Air Emissions from Range Operations

Richard Rehm
MACTEC Federal Programs, Inc., 5001 South Miami Blvd., Suite 300, RTP, NC 27709
rmrehm@mactec.com

Tamera Rush
Booz Allen & Hamilton, Inc., U.S. Army Environmental Center, Aberdeen Proving Ground, MD
tamera.rush@aec.apgea.army.mil

ABSTRACT

The U.S. Army has an increasing need to respond to regulatory questions regarding military test and training practices and the resulting munition/weapon system emissions. The U.S. Army Environmental Center (AEC), in coordination with the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), the U.S. Army Aberdeen Test Center, and Dugway Proving Ground, has developed a program to identify and quantify the emissions resulting from range operations that involve weapons firing and the use of smoke and pyrotechnic devices. The U.S. Environmental Protection Agency's (EPA's) Emissions Measurement Center has provided consultation and oversight in this endeavor. Based on data collected, AEC has performed assessments regarding the possible environmental and health impacts resulting from munitions usage. The data gathered from this program will also provide information on the concentration, transport, dispersion, and fate of the emission products.

MACTEC Federal Programs, Inc. (f/k/a Pacific Environmental Services, Inc.) has provided contract support to AEC in developing air pollution emission factors for munition/weapon systems for possible inclusion in AP-42. The purpose of this paper is to describe the work that AEC has performed in determining air pollutant emissions and factors from munitions used in their tactical configuration.

INTRODUCTION

In 1997, EPA issued an Administrative Order restricting training operations, including weapons firing, at the Massachusetts Military Reservation. The Administrative Order asserted that the training operations were degrading the environment and endangering the aquifer that is the sole source of drinking water on Cape Cod. The Army did not have sufficient data regarding the emissions from the training range and the fate and transport of those emissions in the environment in order to assess this assertion in the Administrative Order. Because of the lack of these data, AEC began conducting a series of emission tests to quantify emissions of air pollutants from training ordnance used in their tactical configurations. The data from this testing will soon be submitted to EPA for inclusion in EPA=s *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (commonly referred to as AP-42).

In 1980, EPA published Section 13.1 of AP-42 addressing explosives detonation. The section provides data on pollutants resulting from the detonation of industrial explosives and from the firing of small arms. The section specifically excludes military applications from the discussion. The U.S. Army has thousands of training ranges and impact areas across the United States and has a requirement to estimate emissions coming from these ranges accurately. Publication of the air emission factors being developed by AEC for munitions usage will help military installations improve the accuracy of the reporting, record keeping, permitting, and analysis required by several environmental regulations.

Military installations are required to estimate air pollution emissions from range operations for several reasons:

- to prepare annual air emission statements,
- to develop/revise Title V permit applications,
- to conduct minor source permitting,
- to perform conformity analyses, and
- to respond to Emergency Planning and Community Right-to-Know (EPCRA) reporting requirements.

While Section 13.1 of AP-42 does not address emission factors for use in military operations, this section has been used to estimate criteria pollutant emissions from small arms due to the lack of information elsewhere. Emission factors used in calculating emissions from large arms have been based on the Army's *Air Pathway Screening Analysis for Resource Conservation and Recovery Act Subpart X Permitting*.[1] The Army's *Combined Obscurational Model for Battlefield-Induced Contaminants,* Volume 11[2] has been used to estimate emissions from smoke devices. While these sources provide emission factors for many types of munitions, current testing shows the presence of many pollutants that are not addressed by the available factors. In addition, some of the emission factor data may be of questionable origin, and the data do not appear to have undergone appropriare quality assurance checks.

In order to estimate HAP emissions, most Army installations use the Toxic Release Inventory Data Delivery System (TRI-DDS) and its associated POLU13 model. This model is used for EPCRA reporting and conservatively estimates HAP emissions on the high side. For example, the POLU13 model predicts lead emission factors for certain munitions that are more than 50 times higher than those developed by AEC under their current test program. The accuracy of the toxic release inventory reports produced by the TRI-DDS will improve as the new air emission factors developed by AEC are incorporated into the program. As another example of improvement, the current version of the TRI-DDS does not report air emission factors for mercury compounds or TCDD. These substances are considered to be persistent bioaccumulative toxic (PBT) chemicals by EPA and have been measured during recent testing by AEC.

BODY

Sources of Emissions Data

The emission factors developed to date are based on data from testing conducted at Dugway Proving Ground, Utah, as contained in two test reports (*Sampling Results for AEC Training Ordnance Emission Characterization, Phase I*[3] and *Phase II*[4]). For each ordnance, one or two test runs were conducted to provide emission estimates. The number of ordnance detonated per run varied with the ordnance. Generally, the number of ordnance detonated was greater for smaller ordnance in order to generate measurable quantities of emissions.

Tests were conducted to quantify emission products produced when training ordnance were used in their tactical configuration. The ordnance were detonated in a thermal treatment characterization facility known as the BangboxJ. The BangboxJ is a 50-foot diameter hemisphere made from plasticized fabric, which is kept rigid by a constant injection of fresh air and a semirigid airlock. Within the test chamber are samplers, a steel-lined detonation pit, an automatically regulated inflation blower, environment control equipment, and a sampling tube. Real-time analyzers were electronically connected to a data recorder. EPA-approved methods were used by the laboratories that provided

sampling and analysis data. The Phase I tests were conducted between March 28 and April 1, 1998. The Phase II tests were conducted between October 12 and 14, 1998.

