0 E-05	--
65-85-0	Benzoic acid	6.5 E-08	8.1 E-05	--
100-47-0	Benzonitrile ^g	2.0 E-08	2.5 E-05	--
100-51-6	Benzyl alcohol	ND	ND	1.8 E-02
108-86-1	Bromobenzene	ND	ND	6.5 E-03
106-97-8	Butane	ND	ND	4.8 E-02
624-64-6	trans-Butene	ND	ND	4.7 E-02
689-97-4	1-Buten-3-yne ^g	1.3 E-08	1.6 E-05	--
503-17-3	2-Butyne	ND	ND	4.5 E-02
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	1.8 E-02
59-50-7	4-Chloro-3-methylphenol	ND	ND	1.8 E-02
4292-75-5	Cyclohexane, hexyl- ^g	3.5 E-08	4.3 E-05	--
540-97-6	Cyclohexasiloxane, dodecamethyl ^g	2.3 E-08	2.9 E-05	--
124-48-1	Dibromochloromethane	ND	ND	8.7 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	4.0 E-03

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
156-60-5	trans-1,2-Dichloroethene	ND	ND	4.0 E-03
84-66-2	Diethylphthalate ^g	4.0 E-08	5.0 E-05	--
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.7 E-02
13150-81-7	2,6-Dimethyldecane ^g	3.3 E-08	4.1 E-05	--
117-84-0	Di-n-octylphthalate	ND	ND	1.8 E-02
112-40-3	Dodecane ^g	1.7 E-07	2.1 E-04	--
143-07-7	Dodecanoic acid ^g	2.0 E-08	2.6 E-05	--
74-84-0	Ethane	7.8 E-08	9.7 E-05	--
64-17-5	Ethanol ^g	0	0	--
141-78-6	Ethyl acetate	ND	ND	3.7 E-03
97-63-2	Ethyl methacrylate	ND	ND	4.7 E-03
622-96-8	4-Ethyltoluene	2.7 E-08	3.4 E-05	--
110-00-9	Furan ^g	1.7 E-08	2.1 E-05	--
142-82-5	Heptane	ND	ND	4.2 E-03
57-10-3	Hexadecanoic acid ^g	2.4 E-08	3.0 E-05	--
66-25-1	Hexaldehyde	ND	ND	4.3 E-02
591-78-6	2-Hexanone	ND	ND	4.2 E-03
2691-41-0	HMX	ND	ND	7.1 E-03
10035-10-6	Hydrogen bromide	ND	ND	2.1 E-01
75-28-5	Isobutane	ND	ND	4.8 E-02
590-86-3	Isovaleraldehyde	ND	ND	3.7 E-02
26730-14-3	Methyl 4-hydroxybenzoate ^g	4.3 E-08	5.4 E-05	--
98-83-9	alpha-Methylstyrene	ND	ND	4.9 E-03
88-74-7	2-Nitroaniline	ND	ND	1.8 E-02
99-09-2	3-Nitroaniline	ND	ND	3.6 E-02
88-72-2	2-Nitrotoluene	ND	ND	1.8 E-01
99-08-1	3-Nitrotoluene	ND	ND	1.8 E-01
99-99-0	4-Nitrotoluene	ND	ND	1.8 E-01
111-65-9	Octane	1.4 E-09	1.8 E-06	--
78-11-5	Pentaerythritol tetranitrate	ND	ND	7.1 E-03
109-66-0	Pentane	ND	ND	6.0 E-02
7664-38-2	Phosphoric acid	ND	ND	2.1 E-01
146-50-9	Phthalic acid diisohexyl ester ^g	1.6 E-08	2.0 E-05	--
74-98-6	Propane	ND	ND	3.7 E-02

