

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 1 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 five tactical configurations of a 155-mm propelling charge used during training exercises at U.S. Army installations. The propelling charge is identified by its Department of Defense Identification Code (DODIC), D540. The air emission factors were developed from test data collected by USAEC and are only representative of emissions associated with the use of the propelling charge itself. Emissions associated with the explosion of projectiles are addressed elsewhere.

Five tactical configurations were tested to address emission product variation as a function of propelling charge, charge size (zone), and cannon type. Two 155-mm propelling charges, M3 and M3A1, were tested. Potential emission product changes caused by the muzzle flash reduction additive in the M3A1 charge were investigated. To gain insight into differences in combustion product distribution that might occur with larger amounts of propellant, two charge sizes, zone 3 and zone 5, were tested. As compared to zone 5, the zone 3 charge is for shorter range use, requires less propellant, and thus is a smaller charge size. Two types of cannon, the M199 and M284 howitzer, were used to investigate emission product differences caused by a bore evacuator; the M284 has a bore evacuator, while the M199 does not. Configurations of propelling charge, zone, and cannon type for which emission factors have been developed are identified in Table 1.

TABLE 1 CONFIGURATIONS OF PROPELLING CHARGE, ZONE, AND CANNON TYPE FOR WHICH EMISSION FACTORS WERE DEVELOPED

DODIC	Configuration No.	Configuration		
		Propelling Charge	Charge Zone	Howitzer Cannon
D540	1	M3	3	M199
	2	M3	5	M199
	3	M3A1	3	M199
	4	M3	3	M284
	5	M3A1	3	M284

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. 1 for the Firing Point Emission Study Phase II*¹ and the document titled *Detailed Test Plan for the Firing Point Emission Characterization of the Propelling Charges, 155MM M3 and M3A1 - Test Matrix No. 1*.² These documents were supplemented by additional data provided by the testing contractor.³ For each configuration, one test run, using two sampling trains, was conducted. One ordnance was detonated per run. Source test protocols were developed by USAEC before any testing was conducted and were reviewed by the U.S. Environmental Protection Agency's (EPA's) Emission Measurement Center. The tests were conducted between May 17 and June 7, 1999.

The compounds that were measured include 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 (VOCs), semivolatile organic compounds (SVOCs), dioxin and furan compounds, acid gases, hydrogen cyanide (HCN), aldehydes and carbonyl compounds, hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and energetic materials. Within the AP-42 section, 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 propelling charge tested is provided in AP-42 Section 15.4.4 and in Table 2.

TABLE 2 ORDNANCE NET EXPLOSIVE WEIGHT

DODIC	Configuration No.	Configuration			NEW (lb/item) ^a
		Propelling Charge	Charge Zone	Howitzer Cannon	
D540	1	M3	3	M199	3.28
	2	M3	5	M199	5.75
	3	M3A1	3	M199	3.50
	4	M3	3	M284	3.28
	5	M3A1	3	M284	3.50

^a NEW values were obtained from Reference 1.

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 configuration, 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 five configurations of propelling charge, zone, and weapon 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 I testing was conducted in the Main Front Firing Barricade 2 (B2) test facility located at the Aberdeen Test Center (ATC), Maryland. B2 is a reinforced concrete structure with interior dimensions of approximately 74-feet wide by 70-feet deep by 36-feet high. The internal volume of the B2 is 184,820 cubic feet. The opening at the front of B2 is closed with a polyvinyl chloride strip-curtain. A steel blast shield, equipped with an internal door and remotely operated external door, is located immediately in front of the strip curtain. Together, the shield and curtain absorb the blast from the weapon's firing and allow the projectile to exit the facility while maintaining the required seal for emissions characterization.

Six high volume fans located around the interior perimeter of the barricade ensure even distribution of the sulfur hexafluoride (SF₆) tracer gas and the weapon emission products. A separate instrumentation and test control building is part of the facility. Instrumentation and firing of the weapon are controlled remotely from this location. Instrumentation and equipment are in place to collect emissions product data.

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. Where necessary, the test methods were adapted to reflect application to the unique testing of ordnance firing in the B2.

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 , CH ₄ , CO, and CO ₂	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]

TABLE 3 (cont.)

Compound	Test Method
TSP	40 CFR 50, Appendix B - <i>Reference Method for the Determination of Suspended Particulate Matter as in the Atmosphere (High Volume Method)</i> [sampling and analysis]
PM-10	40 CFR 50, Appendix J - <i>Reference Method for the Determination of Particulate Matter as PM-10 in the Atmosphere</i> [sampling and analysis]
PM-2.5	40 CFR 50, Appendix L - <i>Reference Method for the Determination of Fine Particulate Matter as PM-2.5 in the Atmosphere</i> [sampling and analysis]
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]
VOCs	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]
PAHs	EPA Compendium Method TO-13 - <i>Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)</i> [sampling and analysis]
SVOCs	EPA Compendium Method TO-13 - <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-9 - <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, n- Hexane, and SF ₆	40 CFR 60, Appendix A, EPA Method 18 - <i>Measurement of Gaseous Organic Compounds by Gas Chromatography</i> [analysis for hydrocarbons] and GC/ECD [analysis for SF ₆]
Energetic Materials	EPA Compendium Method TO-13 - <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 B2 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 B2 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. However, due to a lack of calibration data, the methodologies actually used 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 and Ammonia

Extractive Fourier Transform Infrared (FTIR) spectroscopy was used to measure real-time concentrations of the SF₆ tracer gas and NH₃, as well as to identify qualitatively the presence of CH₄, CO, and CO₂ 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 B2 at a nominal rate of 15 lpm for a minimum of 30 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 B2 was determined using a modified sampling and analysis procedure based on 40 CFR 50, Appendix B - *Reference Method for the Determination of Suspended Particulate Matter as in the Atmosphere (High Volume Method)*. A Graseby[®] ambient air sampling module equipped with a quartz fiber filter was used to extract test chamber air through a Whatman[®] filter at a nominal rate of 1.1 to 1.7 cubic meters per minute (m³/min) for a sampling time of 30 minutes. The TSP concentration was computed 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 B2 were determined using modified sampling and analysis procedures based on 40 CFR 50, Appendix J - *Reference Method for the Determination of Particulate Matter as PM-10 in the Atmosphere* and 40 CFR 50, Appendix L - *Reference Method for the Determination of Fine Particulate Matter as PM-2.5 in the Atmosphere*. A Graseby high volume ambient air sampler with a PM-10 size selective inlet head was used to collect the PM-10 particulate at an approximate sampling rate of 1.13 m³/min for 30 minutes. The PM-2.5 particulate was determined using an R&P Partisol[®] FRM and WINS PM-2.5 impactor at an approximate sampling rate of 16.7 lpm for 30 minutes. The PM-10 and PM-2.5 concentrations were computed by dividing the masses of PM-10 and PM-2.5 collected by the volume of air sampled, corrected to standard conditions.

2.5 Metals

Metal concentrations that resulted from the firing of ordnance in the B2 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 the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air*. The method was modified 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 B2 were determined using 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 Canisters With Subsequent Analysis By Gas Chromatography*. Air samples were collected for 30 minutes using a Scientific Instruments 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 followed.

2.7 Semivolatile Organic Compounds and Polycyclic Aromatic Hydrocarbons

SVOC and PAH concentrations that resulted from the firing of ordnance in the B2 were determined based on procedures found in Method TO-13 - *Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatographic/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 30 minutes at 0.125 m³/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 U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) standard operating procedure (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 dibenzo furan (PCDF) compound concentrations that resulted from the firing of ordnance in the B2 were determined based on procedures

found in Method TO-9 - *Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans*. 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 used to sample for 30 minutes at 0.225 m³/min. After sampling, the filters and cartridges underwent extraction and analysis by GC/High Resolution Mass Spectroscopy according to Method TO-9.

2.9 Acid Gases

Acid gas concentrations that resulted from the firing of ordnance in the B2 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 30 minutes at a rate of 0.5 lpm. Analysis was performed according to NIOSH Method 7903 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 B2 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 30 minutes at a rate of 0.5 to 1 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 the firing of ordnance in the B2 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 30 minutes from the test chamber through ozone denuders at a rate of approximately 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 B2 were determined using the same sample collected for the VOC analysis. Analysis for the light hydrocarbons was by 40 CFR 60, Appendix A, EPA Method 18 - *Measurement of Gaseous Organic Compounds by Gas Chromatography*. SF₆ was analyzed by gas chromatography with electron capture detection (GC/ECD). This measurement served as a backup for the FTIR measurement of SF₆.

2.13 Energetic Materials

Energetic compound concentrations that resulted from the firing of ordnance in the B2 were determined based on procedures found in EPA Compendium Method TO-13 - *Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass*

Spectrometry (GC/MS). During each test, 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 30 minutes at approximately 0.1 m³/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, May 1998. This method specifically addresses the analysis of 2,4 Dinitrotoluene, 2,6-Dinitrotoluene, 2,4,6-Trinitrotoluene, and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) by 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 report¹, the detailed test plan², 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 in which the ordnance were fired (i.e., used) is documented in the final test report. Each ordnance that was tested was fired 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 gases 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.

As documented in the Excel spreadsheets prepared by the testing contractor³, the CEMS-measured CO concentration exceeded the instrumentation sampling range while testing configuration No. 2. A similar situation occurred for the CO₂ concentration during test run No. 4. In both instances, FTIR-measured data were used to develop the CO and CO₂ emission factors, as appropriate, for the test runs. However, the FTIR-measured concentrations used to develop the emission factors could not be duplicated or verified. Furthermore, the FTIR-measured data were only intended to be used to identify

qualitatively the presence of CO and CO₂; they were not intended to be used to quantify the concentrations. Consequently, the test data for both compounds were assigned a “C” rating.

3.2.2.2 Indeno [1,2,3-cd] Pyrene and Dibenz[a,h] Anthracene Data

The analytical methods for indeno [1,2,3-cd] pyrene and dibenz[a,h] anthracene were compromised. The case narrative for PAHs/SVOCs³ stated that indeno [1,2,3-cd] pyrene and dibenz[a,h] anthracene results were considered estimates with a high bias; consequently, the test data for indeno [1,2,3-cd] pyrene and dibenz[a,h] anthracene should be assigned a “C” rating based on this criterion.

3.2.2.3 VOC Compound Data

As described in the final test report¹, several deficiencies in the analysis of VOCs were noted. VOC analysis deficiencies included:

1. A bromofluorobenzene (BFB) tune to evaluate the performance of the mass spectrometer was not performed.
2. An initial two-point calibration, instead of the required three-point initial calibration was performed.
3. Reporting limits could not be verified by performance data or a detection limit study. The original detection and reporting limits were estimated based on chromatographic noise levels.
4. Several analytes were reported below the lowest run standard.
5. No system blank samples were run before analysis of sample canisters.
6. Prior and subsequent blank analyses showed low-level analyte contamination.

Because of these deficiencies, the VOC test quality should be assigned a “B” rating. Furthermore, reporting limits for each compound were increased to eliminate any results reported below the lowest demonstrated detection limit so that realistic assessment of the VOC emissions could be made. This decision did not further downgrade the test data quality rating for the VOC analytes; however, some VOC analytes that were detected at very low levels were eliminated from further consideration.

3.2.2.4 Hydrocarbon Compound Data

Deficiencies in the hydrocarbon compound analysis were also noted during the review of the final test report.¹ These deficiencies are as follows:

1. According to the test report, 13 hydrocarbons were supposed to be analyzed; however, the hydrocarbon analysis covered only 7 of these analytes.
2. Again, no method performance data were supplied to support the reporting limits. Detection limits were estimated based on chromatographic noise.
3. A propane standard, rather than a multi component standard, was used to generate response factors for all analytes.
4. No duplicate injections or matrix spikes were analyzed.

Because of these deficiencies, the hydrocarbon test data quality should be assigned a “B” rating. Furthermore, detection limits for each compound were increased from 50 parts per billion (ppb) to 550 ppb. This decision did not further downgrade the test data rating for the hydrocarbon analytes; however, all but one of the hydrocarbon analytes (methane) were eliminated from further consideration.

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

Twenty-nine compounds were either sampled or analyzed using two methods; these compounds are identified in Table 4. For each of these compounds, emission factors were 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 measurement was obtained using both the SW8270M (SVOCs) and TO-14A (VOCs) methods, the measurement obtained from the TO-14A method was judged to be more accurate and was therefore selected. When a compound was measured using both the SW8270M (SVOCs) and TO-13 (PAHs) methods, the TO-13 value was selected because TO-13 allowed quantification of compounds at lower levels than SW8270M. For compounds measured using a CEMS and FTIR spectroscopy, the CEMS measurements were judged to be more accurate. For compounds measured using both TO-14A and FTIR spectroscopy, measurements from TO-14A were judged to be more accurate and were selected. For compounds measured using both SW8270M (SVOCs) 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 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

Compounds	Selected Method	Other Method Employed
CO ₂ ^a	40 CFR 60 Method 3A (CEMS)	40 CFR 63 (FTIR)
CO ^b	40 CFR 60 Method 10 (CEMS)	40 CFR 63 (FTIR)
Methane	40 CFR 60 Method 18 (Hydrocarbons)	40 CFR 63 (FTIR)
Acenaphthene ^c	TO-13 (PAHs)	SW8270M (SVOCs)
Acenaphthylene	TO-13 (PAHs)	SW8270M (SVOCs)
Anthracene	TO-13 (PAHs)	SW8270M (SVOCs)
Benzo(a)anthracene	TO-13 (PAHs)	SW8270M (SVOCs)
Benzo(b)fluoranthene	TO-13 (PAHs)	SW8270M (SVOCs)
Benzo(k)fluoranthene	TO-13 (PAHs)	SW8270M (SVOCs)
Benzo(g,h,i)perylene	TO-13 (PAHs)	SW8270M (SVOCs)
Benzo(a)pyrene	TO-13 (PAHs)	SW8270M (SVOCs)
Chrysene	TO-13 (PAHs)	SW8270M (SVOCs)
Dibenz(a,h)anthracene	TO-13 (PAHs)	SW8270M (SVOCs)

TABLE 4 (cont.)

