

# Hexachloroethane Smoke

## BACKGROUND INFORMATION

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In this chapter, HCE refers to the compound hexachloroethane, and HC smoke is the term used by the military for smoke produced by combusting HCE with zinc oxide and producing zinc chloride.

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### Military Applications

HC smoke is used by the U.S. military in a wide variety of munitions, some of which are shown in Table 5-1. HC smoke is produced by burning a mixture containing roughly equal parts of HCE and ZnO and approximately 6% granular aluminum.

### Combustion Products

The smoke mixture in a canister or grenade is initially ignited by a pyrotechnic starter mixture. The reaction is self-perpetuating and exothermic. The overall reaction was summarized by Cichowicz (1983):



Another reaction produces carbon monoxide instead of solid carbon.  $\text{ZnCl}_2$  leaves the reaction zone as a hot vapor. On cooling below the condensation point, it nucleates to form an aerosol that rapidly absorbs water from the surrounding atmosphere. Hydrated  $\text{ZnCl}_2$  particles then scatter light, thereby obscuring vision. Because of  $\text{ZnCl}_2$ 's affinity for water, the aerosol likely consists of the hydrated forms of  $\text{ZnCl}_2$  under most atmospheric conditions (Katz et al. 1980). A starter mixture containing silicon, potassium nitrate, charcoal, iron oxide, granular aluminum, cellulose nitrate, and acetone, which is required to initiate the reaction, might generate very small amounts of other airborne contaminants. However, the acute toxic effects of exposure to HC smoke are considered to arise primarily from inhalation of the  $\text{ZnCl}_2$  component, which comprises almost two thirds of the total mass of HC smoke (Table 5-2). All measurements of HC smoke are expressed in this chapter as milligrams of  $\text{ZnCl}_2$ , unless noted otherwise.

The munitions listed in Table 5-1 all use slightly different chemical mixtures (Novak et al. 1987). An analysis of trace materials

TABLE 5-1 Characteristics of HC Smoke Munitions

Smoke-Pot Munitions <sup>a</sup>	Container Size (in.)	Filling Weight (lb)	Ignition Method	Weight (lb) (approx.) with Fuse	Delay Time (sec)	Burning Time (min)
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Smoke pot, HCE, 10-lb, M1	9 by 5.5 diameter	10	Matchhead and scratcher block or electrical	12.5	10	5-8
Smoke pot, HCE, 30-lb, ABC-M5	9.5 by 8.5 diameter	31	Matchhead and scratcher block or electrical	33	20-30	2-22
Smoke pot, floating, HCE, M4A2	13 by 12 diameter	27.5	M207A1 smoke-pot fuse	38	10-20	10-15
Smoke grenade, HCE, M8	4.75 by 2.5 diameter	1.2	M201A1 fuse	1.5	0.7-2 <sup>b</sup>	1.7-2.5
Cartridge, <sup>c</sup> 105-mm, HCE, M84A1		12.3	Mechanical, time, and super-quick fuse	13.0	60-90	3
Projectile, <sup>d</sup> 155-mm, HCE, M116A1		25.8	Mechanical, time, and super-quick fuse	26.2	60-90	4

<sup>a</sup> All HC smokes are type C, which contains granular aluminum, hexachloroethane, and zinc oxide. Other types of HC smoke were used in the early years of smoke generation.

<sup>b</sup> Time to functioning after release of safety lever.

<sup>c</sup> No future production for the M84A1 was planned as of 1983.

<sup>d</sup> M116A1 was completing its production life cycle in 1983 and would be replaced by XM 825 white phosphorus fill.

Source: Cichowicz (1983).

TABLE 5-2 Approximate Composition of HC Smoke<sup>a</sup>

Constituent	Estimated Mass Fraction, %
Zinc chloride	62.5
<u>Zinc oxide</u>	9.6
Iron oxide <sup>b</sup>	10.7
Aluminum oxide <sup>b</sup>	5.4

Lead oxide <sup>b</sup>	1.0
Total particulate phase	89.2
Chlorinated vapors	10.8

<sup>a</sup> The analysis does not take into account any liquid water that associates with ZnCl<sub>2</sub>.

<sup>b</sup> These metals were assumed to be present as the oxide for purposes of calculating the mass fraction.

Source: DeVaul et al. (1989)

in HC smoke mixtures found common zinc impurities (Katz et al., 1980). Arsenic ranged from 0.13 to 5.0 microgram per gram (µg/g), mercury from 0.35 to 0.60 µg/g, cadmium from 53 to 1,523 µg/g, and lead from 50 to 858 µg/g. The cadmium and lead concentrations displayed a strong negative correlation.