TABLE A1 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
115-11-7	1-Propene, 2-methyl- ^g	3.2 E-08	4.0 E-05	--
74-99-7	Propyne	6.9 E-08	8.6 E-05	--
121-82-4	RDX	ND	ND	3.6 E-03
3555-47-3	Tetrakis(trimethylsiloxy)silane ^g	1.2 E-08	1.5 E-05	--
479-45-8	Tetryl	ND	ND	3.6 E-03
420-12-2	Thiirane ^g	3.6 E-08	4.5 E-05	--
110-02-1	Thiophene ^g	1.7 E-08	2.1 E-05	--
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.0 E-01
25323-89-1	Trichloroethane	ND	ND	5.0 E-03
108-67-8	1,3,5-Trimethylbenzene	1.5 E-08	1.9 E-05	--
99-35-4	1,3,5-Trinitrobenzene	ND	ND	3.6 E-03
118-96-7	2,4,6-Trinitrotoluene	ND	ND	3.6 E-03
1120-21-4	Undecane ^g	1.5 E-07	1.9 E-04	--
17301-23-4	Undecane, 2,6-dimethyl- ^g	6.4 E-08	8.0 E-05	--
1002-43-3	Undecane, 3-methyl- ^g	5.1 E-08	6.3 E-05	--
110-62-3	Valeraldehyde	ND	ND	3.7 E-02

^a CASRN = Chemical Abstracts Service Registry Number.

^b ND = nondetected.

^c Emission factors rated C unless otherwise noted.

^d NEW = net explosive weight. The NEW for this ordnance is 8.00 E-04 pounds per item.

^e Data provided for compounds that were not detected.

^f Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.

^g Emission factor rated D because the factor is based upon C-rated test data.

TABLE A2 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR
DODIC B584, M918 40-MM TARGET PRACTICE CHARGE

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Criteria Pollutants, Methane, and Total Suspended Particulate				
124-38-9	Carbon dioxide ^f	2.7 E-03	2.6 E-01	--
630-08-0	Carbon monoxide ^f	2.6 E-03	2.5 E-01	--
7439-92-1	Lead	1.1 E-05	1.1 E-03	--
74-82-8	Methane ^f	5.4 E-06	5.3 E-04	--
--	Oxides of nitrogen	9.7 E-05	9.5 E-03	--
--	PM-2.5 ^f	1.2 E-04	1.1 E-02	--
--	PM-10 ^f	1.4 E-04	1.4 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^f	1.4 E-04	1.4 E-02	--
Hazardous Air Pollutants and Toxic Chemicals				
83-32-9	Acenaphthene	2.4 E-10	2.4 E-08	--
208-96-8	Acenaphthylene	3.3 E-09	3.2 E-07	--
75-07-0	Acetaldehyde ^g	5.9 E-08	5.7 E-06	--
75-05-8	Acetonitrile	1.5 E-07	1.5 E-05	--
107-02-8	Acrolein	4.3 E-08	4.2 E-06	--
107-13-1	Acrylonitrile ^f	1.9 E-07	1.8 E-05	--
107-05-1	Allyl chloride	ND	ND	3.2 E-03
7664-41-7	Ammonia	8.6 E-06	8.4 E-04	--
120-12-7	Anthracene ^f	1.3 E-10	1.3 E-08	--
7440-36-0	Antimony	1.3 E-06	1.2 E-04	--
7440-38-2	Arsenic	2.8 E-09	2.7 E-07	--
7440-39-3	Barium	1.6 E-05	1.5 E-03	--
71-43-2	Benzene	8.9 E-07	8.7 E-05	--
56-55-3	Benzo[a]anthracene	2.4 E-10	2.3 E-08	--
205-99-2	Benzo[b]fluoranthene	1.3 E-10	1.3 E-08	--
207-08-9	Benzo[k]fluoranthene	2.9 E-10	2.8 E-08	--
191-24-2	Benzo[g,h,i]perylene	8.2 E-10	8.0 E-08	--
50-32-8	Benzo[a]pyrene	3.1 E-10	3.1 E-08	--
100-44-7	Benzyl chloride	ND	ND	5.3 E-03
7440-41-7	Beryllium	ND	ND	3.3 E-04
75-25-2	Bromoform	ND	ND	1.1 E-02