Compounds	Selected Method	Other Method Employed
Dibutyl phthalate	SOP CAD 26.1 (Energetics)	SW8270M (SVOCs)
1,2-dichlorobenzene	TO-14A (VOCs)	SW8270M (SVOCs)
1,3-dichlorobenzene	TO-14A (VOCs)	SW8270M (SVOCs)
1,4-dichlorobenzene	TO-14A (VOCs)	SW8270M (SVOCs)
2,4-dinitrotoluene	SOP CAD 26.1 (Energetics)	SW8270M (SVOCs)
2,6-dinitrotoluene	SOP CAD 26.1 (Energetics)	SW8270M (SVOCs)
Diethyl phthalate	SOP CAD 26.1 (Energetics)	SW8270M (SVOCs)
Fluoranthene	TO-13 (PAHs)	SW8270M (SVOCs)
Fluorene	TO-13 (PAHs)	SW8270M (SVOCs)
Hexachlorobutadiene	TO-14A (VOCs)	SW8270M (SVOCs)
Indeno(1,2,3-cd)pyrene	TO-13 (PAHs)	SW8270M (SVOCs)
Naphthalene ^d	TO-13 (PAHs)	SW8270M (SVOCs)
Nitrobenzene	SOP CAD 26.1 (Energetics)	SW8270M (SVOCs)
Phenanthrene	TO-13 (PAHs)	SW8270M (SVOCs)
Pyrene	TO-13 (PAHs)	SW8270M (SVOCs)
1,2,4-trichlorobenzene	TO-14A (VOCs)	SW8270M (SVOCs)

^a FTIR-measured data were used to develop the CO₂ emission factors for Configuration No. 4 because CEMS-measured CO₂ values exceeded the instrumentation measurement range.

^b FTIR-measured data were used to develop the CO emission factors for Configuration No. 2 because CEMS-measured CO values exceeded the instrumentation measurement range.

^c SW8270M data were used to develop the acenaphthene emission factors for Configuration No. 5 because samples measured using TO-13 had a relative percent difference greater than 100 percent, indicating poor precision.

^d SW8270M data were used to develop the naphthalene emission factors for Configuration Nos. 1, 2, and 5 because the compound was present in such high concentrations that the TO-13 method required multiple dilutions. Naphthalene values detected by the SW8270M method were considered to be more accurate at such dilution levels.

3.2.2.6 Tentatively Identified Compounds

During the analysis of the SVOC data, the 20 highest nontarget “peaks” were tentatively identified using computerized mass spectral matching techniques. 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.

The number of SVOCs that were tentatively identified as unique compounds varied from a minimum of four compounds for Configurations No. 3 (M3A1, zone 3, M199), No. 4 (M3, zone 3, M284), and No.5 (M3A1, zone 3, M284) to a maximum of six compounds for Configuration No. 1 (M3, zone 3, M199). A few of these compounds were also identified using higher confidence methods or were present in the method blank. Therefore, using the second and third criteria identified above, the number of emission factors developed for SVOC TICs varied from a minimum of three to a maximum of five for a given configuration. Because of the uncertainty in the true identity of the SVOC TICs, the test data were assigned a “C” rating.

As reported in Reference 1, several VOC TICs were measured, but emission factors were only estimated for two TICs (i.e., acetonitrile and acrylonitrile) due to deficiencies in the VOC analysis. These emission factors were expressed as a benzene equivalent concentration because of internal standard deficiencies. Because of the uncertainty in the true identity of the SVOC TICs, these test data were also 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 two samples within a test were noted for several compounds during a few of the test runs. Specific instances in which these differences were noted included the dioxin/furan compounds measured during test runs No. 2 and 4, and the measurement of sulfuric acid during test run No. 4. The equation below illustrates the calculation of relative percent difference:

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

Due to the large relative percent differences between 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 report¹, detailed test plan², 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). However, 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-HPCDF, met this criterion for Configurations No. 2 and 5. For this compound, the test data should be 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. One compound, 1,2,3,4,7,8-HXCDF, met this criterion for all five configurations.

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 Configuration
Carbon dioxide	B	Configurations 1, 2, 3, and 5
Carbon dioxide	C	Configuration 4
Carbon monoxide	B	Configurations 1, 3, 4, and 5
Carbon monoxide	C	Configuration 2
Oxides of nitrogen	B	All configurations
Sulfur dioxide	B	All configurations
VOCs	B	All configurations
Hydrocarbon compounds	B	All configurations
Acetonitrile	C	All configurations
Acrylonitrile	C	All configurations
Dibenz[a,h]anthracene	C	All configurations
2-(2-Ethoxyethoxy)ethanol	C	Configuration 1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	C	Configuration 2
1,2,3,4,6,7,8-Heptachlorodibenzofuran	C	Configuration 2
1,2,3,4,6,7,8-Heptachlorodibenzofuran	B	Configuration 5
1,2,3,4,7,8,9-Heptachlorodibenzofuran	C	Configuration 2
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	C	Configuration 2
1,2,3,6,7,8-Hexachlorodibenzofuran	C	Configurations 2 and 4

TABLE 5 (cont)

Compound or Class of Compounds	Data Quality Rating	Applicable Configuration
2,3,4,6,7,8-Hexachlorodibenzofuran	C	Configuration 2
Indeno[1,2,3-cd]pyrene	C	All configurations
Octabenzene	C	All configurations
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	C	Configuration 2
1,2,3,7,8-Pentachlorodibenzofuran	C	Configuration 2
2,3,4,7,8-Pentachlorodibenzofuran	C	Configurations 2 and 4
Sulfuric acid	C	Configuration 4
2,3,7,8-Tetrachlorodibenzo-p-dioxin	C	Configuration 2
2,3,7,8-Tetrachlorodibenzofuran	C	Configuration 2
Benzaldehyde, 4-ethyl	C	Configurations 3 and 5
Benzoic Acid	C	Configuration 1
Dodecamethylcyclohexasiloxane	C	Configuration 1
1-Hexanol, 2-ethyl	C	Configurations 2, 3, 4, and 5
Hexanoic acid, 2-ethyl	C	Configuration 3
Octasulfur	C	Configuration 4
Sulfur	C	Configurations 1, 2, and 3

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, SVOCs, PAHs, and energetic materials. The calculation steps that were performed for each sample and each configuration 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. Background testing was conducted on several days. When more than one set of background data was available, background compound concentrations were averaged to provide one background concentration for each compound under each test method. Analytical detection limits were incorporated into the background data during averaging.
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 B2.
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 VOCs, hydrocarbons, FTIR-, 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 VOCs, hydrocarbons, and FTIR-, and CEMS-measured compounds, as described in step 2. Where present, ppmv and ppbv values were converted to mg/m^3 .

Background run concentrations for VOCs and hydrocarbons were averaged, incorporating analytical detection limits. Emission factors for VOCs 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 corrected volumes to conditions that differed from EPA Stationary Source Program standard conditions. Concentration data received from the lab were corrected for volume at Stationary Source Program standard conditions and analytical detection limits were incorporated as described in step 2.

After correcting the background run concentrations for acid gases, hydrogen cyanide, aldehydes, and dioxin/furan compounds to standard conditions, the values were averaged, incorporating analytical detection limits, to provide one background concentration for each compound sampled under each method. Emission factors for acid gases, cyanide, aldehyde, and dioxin/furan compounds were then estimated in accordance with steps 5 through 9 described above.

The following sections describe the emission factor calculation steps in more detail. Sections 4.1 through 4.9 discuss the calculations involved with the completion of the nine basic steps listed above. Section 4.10 discusses the calculation of average emission factors across all of the configurations tested.

4.1 Correction of Sample Volume to Stationary Source Program 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:

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

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 sampling train was used per test). 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, metals, SVOCs, and PAHs, 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}). This calculation is illustrated by the following equation:

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

The background compound concentrations of acid gases, hydrogen cyanide, and aldehydes 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:

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

The background compound concentrations of dioxin/furan compounds provided by the lab were calculated using a sample volume at non standard conditions. In order to correct the concentrations to Stationary Source Program standard conditions, the uncorrected concentrations were multiplied by the ratio of volume at non standard conditions (V_{amb}) to volume at EPA Stationary Source Program standard conditions (V_{stat}). This calculation is illustrated by the following equation:

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

From one to three background runs were conducted for each class of compounds. Table 6 identifies and describes each background run that was conducted as well as the manner by which composite data were obtained. When more than one background run was conducted per test method, the background compound concentrations were averaged, incorporating analytical detection limits, as described in Section 4.2.

TABLE 6 BACKGROUND RUN INFORMATION

Compound(s)	Background Run(s) Conducted	Date(s) Conducted	Composite Data Used
VOCs/ Hydrocarbons	Two 24-hr runs	5/13/99, 6/8/99	Average
Dioxins/Furans	Two 24-hr runs	5/13/99, 6/7/99	Average
Metals	Two 24-hr runs	5/13/99, 6/7/99	Average
Acid Gases	Two 30-min runs	5/17/99, 6/1/99	Data from 5/17/99 for Configurations 1-3 Data from 6/1/99 for Configurations 4, 5
Hydrogen Cyanide	Two 30-min runs	5/17/99, 6/1/99	Average
Particulate Matter	Three 24-hr runs	4/26/99, 5/13/99, 6/7/99	Average
Aldehydes	Two 30-min runs	5/17/99, 6/1/99	Average
Energetic Materials	Two 90-min runs	5/13/99, 6/7/99	Average
SVOCs/PAHs	One 24-hr run, two 30-min pretest runs	5/13/99, 6/1/99, 6/7/99	Data from 5/13/99 for Configurations 1-3 Data from 6/1/99 for Configuration 4 Data from 6/7/99 for Configuration 5

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, SVOCs, PAHs, 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}). This calculation is illustrated by the following equation:

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

Test compound concentrations of acid gases, hydrogen cyanide, and aldehydes 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:

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

Test compound concentrations of dioxin/furan compounds provided by the lab were calculated using the sample volume at non standard conditions. In order to correct the concentrations to Stationary Source Program standard conditions, the uncorrected concentrations were multiplied by the ratio of the volume at non standard conditions (V_{amb}) to the volume at Stationary Source Program standard conditions (V_{stat}). This calculation is illustrated by the following equation:

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

For VOCs, hydrocarbons, FTIR- 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 B2, 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:

$$BCC = TC - BC$$

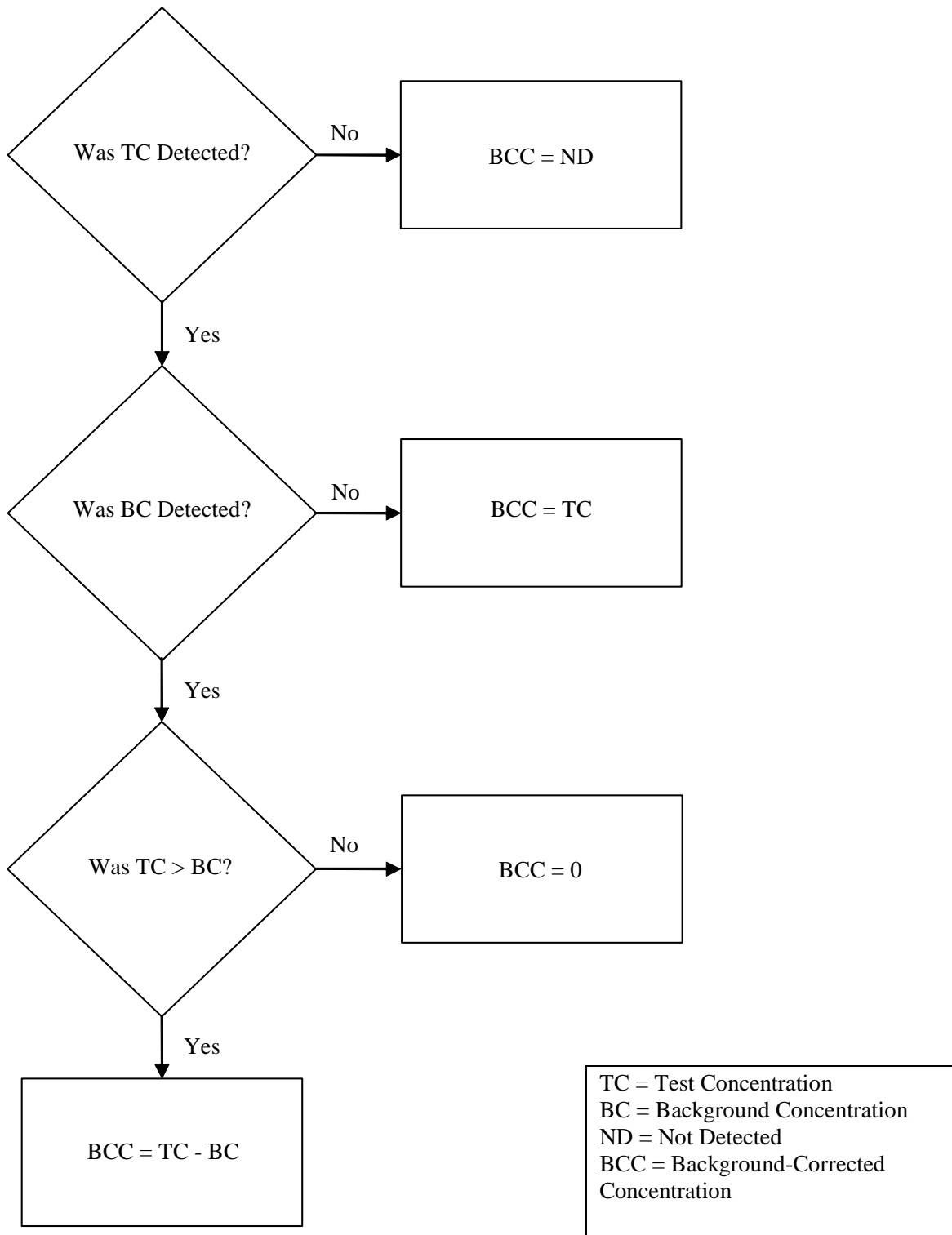


Figure 1 Calculation of background-corrected concentration.

