

15.4 Projectiles, Canisters, And Charges

Munitions listed in this section begin with the Department of Defense Identification Code (DODIC) letter “D.” A variety of munitions fall under this category, including bursters, projectiles, canisters, and charges. Examples include illumination rounds and propellant bags.

15.4.1 D505, M485A2 155-mm Illumination Round

15.4.1.1 Ordnance Description¹

The M485A2 155-mm Illumination Round (DODIC D505) is a relatively large pyrotechnic device that is used to spot infiltrating troops by lighting up the field. This ammunition is used during combat and on firing ranges during training. It is fired from a 155-mm howitzer, a cannon used for firing projectiles at medium muzzle velocities and with relatively high trajectories. A propellant charge carries the round to a height of about 1,800 feet. The propellant charge is not included in these emission factors. The illumination charge then activates and a parachute opens, creating a bright light that lasts for approximately 2 minutes as the parachute drifts to the ground.

The M485A2 155-mm Illumination Round is used during many Army training exercises, which are held at nearly every Army training installation. At most locations, the training areas are at least 1,000 meters (over 0.5 mile) away from populated areas. Typically, three M485A2 155-mm Illumination Rounds are used during each training event, which occur approximately five times a year at a given training facility.

15.4.1.2 Emissions And Controls²⁻⁵

The primary emissions from the detonation of the M485A2 155-mm Illumination Round are particulate matter and carbon dioxide (CO₂). Other criteria pollutants, hazardous air pollutants in 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 very low levels. As these ordnance are typically detonated in the field, there are no controls associated with their use.

Table 15.4.1-1 presents emission factors for CO₂, criteria pollutants, total nonmethane hydrocarbons (TNMHC), and total suspended particulate (TSP). Table 15.4.1-2 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 15.4.1-1 EMISSION FACTORS FOR THE USE OF DODIC D505,
M485A2 155-MM ILLUMINATION ROUND (PROJECTILE) – CARBON DIOXIDE, CRITERIA
POLLUTANTS, TOTAL NONMETHANE HYDROCARBONS, AND TOTAL SUSPENDED
PARTICULATE^a

EMISSION FACTOR RATING: A (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
124-38-9	CO ₂	1.8	3.0 E-01
630-08-0	Carbon monoxide (CO)	2.6 E-02	4.3 E-03
7439-92-1	Lead (Pb) ^f	5.8 E-05	9.5 E-06
10102-44-0	Nitrogen dioxide (NO ₂) ^f	5.9 E-02	9.6 E-03
10102-43-9	Nitrogen oxide (NO) ^e	3.9 E-03	6.4 E-04
--	Oxides of nitrogen (NO _x)	9.4 E-02	1.5 E-02
--	PM-10 ^d	3.0	4.9 E-01
7446-09-5	Sulfur dioxide (SO ₂) ^e	2.7 E-03	4.5 E-04
--	TNMHC ^e	1.5 E-03	2.5 E-04
12789-66-1	TSP	2.1	3.5 E-01

^a Factors represent uncontrolled emissions. References 2 and 3.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 6.123 pounds per item. Reference 4.

^d PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 micrometers (µm).

^e EMISSION FACTOR RATING B.

^f EMISSION FACTOR RATING C.

Table 15.4.1-2 EMISSION FACTORS FOR THE USE OF DODIC D505,
M485A2 155-MM ILLUMINATION ROUND (PROJECTILE) –
HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS^a