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
74-83-9	Bromomethane	ND	ND	3.9 E-03
101-55-3	4-Bromophenylphenylether	ND	ND	1.7 E-02
106-99-0	1,3-Butadiene	ND	ND	4.5 E-02
75-65-0	t-Butyl alcohol ^g	7.2 E-08	7.0 E-06	--
85-68-7	Butylbenzylphthalate	ND	ND	1.7 E-02
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	ND	ND	8.1 E-04
75-15-0	Carbon disulfide	4.0 E-09	3.9 E-07	--
56-23-5	Carbon tetrachloride	ND	ND	6.4 E-03
106-47-8	4-Chloroaniline	ND	ND	3.4 E-02
108-90-7	Chlorobenzene	ND	ND	4.7 E-03
75-68-3	1-Chloro-1,1-difluoroethane ^g	5.7 E-08	5.6 E-06	--
75-45-6	Chlorodifluoromethane	4.9 E-09	4.8 E-07	--
75-00-3	Chloroethane	ND	ND	2.7 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	1.7 E-02
111-44-4	bis(2-Chloroethyl)ether	ND	ND	1.7 E-02
67-66-3	Chloroform	ND	ND	5.0 E-03
74-87-3	Chloromethane	2.7 E-09	2.6 E-07	--
91-58-7	2-Chloronaphthalene	ND	ND	1.7 E-02
95-57-8	2-Chlorophenol	ND	ND	1.7 E-02
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	1.7 E-02
7440-47-3	Chromium	1.1 E-08	1.1 E-06	--
218-01-9	Chrysene	ND	ND	1.7 E-02
7440-48-4	Cobalt	3.2 E-09	3.1 E-07	--
7440-50-8	Copper	2.5 E-05	2.5 E-03	--
106-44-5	p-Cresol	ND	ND	1.7 E-02
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
98-82-8	Cumene	3.2 E-09	3.1 E-07	--
57-12-5	Particulate cyanide	2.2 E-07	2.1 E-05	--
53-70-3	Dibenz[a,h]anthracene	2.4 E-11	2.4 E-09	--
132-64-9	Dibenzofuran	ND	ND	1.7 E-02
106-93-4	1,2-Dibromoethane	ND	ND	7.8 E-03
84-74-2	Dibutyl phthalate	ND	ND	1.6 E-01

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
95-50-1	1,2-Dichlorobenzene	ND	ND	6.1 E-03
541-73-1	1,3-Dichlorobenzene	ND	ND	6.1 E-03
106-46-7	1,4-Dichlorobenzene	ND	ND	6.1 E-03
91-94-1	3,3'-Dichlorobenzidine	ND	ND	3.4 E-02
75-27-4	Dichlorobromomethane	ND	ND	6.8 E-03
75-71-8	Dichlorodifluoromethane	4.1 E-09	4.0 E-07	--
75-34-3	1,1-Dichloroethane	ND	ND	4.1 E-03
107-06-2	1,2-Dichloroethane	1.9 E-08	1.8 E-06	--
75-43-4	Dichlorofluoromethane	ND	ND	4.3 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	1.7 E-02
78-87-5	1,2-Dichloropropane	ND	ND	4.7 E-03
10061-02-6	trans-1,3-Dichloropropene	ND	ND	4.6 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	7.1 E-03
105-67-9	2,4-Dimethylphenol	ND	ND	1.7 E-02
131-11-3	Dimethyl phthalate	ND	ND	1.7 E-02
99-65-0	1,3-Dinitrobenzene	ND	ND	3.3 E-03
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	1.7 E-02
51-28-5	2,4-Dinitrophenol	ND	ND	1.7 E-02
121-14-2	2,4-Dinitrotoluene	ND	ND	3.3 E-03
606-20-2	2,6-Dinitrotoluene	ND	ND	3.3 E-03
122-39-4	Diphenyl amine	ND	ND	8.2 E-02
123-91-1	1,4-Dioxane	ND	ND	3.7 E-03
--	Total dioxin/furan compounds	8.9 E-14	8.7 E-12	--
140-88-5	Ethyl acrylate	ND	ND	4.2 E-03
100-41-4	Ethylbenzene	2.0 E-08	2.0 E-06	--
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	1.6 E-01
74-85-1	Ethylene ^g	2.1 E-06	2.1 E-04	--
206-44-0	Fluoranthene	5.3 E-10	5.2 E-08	--
86-73-7	Fluorene	6.3 E-10	6.1 E-08	--
50-00-0	Formaldehyde ^g	1.7 E-07	1.7 E-05	--
76-13-1	Freon 113	ND	ND	7.8 E-03
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	7.0 E-15	6.8 E-13	--