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 B2. This calculation is illustrated by the following equation:

$$\text{Mass compound released} = DCC \times B2 \text{ volume}$$

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 for Each Configuration

Steps 1 through 8, as described in Sections 4.1 through 4.8, are applicable to individual samples within individual test runs. The next 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 for all dioxin/furan compounds.

4.10 Determination of Average Emission Factors Across Configurations

As previously described, a total of five tactical configurations were tested to address emission product variation as a function of propelling charge, charge size (zone), and cannon type. Results from the test program indicate that the type of cannon used affects the particulate and metals emissions distributions. The test program results also indicate that there are no consistent emission factor differences between the M3 and M3A1 propelling charges and that, on a NEW basis, there are only subtle emission factor differences between the zone 3 and zone 5 charges.

Because the emission factor differences across configurations were minor and because the user community may not have access to data regarding the type of cannon or the type of propelling charge

used in the field, average emission factors were developed across all configurations tested. Because the charge size affects the magnitude of emissions produced, the average emission factors were only determined in terms of pounds per pound NEW.

The average emission factor for each compound was determined as the arithmetic mean of the individual emission factors associated with each configuration. If all of the emission factors were “ND,” then the average emission factor was assigned a value of ND. If a compound was assigned a value of ND for some but not all configurations, then the ND values were replaced with a value equal to one half of the compound’s analytical detection limit prior to calculating the arithmetic average emission factor across configurations.

Average emission factors for tentatively identified compounds were determined in a slightly different manner. Analytical detection limits were not available for all TICs. In addition, different TICs were identified for different configurations. Therefore, for the configurations in which a specific TIC was not detected, an emission factor value of zero was assigned prior to calculating the arithmetic average emission factor across configurations.

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 7 along with a comment field describing the number of data points.

TABLE 7 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	
MM50 ^a	M221 Shaped Charge	EO11		

TABLE 7 (cont.)

Category	DODIC	Ordnance Description	Test Series	Comment
Demolition, continued	MN02 ^a	M12 Blasting Cap	EO7	20+ data points
	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 7 (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 7 (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 7 (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 7 (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 7 (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 7 (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>.

Within the current test series, DODIC D540 was included in the Propellant category, which included more than 20 test data points. As a result, some emission factor ratings associated with this ordnance were elevated. The emission factor ratings assigned are presented in Appendix A.

6.0 REFERENCES

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2. *Detailed Test Plan for the Firing Point Emissions Characterization of the Propelling Charges, 155MM M3 and M3A1 - Test Matrix No. 1*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, March 1999.

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, July 2004.
4. *Procedures for Preparing Emission Factor Documents*, EPA-454/R-95-015, U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1997.
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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, 2003.
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 1 TESTING,
ABERDEEN PROVING GROUND, MARYLAND**

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TABLE A1 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR DODIC D540, CONFIGURATION 1 (M3, ZONE 3, M199 CANNON)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates				
124-38-9	Carbon dioxide ^f	6.5E-01	2.0E-01	--
630-08-0	Carbon monoxide ^f	1.8E+00	5.6E-01	--
7439-92-1	Lead ^g	2.6E-04	8.1E-05	--
74-82-8	Methane ^f	1.1E-02	3.3E-03	--
--	Oxides of nitrogen ^f	2.0E-02	6.1E-03	--
--	PM-2.5 ^g	2.4E-02	7.4E-03	--
--	PM-10 ^g	6.2E-02	1.9E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^g	8.2E-02	2.5E-02	--
Toxic Chemicals and Hazardous Air Pollutants				
83-32-9	Acenaphthene ^g	6.1E-07	1.8E-07	--
208-96-8	Acenaphthylene ^f	6.0E-06	1.8E-06	--
75-07-0	Acetaldehyde ^g	ND	ND	1.8 E-02
75-08-8	Acetonitrile ^j	7.2 E-05	2.2 E-05	--
107-02-8	Acrolein	ND	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	5.0 E-05	1.5 E-05	--
107-05-1	Allyl chloride	ND	ND	2.8 E-03
7664-41-7	Ammonia ^f	4.2 E-02	1.3 E-02	--
120-12-7	Anthracene ^g	6.0 E-07	1.8 E-07	--
7440-36-0	Antimony	2.2 E-06	6.8 E-07	--
7440-38-2	Arsenic ^g	4.5 E-06	1.4 E-06	--
7440-39-3	Barium	1.2 E-04	3.5 E-05	--
71-43-2	Benzene ^g	7.4 E-04	2.3 E-04	--
56-55-3	Benzo[a]anthracene ^f	5.5E-07	1.7E-07	--
205-99-2	Benzo[b]fluoranthene ^g	8.4E-07	2.6E-07	--
207-08-9	Benzo[k]fluoranthene ^g	1.2E-06	3.6E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	8.1E-06	2.5E-06	--
50-32-8	Benzo[a]pyrene ^g	1.9E-06	5.8E-07	--
100-44-7	Benzyl chloride	ND	ND	5.2 E-03
7440-41-7	Beryllium	ND	ND	7.7 E-05
74-83-9	Bromomethane	ND	ND	3.1 E-03
101-55-3	4-Bromophenylphenylether	ND	ND	2.0 E-03
106-99-0	1,3-Butadiene	ND	ND	1.8 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	
85-68-7	Butylbenzylphthalate	ND	ND	2.0 E-03
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	2.0 E-06	5.9 E-07	--
56-23-5	Carbon tetrachloride	ND	ND	4.6 E-03
106-47-8	4-Chloroaniline	ND	ND	2.0 E-03
108-90-7	Chlorobenzene	ND	ND	2.4 E-04
75-00-3	Chloroethane	ND	ND	2.1 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	2.0 E-03
111-44-4	bis(2-Chloroethyl)ether	ND	ND	2.0 E-03
67-66-3	Chloroform	ND	ND	4.2 E-03
74-87-3	Chloromethane	ND	ND	1.6 E-03
91-58-7	2-Chloronaphthalene	ND	ND	2.0 E-03
95-57-8	2-Chlorophenol	ND	ND	2.0 E-03
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	2.0 E-03
7440-47-3	Chromium	1.7 E-05	5.2 E-06	--
218-01-9	Chrysene	5.4 E-07	1.7 E-07	--
7440-48-4	Cobalt	1.5 E-06	4.5 E-07	--
7440-50-8	Copper ^g	1.4 E-02	4.1 E-03	--
106-44-5	p-Cresol	ND	ND	2.0 E-03
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
57-12-5	Particulate cyanide	ND	ND	7.9 E-02
53-70-3	Dibenz[a,h]anthracene ⁱ	1.2 E-07	3.7 E-08	--
132-64-9	Dibenzofuran	ND	ND	2.0 E-03
106-93-4	1,2-Dibromoethane	ND	ND	5.9 E-03
84-74-2	Dibutyl phthalate	ND	ND	2.4 E-02
541-73-1	m-Dichlorobenzene	ND	ND	3.4 E-03
95-50-1	o-Dichlorobenzene	ND	ND	3.7 E-03
106-46-7	p-Dichlorobenzene	ND	ND	3.0 E-03
75-71-8	Dichlorodifluoromethane ^g	ND	ND	3.8 E-03
75-34-3	1,1-Dichloroethane	ND	ND	3.2 E-03
107-06-2	1,2-Dichloroethane ^g	ND	ND	3.5 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	2.0 E-03
10061-02-6	trans-1,3-Dichloropropene	ND	ND	2.9 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	4.8 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	
105-67-9	2,4-Dimethylphenol	ND	ND	2.0 E-03
131-11-3	Dimethyl phthalate	ND	ND	2.0 E-03
99-65-0	1,3-Dinitrobenzene	ND	ND	4.9 E-04
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	2.0 E-03
51-28-5	2,4-Dinitrophenol	ND	ND	2.0 E-03
121-14-2	2,4-Dinitrotoluene	ND	ND	4.9 E-04
606-20-2	2,6-Dinitrotoluene	ND	ND	4.9 E-04
--	Total dioxin	9.9 E-09	3.0 E-09	--
122-39-4	Diphenyl amine	ND	ND	1.2 E-02
111-90-0	2-(2-Ethoxyethoxy)ethanol ^k	4.4 E-05	1.3 E-05	--
100-41-4	Ethylbenzene ^f	ND	ND	2.4 E-03
74-85-1	Ethylene ^f	ND	ND	6.4 E-01
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	2.4 E-02
206-44-0	Fluoranthene ^g	3.7E-06	1.1E-06	--
86-73-7	Fluorene ^f	1.9E-06	5.8E-07	--
50-00-0	Formaldehyde ^g	ND	ND	1.2 E-02
76-13-1	Freon 113 ^g	6.2 E-06	1.9 E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.4 E-09	4.3 E-10	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	5.1 E-11	1.5 E-11	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	8.4 E-12	2.5 E-12	--
118-74-1	Hexachlorobenzene	ND	ND	2.0 E-03
87-68-3	Hexachlorobutadiene	ND	ND	4.8 E-03
77-47-4	Hexachlorocyclopentadiene	ND	ND	2.0 E-03
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	2.5 E-11	7.6 E-12	--
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	7.2 E-11	2.2 E-11	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.9 E-11	2.1 E-11	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	2.8 E-12	8.5 E-13	--
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	2.9 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	2.4 E-10

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	
67-72-1	Hexachloroethane	ND	ND	2.0 E-03
7647-01-0	Hydrochloric acid	ND	ND	1.3 E-01
74-90-8	Hydrogen cyanide ^g	1.2 E-02	3.5 E-03	--
7664-39-3	Hydrogen fluoride	ND	ND	1.4 E-01
193-39-5	Indeno[1,2,3-cd]pyrene ^h	3.6 E-06	1.1 E-06	--
78-59-1	Isophorone	ND	ND	2.0 E-03
7439-96-5	Manganese ^f	4.9 E-05	1.5 E-05	--
75-09-2	Methylene chloride ^g	2.0 E-03	6.0 E-04	--
91-57-6	2-Methylnaphthalene	ND	ND	2.0 E-03
95-48-7	2-Methylphenol	ND	ND	2.0 E-03
91-20-3	Naphthalene ^f	4.2 E-05	1.3 E-05	--
7440-02-0	Nickel	3.0 E-05	9.3 E-06	--
7697-37-2	Nitric acid ^g	ND	ND	1.4 E-01
100-01-6	4-Nitroaniline	ND	ND	2.0 E-03
98-95-3	Nitrobenzene	ND	ND	4.9 E-04
55-63-0	Nitroglycerin ^g	ND	ND	4.9 E-04
88-75-5	2-Nitrophenol	ND	ND	2.0 E-03
100-02-7	4-Nitrophenol	ND	ND	2.0 E-03
62-75-9	n-Nitrosodimethylamine	ND	ND	2.0 E-03
86-30-6	n-Nitrosodiphenylamine	ND	ND	2.0 E-03
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	2.0 E-03
1843-05-6	Octabenzene ^j	1.6 E-04	4.9 E-05	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	8.1 E-09	2.5 E-09	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.5 E-10	4.6 E-11	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.7 E-11	5.1 E-12	--
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	2.8 E-10
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	1.5 E-12	4.6 E-13	--
87-86-5	Pentachlorophenol	ND	ND	2.0 E-03
85-01-8	Phenanthrene ^g	5.5 E-06	1.7 E-06	--
108-95-2	Phenol ^g	2.4E-06	7.2E-07	--
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene ^g	ND	ND	9.6 E-01

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	
78-87-5	1,2-Dichloropropane	ND	ND	3.5 E-03
129-00-0	Pyrene ^g	1.1 E-05	3.2 E-06	--
7782-49-2	Selenium	ND	ND	2.6 E-04
7440-22-4	Silver	8.5 E-07	2.6 E-07	--
100-42-5	Styrene	ND	ND	2.7 E-03
7664-93-9	Sulfuric acid	ND	ND	1.4 E-01
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	3.8 E-12	1.2 E-12	--
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	1.2 E-12	3.8 E-13	--
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	4.5 E-03
127-18-4	Tetrachloroethylene	ND	ND	4.6 E-03
7440-28-0	Thallium	ND	ND	7.7 E-05
108-88-3	Toluene ^g	2.1 E-05	6.6 E-06	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	4.6 E-03
71-55-6	1,1,1-Trichloroethane	0	0	--
79-00-5	1,1,2-Trichloroethane	ND	ND	3.9 E-03
79-01-6	Trichloroethylene	ND	ND	3.9 E-03
75-69-4	Trichlorofluoromethane	ND	ND	4.0 E-03
95-95-4	2,4,5-Trichlorophenol	ND	ND	2.0 E-03
88-06-2	2,4,6-Trichlorophenol	ND	ND	2.0 E-03
95-63-6	1,2,4-Trimethylbenzene	ND	ND	2.3 E-03
75-01-4	Vinyl chloride	ND	ND	5.1 E-03
75-35-4	Vinylidene chloride ^g	3.9 E-05	1.2 E-05	--
106-42-3 / 108-38-3	mXylene / p-Xylene ^g	ND	ND	2.3 E-03
95-47-6	ortho-Xylene ^g	ND	ND	2.5 E-03
7440-66-6	Zinc	1.9 E-03	5.9 E-04	--
Other Pollutants				
67-64-1	Acetone	0	0	--
74-86-2	Acetylene ^g	ND	ND	6.0 E-01
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	4.9 E-04
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	4.9 E-04
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
65-85-0	Benzoic acid ^k	3.4 E-05	1.0 E-05	--
100-51-6	Benzyl alcohol	ND	ND	2.0 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	
106-97-8	Butane	ND	ND	1.3
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	2.0 E-03
59-50-7	4-Chloro-3-methylphenol	ND	ND	2.0 E-03
540-97-6	Cyclohexasiloxane, dodecamethy ^k	0	0	--
156-59-2	cis-1,2-Dichloroethene	ND	ND	3.3 E-03
10061-01-5	cis-1,3-Dichloropropene	ND	ND	3.4 E-03
84-66-2	Diethylphthalate	ND	ND	2.0 E-03
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	2.0 E-03
74-84-0	Ethane	ND	ND	6.9 E-01
622-96-8	4-Ethyltoluene ^g	ND	ND	2.2 E-03
66-25-1	Hexaldehyde	ND	ND	8.3 E-02
2691-41-0	HMX	ND	ND	9.8 E-04
10035-10-6	Hydrogen bromide	ND	ND	1.4 E-01
75-28-5	Isobutane	ND	ND	1.3
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
88-74-7	2-Nitroaniline	ND	ND	2.0 E-03
99-09-2	3-Nitroaniline	ND	ND	2.0 E-03
88-72-2	2-Nitrotoluene	ND	ND	4.9 E-04
99-08-1	3-Nitrotoluene	ND	ND	4.9 E-04
99-99-0	4-Nitrotoluene	ND	ND	4.9 E-04
78-11-5	Pentaerythritol tetranitrate	ND	ND	9.8 E-04
7664-38-2	Phosphoric acid	ND	ND	1.4 E-01
74-98-6	Propane	ND	ND	1.0
121-82-4	RDX	ND	ND	4.9 E-04
7704-34-9	Sulfur ^k	8.5 E-05	2.6 E-05	--
479-45-8	Tetryl	ND	ND	4.9 E-04
1334-78-7	o,m,p-Tolualdehyde	ND	ND	5.0 E-02
108-67-8	1,3,5-Trimethylbenzene	ND	ND	2.5 E-03
99-35-4	1,3,5-Trinitrobenzene	ND	ND	4.9 E-04
118-96-7	2,4,6-Trinitrotoluene ^g	ND	ND	4.9 E-04
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

TABLE A1 (cont.)