### Physical and Chemical Properties of Zinc Chloride

CAS no.:	7646-85-7
Molecular formula:	ZnCl <sub>2</sub>
<u>Molecular weight:</u>	136.29
<u>Chemical name:</u>	<u>Zinc chloride</u>
Synonyms:	Butter of zinc, zinc butter, zinc
Physical state:	Solid
Melting point:	290°C
Boiling point:	732°C
Density:	2.907 at 25°C
<u>Vapor pressure:</u>	1 mm Hg at 428°C
Solubility:	4.32 × 10 <sup>6</sup> mg/L at 25°C
	6.15 × 10 <sup>6</sup> mg/L at 100°C
	1 g/1.3 mL <u>ethyl alcohol</u>
	1 g/2 mL glycerol
	1 g/0.25 mL 2% hydrochloroacetic acid

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TABLE 5-3 Chemical Analysis of Vapor Reaction Products from Field Test of 30-lb Military HC Smoke Pot

Distance from Mount to Pot (cm)	CO (ppm)	HCl (ppm)	COCl <sub>2</sub> (ppm)	CCl <sub>4</sub> (ppm)	C <sub>2</sub> Cl <sub>4</sub> (ppm)	C <sub>2</sub> Cl <sub>6</sub> (ppm)	C <sub>6</sub> Cl <sub>6</sub> (ppm)
≈ 15	<1	1128	30	33	36	nd	nd
≈ 15	<1	1958	16	8	9	nd	nd
≈ 15	<1	5693	30	57	192	40	103
≈ 15	<1	6822	20	36	81	40	95
≈ 200	<1	1137	1	1	2	nd	nd

Abbreviation: nd, not determined.  
 Source: Katz et al. (1980).

**Occurrence and Use**

ZnCl<sub>2</sub> is used in preserving wood and in the manufacture and dyeing of fabrics. In addition to its use in military obscurants, ZnCl<sub>2</sub> is also the major ingredient in smoke from smoke bombs used for crowd dispersal and in fire-fighting exercises (by both military and civilian communities) (ASTDR 1994). ZnCl<sub>2</sub> also has uses in dental, medical, and household applications, as well as in herbicides (ATSDR 1994).

## 15.7.6 K866, ABC-M5 30-Pound HC Smoke Pot

### 15.7.6.1 Ordnance Description<sup>1,2</sup>

The ABC-M5 30-Pound HC Smoke Pot (DODIC K866) is used to produce screening smoke for training exercises and demonstrations as well as during combat situations. Upon initiation, the smoke pot produces a dense white smoke cloud for 12 to 22 minutes.

The ABC-M5 30-Pound HC Smoke Pot consists of a cylindrical sheet-metal container filled with a Type-C, hexachloroethane (HC) smoke mixture. The smoke pot can be ignited either by remote electric ignition or by using an attached scratcher block to ignite a matchhead. After ignition of the matchhead the starter mixture is ignited which in turn ignites the HC filling.

### 15.7.6.2 Emissions And Controls<sup>1-4</sup>

Particulate matter is the primary emission from the use of the ABC-M5 30-Pound HC Smoke Pot. Other criteria pollutants, hazardous air pollutants as defined by the *Clean Air Act* (CAA), and toxic chemicals (i.e. those chemicals regulated under Section 313 of the *Emergency Planning and Community Right to Know Act* [EPCRA]) are emitted at low levels. As this ordnance is typically used in the field, there are no controls associated with its use.

Table 15.7.6-1 presents emission factors for carbon dioxide (CO<sub>2</sub>), criteria pollutants, total nonmethane hydrocarbons (TNMHC), and total suspended particulate (TSP). Table 15.7.6-2 presents emission factors for hazardous air pollutants and toxic chemicals. In both tables, the emission factors are presented in units of pounds of emissions per item (lb per item) and in units of pounds of emissions per pound net explosive weight contained in the item (lb per lb NEW).