EMISSION FACTOR RATING: C (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
75-05-8	Acetonitrile ^d	2.6 E-05	4.2 E-06
98-86-2	Acetophenone ^d	7.7 E-06	1.3 E-06
107-02-8	Acrolein ^{d,h}	2.9 E-05	4.7 E-06
107-13-1	Acrylonitrile ^{d,h}	2.1 E-05	3.4 E-06
7429-90-5	Aluminum ^{e,g}	3.6 E-04	5.8 E-05
7440-36-0	Antimony ^d	2.1 E-05	3.5 E-06
7440-39-3	Barium ^e	3.9 E-04	6.4 E-05
71-43-2	Benzene ^{d,g}	1.1 E-04	1.8 E-05
7440-41-7	Beryllium ^d	2.1 E-07	3.4 E-08
123-72-8	Butanal ^e	3.5 E-06	5.7 E-07
85-68-7	Butylbenzylphthalate ^e	5.1 E-06	8.4 E-07
7440-43-9	Cadmium ^{d,h}	7.4 E-05	1.2 E-05
75-15-0	Carbon disulfide ^{d,h}	6.4 E-05	1.0 E-05
56-23-5	Carbon tetrachloride ^{d,h}	1.7 E-07	2.7 E-08
463-58-1	Carbonyl sulfide ^d	3.8 E-06	6.3 E-07
7782-50-5	Chlorine ^d	2.0 E-06	3.3 E-07
7440-47-3	Chromium ^{e,h}	7.0 E-06	1.1 E-06
7440-48-4	Cobalt ^{d,h}	1.8 E-06	3.0 E-07
7440-50-8	Copper ^{e,g}	7.6 E-05	1.2 E-05
110-82-7	Cyclohexane ^e	5.7 E-07	9.2 E-08
84-74-2	Dibutyl phthalate ^d	9.5 E-06	1.6 E-06
75-71-8	Dichlorodifluoromethane ^e	1.0 E-06	1.6 E-07
100-41-4	Ethylbenzene ^{d,h}	7.3 E-06	1.2 E-06
74-85-1	Ethylene ^{e,h}	2.8 E-04	4.6 E-05
110-54-3	Hexane ^d	2.6 E-06	4.3 E-07
76-13-1	Freon 113 ^e	4.7 E-08	7.6 E-09
7439-92-1	Lead ^d	5.8 E-05	9.5 E-06
7439-96-5	Manganese ^{d,h}	5.4 E-05	8.9 E-06
7439-97-6	Mercury ^d	1.2 E-08	2.0 E-09
1634-04-4	Methyl tert-butyl ether ^d	2.1 E-07	3.4 E-08

Table 15.4.1-2 (cont.)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
75-09-2	Methylene chloride ^d	1.6 E-03	2.6 E-04
91-20-3	Naphthalene ^{d,h}	1.6 E-05	2.6 E-06
7440-02-0	Nickel ^{d,g}	9.2 E-06	1.5 E-06
85-01-8	Phenanthrene ^d	3.5 E-06	5.7 E-07
115-07-1	Propene ^{e,h}	4.3 E-05	7.0 E-06
--	2,3,7,8-Tetrachlorodibenzo-p-dioxin toxic equivalent ^{d,h}	2.1 E-11	3.5 E-12
108-88-3	Toluene ^{d,h}	2.4 E-05	4.0 E-06
75-69-4	Trichloromonofluoromethane ^e	1.3 E-07	2.1 E-08
95-63-6	1,2,4-Trimethylbenzene ^e	2.1 E-06	3.4 E-07
540-84-1	2,2,4-Trimethylpentane ^f	4.1 E-06	6.7 E-07
108-38-3, 106-42-3	m-Xylene, p-Xylene ^{d,h}	4.2 E-06	6.9 E-07
95-47-6	o-Xylene ^d	4.5 E-06	7.3 E-07
7440-66-6	Zinc ^e	1.2 E-03	1.9 E-04

^a Factors represent uncontrolled emissions. References 2 and 3.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 6.123 pounds per item. Reference 4.

^d Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

^e Reportable chemical under EPCRA Section 313.

^f Hazardous air pollutant under CAA Section 112(b).

^g EMISSION FACTOR RATING A.

^h EMISSION FACTOR RATING B.

References For Section 15.4.1

1. *M485A2 155-mm Illumination Round, Pyrotechnics Fact Sheet*, U.S. Army Environmental Center, P2/Compliance, Acquisition, and Technology Division, Aberdeen Proving Ground, MD, Undated.
2. *Sampling Results for AEC Phase I Training Ordnance Emission Characterization*, Radian International LLC, Oak Ridge, TN, March 1999.
3. *Supporting Information for Phase I and Phase II Tests at Dugway Proving Ground*, URS Corporation, Oak Ridge, TN, July 11, 2001.
4. *Hazard Classification of United States Military Explosives and Munitions*, U.S. Army Defense Ammunition Center, Logistics Review and Technical Assistance Office, McAlester, OK, Revision 11, February 2001.

5. *Background Document, Report on Creation of 5th Edition AP-42 Chapter 15 - Ordnance Detonation*, MACTEC Federal Programs, Inc., Research Triangle Park, NC, July 2006.