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	5.1 E-15	4.9 E-13	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND	ND	2.9 E-09
118-74-1	Hexachlorobenzene	ND	ND	1.7 E-02
87-68-3	Hexachlorobutadiene	ND	ND	1.1 E-02
77-47-4	Hexachlorocyclopentadiene	ND	ND	1.7 E-02
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	1.4 E-09
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	1.4 E-09
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ND	ND	3.8 E-09
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	ND	ND	2.0 E-09
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran ^g	2.1 E-15	2.1 E-13	--
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	3.5 E-09
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	1.9 E-09
67-72-1	Hexachloroethane	ND	ND	9.8 E-03
110-54-3	Hexane	4.9 E-07	4.8 E-05	--
7647-01-0	Hydrochloric acid	6.5 E-07	6.4 E-05	--
74-90-8	Hydrogen cyanide ^f	1.3 E-06	1.3 E-04	--
7664-39-3	Hydrogen fluoride	ND	ND	1.1 E-01
193-39-5	Indeno[1,2,3-cd]pyrene	2.5 E-10	2.4 E-08	--
78-59-1	Isophorone	ND	ND	1.7 E-02
7439-96-5	Manganese	2.1 E-08	2.0 E-06	--
96-33-3	Methyl acrylate	ND	ND	3.6 E-03
74-95-3	Methylene bromide	ND	ND	7.2 E-03
75-09-2	Methylene chloride	1.4 E-07	1.4 E-05	--
78-93-3	Methyl ethyl ketone	8.2 E-09	8.0 E-07	--
74-88-4	Methyl iodide	ND	ND	5.9 E-03
108-10-1	Methyl isobutyl ketone	ND	ND	4.2 E-03
80-62-6	Methyl methacrylate	ND	ND	4.2 E-03
91-57-6	2-Methylnaphthalene	ND	ND	1.7 E-02
95-48-7	2-Methylphenol	ND	ND	1.7 E-02

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
1634-04-4	Methyl tert-butyl ether	ND	ND	3.7 E-03
91-20-3	Naphthalene	2.2 E-08	2.2 E-06	--
7440-02-0	Nickel	5.9 E-08	5.7 E-06	--
7697-37-2	Nitric acid	1.4 E-06	1.4 E-04	--
100-01-6	4-Nitroaniline	ND	ND	3.4 E-02
98-95-3	Nitrobenzene	ND	ND	3.3 E-03
55-63-0	Nitroglycerin	ND	ND	3.3 E-03
88-75-5	2-Nitrophenol	ND	ND	1.7 E-02
100-02-7	4-Nitrophenol	ND	ND	3.4 E-02
62-75-9	n-Nitrosodimethylamine	ND	ND	1.7 E-02
86-30-6	n-Nitrosodiphenylamine	ND	ND	1.7 E-02
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	1.7 E-02
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin ^g	6.8 E-14	6.6 E-12	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	7.0 E-15	6.8 E-13	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND	ND	3.2 E-09
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	1.5 E-09
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	ND	ND	6.7 E-10
87-86-5	Pentachlorophenol	ND	ND	1.7 E-02
85-01-8	Phenanthrene	7.7 E-10	7.5 E-08	--
108-95-2	Phenol	ND	ND	1.7 E-02
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene	3.8 E-07	3.7 E-05	--
129-00-0	Pyrene ^f	1.1 E-09	1.1 E-07	--
7782-49-2	Selenium	ND	ND	1.6 E-03
7440-22-4	Silver	7.4 E-10	7.2 E-08	--
100-42-5	Styrene	2.4 E-08	2.3 E-06	--
7664-93-9	Sulfuric acid	ND	ND	3.0 E-02
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND	ND	2.0 E-09
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	ND	ND	1.7 E-09
630-20-6	1,1,1,2-Tetrachloroethane	ND	ND	7.0 E-03
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	7.0 E-03