- ^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 3.28 pounds per item.
- ^e Data provided for compounds that were not detected.
- ^f Emission factor rated A because of correlation with emission factors for similar ordnance and number of test data points.
- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated "D" because the compound was tentatively identified.

TABLE A2 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR
DODIC D540, CONFIGURATION 2, M3, ZONE 5, M199 CANNON

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates				
124-38-9	Carbon dioxide ^f	1.3	2.2 E-01	--
630-08-0	Carbon monoxide ^h	3.3	5.8 E-01	--
7439-92-1	Lead ^g	3.7 E-04	6.4 E-05	--
74-82-8	Methane ^f	2.1 E-02	3.7 E-03	--
--	Oxides of nitrogen ^f	7.1 E-02	1.2 E-02	--
--	PM-2.5 ^g	3.8 E-02	6.7 E-03	--
--	PM-10 ^g	9.7 E-02	1.7 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^g	1.4 E-01	2.4 E-02	--
Toxic Chemicals and Hazardous Air Pollutants				
83-32-9	Acenaphthene ^g	0	0	--
208-96-8	Acenaphthylene ^f	3.4 E-06	5.8 E-07	--
75-07-0	Acetaldehyde ^g	ND	ND	1.8 E-02
75-05-8	Acetonitrile ^j	6.4 E-05	1.0 E-05	--
107-02-8	Acrolein	ND	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	5.3 E-05	8.9 E-06	--
107-05-1	Allyl chloride	ND	ND	2.8 E-03
7664-41-7	Ammonia ^f	9.8 E-02	1.7 E-02	--
120-12-7	Anthracene ^g	6.8E-07	1.2E-07	--
7440-36-0	Antimony	3.4 E-06	5.9 E-07	--
7440-38-2	Arsenic ^g	7.5 E-06	1.3 E-06	--
7440-39-3	Barium	7.4 E-05	1.3 E-05	--
71-43-2	Benzene ^g	9.1 E-04	1.6 E-04	--
56-55-3	Benzo[a]anthracene ^f	6.3E-07	1.1E-07	--
205-99-2	Benzo[b]fluoranthene ^g	1.2E-06	2.1E-07	--
207-08-9	Benzo[k]fluoranthene ^g	1.6E-06	2.8E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	8.6E-06	1.5E-06	--
50-32-8	Benzo[a]pyrene ^g	2.2E-06	3.9E-07	--
100-44-7	Benzyl chloride	ND	ND	5.2 E-03
7440-41-7	Beryllium	ND	ND	7.8 E-05
74-83-9	Bromomethane	ND	ND	3.1 E-03
101-55-3	4-Bromophenylphenylether	ND	ND	2.1 E-03
106-99-0	1,3-Butadiene	ND	ND	1.8 E-03

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
85-68-7	Butylbenzylphthalate	ND	ND	2.1 E-03
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	2.6 E-06	4.5 E-07	--
56-23-5	Carbon tetrachloride	ND	ND	4.6 E-03
106-47-8	4-Chloroaniline	ND	ND	2.1 E-02
108-90-7	Chlorobenzene	ND	ND	2.4 E-04
75-00-3	Chloroethane	ND	ND	2.1 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	2.1 E-03
111-44-4	bis(2-Chloroethyl)ether	ND	ND	2.1 E-03
67-66-3	Chloroform	ND	ND	4.2 E-03
74-87-3	Chloromethane	ND	ND	1.6 E-03
91-58-7	2-Chloronaphthalene	ND	ND	2.1 E-03
95-57-8	2-Chlorophenol	ND	ND	2.1 E-03
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	2.1 E-03
7440-47-3	Chromium	1.6 E-05	2.8 E-06	--
218-01-9	Chrysene	6.7 E-07	1.2 E-07	--
7440-48-4	Cobalt	2.1 E-06	3.6 E-07	--
7440-50-8	Copper ^g	1.9 E-02	3.2 E-03	--
106-44-5	p-Cresol	ND	ND	2.1 E-03
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
57-12-5	Particulate cyanide	1.5 E-03	2.5 E-04	--
53-70-3	Dibenz[a,h]anthracene ⁱ	1.1 E-07	2.0 E-08	--
132-64-9	Dibenzofuran	ND	ND	2.1 E-03
106-93-4	1,2-Dibromoethane	ND	ND	5.9 E-03
84-74-2	Dibutyl phthalate	ND	ND	2.4 E-02
541-73-1	m-Dichlorobenzene	ND	ND	3.4 E-03
95-50-1	o-Dichlorobenzene	ND	ND	3.7 E-03
106-46-7	p-Dichlorobenzene	ND	ND	3.0 E-03
75-71-8	Dichlorodifluoromethane ^g	ND	ND	3.8 E-03
75-34-3	1,1-Dichloroethane	ND	ND	3.2 E-03
107-06-2	1,2-Dichloroethane ^g	ND	ND	3.5 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	2.1 E-03
78-87-5	1,2-Dichloropropane	ND	ND	3.5 E-03
10061-02-6	trans-1,3-Dichloropropene	ND	ND	2.9 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	4.8 E-03

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
105-67-9	2,4-Dimethylphenol	ND	ND	2.1 E-03
131-11-3	Dimethyl phthalate	ND	ND	2.1 E-03
99-65-0	1,3-Dinitrobenzene	ND	ND	4.8 E-04
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	4.1 E-03
51-28-5	2,4-Dinitrophenol	ND	ND	4.1 E-03
121-14-2	2,4-Dinitrotoluene	ND	ND	4.8 E-04
606-20-2	2,6-Dinitrotoluene	ND	ND	4.8 E-04
--	Total dioxin	3.0 E-09	5.3 E-10	--
122-39-4	Diphenyl amine	ND	ND	1.2 E-02
100-41-4	Ethylbenzene ^f	ND	ND	2.4 E-03
74-85-1	Ethylene ^f	ND	ND	6.4 E-01
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	2.4 E-02
206-44-0	Fluoranthene ^g	3.6E-06	6.2E-07	--
86-73-7	Fluorene ^f	1.8E-06	3.1E-07	--
50-00-0	Formaldehyde ^g	ND	ND	1.2 E-02
76-13-1	Freon-113 ^g	9.7 E-06	1.7 E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	3.6 E-10	6.3 E-11	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran ^k	1.5 E-10	2.7 E-11	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran ^k	4.5 E-12	7.8 E-13	--
118-74-1	Hexachlorobenzene	ND	ND	2.1 E-03
87-68-3	Hexachlorobutadiene	ND	ND	4.8 E-03
77-47-4	Hexachlorocyclopentadiene	ND	ND	2.1 E-03
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	5.0 E-10
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	4.2 E-11	7.3 E-12	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.5 E-11	2.7 E-12	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.4 E-11	2.5 E-12	--
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	3.1 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	7.7 E-12	1.3 E-12	--
67-72-1	Hexachloroethane	ND	ND	2.1 E-03
7647-01-0	Hydrochloric acid	ND	ND	1.3 E-01

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
74-90-8	Hydrogen cyanide ^g	2.0 E-02	3.5 E-03	--
7664-39-3	Hydrogen fluoride	ND	ND	1.4 E-01
193-39-5	Indeno[1,2,3-cd]pyrene ^h	3.6 E-06	6.2 E-07	--
78-59-1	Isophorone	ND	ND	2.1 E-03
7439-96-5	Manganese ^f	9.1 E-05	1.6 E-05	--
75-09-2	Methylene chloride ^g	1.8 E-03	3.2 E-04	--
91-57-6	2-Methylnaphthalene	ND	ND	2.1 E-03
95-48-7	2-Methylphenol	ND	ND	2.1 E-03
91-20-3	Naphthalene ^f	2.2E-05	3.8E-06	--
7440-02-0	Nickel	3.0 E-05	5.3 E-06	--
7697-37-2	Nitric acid ^g	ND	ND	1.4 E-01
100-01-6	4-Nitroaniline	ND	ND	4.1 E-03
98-95-3	Nitrobenzene	ND	ND	4.8 E-04
55-63-0	Nitroglycerin ^g	ND	ND	4.8 E-04
88-75-5	2-Nitrophenol	ND	ND	2.1 E-03
100-02-7	4-Nitrophenol	ND	ND	4.1 E-03
62-75-9	n-Nitrosodimethylamine	ND	ND	2.1 E-03
86-30-6	n-Nitrosodiphenylamine	ND	ND	2.1 E-03
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	2.1 E-03
1843-05-6	Octabenzene ^j	2.9 E-04	5.1 E-05	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	2.1 E-09	3.7 E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	9.6 E-11	1.7 E-11	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	8.1 E-12	1.4 E-12	--
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran ^k	2.2 E-11	3.9 E-12	--
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran ^k	2.0 E-11	3.5 E-12	--
87-86-5	Pentachlorophenol	ND	ND	4.1 E-03
85-01-8	Phenanthrene ^g	5.2E-06	9.0E-07	--
108-95-2	Phenol ^g	3.9E-05	6.7E-06	--
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene	ND	ND	9.6 E-01
129-00-0	Pyrene ^g	1.1E-05	1.9E-06	--
7782-49-2	Selenium	ND	ND	2.6 E-04

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
7440-22-4	Silver	1.2 E-06	2.2 E-07	--
100-42-5	Styrene	ND	ND	2.7 E-03
7664-93-9	Sulfuric acid	ND	ND	1.4 E-01
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin ^k	1.0 E-10	1.8 E-11	--
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran ^k	4.6 E-11	8.0 E-12	--
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	4.5 E-03
127-18-4	Tetrachloroethylene	ND	ND	4.6 E-03
7440-28-0	Thallium	ND	ND	7.8 E-05
108-88-3	Toluene ^g	2.5 E-05	4.4 E-06	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	4.6 E-03
71-55-6	1,1,1-Trichloroethane	0	0	--
79-00-5	1,1,2-Trichloroethane	ND	ND	3.9 E-03
79-01-6	Trichloroethylene	ND	ND	3.9 E-03
75-69-4	Trichlorofluoromethane	ND	ND	4.0 E-03
95-95-4	2,4,5-Trichlorophenol	ND	ND	2.1 E-03
88-06-2	2,4,6-Trichlorophenol	ND	ND	2.1 E-03
95-63-6	1,2,4-Trimethylbenzene	ND	ND	2.3 E-03
75-01-4	Vinyl chloride	ND	ND	5.1 E-03
75-35-4	Vinylidene chloride ^g	4.2 E-05	7.2 E-06	--
106-42-3 / 108-38-3	mXylene / p-Xylene ^g	ND	ND	2.3 E-03
95-47-6	ortho-Xylene ^g	ND	ND	2.5 E-03
7440-66-6	Zinc	2.9 E-03	5.1 E-04	--
Other Pollutants				
67-64-1	Acetone	0	0	--
74-86-2	Acetylene ^g	ND	ND	6.0 E-01
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	4.8 E-04
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	4.8 E-04
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
100-51-6	Benzyl alcohol	ND	ND	2.1 E-03
106-97-8	Butane	ND	ND	1.3
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	2.1 E-03
59-50-7	4-Chloro-3-methylphenol	ND	ND	2.1 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	3.3 E-03
10061-01-5	cis-1,3-Dichloropropene	ND	ND	3.4 E-03

TABLE A2 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb/item	lb/lb NEW ^d	
84-66-2	Diethylphthalate	ND	ND	2.1 E-03
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	2.1 E-03
74-84-0	Ethane	ND	ND	6.9 E-01
622-96-8	4-Ethyltoluene ^g	ND	ND	2.2 E-03
66-25-1	Hexaldehyde	ND	ND	4.2 E-02
149-57-5	Hexanoic acid, 2-ethyl ^l	2.7 E-05	4.7 E-06	--
104-76-7	1-Hexanol, 2-ethyl ^l	0	0	--
2691-41-0	HMX	ND	ND	9.7 E-04
10035-10-6	Hydrogen bromide	ND	ND	1.4 E-01
75-28-5	Isobutane	ND	ND	1.3
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
88-74-7	2-Nitroaniline	ND	ND	2.1 E-03
99-09-2	3-Nitroaniline	ND	ND	4.1 E-03
88-72-2	2-Nitrotoluene	ND	ND	4.8 E-04
99-08-1	3-Nitrotoluene	ND	ND	4.8 E-04
99-99-0	4-Nitrotoluene	ND	ND	4.8 E-04
78-11-5	Pentaerythritol tetranitrate	ND	ND	9.7 E-04
7664-38-2	Phosphoric acid	ND	ND	1.4 E-01
74-98-6	Propane	ND	ND	1.0
121-82-4	RDX	ND	ND	4.8 E-04
7704-34-9	Sulfur ^l	1.4 E-04	2.5 E-05	--
479-45-8	Tetryl	ND	ND	4.8 E-04
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.5 E-01
108-67-8	1,3,5-Trimethylbenzene	ND	ND	2.5 E-03
99-35-4	1,3,5-Trinitrobenzene	ND	ND	4.8 E-04
118-96-7	2,4,6-Trinitrotoluene ^g	ND	ND	4.8 E-04
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

^a CASRN = Chemical Abstracts Service Registry Number.