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15.4.3 D533, M119A2 155-mm Propelling Charge, Zone 7

15.4.3.1 Ordnance Description^{1,2}

The M119A2 155-mm Propelling Charge, Zone 7 (DODIC D533) is a single increment red bag propelling charge used in the M185 and M199 155-mm howitzers. The charge is used to fire various projectiles at down range targets. Note that emission factors presented herein include only those associated with the firing of the propelling charge; emissions associated with the explosion of the propelled projectile are not addressed in this section.

The M119A2 155-mm Propelling Charge, Zone 7 consists of propellant, a base igniter pad with clean burning igniter powder, and a center spot of black powder. The charge has a lead foil liner at its forward end. Four flash reducer pockets are sewn longitudinally to the circumference.

15.4.3.2 Emissions And Controls¹⁻⁵

The primary emissions from the firing of the M119A2 155-mm Propelling Charge, Zone 7 are carbon dioxide (CO₂) and carbon monoxide (CO). 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 detonated in the field, there are no controls associated with its use.

Table 15.4.3-1 presents emission factors for CO₂, criteria pollutants, methane, and total suspended particulate (TSP). Table 15.4.3-2 presents emission factors for hazardous air pollutants and toxic chemicals. 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 15.4.3-1 EMISSION FACTORS FOR THE USE OF DODIC D533,
M119A2 155-MM PROPELLING CHARGE, ZONE 7 – CARBON DIOXIDE, CRITERIA
POLLUTANTS, METHANE, AND TOTAL SUSPENDED PARTICULATE^a

EMISSION FACTOR RATING: A (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
124-38-9	CO ₂	4.2	1.9 E-01
630-08-0	CO	8.6	3.8 E-01
7439-92-1	Lead (Pb) ^f	2.9 E-02	1.3 E-03
74-82-8	Methane	4.6 E-02	2.1 E-03
--	Oxides of nitrogen (NO _x)	2.8 E-02	1.2 E-03
--	PM-2.5 ^{d,f}	1.3 E-01	5.9 E-03
--	PM-10 ^{e,f}	4.4 E-01	1.9 E-02
12789-66-1	TSP ^f	6.2 E-01	2.8 E-02

^a Factors represent uncontrolled emissions. References 1, 2, and 3.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 22.47 pounds per item. Reference 2.

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

^e PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 µm.

^f EMISSION FACTOR RATING B.

Table 15.4.3-2 EMISSION FACTORS FOR THE USE OF DODIC D533,
M119A2 155-MM PROPELLING CHARGE, ZONE 7 –
HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS^a

EMISSION FACTOR RATING: B (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
83-32-9	Acenaphthene ^d	5.2 E-08	2.3 E-09
208-96-8	Acenaphthylene ^{d,g}	1.3 E-06	5.8 E-08
75-07-0	Acetaldehyde ^e	4.3 E-05	1.9 E-06
75-05-8	Acetonitrile ^e	1.3 E-04	5.9 E-06
7429-90-5	Aluminum ^f	1.7 E-03	7.7 E-05
7664-41-7	Ammonia ^{d,g}	2.0 E-01	8.7 E-03
120-12-7	Anthracene ^e	3.0 E-07	1.3 E-08
7440-39-3	Barium ^{f,h}	2.7 E-05	1.2 E-06
71-43-2	Benzene ^e	7.4 E-04	3.3 E-05
56-55-3	Benzo[a]anthracene ^{e,g}	6.7 E-08	3.0 E-09
205-99-2	Benzo[b]fluoranthene ^e	1.5 E-07	6.9 E-09
207-08-9	Benzo[k]fluoranthene ^e	5.2 E-08	2.3 E-09
191-24-2	Benzo[g,h,i]perylene ^e	1.1 E-06	5.0 E-08
50-32-8	Benzo[a]pyrene ^e	1.4 E-07	6.0 E-09
192-97-2	Benzo[e]pyrene ^d	1.9 E-07	8.6 E-09
18540-29-9	Hexavalent chromium ^{e,h}	8.9 E-06	3.9 E-07
218-01-9	Chrysene ^{e,h}	1.0 E-07	4.5 E-09
7440-50-8	Copper ^f	3.7 E-02	1.6 E-03
--	Total dioxin/furan compounds ^{e,h}	7.5 E-10	3.3 E-11
100-41-4	Ethylbenzene ^{e,g}	2.4 E-05	1.1 E-06
74-85-1	Ethylene ^f	3.1 E-04	1.4 E-05
206-44-0	Fluoranthene ^e	4.3 E-07	1.9 E-08
86-73-7	Fluorene ^{d,g}	7.5 E-07	3.4 E-08
50-00-0	Formaldehyde ^e	7.2 E-05	3.2 E-06
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin ^{e,h}	5.9 E-11	2.6 E-12
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran ^{e,h}	1.3 E-11	5.9 E-13
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin ^{e,h}	2.8 E-12	1.3 E-13
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran ^{e,i}	1.8 E-12	8.1 E-14
74-90-8	Hydrogen cyanide ^e	2.6 E-02	1.2 E-03
7439-92-1	Lead ^e	2.9 E-02	1.3 E-03