Compounds and Emission Measurement Methods

The compounds measured included total suspended particulate (TSP), particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}), metals, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), dioxins/furans, carbon monoxide (CO), carbon dioxide (CO_2), oxides of nitrogen (NO_x), and sulfur dioxide (SO_2). For metals, VOC, and SVOC, emission factors were developed for compounds listed as hazardous pollutants under ' 112(b)(1) of the Clean Air Act (CAA) and/or as reportable chemicals under ' 313 of EPCRA.

A number of different emission test methods were used to collect the emission data used in the development of emission factors for detonation of ordnance. Table 1 lists each emission test method used. Most of the emissions data were collected using EPA reference test methods, many of which are found in *Second Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*.[5] The test methods were adapted to reflect their application to the unique testing of ordnance detonation in the BangboxJ. The source test protocols were developed by AEC before any testing was conducted and have been reviewed by EPA=s Emission Measurement Center.

TABLE 1. LIST OF EMISSION TEST METHODS AND COMPOUNDS

Test Method	Compounds
Appendix B to 40 CFR 50 (High-Volume Method)	TSP
40 CFR 60 Method 29 Analysis of TSP	Metals
Appendix J to 40 CFR 50	PM_{10}
40 CFR 60 Method 3A	CO_2
40 CFR 60 Method 6C	SO_2
40 CFR 60 Method 7E	NO_x
40 CFR 60 Method 10	CO
TO-9 (SW-846 Method 8290 Analysis) - Determination of Polychlorinated, Polybrominated, and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air	CDD/CDF
TO-12 - Method for the Determination of Non-Methane Organic Compounds (NMOC) in Ambient Air Using Cryogenic Preconcentration and Direct Flame Ionization Detection (FID)	VOC
TO-13 (SW-846 Method 8270 Analysis) - Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS)	SVOC
TO-14 - Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by GC	Speciated VOC

NOTE: All TO methods are from *Second Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*.

Review of Emission Test Reports

As part of the analysis of the emissions data, the quantity and quality of the information contained in the two emission reports were evaluated. None of the data were excluded from consideration in developing the emission factors. The review of the emission test reports was conducted in two parts. The first part evaluated the test methods and sampling procedures used to obtain the data. This evaluation was accomplished by first reviewing the information presented in the reports to identify any missing information that would affect determining whether or not the test procedures and sampling procedures used were appropriate and consistent with EPA test methods or similar appropriate test methods. Then, based on the information available, the implementation of the test procedures were evaluated to see if they conformed to the procedures in the test methods. This second step was performed by reviewing information in the report that described the implementation of the procedures and by reviewing the available raw data for consistency with the implementation of the procedures.

The second part of the review examined the analysis and calculations by using the raw data available to determine if the emission test results could be duplicated. This evaluation was accomplished by creating spreadsheets reflecting the sample calculations presented in the test reports, entering as much Araw@ data as provided, and comparing the emission factor results from the spreadsheets to those reported in the two test reports. Where differences were found, an examination was made to determine the reason for the difference. Identification of missing raw data was also made to assess the degree to which the lack of such data would affect the test data quality rating.

Emission Factor Calculations and Ratings

In general, the calculation of emission factors for TSP, PM_{10}, metals, some SVOC, and dioxin/furan followed very similar steps: the amount (mass) of compound was obtained, the sample volume associated with the mass was calculated, and the concentration of compound was calculated (mg/m^3). However, as fresh air was constantly introduced into the BangBoxJ to maintain its volume, sampling occurred with an increasing amount of fresh air. This dilution of the BangBoxJ volume with fresh air was accounted for by the calculation of a Adilution correction factor.@ Once the sample concentration was calculated, it was divided by the applicable dilution correction factor to obtain the corrected concentration. The corrected compound concentration was then applied to the BangBoxJ volume to estimate total mass released from the detonated ordnance.

For VOC, some SVOC, and the CEMS-measured compounds, the initial starting point (i.e., the raw data) was already a concentration (mg/m^3, ppmv, ppbv). The ppmv and ppbv values were converted to mg/m^3. The applicable dilution correction factors were then applied to obtain the corrected concentrations. The corrected mg/m^3 concentrations were then applied to the BangBoxJ volume to estimate total mass released from the detonated ordnance. Once the total mass released was calculated, two emission factors were developed. One was the mass of compound released per item (per single ordnance) and the other, the mass of compound released per net explosive weight.

SUMMARY

To date, emission factors appropriate for inclusion into AP-42 have been developed for 10 ordnance types and 75 more are planned for FY03. In the near future, data for the first 10 will be presented to EPA's Emission Factors and Inventory Group, followed by external review and comment.

AEC continues to measure pollutants emitted from detonation of munitions in their tactical configuration. It is anticipated that emission factors will be published for over 200 munition types.

REFERENCES

1. Department of the Army. *Air Pathway Screening Analysis for Resource Conservation and Recovery Act Subpart X Permitting*. U.S. Army Environmental Center. Aberdeen Proving Ground, MD. May 1995.

2. Department of the Army. *Combined Obscurational Model for Battlefield-Induced Contaminants*. Volume 11. TR-022011. U.S. Army Laboratory Command. Atmospheric Sciences Laboratory. White Sands Missile Range, NM. October 1987.

3. Department of the Army. *Sampling Results for AEC Training Ordnance Emission Characterization, Phase I, Volumes I through V*. Prepared for the U.S. Army Environmental Center by Radian International LLC. Oak Ridge, TN. March 1999.

4. Department of the Army. *Sampling Results for AEC Training Ordnance Emission Characterization, Phase II, Volumes I through V*. Prepared for the U.S. Army Environmental Center by Radian International LLC. Oak Ridge, TN. July 1999.

5. U.S. Environmental Protection Agency. *Second Supplement to Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. EPA-600/4-89-014. Office of Research and Development. March 1989.

KEYWORDS

Army
Ranges
Ordnance
Munitions
Emission Factors
AP-42