^b ND = nondetected.

^c

^d NEW = net explosive weight. The NEW for this ordnance is 5.75 pounds per item.

^e Data provided for compounds that were not detected.

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

TABLE A2 (cont.)

- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated “D” because the factor is based upon “C” rated test data.
- ^l Emission factor rated “D” because the compound was tentatively identified.

TABLE A3 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR DODIC D540, CONFIGURATION 3, M3A1, ZONE 3, M199 CANNON

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates				
124-38-9	Carbon dioxide ^f	7.6 E-01	2.2 E-01	--
630-08-0	Carbon monoxide ^f	2.0	5.8 E-01	--
7439-92-1	Lead ^g	2.5 E-04	7.1 E-05	--
74-82-8	Methane ^f	1.1 E-02	3.1 E-03	--
--	Oxides of nitrogen ^f	ND	ND	3.8 E-01
--	PM-2.5 ^g	2.5 E-02	7.0 E-03	--
--	PM-10 ^g	4.6 E-02	1.3 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^g	6.4 E-02	1.8 E-02	--
Toxic Chemicals and Hazardous Air Pollutants				
83-32-9	Acenaphthene ^g	7.0E-07	2.0E-07	--
208-96-8	Acenaphthylene ^f	6.1E-06	1.8E-06	--
75-07-0	Acetaldehyde ^g	ND	ND	1.8 E-02
75-05-8	Acetonitrile ^j	5.4 E-05	1.6 E-05	--
107-02-8	Acrolein	ND	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	8.6 E-05	2.5 E-05	--
107-05-1	Allyl chloride	ND	ND	2.8 E-03
7664-41-7	Ammonia ^f	4.4 E-02	1.3 E-02	--
120-12-7	Anthracene ^g	5.1 E-07	1.4 E-07	--
7440-36-0	Antimony	ND	ND	1.8 E-04
7440-38-2	Arsenic ^g	1.5 E-06	4.2 E-07	--
7440-39-3	Barium	3.1 E-05	8.9 E-06	--
71-43-2	Benzene ^g	7.4 E-04	2.1 E-04	--
56-55-3	Benzo[a]anthracene ^f	3.1E-07	8.8E-08	--
205-99-2	Benzo[b]fluoranthene ^g	1.1E-06	3.1E-07	--
207-08-9	Benzo[k]fluoranthene ^g	7.1E-07	2.0E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	4.9E-06	1.4E-06	--
50-32-8	Benzo[a]pyrene ^g	1.4E-06	4.0E-07	--
100-44-7	Benzyl chloride	ND	ND	5.2 E-03
7440-41-7	Beryllium	ND	ND	7.9 E-05
74-83-9	Bromomethane	ND	ND	3.1 E-03
101-55-3	4-Bromophenylphenylether	ND	ND	2.6 E-03
106-99-0	1,3-Butadiene	ND	ND	1.8 E-03

TABLE A3 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
85-68-7	Butylbenzylphthalate	ND	ND	2.6 E-03
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	7.9 E-07	2.3 E-07	--
56-23-5	Carbon tetrachloride	ND	ND	4.6 E-03
106-47-8	4-Chloroaniline	ND	ND	2.6 E-03
108-90-7	Chlorobenzene	ND	ND	2.4 E-04
75-00-3	Chloroethane	ND	ND	2.1 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	2.6 E-03
111-44-4	bis(2-Chloroethyl)ether	ND	ND	2.6 E-03
67-66-3	Chloroform	ND	ND	4.2 E-03
74-87-3	Chloromethane	ND	ND	1.6 E-03
91-58-7	2-Chloronaphthalene	ND	ND	2.6 E-03
95-57-8	2-Chlorophenol	ND	ND	2.6 E-03
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	2.6 E-03
7440-47-3	Chromium	8.7 E-06	2.5 E-06	--
218-01-9	Chrysene	3.8 E-07	1.1 E-07	--
7440-48-4	Cobalt	7.8 E-07	2.2 E-07	--
7440-50-8	Copper ^g	8.5 E-03	2.4 E-03	--
106-44-5	p-Cresol	ND	ND	2.6 E-03
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
57-12-5	Particulate cyanide	ND	ND	8.0 E-02
53-70-3	Dibenz[a,h]anthracene ⁱ	7.8 E-08	2.2 E-08	--
132-64-9	Dibenzofuran	ND	ND	2.6 E-03
106-93-4	1,2-Dibromoethane	ND	ND	5.9 E-03
84-74-2	Dibutyl phthalate	ND	ND	2.4 E-02
541-73-1	m-Dichlorobenzene	ND	ND	3.4 E-03
95-50-1	o-Dichlorobenzene	ND	ND	3.7 E-03
106-46-7	p-Dichlorobenzene	ND	ND	3.0 E-03
75-71-8	Dichlorodifluoromethane ^g	ND	ND	3.8 E-03
75-34-3	1,1-Dichloroethane	ND	ND	3.2 E-03
107-06-2	1,2-Dichloroethane ^g	ND	ND	3.5 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	2.6 E-03
78-87-5	1,2-Dichloropropane	ND	ND	3.5 E-03
10061-02-6	trans-1,3-Dichloropropene	ND	ND	2.9 E-03

TABLE A3 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
76-14-2	1,2-Dichlorotetrafluoroethane	ND	ND	4.8 E-03
105-67-9	2,4-Dimethylphenol	ND	ND	2.6 E-03
131-11-3	Dimethyl phthalate	ND	ND	2.6 E-03
99-65-0	1,3-Dinitrobenzene	ND	ND	4.8 E-04
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	2.6 E-03
51-28-5	2,4-Dinitrophenol	ND	ND	2.6 E-03
121-14-2	2,4-Dinitrotoluene	ND	ND	4.8 E-04
606-20-2	2,6-Dinitrotoluene	ND	ND	4.8 E-04
--	Total dioxin	6.4 E-10	1.8 E-10	--
122-39-4	Diphenyl amine	ND	ND	1.2 E-02
100-41-4	Ethylbenzene ^f	ND	ND	2.4 E-03
74-85-1	Ethylene ^f	ND	ND	6.4 E-01
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	2.4 E-02
206-44-0	Fluoranthene ^g	2.3E-06	6.5E-07	--
86-73-7	Fluorene ^f	2.4E-06	6.9E-07	--
50-00-0	Formaldehyde ^g	ND	ND	1.2 E-02
76-13-1	Freon-113 ^g	1.1 E-05	3.0 E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.2 E-10	3.4 E-11	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	7.9 E-12	2.3 E-12	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND	ND	2.5 E-10
118-74-1	Hexachlorobenzene	ND	ND	2.6 E-03
87-68-3	Hexachlorobutadiene	ND	ND	4.8 E-03
77-47-4	Hexachlorocyclopentadiene	ND	ND	2.6 E-03
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	4.5 E-10
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1.2 E-11	3.4 E-12	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.4 E-11	3.9 E-12	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	ND	ND	1.4 E-10
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	2.7 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	2.2 E-10
67-72-1	Hexachloroethane	ND	ND	2.6 E-03

TABLE A3 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
7647-01-0	Hydrochloric acid	ND	ND	1.3 E-01
74-90-8	Hydrogen cyanide ^g	4.7 E-03	1.4 E-03	--
7664-39-3	Hydrogen fluoride	ND	ND	1.4 E-01
193-39-5	Indeno[1,2,3-cd]pyrene ^h	2.5 E-06	7.1 E-07	--
78-59-1	Isophorone	ND	ND	2.6 E-03
7439-96-5	Manganese ^f	2.8 E-05	7.9 E-06	--
75-09-2	Methylene dichloride	2.6 E-03	7.5 E-04	--
91-57-6	2-Methylnaphthalene	ND	ND	2.6 E-03
95-48-7	2-Methylphenol	ND	ND	2.6 E-03
91-20-3	Naphthalene ^f	3.3 E-05	9.3 E-06	--
7440-02-0	Nickel	1.5 E-05	4.4 E-06	--
7697-37-2	Nitric acid ^g	ND	ND	1.4 E-01
100-01-6	4-Nitroaniline	ND	ND	2.6 E-03
98-95-3	Nitrobenzene	ND	ND	4.8 E-04
55-63-0	Nitroglycerin ^g	ND	ND	4.8 E-04
88-75-5	2-Nitrophenol	ND	ND	2.6 E-03
100-02-7	4-Nitrophenol	ND	ND	2.6 E-03
62-75-9	n-Nitrosodimethylamine	ND	ND	2.6 E-03
86-30-6	n-Nitrosodiphenylamine	ND	ND	2.6 E-03
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	2.6 E-03
1843-05-6	Octabenzene ^j	3.5 E-05	9.9 E-06	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	4.7 E-10	1.3 E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.6 E-11	4.5 E-12	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	4.3 E-12	1.2 E-12	--
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	2.8 E-10
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	ND	ND	1.5 E-10
87-86-5	Pentachlorophenol	ND	ND	2.6 E-03
85-01-8	Phenanthrene ^g	4.1E-06	1.2E-06	--
108-95-2	Phenol ^g	1.7E-04	5.0E-05	--
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene ^g	ND	ND	9.6 E-01
129-00-0	Pyrene ^g	5.5 E-06	1.6 E-06	--

TABLE A3 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
7782-49-2	Selenium	ND	ND	2.6 E-04
7440-22-4	Silver	5.1 E-07	1.4 E-07	--
100-42-5	Styrene	ND	ND	2.7 E-03
7664-93-9	Sulfuric acid	ND	ND	1.4 E-01
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND	ND	3.4 E-10
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	ND	ND	4.4 E-10
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	4.5 E-03
127-18-4	Tetrachloroethylene	ND	ND	4.6 E-03
7440-28-0	Thallium	ND	ND	7.9 E-05
108-88-3	Toluene ^g	3.6 E-05	1.0 E-05	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	4.6 E-03
71-55-6	1,1,1-Trichloroethane	0	0	--
79-00-5	1,1,2-Trichloroethane	ND	ND	3.9 E-03
79-01-6	Trichloroethylene	ND	ND	3.9 E-03
75-69-4	Trichlorofluoromethane	ND	ND	4.0 E-03
95-95-4	2,4,5-Trichlorophenol	ND	ND	2.6 E-03
88-06-2	2,4,6-Trichlorophenol	ND	ND	2.6 E-03
95-63-6	1,2,4-Trimethylbenzene	ND	ND	2.3 E-03
75-01-4	Vinyl chloride	ND	ND	5.1 E-03
75-35-4	Vinylidene chloride ^g	4.1 E-05	1.2 E-05	--
106-42-3 / 108-38-3	mXylene / p-Xylene ^g	ND	ND	2.3 E-03
95-47-6	ortho-Xylene ^g	ND	ND	2.5 E-03
7440-66-6	Zinc	1.8 E-03	5.2 E-04	--
Other Pollutants				
67-64-1	Acetone	0	0	--
74-86-2	Acetylene ^g	ND	ND	6.0 E-01
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	4.8 E-04
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	4.8 E-04
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
4748-78-1	Benzaldehyde, 4-ethyl ^k	3.8 E-05	1.1 E-05	--
100-51-6	Benzyl alcohol	ND	ND	2.6 E-03
106-97-8	Butane	ND	ND	1.3
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	2.6 E-03

TABLE A3 (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	2.6 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	3.3 E-03
10061-01-5	cis-1,3-Dichloropropene	ND	ND	3.4 E-03
84-66-2	Diethylphthalate	ND	ND	2.6 E-03
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	2.6 E-03
74-84-0	Ethane	ND	ND	6.9 E-01
622-96-8	4-Ethyltoluene ^g	ND	ND	2.2 E-03
66-25-1	Hexaldehyde	ND	ND	4.2 E-02
104-76-7	1-Hexanol, 2-ethyl- ^k	0	0	--
2691-41-0	HMX	ND	ND	9.6 E-04
10035-10-6	Hydrogen bromide	ND	ND	1.4 E-01
75-28-5	Isobutane	ND	ND	1.3
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
88-74-7	2-Nitroaniline	ND	ND	2.6 E-03
99-09-2	3-Nitroaniline	ND	ND	2.6 E-03
88-72-2	2-Nitrotoluene	ND	ND	4.8 E-04
99-08-1	3-Nitrotoluene	ND	ND	4.8 E-04
99-99-0	4-Nitrotoluene	ND	ND	4.8 E-04
78-11-5	Pentaerythritol tetranitrate	ND	ND	9.6 E-04
7664-38-2	Phosphoric acid	ND	ND	1.4 E-01
74-98-6	Propane	ND	ND	1.0
121-82-4	RDX	ND	ND	4.8 E-04
7704-34-9	Sulfur ^k	8.2 E-05	2.4 E-05	--
479-45-8	Tetryl	ND	ND	4.8 E-04
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.0 E-01
108-67-8	1,3,5-Trimethylbenzene	ND	ND	2.5 E-03
99-35-4	1,3,5-Trinitrobenzene ^g	ND	ND	4.8 E-04
118-96-7	2,4,6-Trinitrotoluene	ND	ND	4.8 E-04
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

TABLE A3 (cont.)

- ^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 3.50 pounds per item.
- ^e Data provided for compounds that were not detected.
- ^f Emission factor rated A because of correlation with emission factors for similar ordnance and number of test data points.
- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated "D" because the compound was tentatively identified.