TABLE 15.7.6-1 EMISSION FACTORS FOR THE USE OF DODIC K866,  
ABC-M5 30-POUND HC SMOKE POT - CARBON DIOXIDE, CRITERIA POLLUTANTS, TOTAL  
NONMETHANE HYDROCARBONS, AND TOTAL SUSPENDED PARTICULATE<sup>a</sup>

EMISSION FACTOR RATING: A (except as noted)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
124-38-9	CO <sub>2</sub>	4.6 E-01	1.5 E-02
630-08-0	Carbon monoxide (CO) <sup>f</sup>	7.9 E-01	2.5 E-02
7439-92-1	Lead (Pb) <sup>g</sup>	2.4 E-02	7.9 E-04
--	Oxides of nitrogen (NO <sub>x</sub> ) <sup>f</sup>	2.6 E-03	8.4 E-05
--	PM-2.5 <sup>d,f</sup>	17	5.6 E-01
--	PM-10 <sup>e</sup>	32	1.0
7446-09-5	Sulfur dioxide (SO <sub>2</sub> ) <sup>g</sup>	4.4 E-03	1.4 E-04
--	TNMHC <sup>g</sup>	1.7 E-02	5.4 E-04
12789-66-1	TSP	21	6.9 E-01

<sup>a</sup> Factors represent uncontrolled emissions. References 1-4.

<sup>b</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>c</sup> NEW = net explosive weight. The NEW for this ordnance is 31.0 pounds per item. References 1 and 5.

<sup>d</sup> PM-2.5 = particulate matter with an aerodynamic diameter equal to or less than 2.5 micrometers (µm).

<sup>e</sup> PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 µm.

<sup>f</sup> EMISSION FACTOR RATING B.

<sup>g</sup> EMISSION FACTOR RATING C.

Table 15.7.6-2 EMISSION FACTORS FOR THE USE OF DODIC K866,  
 ABC-M5 30-POUND HC SMOKE POT -  
 HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS<sup>a</sup>

EMISSION FACTOR RATING: C (except as noted)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
75-05-8	Acetonitrile <sup>d</sup>	3.1 E-04	1.0 E-05
7429-90-5	Aluminum <sup>c,h</sup>	1.6 E-01	5.1 E-03
7440-36-0	Antimony <sup>d</sup>	1.3 E-03	4.2 E-05
7440-38-2	Arsenic <sup>d,h</sup>	1.5 E-04	4.8 E-06
71-43-2	Benzene <sup>d,g</sup>	4.9 E-04	1.6 E-05
29082-74-4	Benzene, pentachloro(trichloroethenyl)- <sup>e,h</sup>	3.7 E-04	1.2 E-05
7440-43-9	Cadmium <sup>d,h</sup>	1.8 E-03	5.7 E-05
75-15-0	Carbon disulfide <sup>d</sup>	4.6 E-03	1.5 E-04
56-23-5	Carbon tetrachloride <sup>d,h</sup>	2.7 E-02	8.6 E-04
67-66-3	Chloroform <sup>d</sup>	1.4 E-03	4.4 E-05
74-87-3	Chloromethane <sup>d,h</sup>	5.4 E-04	1.7 E-05
7440-47-3	Chromium <sup>d</sup>	2.7 E-04	8.6 E-06
7440-50-8	Copper <sup>c,h</sup>	3.7 E-02	1.2 E-03
78-87-5	1,2-Dichloropropane <sup>d,h</sup>	1.4 E-04	4.4 E-06
121-14-2	2,4-Dinitrotoluene <sup>d</sup>	1.6 E-03	5.3 E-05
--	Total dioxin/furan compounds <sup>d,g</sup>	1.2 E-05	4.0 E-07
74-85-1	Ethylene <sup>e</sup>	6.7 E-04	2.2 E-05
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin <sup>d,g</sup>	1.5 E-08	4.9 E-10
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran <sup>d,h</sup>	1.5 E-06	4.8 E-08
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran <sup>d,h</sup>	1.7 E-07	5.6 E-09
118-74-1	Hexachlorobenzene <sup>d</sup>	2.1 E-02	6.9 E-04
87-68-3	Hexachlorobutadiene <sup>d</sup>	1.4 E-03	4.5 E-05
77-47-4	Hexachlorocyclopentadiene <sup>d,h</sup>	1.3 E-02	4.2 E-04
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin <sup>d</sup>	1.5 E-09	4.8 E-11
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin <sup>d</sup>	3.8 E-09	1.2 E-10
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin <sup>d</sup>	4.1 E-09	1.3 E-10
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran <sup>d,h</sup>	1.8 E-07	5.9 E-09
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran <sup>d</sup>	7.8 E-08	2.5 E-09
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran <sup>d</sup>	1.2 E-08	3.9 E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran <sup>d</sup>	6.8 E-08	2.2 E-09