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
127-18-4	Tetrachloroethylene	4.4 E-09	4.3 E-07	--
7440-28-0	Thallium	ND	ND	8.1 E-04
108-88-3	Toluene	1.4 E-07	1.4 E-05	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	7.5 E-03
71-55-6	1,1,1-Trichloroethane	0	0	--
79-00-5	1,1,2-Trichloroethane	ND	ND	5.5 E-03
75-69-4	Trichlorofluoromethane ^f	3.1 E-09	3.1 E-07	--
95-95-4	2,4,5-Trichlorophenol	ND	ND	1.7 E-02
88-06-2	2,4,6-Trichlorophenol	ND	ND	1.7 E-02
96-18-4	1,2,3-Trichloropropane	ND	ND	6.1 E-03
95-63-6	1,2,4-Trimethylbenzene	9.1 E-09	8.9 E-07	--
540-84-1	2,2,4-Trimethylpentane	ND	ND	4.8 E-03
108-05-4	Vinyl acetate	ND	ND	3.6 E-03
75-01-4	Vinyl chloride	2.4 E-09	2.3 E-07	--
75-35-4	Vinylidene chloride	ND	ND	4.1 E-03
106-42-3, 108-38-3	m-Xylene, p-Xylene	3.2 E-08	3.1 E-06	--
95-47-6	o-Xylene	1.6 E-08	1.6 E-06	--
7440-66-6	Zinc	1.9 E-06	1.9 E-04	--
Other Pollutants				
67-64-1	Acetone	8.3 E-07	8.1 E-05	--
74-86-2	Acetylene ^g	1.1 E-06	1.0 E-04	--
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	3.3 E-03
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	3.3 E-03
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
65-85-0	Benzoic acid	6.7 E-08	6.5 E-06	--
100-51-6	Benzyl alcohol	ND	ND	1.7 E-02
108-86-1	Bromobenzene	ND	ND	6.5 E-03
106-97-8	Butane	ND	ND	4.8 E-02
624-64-6	trans-Butene	ND	ND	4.7 E-02
689-97-4	1-Buten-3-yne ^g	2.2 E-08	2.1 E-06	--
503-17-3	2-Butyne	ND	ND	4.5 E-02
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	1.7 E-02