TABLE A4 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR DODIC D540, CONFIGURATION 4, M3A1, ZONE 3, M284 CANNON

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates				
124-38-9	Carbon dioxide ^h	7.6 E-01	2.3 E-01	No Data
630-08-0	Carbon monoxide ^f	2.0	6.0 E-01	--
7439-92-1	Lead ^g	3.1 E-04	9.5 E-05	--
74-82-8	Methane ^f	8.6 E-03	2.6 E-03	--
--	Oxides of nitrogen ^f	2.4 E-02	7.4 E-03	--
--	PM-2.5 ^g	2.7 E-02	8.2 E-03	--
--	PM-10 ^g	5.1 E-02	1.5 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^g	5.9 E-02	1.8 E-02	--
Hazardous Air Pollutants and Toxic Chemicals				
83-32-9	Acenaphthene ^g	1.8 E-06	5.5 E-07	--
208-96-8	Acenaphthylene ^f	7.8 E-06	2.4 E-06	--
75-07-0	Acetaldehyde ^g	ND	ND	1.8 E-02
75-05-8	Acetonitrile ^j	8.7 E-05	2.6 E-05	--
107-02-8	Acrolein	ND	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	1.1 E-04	3.5 E-05	--
107-05-1	Allyl chloride	ND	ND	2.8 E-03
7664-41-7	Ammonia ^f	4.4 E-02	1.3 E-02	--
120-12-7	Anthracene ^g	7.8 E-07	2.4 E-07	--
7440-36-0	Antimony	ND	ND	1.9 E-04
7440-38-2	Arsenic ^g	3.7 E-06	1.1 E-06	--
7440-39-3	Barium	3.7 E-05	1.1 E-05	--
71-43-2	Benzene ^g	6.3 E-04	1.9 E-04	--
56-55-3	Benzo[a]anthracene ^f	5.2 E-07	1.6 E-07	--
205-99-2	Benzo[b]fluoranthene ^g	1.1 E-06	3.4 E-07	--
207-08-9	Benzo[k]fluoranthene ^g	9.5 E-07	2.9 E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	6.7 E-06	2.0 E-06	--
50-32-8	Benzo[a]pyrene ^g	1.8 E-06	5.5 E-07	--
100-44-7	Benzyl chloride	ND	ND	5.2 E-03
7440-41-7	Beryllium	ND	ND	7.9 E-05
74-83-9	Bromomethane	ND	ND	3.1 E-03
101-55-3	4-Bromophenyl phenylether	ND	ND	2.3 E-03

TABLE A4 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
106-99-0	1,3-Butadiene	ND	ND	1.8 E-03
85-68-7	Butylbenzylphthalate	ND	ND	2.3 E-03
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	ND	ND	7.9 E-05
56-23-5	Carbon tetrachloride	ND	ND	4.6 E-03
106-47-8	4-Chloroaniline	ND	ND	2.3 E-02
108-90-7	Chlorobenzene	ND	ND	2.4 E-04
75-00-3	Chloroethane	ND	ND	2.1 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	2.3 E-03
111-44-4	bis(2-Chloroethyl)ether	ND	ND	2.3 E-03
67-66-3	Chloroform	ND	ND	4.2 E-03
74-87-3	Chloromethane	ND	ND	1.6 E-03
91-58-7	2-Chloronaphthalene	ND	ND	2.3 E-03
95-57-8	2-Chlorophenol	ND	ND	2.3 E-03
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	2.3 E-03
7440-47-3	Chromium	6.5 E-06	2.0 E-06	--
218-01-9	Chrysene	5.0 E-07	1.5 E-07	--
7440-48-4	Cobalt	1.1 E-06	3.4 E-07	--
7440-50-8	Copper ^g	3.4 E-03	1.0 E-03	--
106-44-5	p-Cresol	ND	ND	2.3 E-03
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
57-12-5	Particulate cyanide	ND	ND	8.1 E-02
53-70-3	Dibenz[a,h]anthracene ⁱ	7.0 E-08	2.1 E-08	--
132-64-9	Dibenzofuran	ND	ND	2.3 E-03
106-93-4	1,2-Dibromoethane	ND	ND	5.9 E-03
84-74-2	Dibutyl phthalate	ND	ND	2.4 E-02
541-73-1	m-Dichlorobenzene	ND	ND	3.4 E-03
95-50-1	o-Dichlorobenzene	ND	ND	3.7 E-03
106-46-7	p-Dichlorobenzene	ND	ND	3.0 E-03
75-71-8	Dichlorodifluoromethane ^g	ND	ND	3.8 E-03
75-34-3	1,1-Dichloroethane	ND	ND	3.2 E-03
107-06-2	1,2-Dichloroethane ^g	ND	ND	3.5 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	2.3 E-03
78-87-5	1,2-Dichloropropane	ND	ND	3.5 E-03

TABLE A4 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
10061-02-6	trans-1,3-Dichloropropene	ND	ND	2.9 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	4.8 E-03
105-67-9	2,4-Dimethylphenol	ND	ND	2.3 E-03
131-11-3	Dimethyl phthalate	ND	ND	2.3 E-03
99-65-0	1,3-Dinitrobenzene	ND	ND	4.7 E-04
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	4.7 E-03
51-28-5	2,4-Dinitrophenol	ND	ND	4.7 E-03
121-14-2	2,4-Dinitrotoluene	ND	ND	4.7 E-04
606-20-2	2,6-Dinitrotoluene	ND	ND	4.7 E-04
--	Total dioxin/furan compounds	7.4 E-10	2.2 E-10	--
122-39-4	Diphenyl amine	ND	ND	1.2 E-02
100-41-4	Ethylbenzene ^f	ND	ND	2.4 E-03
74-85-1	Ethylene ^f	ND	ND	6.4 E-01
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	2.4 E-02
206-44-0	Fluoranthene ^g	2.6 E-06	8.0 E-07	--
86-73-7	Fluorene ^f	2.8 E-06	8.4 E-07	--
50-00-0	Formaldehyde ^g	ND	ND	1.2 E-02
76-13-1	Freon-113 ^g	1.5 E-05	4.7 E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	7.3 E-11	2.2 E-11	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.5 E-11	7.5 E-12	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND	ND	2.7 E-10
118-74-1	Hexachlorobenzene	ND	ND	2.3 E-03
87-68-3	Hexachlorobutadiene	ND	ND	4.8 E-03
77-47-4	Hexachlorocyclopentadiene	ND	ND	2.3 E-03
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	4.8 E-10
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	5.6 E-12	1.7 E-12	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	3.2 E-12	9.9 E-13	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran ^k	1.8 E-12	5.5 E-13	--
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	2.8 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	2.3 E-10

TABLE A4 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
67-72-1	Hexachloroethane	ND	ND	2.3 E-03
7647-01-0	Hydrochloric acid	ND	ND	1.3 E-01
74-90-8	Hydrogen cyanide ^g	1.8 E-02	5.4 E-03	--
7664-39-3	Hydrogen fluoride	ND	ND	1.4 E-01
193-39-5	Indeno[1,2,3-cd]pyrene ^h	2.8 E-06	8.6 E-07	--
78-59-1	Isophorone	ND	ND	2.3 E-03
7439-96-5	Manganese ^f	2.6 E-05	7.9 E-06	--
75-09-2	Methylene dichloride	3.1 E-03	9.6 E-04	--
91-57-6	2-Methylnaphthalene	ND	ND	2.3 E-03
95-48-7	2-Methylphenol	ND	ND	2.3 E-03
91-20-3	Naphthalene ^f	4.8 E-05	1.5 E-05	--
7440-02-0	Nickel	1.1 E-05	3.4 E-06	--
7697-37-2	Nitric acid ^g	6.5 E-05	2.0 E-05	--
100-01-6	4-Nitroaniline	ND	ND	4.7 E-03
98-95-3	Nitrobenzene	ND	ND	4.7 E-04
55-63-0	Nitroglycerin ^g	ND	ND	4.7 E-04
88-75-5	2-Nitrophenol	ND	ND	2.3 E-03
100-02-7	4-Nitrophenol	ND	ND	4.7 E-03
62-75-9	n-Nitrosodimethylamine	ND	ND	2.3 E-03
86-30-6	n-Nitrosodiphenylamine	ND	ND	2.3 E-03
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	2.3 E-03
1843-05-6	Octabenzene ^l	1.4 E-05	4.2 E-06	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	5.8 E-10	1.8 E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	3.0 E-11	9.2 E-12	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND	ND	2.6 E-10
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	2.8 E-10
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran ^k	1.9 E-12	5.9 E-13	--
87-86-5	Pentachlorophenol	ND	ND	4.7 E-03
85-01-8	Phenanthrene ^g	5.1 E-06	1.5 E-06	--
108-95-2	Phenol ^g	1.8 E-05	5.4 E-06	--
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene ^g	ND	ND	9.6 E-01

TABLE A4 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
129-00-0	Pyrene ^g	7.4 E-06	2.3 E-06	--
7782-49-2	Selenium	ND	ND	2.6 E-04
7440-22-4	Silver	ND	ND	5.3 E-05
100-42-5	Styrene	ND	ND	2.7 E-03
7664-93-9	Sulfuric acid ^k	2.4 E-03	7.2 E-04	--
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.0 E-11	3.1 E-12	--
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	6.6 E-12	2.0 E-12	--
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	4.5 E-03
127-18-4	Tetrachloroethylene	ND	ND	4.6 E-03
7440-28-0	Thallium	ND	ND	7.9 E-05
108-88-3	Toluene ^g	8.3 E-06	2.5 E-06	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	4.6 E-03
71-55-6	1,1,1-Trichloroethane	3.0 E-04	9.2 E-05	--
79-00-5	1,1,2-Trichloroethane	ND	ND	3.9 E-03
79-01-6	Trichloroethylene	ND	ND	3.9 E-03
75-69-4	Trichlorofluoromethane	ND	ND	4.0 E-03
95-95-4	2,4,5-Trichlorophenol	ND	ND	2.3 E-03
88-06-2	2,4,6-Trichlorophenol	ND	ND	2.3 E-03
95-63-6	1,2,4-Trimethylbenzene	ND	ND	2.3 E-03
75-01-4	Vinyl chloride	ND	ND	5.1 E-03
75-35-4	Vinylidene chloride ^g	4.5 E-05	1.4 E-05	--
106-42-3, 108-38-3	m-Xylene, p-Xylene ^g	ND	ND	2.3 E-03
95-47-6	o-Xylene ^g	ND	ND	2.5 E-03
7440-66-6	Zinc	6.0 E-04	1.8 E-04	--
Other Pollutants				
67-64-1	Acetone	0	0	--
74-86-2	Acetylene ^g	ND	ND	6.0 E-01
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	4.7 E-04
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	4.7 E-04
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
100-51-6	Benzyl alcohol	ND	ND	2.3 E-03
106-97-8	Butane	ND	ND	1.3
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	2.3 E-03

TABLE A4 (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	2.3 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	3.3 E-03
10061-01-5	cis-1,3-Dichloropropene	ND	ND	3.4 E-03
84-66-2	Diethylphthalate	ND	ND	2.3 E-03
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	2.3 E-03
74-84-0	Ethane	ND	ND	6.9 E-01
622-96-8	4-Ethyltoluene ^g	ND	ND	2.2 E-03
66-25-1	Hexaldehyde	ND	ND	4.2 E-02
104-76-7	1-Hexanol, 2-ethyl ^l	0	0	--
2691-41-0	HMX	ND	ND	9.5 E-04
10035-10-6	Hydrogen bromide	ND	ND	1.4 E-01
75-28-5	Isobutane	ND	ND	1.3
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
88-74-7	2-Nitroaniline	ND	ND	2.3 E-03
99-09-2	3-Nitroaniline	ND	ND	4.7 E-03
88-72-2	2-Nitrotoluene	ND	ND	4.7 E-04
99-08-1	3-Nitrotoluene	ND	ND	4.7 E-04
99-99-0	4-Nitrotoluene	ND	ND	4.7 E-04
10544-50-0	Octasulfur ^l	5.6 E-05	1.7 E-05	--
78-11-5	Pentaerythritol tetranitrate	ND	ND	9.5 E-04
7664-38-2	Phosphoric acid	ND	ND	1.4 E-01
74-98-6	Propane	ND	ND	1.0E
121-82-4	RDX	ND	ND	4.7 E-04
479-45-8	Tetryl	ND	ND	4.7 E-04
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.0 E-01
108-67-8	1,3,5-Trimethylbenzene	ND	ND	2.5 E-03
99-35-4	1,3,5-Trinitrobenzene	ND	ND	4.7 E-04
118-96-7	2,4,6-Trinitrotoluene ^g	ND	ND	4.7 E-04
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

TABLE A4 (cont.)

- ^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 3.28 pounds per item.
- ^e Data provided for compounds that were not detected.
- ^f Emission factor rated A because of correlation with emission factors for similar ordnance and number of test data points.
- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated "D" because the factor is based upon "C" rated test data.
- ^l Emission factor rated "D" because the compound was tentatively identified.