Table 15.7.6-2 (cont.)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
67-72-1	Hexachloroethane <sup>d,h</sup>	2.0 E-03	6.5 E-05
7647-01-0	Hydrochloric acid <sup>d</sup>	2.8 E-01	9.1 E-03
193-39-5	Indeno[1,2,3-cd]pyrene <sup>d,h</sup>	6.9 E-04	2.2 E-05
78-59-1	Isophorone <sup>f,h</sup>	5.5 E-03	1.8 E-04
7439-92-1	Lead <sup>d</sup>	2.4 E-02	7.9 E-04
7439-96-5	Manganese <sup>d</sup>	6.6 E-03	2.1 E-04
75-09-2	Methylene chloride <sup>d,h</sup>	7.0 E-04	2.3 E-05
2234-13-1	Naphthalene, octachloro- <sup>e,h</sup>	7.6 E-04	2.5 E-05
7440-02-0	Nickel <sup>d,g</sup>	3.4 E-04	1.1 E-05
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin <sup>d,g</sup>	5.3 E-08	1.7 E-09
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran <sup>d,h</sup>	1.2 E-05	3.7 E-07
608-93-5	Pentachlorobenzene <sup>e</sup>	8.8 E-04	2.8 E-05
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin <sup>d,g</sup>	2.8 E-09	8.9 E-11
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran <sup>d</sup>	3.5 E-08	1.1 E-09
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran <sup>d,h</sup>	5.9 E-08	1.9 E-09
115-07-1	Propylene <sup>e</sup>	1.5 E-05	4.9 E-07
7440-22-4	Silver <sup>e</sup>	5.5 E-05	1.8 E-06
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin <sup>d,g</sup>	1.5 E-09	4.9 E-11
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran <sup>d</sup>	1.1 E-08	3.6 E-10
127-18-4	Tetrachloroethylene <sup>d</sup>	4.3 E-02	1.4 E-03
79-01-6	Trichloroethylene <sup>d</sup>	3.2 E-04	1.0 E-05
88-06-2	2,4,6-Trichlorophenol <sup>d,h</sup>	9.5 E-04	3.1 E-05
75-01-4	Vinyl chloride <sup>d,g</sup>	1.2 E-04	4.0 E-06
7440-66-6	Zinc <sup>e</sup>	9.5 E-02	3.1 E-03

<sup>a</sup> Factors represent uncontrolled emissions. References 1-4.

<sup>b</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>c</sup> NEW = net explosive weight. The NEW for this ordnance is 31.0 pounds per item. References 1 and 5.

<sup>d</sup> Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

<sup>e</sup> Reportable chemical under EPCRA Section 313.

<sup>f</sup> Hazardous air pollutant under CAA Section 112(b).

<sup>g</sup> EMISSION FACTOR RATING B.

<sup>h</sup> EMISSION FACTOR RATING D.

References For Section 15.7.6

1. *Sampling Results for AEC Phase VII Emission Characterization of Exploding Ordnance and Smoke/Pyrotechnics*, URS Group, Inc., Oak Ridge, TN, April 2007.
2. *Detailed Test Plan for Phase VII Emission Characterization of Exploding Ordnance and Smoke/Pyrotechnics*, West Desert Test Center, U.S. Army Dugway Proving Ground, UT, February 2005.
3. Supporting information including Excel spreadsheets supplied upon request by the U.S. Army Dugway Proving Ground test support contractor, URS Group, Inc., Oak Ridge, TN, August 2007.
4. *Background Document, Report on Revisions to 5<sup>th</sup> Edition AP-42 Chapter 15 - Ordnance Detonation, Emission Factors Developed Based on Phase VII Testing Conducted at Dugway Proving Ground, Utah*, MACTEC Federal Programs, Inc., Research Triangle Park, NC, June 2008.
5. *Munitions Items Disposition Action System (MIDAS) website*, <https://midas.dac.army.mil/>, U.S. Army Defense Ammunition Center, McAlester, OK, December 2007.

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## 15.7.7 K867, M4A2 Floating Type HC Smoke Pot

### 15.7.7.1 Ordnance Description<sup>1,2</sup>

The M4A2 Floating Type HC Smoke Pot (DODIC K867) is used to generate screening smoke when a floating source of smoke is required for river crossings and beach landings. It can also be used on land. Upon initiation, the smoke pot produces a dense white smoke cloud for 10 to 15 minutes. This ammunition is used during combat and on firing ranges during training.