Table 15.4.3-2 (cont.)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
7439-96-5	Manganese ^{e,g}	3.7 E-05	1.6 E-06
91-20-3	Naphthalene ^{e,g}	1.5 E-05	6.9 E-07
7440-02-0	Nickel ^{e,i}	2.4 E-05	1.1 E-06
7697-37-2	Nitric acid ^f	1.6 E-03	7.3 E-05
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin ^{e,h}	6.5 E-10	2.9 E-11
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran ^{e,h}	2.0 E-11	8.7 E-13
85-01-8	Phenanthrene ^e	1.3 E-06	5.9 E-08
108-95-2	Phenol ^e	7.6 E-06	3.4 E-07
129-00-0	Pyrene ^d	1.0 E-06	4.5 E-08
100-42-5	Styrene ^{e,h}	1.7 E-04	7.4 E-06
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran ^{e,h}	2.8 E-12	1.2 E-13
108-88-3	Toluene ^e	6.4 E-05	2.9 E-06
540-84-1	2,2,4-Trimethylpentane ^{d,i}	1.4 E-04	6.3 E-06
7440-62-2	Vanadium ^{f,h}	2.6 E-05	1.2 E-06
106-42-3, 108-38-3	m-Xylene, p-Xylene ^e	2.7 E-05	1.2 E-06
7440-66-6	Zinc ^{f,h}	5.3 E-03	2.3 E-04

^a Factors represent uncontrolled emissions. References 1, 2, and 3.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 22.47 pounds per item. Reference 2.

^d Hazardous air pollutant under CAA Section 112(b).

^e Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

^f Reportable chemical under EPCRA Section 313.

^g EMISSION FACTOR RATING A.

^h EMISSION FACTOR RATING C.

ⁱ EMISSION FACTOR RATING D.

References For Section 15.4.3

1. *Report No. 5 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, September 2003.
2. *Detailed Test Plan No. 5 for the Firing Point Emission Study, Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, August 2001.

3. *Hazard Classification of United States Military Explosives and Munitions*, U.S. Army Defense Ammunition Center, Logistics Review and Technical Assistance Office, McAlester, OK, Revision 11, February 2001.
4. *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 5 Testing Conducted at Aberdeen Proving Ground, Maryland*, MACTEC Federal Programs, Inc., Research Triangle Park, NC, July 2006.
5. 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, January 2005 and June 2005.

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15.4.4 D540, M3 and M3A1 155-mm Propelling Charges

15.4.4.1 Ordnance Description^{1,2}

The M3 and M3A1 155-mm Propelling Charges (DODIC D540) are separate, loaded charges used in 155-mm howitzers for short-range training/test exercises. The charges are used to fire various projectiles at down-range targets. Note that emission factors presented herein include only those associated with the firing of the propelling charge; emissions associated with the explosion of the propelled projectile are not addressed in this section.

The M3 and M3A1 155-mm Propelling Charges consist of propellant including a base charge and four increments denoted as charge zone 2, charge zone 3, charge zone 4, and charge zone 5. The increments contain unequal amounts of propellant and from one to four of the increments may be used, depending upon the target range, projectile selected, and cannon used. The bags are fastened together with four cloth straps sewn to the base and tied on top of the charge zone 5 increment. Unnecessary charge increments are removed prior to loading the howitzer.

The M3 and M3A1 155-mm Propelling Charges contain an igniter charge in a red cloth bag sewn to the rear of the base charge. The M3 igniter charge consists of black powder while the M3A1 igniter charge consists of clean burning igniter. Although the M3 155-mm Propelling Charge is assembled without flash reducer pads, the M3A1 155-mm Propelling Charge includes from one to three pads to limit breech flare back, muzzle flash, and blast over pressure. A pad is assembled forward of the base charge and two pads are assembled forward of the charge zone 4 and 5 increments.