TABLE A5 COMPOUNDS ANALYZED AND EMISSION FACTORS DEVELOPED FOR
DODIC D540, CONFIGURATION 5, M3A1, ZONE 3, M284 CANNON

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates				
124-38-9	Carbon dioxide ^f	7.2E-01	2.1 E-01	--
630-08-0	Carbon monoxide ^f	1.9	5.5 E-01	--
7439-92-1	Lead ^g	1.9 E-04	5.5 E-05	--
74-82-8	Methane ^f	9.7 E-03	2.8 E-03	--
--	Oxides of nitrogen ^f	5.3 E-02	1.5 E-02	--
--	PM-2.5 ^g	3.4 E-02	9.8 E-03	--
--	PM-10 ^g	6.1 E-02	1.7 E-02	--
7446-09-5	Sulfur dioxide	ND	ND	5.3 E-01
12789-66-1	Total suspended particulate ^g	6.9 E-02	2.0 E-02	--
Hazardous Air Pollutants and Toxic Chemicals				
83-32-9	Acenaphthene ^g	ND	ND	2.2 E-03
208-96-8	Acenaphthylene ^f	6.5 E-06	1.9 E-06	--
75-07-0	Acetaldehyde ^g	ND	ND	1.8 E-02
75-05-5	Acetonitrile ^j	1.4 E-04	4.1 E-05	--
107-02-8	Acrolein	ND	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	4.6 E-04	1.3 E-04	--
107-05-1	Allyl chloride	ND	ND	2.8 E-03
7664-41-7	Ammonia ^f	6.4 E-02	1.8 E-02	--
120-12-7	Anthracene ^g	5.6 E-07	1.6 E-07	--
7440-36-0	Antimony	ND	ND	1.9 E-04
7440-38-2	Arsenic ^g	2.4 E-06	6.8 E-07	--
7440-39-3	Barium	5.4 E-05	1.6 E-05	--
71-43-2	Benzene ^g	6.9 E-04	2.0 E-04	--
56-55-3	Benzo[a]anthracene ^f	3.5 E-07	1.0 E-07	--
205-99-2	Benzo[b]fluoranthene ^g	9.4 E-07	2.7 E-07	--
207-08-9	Benzo[k]fluoranthene ^g	5.8 E-07	1.7 E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	3.4 E-06	9.8 E-07	--
50-32-8	Benzo[a]pyrene ^g	1.4 E-06	4.0 E-07	--
100-44-7	Benzyl chloride	ND	ND	5.2 E-03
7440-41-7	Beryllium	ND	ND	8.2 E-05
74-83-9	Bromomethane	ND	ND	3.1 E-03
101-55-3	4-Bromophenyl phenylether	ND	ND	2.2 E-03

TABLE A5 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
106-99-0	1,3-Butadiene	ND	ND	1.8 E-03
85-68-7	Butylbenzylphthalate	ND	ND	2.2 E-03
123-72-8	Butyraldehyde	ND	ND	3.0 E-02
7440-43-9	Cadmium	ND	ND	8.2 E-05
56-23-5	Carbon tetrachloride	ND	ND	4.6 E-03
106-47-8	4-Chloroaniline	ND	ND	2.2 E-02
108-90-7	Chlorobenzene	ND	ND	2.4 E-04
75-00-3	Chloroethane	ND	ND	2.1 E-03
111-91-1	bis(2-Chloroethoxy)methane	ND	ND	2.2 E-03
111-44-4	bis(2-Chloroethyl)ether	ND	ND	2.2 E-03
67-66-3	Chloroform	ND	ND	4.2 E-03
74-87-3	Chloromethane	ND	ND	1.6 E-03
91-58-7	2-Chloronaphthalene	ND	ND	2.2 E-03
95-57-8	2-Chlorophenol	ND	ND	2.2 E-03
7005-72-3	4-Chlorophenyl-phenylether	ND	ND	2.2 E-03
7440-47-3	Chromium	5.0 E-06	1.4 E-06	--
218-01-9	Chrysene	3.5 E-07	1.0 E-07	--
7440-48-4	Cobalt	7.7 E-07	2.2 E-07	--
7440-50-8	Copper	2.7 E-03	7.6 E-04	--
106-44-5	p-Cresol	ND	ND	2.2 E-03
4170-30-3	Crotonaldehyde	ND	ND	2.9 E-02
57-12-5	Particulate cyanide	ND	ND	8.1 E-02
53-70-3	Dibenz[a,h]anthracene ⁱ	6.8 E-08	2.0 E-08	--
132-64-9	Dibenzofuran	ND	ND	2.2 E-03
106-93-4	1,2-Dibromoethane	ND	ND	5.9 E-03
84-74-2	Dibutyl phthalate	ND	ND	2.4 E-02
541-73-1	m-Dichlorobenzene	ND	ND	3.4 E-03
95-50-1	o-Dichlorobenzene	ND	ND	3.7 E-03
106-46-7	p-Dichlorobenzene	ND	ND	3.0 E-03
75-71-8	Dichlorodifluoromethane ^g	ND	ND	3.8 E-03
75-34-3	1,1-Dichloroethane	ND	ND	3.2 E-03
107-06-2	1,2-Dichloroethane ^g	ND	ND	3.5 E-03
120-83-2	2,4-Dichlorophenol	ND	ND	2.2 E-03
78-87-5	1,2-Dichloropropane	ND	ND	3.5 E-03

TABLE A5 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
10061-02-6	trans-1,3-Dichloropropene	ND	ND	2.9 E-03
76-14-2	Dichlorotetrafluoroethane	ND	ND	4.8 E-03
105-67-9	2,4-Dimethylphenol	ND	ND	2.2 E-03
131-11-3	Dimethyl phthalate	ND	ND	2.2 E-03
99-65-0	1,3-Dinitrobenzene	ND	ND	4.8 E-04
534-52-1	4,6-Dinitro-2-methylphenol	ND	ND	4.4 E-03
51-28-5	2,4-Dinitrophenol	ND	ND	4.4 E-03
121-14-2	2,4-Dinitrotoluene	ND	ND	4.8 E-04
606-20-2	2,6-Dinitrotoluene	ND	ND	4.8 E-04
--	Total dioxin/furan compounds	7.0 E-10	2.0 E-10	--
122-39-4	Diphenyl amine	ND	ND	1.2 E-02
100-41-4	Ethyl benzene ^f	ND	ND	2.4 E-03
74-85-1	Ethylene ^f	ND	ND	6.4 E-01
117-81-7	bis(2-Ethylhexyl)phthalate	ND	ND	2.4 E-02
206-44-0	Fluoranthene ^g	1.9 E-06	5.5 E-07	--
86-73-7	Fluorene ^f	2.5 E-07	7.1 E-08	--
50-00-0	Formaldehyde ^g	ND	ND	1.2 E-02
76-13-1	Freon-113 ^g	1.0 E-05	2.9 E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.1 E-10	3.2 E-11	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	7.9 E-12	2.3 E-12	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	ND	ND	3.2 E-10
118-74-1	Hexachlorobenzene	ND	ND	2.2 E-03
87-68-3	Hexachlorobutadiene	ND	ND	4.8 E-03
77-47-4	Hexachlorocyclopentadiene	ND	ND	2.2 E-03
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ND	ND	5.4 E-10
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	9.5 E-12	2.7 E-12	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.1 E-11	3.1 E-12	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	ND	ND	1.8 E-10
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	ND	3.1 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	ND	ND	2.6 E-10

TABLE A5 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
67-72-1	Hexachloroethane	ND	ND	2.2 E-03
7647-01-0	Hydrochloric acid	ND	ND	1.3 E-01
74-90-8	Hydrogen cyanide ^g	1.1 E-02	3.2 E-03	--
7664-39-3	Hydrogen fluoride	ND	ND	1.4 E-01
193-39-5	Indeno[1,2,3-cd]pyrene ^h	1.9 E-06	5.6 E-07	--
78-59-1	Isophorone	ND	ND	2.2 E-03
7439-96-5	Manganese ^f	1.6 E-05	4.7 E-06	--
75-09-2	Methylene chloride ^g	2.1 E-03	6.0 E-04	--
91-57-6	2-Methylnaphthalene	ND	ND	2.2 E-03
95-48-7	2-Methylphenol	ND	ND	2.2 E-03
91-20-3	Naphthalene ^f	4.0 E-05	1.1 E-05	--
7440-02-0	Nickel	7.8 E-06	2.2 E-06	--
7697-37-2	Nitric acid ^g	2.5 E-04	7.1 E-05	--
100-01-6	4-Nitroaniline	ND	ND	4.4 E-03
98-95-3	Nitrobenzene	ND	ND	4.8 E-04
55-63-0	Nitroglycerin ^g	ND	ND	4.8 E-04
88-75-5	2-Nitrophenol	ND	ND	2.2 E-03
100-02-7	4-Nitrophenol	ND	ND	4.4 E-03
62-75-9	n-Nitrosodimethylamine	ND	ND	2.2 E-03
86-30-6	n-Nitrosodiphenylamine	ND	ND	2.2 E-03
621-64-7	n-Nitroso-di-n-propylamine	ND	ND	2.2 E-03
1843-05-6	Octabenzene ^j	6.9 E-05	2.0 E-05	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	5.4 E-10	1.5 E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.7 E-11	4.8 E-12	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ND	ND	3.3 E-10
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	ND	ND	3.4 E-10
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	ND	ND	2.0 E-10
87-86-5	Pentachlorophenol	ND	ND	4.4 E-03
85-01-8	Phenanthrene ^g	1.9 E-06	5.5 E-07	--
108-95-2	Phenol ^g	1.2 E-04	3.4 E-05	--
123-38-6	Propionaldehyde	ND	ND	2.4 E-02
115-07-1	Propylene ^g	ND	ND	9.6 E-01

TABLE A5 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
129-00-0	Pyrene ^g	3.9 E-06	1.1 E-06	--
7782-49-2	Selenium	ND	ND	2.7 E-04
7440-22-4	Silver	ND	ND	5.4 E-05
100-42-5	Styrene	ND	ND	2.7 E-03
7664-93-9	Sulfuric acid	3.7 E-03	1.1 E-03	--
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND	ND	4.3 E-10
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	ND	ND	1.2 E-10
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	4.5 E-03
127-18-4	Tetrachloroethylene	ND	ND	4.6 E-03
7440-28-0	Thallium	ND	ND	8.2 E-05
108-88-3	Toluene ^g	4.5 E-05	1.3 E-05	--
120-82-1	1,2,4-Trichlorobenzene	ND	ND	4.6 E-03
71-55-6	1,1,1-Trichloroethane	8.8 E-04	2.5 E-04	--
79-00-5	1,1,2-Trichloroethane	ND	ND	3.9 E-03
79-01-6	Trichloroethylene	ND	ND	3.9 E-03
75-69-4	Trichlorofluoromethane	ND	ND	4.0 E-03
95-95-4	2,4,5-Trichlorophenol	ND	ND	2.2 E-03
88-06-2	2,4,6-Trichlorophenol	ND	ND	2.2 E-03
95-63-6	1,2,4-Trimethylbenzene	ND	ND	2.3 E-03
75-01-4	Vinyl chloride ^g	ND	ND	5.1 E-03
75-35-4	Vinylidene chloride	4.1 E-05	1.2 E-05	--
106-42-3, 108-38-3	m-Xylene, p-Xylene ^g	ND	ND	2.3 E-03
95-47-6	o-Xylene ^g	ND	ND	2.5 E-03
7440-66-6	Zinc	5.0 E-04	1.4 E-04	--
Other Pollutants				
67-64-1	Acetone	0	0	--
74-86-2	Acetylene ^g	ND	ND	6.0 E-01
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	4.8 E-04
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	4.8 E-04
100-52-7	Benzaldehyde	ND	ND	4.4 E-02
4748-78-1	Benzaldehyde, 4-ethyl ^k	4.1 E-05	1.2 E-05	--
100-51-6	Benzyl alcohol	ND	ND	2.2 E-03
106-97-8	Butane	ND	ND	1.3

TABLE A5 (cont.)

CASRN ^a	Compound	Emission Factor ^{b,c}		Minimum Detection Level mg/m ^{3,e}
		lb per item	lb per lb NEW ^d	
39638-32-9	bis(2-Chloroisopropyl)ether	ND	ND	2.2 E-03
59-50-7	4-Chloro-3-methylphenol	ND	ND	2.2 E-03
156-59-2	cis-1,2-Dichloroethene	ND	ND	3.3 E-03
10061-01-5	cis-1,3-Dichloropropene	ND	ND	3.4 E-03
84-66-2	Diethylphthalate	ND	ND	2.2 E-03
5779-94-2	2,5-Dimethylbenzaldehyde	ND	ND	5.6 E-02
117-84-0	Di-n-octylphthalate	ND	ND	2.2 E-03
74-84-0	Ethane	ND	ND	6.9 E-01
622-96-8	4-Ethyltoluene ^g	ND	ND	2.2 E-03
66-25-1	Hexaldehyde	ND	ND	4.2 E-02
104-76-7	1-Hexanol, 2-ethyl ^k	5.9 E-05	1.7 E-05	--
2691-41-0	HMX	ND	ND	9.6 E-04
10035-10-6	Hydrogen bromide	ND	ND	1.4 E-01
75-28-5	Isobutane	ND	ND	1.3
590-86-3	Isovaleraldehyde	ND	ND	3.6 E-02
88-74-7	2-Nitroaniline	ND	ND	2.2 E-03
99-09-2	3-Nitroaniline	ND	ND	4.4 E-03
88-72-2	2-Nitrotoluene	ND	ND	4.8 E-04
99-08-1	3-Nitrotoluene	ND	ND	4.8 E-04
99-99-0	4-Nitrotoluene	ND	ND	4.8 E-04
78-11-5	Pentaerythritol tetranitrate	ND	ND	9.6 E-04
7664-38-2	Phosphoric acid	ND	ND	1.4 E-01
74-98-6	Propane	ND	ND	1.0
121-82-4	RDX	ND	ND	4.8 E-04
479-45-8	Tetryl	ND	ND	4.8 E-04
1334-78-7	o,m,p-Tolualdehyde	ND	ND	1.0 E-01
108-67-8	1,3,5-Trimethylbenzene	ND	ND	2.5 E-03
99-35-4	1,3,5-Trinitrobenzene	ND	ND	4.8 E-04
118-96-7	2,4,6-Trinitrotoluene ^g	ND	ND	4.8 E-04
110-62-3	Valeraldehyde	ND	ND	3.6 E-02

TABLE A5 (cont.)

- ^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 3.50 pounds per item.
- ^e Data provided for compounds that were not detected.
- ^f Emission factor rated A because of correlation with emission factors for similar ordnance and number of test data points.
- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated "D" because the compound was tentatively identified.