The M4A2 Floating Type HC Smoke Pot consists of a 5-gallon metal pail with its lower third filled with a Type-C, hexachloroethane (HC) smoke mixture and fused with an M207A1 floating smoke pot fuse. When the fuze safety lever is released, the striker spring drives the striker which hits the primer. The primer ignites the firstfire charge, which, in turn, ignites the delay charge and subsequently the ignition charge. Flame from the ignition charge travels through the pot's igniter tube to ignite the starter mixture, which then ignites the HC smoke-mixture filling.

### 15.7.7.2 Emissions And Controls<sup>1-4</sup>

Particulate matter is the primary emission from the use of the M4A2 Floating Type HC Smoke Pot. Other criteria pollutants, hazardous air pollutants as defined by the *Clean Air Act (CAA)*, and toxic chemicals (i.e. those chemicals regulated under Section 313 of the *Emergency Planning and Community Right to Know Act [EPCRA]*) are emitted at low levels. As this ordnance is typically used in the field, there are no controls associated with its use.

Table 15.7.7-1 presents emission factors for carbon dioxide (CO<sub>2</sub>), criteria pollutants, total nonmethane hydrocarbons (TNMHC), and total suspended particulate (TSP). Table 15.7.7-2 presents emission factors for hazardous air pollutants and toxic chemicals. In both tables, the emission factors are presented in units of pounds of emissions per item (lb per item) and in units of pounds of emissions per pound net explosive weight contained in the item (lb per lb NEW).

TABLE 15.7.7-1 EMISSION FACTORS FOR THE USE OF DODIC K867,  
M4A2 FLOATING TYPE HC SMOKE POT - CARBON DIOXIDE, CRITERIA POLLUTANTS,  
TOTAL NONMETHANE HYDROCARBONS, AND TOTAL SUSPENDED PARTICULATE<sup>a</sup>

EMISSION FACTOR RATING: B (except as noted)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
124-38-9	CO <sub>2</sub> <sup>f</sup>	5.3 E-01	1.9 E-02
630-08-0	Carbon monoxide (CO)	8.9 E-01	3.2 E-02
7439-92-1	Lead (Pb)	1.6 E-02	5.9 E-04
--	Oxides of nitrogen (NO <sub>x</sub> )	2.8 E-03	1.0 E-04
--	PM-2.5 <sup>d</sup>	23	8.2 E-01
--	PM-10 <sup>e,f</sup>	30	1.1
7446-09-5	Sulfur dioxide (SO <sub>2</sub> ) <sup>g</sup>	3.2 E-03	1.1 E-04
--	TNMHC	2.2 E-02	7.9 E-04
12789-66-1	TSP <sup>f</sup>	42	1.5

<sup>a</sup> Factors represent uncontrolled emissions. References 1-4.

<sup>b</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>c</sup> NEW = net explosive weight. The NEW for this ordnance is 27.5 pounds per item. References 1 and 5.

<sup>d</sup> PM-2.5 = particulate matter with an aerodynamic diameter equal to or less than 2.5 micrometers (µm).

<sup>e</sup> PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 µm.

<sup>f</sup> EMISSION FACTOR RATING A.

<sup>g</sup> EMISSION FACTOR RATING C.

Table 15.7.7-2 EMISSION FACTORS FOR THE USE OF DODIC K867,  
M4A2 FLOATING TYPE HC SMOKE POT -  
HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS<sup>a</sup>