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
59-50-7	4-Chloro-3-methylphenol	ND	ND	1.7 E-02
540-97-6	Cyclohexasiloxane, dodecamethyl ^g	4.6 E-08	4.5 E-06	--
1191-96-4	Cyclopropane, ethyl- ^g	4.0 E-08	3.9 E-06	--
122-62-3	Decanedioic acid, bis(2-ethylhexyl) ester ^g	1.5 E-06	1.4 E-04	--
124-48-1	Dibromochloromethane	ND	ND	8.7 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	4.0 E-03
156-60-5	Trans-1,2-Dichloroethene	ND	ND	4.0 E-03
84-66-2	Diethylphthalate	ND	ND	1.7 E-02
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	1.7 E-02
74-84-0	Ethane ^g	2.9 E-07	2.8 E-05	--
141-78-6	Ethyl acetate	ND	ND	3.7 E-03
97-63-2	Ethyl methacrylate	ND	ND	4.7 E-03
622-96-8	4-Ethyltoluene	5.5 E-09	5.3 E-07	--
110-00-9	Furan ^g	3.9 E-08	3.8 E-06	--
142-82-5	Heptane ^g	9.5 E-09	9.3 E-07	--
57-10-3	Hexadecanoic acid ^g	3.8 E-08	3.7 E-06	--
66-25-1	Hexaldehyde	ND	ND	4.2 E-02
591-78-6	2-Hexanone	5.7 E-09	5.5 E-07	--
592-41-6	1-Hexene ^g	5.8 E-08	5.6 E-06	--
2691-41-0	HMX	ND	ND	6.6 E-03
10035-10-6	Hydrogen bromide	ND	ND	2.1 E-01
75-28-5	Isobutane	ND	ND	4.8 E-02
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
98-83-9	alpha-Methylstyrene	ND	ND	4.9 E-03
88-74-7	2-Nitroaniline	ND	ND	1.8 E-02
99-09-2	3-Nitroaniline	ND	ND	1.7 E-02
88-72-2	2-Nitrotoluene	ND	ND	3.3 E-01
99-08-1	3-Nitrotoluene	ND	ND	3.3 E-01
99-99-0	4-Nitrotoluene	ND	ND	3.3 E-01
111-65-9	Octane	ND	ND	4.8 E-03
57-11-4	Octadecanoic acid ^g	5.2 E-08	5.1 E-06	--

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
78-11-5	Pentaerythritol tetranitrate	ND	ND	6.6 E-03
109-66-0	Pentane ^g	1.3 E-06	1.2 E-04	--
107-39-1	1-Pentene, 2,4,4-trimethyl- ^g	1.4 E-07	1.4 E-05	--
7664-38-2	Phosphoric acid	ND	ND	2.1 E-01
463-49-0	1,2-Propadiene ^g	7.3 E-08	7.1 E-06	--
74-98-6	Propane	1.3 E-07	1.3 E-05	--
115-11-7	1-Propene, 2-methyl- ^g	4.5 E-07	4.4 E-05	--
74-99-7	Propyne	ND	ND	3.3 E-02
121-82-4	RDX	ND	ND	3.3 E-03
479-45-8	Tetryl	ND	ND	3.3 E-03
5955-98-6	Thiirane, 2,3-dimethyl-, trans- ^g	8.7 E-08	8.5 E-06	--
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.0 E-01
25323-89-1	Trichloroethane	ND	ND	5.0 E-03
108-67-8	1,3,5-Trimethylbenzene	4.1 E-09	4.0 E-07	--
99-35-4	1,3,5-Trinitrobenzene	ND	ND	3.3 E-03
118-96-7	2,4,6-Trinitrotoluene	ND	ND	3.3 E-03
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

^a CASRN = Chemical Abstracts Service Registry Number.

^b ND = nondetected.

^c Emission factors rated C unless otherwise noted.

^d NEW = net explosive weight. The NEW for this ordnance is 1.03 E-02 pounds per item.

^e Data provided for compounds that were not detected.

^f Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.

^g Emission factor rated D because the factor is based upon C-rated test data.

APPENDIX B

NEW AP-42 SECTIONS FOR ORDNANCE INCLUDED IN FIRING POINT EMISSION STUDY PHASE II SERIES 2 TESTING, ABERDEEN PROVING GROUND, MARYLAND

Electronic versions of the new AP-42 sections for ordnance included in Firing Point Emission Study Phase II Series 2 testing at Aberdeen Proving Ground, Maryland, are located on the EPA website at: <http://www.epa.gov/ttn/chief/ap42/index.html>.

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APPENDIX C

PUBLIC COMMENTS ON AP-42 SECTIONS FOR ORDNANCE INCLUDED IN FIRING POINT EMISSION STUDY PHASE II SERIES 2 TESTING AT ABERDEEN PROVING GROUND, MARYLAND

No public comments were received on the draft version of this document. However, the document has been modified since the publication of the draft to incorporate revised emission factor ratings for numerous pollutants. The methodology used to revise the emission factor ratings is presented in Section 5 of this document, while the revised emission factor ratings are presented in Appendix A.

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