TABLE A6 AVERAGE EMISSION FACTORS DEVELOPED FOR
DODIC D540, 155-MM PROPELLING CHARGE

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
Carbon Dioxide, Methane, Criteria Pollutants, and Total Suspended Particulates			
124-38-9	Carbon dioxide ^f	2.1E-01	--
630-08-0	Carbon monoxide ^f	5.7E-01	--
7439-92-1	Lead ^g	7.3E-05	--
74-82-8	Methane ^f	3.1E-03	--
--	Oxides of nitrogen ^f	4.6E-02	--
--	PM-2.5 ^g	7.8E-03	--
--	PM-10 ^g	1.6E-02	--
7446-09-5	Sulfur dioxide	ND	1.8E-03
12789-66-1	Total suspended particulate ^g	2.1E-02	--
Hazardous Air Pollutants and Toxic Chemicals			
83-32-9	Acenaphthene ^g	2.2 E-06	--
208-96-8	Acenaphthylene ^f	1.7 E-06	--
75-07-0	Acetaldehyde ^g	ND	1.8 E-02
75-05-5	Acetonitrile ^j	2.3 E-05	--
107-02-8	Acrolein	ND	2.3 E-02
107-13-1	Acrylonitrile ^j	4.3 E-05	--
107-05-1	Allyl chloride	ND	2.8 E-03
7664-41-7	Ammonia ^f	1.5 E-02	--
120-12-7	Anthracene ^g	1.7 E-07	--
7440-36-0	Antimony	5.6 E-07	--
7440-38-2	Arsenic ^g	9.8 E-07	--
7440-39-3	Barium	1.7 E-05	--
71-43-2	Benzene ^g	2.0 E-04	--
56-55-3	Benzo[a]anthracene ^f	1.2E-07	--
205-99-2	Benzo[b]fluoranthene ^g	2.8E-07	--
207-08-9	Benzo[k]fluoranthene ^g	2.6E-07	--
191-24-2	Benzo[g,h,i]perylene ^g	1.7E-06	--
50-32-8	Benzo[a]pyrene ^f	4.6E-07	--
100-44-7	Benzyl chloride	ND	1.8E-05
7440-41-7	Beryllium	ND	2.8E-07
74-83-9	Bromomethane	ND	1.1E-05
101-55-3	4-Bromophenylphenylether	ND	7.8E-06
106-99-0	1,3-Butadiene	ND	6.4E-06

TABLE A6 (cont.)

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
85-68-7	Butylbenzylphthalate	ND	7.8E-06
123-72-8	Butyraldehyde	ND	1.1E-04
7440-43-9	Cadmium	1.6E-05	--
56-23-5	Carbon tetrachloride	ND	1.6E-05
106-47-8	4-Chloroaniline	ND	9.1E-06
108-90-7	Chlorobenzene	ND	8.3E-07
75-00-3	Chloroethane	ND	7.6E-06
111-91-1	bis(2-Chloroethoxy)methane	ND	7.8E-06
111-44-4	bis(2-Chloroethyl)ether	ND	7.8E-06
67-66-3	Chloroform	ND	1.5E-05
74-87-3	Chloromethane	ND	5.7E-06
91-58-7	2-Chloronaphthalene	ND	7.8E-06
95-57-8	2-Chlorophenol	ND	7.8E-06
7005-72-3	4-Chlorophenyl-phenylether	ND	7.8E-06
7440-47-3	Chromium	2.8 E-06	--
218-01-9	Chrysene	1.3 E-07	--
7440-48-4	Cobalt	3.2 E-07	--
7440-50-8	Copper ^g	2.3 E-03	--
106-44-5	p-Cresol	ND	7.8E-06
4170-30-3	Crotonaldehyde	ND	1.0E-04
57-12-5	Particulate cyanide	1.7 E-04	--
53-70-3	Dibenz[a,h]anthracene ⁱ	2.4 E-08	--
132-64-9	Dibenzofuran	ND	7.8E-06
106-93-4	1,2-Dibromoethane	ND	2.1E-05
84-74-2	Dibutyl phthalate	ND	8.5E-05
541-73-1	m-Dichlorobenzene	ND	1.3E-05
95-50-1	o-Dichlorobenzene	ND	1.2E-05
106-46-7	p-Dichlorobenzene	ND	1.1E-05
75-71-8	Dichlorodifluoromethane ^g	ND	1.4E-05
75-34-3	1,1-Dichloroethane	ND	1.1E-05
107-06-2	1,2-Dichloroethane ^g	ND	1.2E-05
120-83-2	2,4-Dichlorophenol	ND	7.8E-06
78-87-5	1,2-Dichloropropane	ND	1.2E-05
10061-02-6	trans-1,3-Dichloropropene	ND	1.0E-05

TABLE A6 (cont.)

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
76-14-2	Dichlorotetrafluoroethane	ND	1.7E-05
105-67-9	2,4-Dimethylphenol	ND	7.8E-06
131-11-3	Dimethyl phthalate	ND	7.8E-06
99-65-0	1,3-Dinitrobenzene	ND	1.7E-06
534-52-1	4,6-Dinitro-2-methylphenol	ND	9.1E-06
51-28-5	2,4-Dinitrophenol	ND	9.1E-06
121-14-2	2,4-Dinitrotoluene	ND	1.7E-06
606-20-2	2,6-Dinitrotoluene	ND	1.7E-06
--	Total dioxin/furan compounds	8.3 E-10	--
122-39-4	Diphenyl amine	ND	4.2E-05
111-90-0	2-(2-Ethoxyethoxy)ethanol ^k	1.3E-05	--
100-41-4	Ethylbenzene ^f	ND	8.4E-06
74-85-1	Ethylene ^f	ND	2.3E-03
117-81-7	bis(2-Ethylhexyl)phthalate	ND	8.5E-05
206-44-0	Fluoranthene ^g	7.5E-07	--
86-73-7	Fluorene ^f	5.0E-07	--
50-00-0	Formaldehyde ^g	ND	4.4E-05
76-13-1	Freon 113 ^g	2.8E-06	--
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.2E-10	--
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.1E-11	--
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	8.5E-11	--
118-74-1	Hexachlorobenzene	ND	7.8E-06
87-68-3	Hexachlorobutadiene	ND	1.7E-05
77-47-4	Hexachlorocyclopentadiene	ND	7.8E-06
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.5E-10	--
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	7.5E-12	--
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	6.3E-12	--
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	3.3E-11	--
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	ND	9.5E-13
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	7.1E-11	--

TABLE A6 (cont.)

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
67-72-1	Hexachloroethane	ND	7.8E-06
7647-01-0	Hydrochloric acid	ND	4.6E-04
74-90-8	Hydrogen cyanide ^g	3.4E-03	--
7664-39-3	Hydrogen fluoride	ND	5.0E-04
193-39-5	Indeno[1,2,3-cd]pyrene ^h	7.7E-07	--
78-59-1	Isophorone	ND	7.8E-06
7439-96-5	Manganese ^f	1.0E-05	--
75-09-2	Methylene chloride ^g	6.4E-04	--
91-57-6	2-Methylnaphthalene	ND	7.8E-06
95-48-7	2-Methylphenol	ND	7.8E-06
91-20-3	Naphthalene ^f	1.0E-05	--
7440-02-0	Nickel	4.9E-06	--
7697-37-2	Nitric acid ^g	1.4E-02	--
100-01-6	4-Nitroaniline	ND	9.1E-06
98-95-3	Nitrobenzene	ND	1.7E-06
55-63-0	Nitroglycerin ^g	ND	1.7E-06
88-75-5	2-Nitrophenol	ND	7.8E-06
100-02-7	4-Nitrophenol	ND	9.1E-06
62-75-9	n-Nitrosodimethylamine	ND	7.8E-06
86-30-6	n-Nitrosodiphenylamine	ND	7.8E-06
621-64-7	n-Nitroso-di-n-propylamine	ND	7.8E-06
1843-05-6	Octabenzene ⁱ	2.7E-05	--
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	6.6E-10	--
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	1.6E-11	--
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	6.0E-11	--
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	9.0E-11	--
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	3.6E-11	--
87-86-5	Pentachlorophenol	ND	9.1E-06
85-01-8	Phenanthrene ^g	1.2E-06	--
108-95-2	Phenol ^g	1.9E-05	--
123-38-6	Propionaldehyde	ND	8.5E-05
115-07-1	Propylene ^g	ND	3.4E-03

TABLE A6 (cont.)

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
129-00-0	Pyrene ^g	2.0E-06	--
7782-49-2	Selenium	ND	9.3E-07
7440-22-4	Silver	1.1E-05	--
100-42-5	Styrene	ND	9.5E-06
7664-93-9	Sulfuric acid	1.5E-02	--
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	8.1E-11	--
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	5.9E-11	--
79-34-5	1,1,2,2-Tetrachloroethane	ND	1.6E-05
127-18-4	Tetrachloroethylene	ND	1.6E-05
7440-28-0	Thallium	ND	2.8E-07
108-88-3	Toluene ^g	7.3E-06	--
120-82-1	1,2,4-Trichlorobenzene	ND	1.6E-05
71-55-6	1,1,1-Trichloroethane	6.9E-05	--
79-00-5	1,1,2-Trichloroethane	ND	1.4E-05
79-01-6	Trichloroethylene	ND	1.4E-05
75-69-4	Trichlorofluoromethane	ND	1.4E-05
95-95-4	2,4,5-Trichlorophenol	ND	7.8E-06
88-06-2	2,4,6-Trichlorophenol	ND	7.8E-06
95-63-6	1,2,4-Trimethylbenzene	ND	8.3E-06
75-01-4	Vinyl chloride	ND	1.8E-05
75-35-4	Vinylidene chloride ^g	1.1E-05	--
106-42-3, 108-38-3	m-Xylene, p-Xylene ^g	ND	8.1E-06
95-47-6	o-Xylene ^g	ND	8.9E-06
7440-66-6	Zinc	3.9E-04	--
Other Pollutants			
67-64-1	Acetone	0	--
74-86-2	Acetylene ^g	ND	2.1E-03
35572-78-2	2-Amino-4,6-dinitrotoluene	ND	1.7E-06
19406-51-0	4-Amino-2,6-dinitrotoluene	ND	1.7E-06
100-52-7	Benzaldehyde	ND	1.6E-04
65-85-0	Benzoic acid ^k	1.1E-05	--
4748-78-1	Benzaldehyde, 4-ethyl ^k	3.5E-06	--
100-51-6	Benzyl alcohol	ND	7.8E-06
106-97-8	Butane	ND	4.7E-03

TABLE A6 (cont.)

CASRN ^a	Compound	Average Emission Factor, lb per lb NEW ^{b,c,d}	Minimum Detection Level mg/m ^{3,e}
39638-32-9	bis(2-Chloroisopropyl)ether	ND	7.8E-06
59-50-7	4-Chloro-3-methylphenol	ND	7.8E-06
540-97-6	Cyclohexasiloxane, dodecamethy ^k	0	--
156-59-2	cis-1,2-Dichloroethene	ND	1.2E-05
10061-01-5	cis-1,3-Dichloropropene	ND	1.2E-05
84-66-2	Diethylphthalate	ND	7.8E-06
5779-94-2	2,5-Dimethylbenzaldehyde	ND	2.0E-04
117-84-0	Di-n-octylphthalate	ND	7.8E-06
74-84-0	Ethane	ND	2.4E-03
622-96-8	4-Ethyltoluene ^g	ND	8.0E-06
66-25-1	Hexaldehyde	ND	1.5E-04
149-57-5	Hexanoic acid, 2-ethyl- ^k	4.7E-06	--
104-76-7	1-Hexanol, 2-ethyl ^k	4.2E-06	--
2691-41-0	HMX	ND	3.4E-06
10035-10-6	Hydrogen bromide	ND	5.0E-04
75-28-5	Isobutane	ND	4.7E-03
590-86-3	Isovaleraldehyde	ND	1.3E-04
1334-78-7	Methyl benzaldehyde	ND	7.8E-06
88-74-7	2-Nitroaniline	ND	9.1E-06
99-09-2	3-Nitroaniline	ND	1.7E-06
88-72-2	2-Nitrotoluene	ND	1.7E-06
99-08-1	3-Nitrotoluene	ND	1.7E-06
99-99-0	4-Nitrotoluene	1.7E-05	--
10544-50-0	Octasulfur ^k	ND	3.4E-06
78-11-5	Pentaerythritol tetranitrate	ND	5.0E-04
7664-38-2	Phosphoric acid	ND	3.6E-03
74-98-6	Propane	ND	1.7E-06
121-82-4	RDX	2.5E-05	--
7704-34-9	Sulfur ^k	ND	1.7E-06
479-45-8	Tetryl	ND	3.5E-04
108-67-8	1,3,5-Trimethylbenzene	ND	8.8E-06
99-35-4	1,3,5-Trinitrobenzene	ND	1.7E-06
118-96-7	2,4,6-Trinitrotoluene ^g	ND	1.7E-06
110-62-3	Valeraldehyde	ND	1.3E-04

TABLE A6 (cont.)

- ^a CASRN = Chemical Abstracts Service Registry Number.
- ^b NEW = net explosive weight. The NEW for this ordnance is varies from 3.28 pounds per item to 5.75 pounds per item, depending upon the charge zone used.
- ^c Emission factors rated C unless otherwise noted.
- ^d ND = nondetected.
- ^e Data provided for compounds that were not detected.
- ^f Emission factor rated A because of correlation with emission factors for similar ordnance and number of test data points.
- ^g Emission factor rated B because of correlation with emission factors for similar ordnance and number of test data points.
- ^h Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a B rating.
- ⁱ Emission factor based upon C-rated test data, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^j Emission factor was originally rated D because the factor is for a tentatively identified compound, but because of correlation with emission factors for similar ordnance and number of data points the factor was upgraded from a D rating to a C rating.
- ^k Emission factor rated "D" because the compound was tentatively identified.

APPENDIX B

NEW AP-42 SECTIONS FOR ORDNANCE INCLUDED IN FIRING POINT EMISSION STUDY PHASE II SERIES 1 TESTING AT ABERDEEN PROVING GROUND, MARYLAND

Electronic versions of the new AP-42 sections for ordnance included in Firing Point Emission Study Phase II Series I 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 1 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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