EMISSION FACTOR RATING: C (except as noted)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
75-07-0	Acetaldehyde <sup>d</sup>	2.3E-04	8.2E-06
7429-90-5	Aluminum <sup>e</sup>	1.5E-01	5.3E-03
7440-38-2	Arsenic <sup>d</sup>	7.1E-06	2.6E-07
71-43-2	Benzene <sup>d,g</sup>	3.9E-04	1.4E-05
106-99-0	1,3-Butadiene <sup>d</sup>	1.0E-04	3.8E-06
7440-43-9	Cadmium <sup>d</sup>	5.4E-03	2.0E-04
75-15-0	Carbon disulfide <sup>d</sup>	9.7E-04	3.5E-05
56-23-5	Carbon tetrachloride <sup>d</sup>	1.1E-02	4.1E-04
67-66-3	Chloroform <sup>d,g</sup>	5.4E-04	2.0E-05
7440-47-3	Chromium <sup>d,g</sup>	1.6E-04	6.0E-06
7440-48-4	Cobalt <sup>d</sup>	1.3E-05	4.8E-07
7440-50-8	Copper <sup>e</sup>	2.3E-02	8.4E-04
--	Total dioxin/furan compounds <sup>d,g</sup>	4.1E-06	1.5E-07
74-85-1	Ethylene <sup>e,g</sup>	4.9E-04	1.8E-05
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin <sup>d,g</sup>	1.0E-08	3.8E-10
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran <sup>d</sup>	3.3E-07	1.2E-08
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran <sup>d</sup>	8.7E-08	3.2E-09
118-74-1	Hexachlorobenzene <sup>d</sup>	7.4E-02	2.7E-03
87-68-3	Hexachlorobutadiene <sup>d</sup>	1.5E-03	5.5E-05
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin <sup>d,h</sup>	8.4E-10	3.1E-11
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin <sup>d</sup>	1.5E-09	5.5E-11
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin <sup>d</sup>	1.9E-09	6.8E-11
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran <sup>d</sup>	1.0E-07	3.8E-09
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran <sup>d,g</sup>	5.7E-08	2.1E-09
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran <sup>d,g</sup>	1.2E-08	4.3E-10
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran <sup>d,g</sup>	3.6E-08	1.3E-09
7647-01-0	Hydrochloric acid <sup>d</sup>	4.5E-01	1.7E-02
7439-92-1	Lead <sup>d,g</sup>	1.6E-02	5.9E-04
7439-96-5	Manganese <sup>d,g</sup>	5.3E-03	1.9E-04
75-09-2	Methylene chloride <sup>d</sup>	4.2E-04	1.5E-05

Table 15.7.7-2 (cont.)

CASRN <sup>b</sup>	Pollutant	lb per item	lb per lb NEW <sup>c</sup>
7440-02-0	Nickel <sup>d,h</sup>	2.8E-04	1.0E-05
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin <sup>d,g</sup>	1.8E-08	6.6E-10
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran <sup>d</sup>	3.7E-06	1.3E-07
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin <sup>d,g</sup>	2.0E-09	7.3E-11
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran <sup>d</sup>	4.0E-08	1.5E-09
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran <sup>d</sup>	3.5E-08	1.3E-09
7723-14-0	Phosphorus <sup>f</sup>	1.5E-03	5.3E-05
123-38-6	Propionaldehyde <sup>d</sup>	7.0E-05	2.6E-06
115-07-1	Propylene <sup>c,g</sup>	1.5E-04	5.5E-06
7782-49-2	Selenium <sup>d,g</sup>	2.9E-05	1.1E-06
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin <sup>d,g</sup>	8.3E-10	3.0E-11
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran <sup>d</sup>	2.1E-08	7.5E-10
127-18-4	Tetrachloroethylene <sup>d</sup>	7.9E-02	2.9E-03
108-88-3	Toluene <sup>d,g</sup>	2.0E-04	7.3E-06
79-01-6	Trichloroethylene <sup>d,g</sup>	3.7E-04	1.3E-05
75-01-4	Vinyl chloride <sup>d,g</sup>	2.2E-04	7.8E-06
75-35-4	Vinylidene chloride <sup>d</sup>	1.3E-04	4.6E-06
7440-66-6	Zinc <sup>c</sup>	11	3.9E-01

<sup>a</sup> Factors represent uncontrolled emissions. References 1-4.

<sup>b</sup> CASRN = Chemical Abstracts Service Registry Number.

<sup>c</sup> NEW = net explosive weight. The NEW for this ordnance is 27.5 pounds per item. References 1 and 5.

<sup>d</sup> Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

<sup>e</sup> Reportable chemical under EPCRA Section 313.

<sup>f</sup> Hazardous air pollutant under CAA Section 112(b).

<sup>g</sup> EMISSION FACTOR RATING B.

<sup>h</sup> EMISSION FACTOR RATING D.

#### References For Section 15.7.7

1. *Sampling Results for AEC Phase VII Emission Characterization of Exploding Ordnance and Smoke/Pyrotechnics*, URS Group, Inc., Oak Ridge, TN, April 2007.
2. *Detailed Test Plan for Phase VII Emission Characterization of Exploding Ordnance and Smoke/Pyrotechnics*, West Desert Test Center, U.S. Army Dugway Proving Ground, UT, February 2005.
3. Supporting information including Excel spreadsheets supplied upon request by the U.S. Army Dugway Proving Ground test support contractor, URS Group, Inc., Oak Ridge, TN, August 2007.