The M3 and M3A1 155-mm Propelling Charges are used during many Army training exercises, which are held at nearly every Army training installation. At most locations, the training areas are at least 1,000 meters (over 0.5 mile) away from populated areas. Typically, ninety-eight 155-mm Propelling Charges are used during each training event, which occurs approximately two times a year at a given training facility.

15.4.4.2. Weapon Description^{1,2}

The M3 and M3A1 155-mm Propelling Charges are typically used in the M199 155-mm Cannon and the M284 155-mm Cannon. These cannons are found on howitzers typically used in training activities, including the M198 towed howitzer, which employs the M199 cannon, and the M109A6 Paladin self-propelled howitzer, which employs the M284 cannon. The physical characteristics of the cannons are very similar, the main difference being that the M284 155-mm Cannon includes a bore evacuator while the M199 155-mm Cannon does not. Major chemical constituents of both cannon tubes include steel alloy and chrome alloy.

15.4.4.3 Emissions And Controls^{1,3-6}

Primary emissions from the firing of the M3 and M3A1 155-mm Propelling Charges include carbon monoxide (CO) and carbon dioxide (CO₂). Other criteria pollutants, hazardous air pollutants in 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 from each configuration at low levels. Because M3 and M3A1 155-mm Propelling Charges are typically fired in the field, there are no controls associated with their use.

Five tactical configurations were tested to address emission product variation as a function of howitzer cannon type, propelling charge, and charge increment (zone); these configurations are identified

in Table 15.4.4-1. Little variation was noted in the emission factors that were developed for each configuration; therefore, only average emission factors are presented herein.

Table 15.4.4-2 presents emission factors, in units of pounds of emissions per pound net explosive weight (NEW) contained in the item, for CO₂, criteria pollutants, methane, and total suspended particulate (TSP) emitted from the detonation of the M3 and M3A1 155-mm Propelling Charges. Table 15.4.4-3 presents emission factors for hazardous air pollutants and toxic chemicals. Because of the variation in NEW between configurations, emission factors were not developed in units of pounds of emissions per item.

Table 15.4.4-1 CANNON, PROPELLING CHARGE, AND CHARGE SIZE CONFIGURATIONS FOR WHICH EMISSIONS WERE QUANTIFIED

Configuration No.	Configuration ^a			
	Cannon	Propelling Charge	Charge Zone	NEW (lb per item)
1 ^b	M199	M3	3	3.28
2	M199	M3	5	5.75
3	M199	M3A1	3	3.5
4	M284	M3	3	3.28
5	M284	M3A1	3	3.5

^a Reference 1.

^b This configuration was tested during both the Firing Point 1 test series (References 1, 3, 5, and 6) and the Firing Point 5 test series (References 7, 8, 9, and 10)

Table 15.4.4-2 EMISSION FACTORS FOR THE USE OF DODIC D540, M3 AND M3A1 155-MM PROPELLING CHARGES - CARBON DIOXIDE, CRITERIA POLLUTANTS, METHANE, AND TOTAL SUSPENDED PARTICULATE^a

EMISSION FACTOR RATING: A (except as noted)

CASRN ^b	Pollutant	lb per lb NEW ^c
124-38-9	CO ₂	2.1 E-01
630-08-0	CO	5.9 E-01
7439-92-1	Lead (Pb) ^f	9.9 E-05
74-82-8	Methane	3.3 E-03
--	Oxides of nitrogen (NO _x)	3.9 E-02
--	PM-2.5 ^{d,f}	8.1 E-03
--	PM-10 ^{e,f}	1.7 E-02
12789-66-1	TSP ^f	2.1 E-02

^a Factors represent uncontrolled emissions. References 7, 8, and 10.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for each configuration tested is identified in Table 15.4.4-1.

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

^e PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 µm.

^f EMISSION FACTOR RATING B.

Table 15.4.4-3 EMISSION FACTORS FOR THE USE OF DODIC D540,
M3 AND M3A1 155-MM PROPELLING CHARGES –
HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS^a

EMISSION FACTOR RATING: C (except as noted)

CASRN ^b	Pollutant	lb/lb NEW ^c
83-32-9	Acenaphthene ^{d,h}	1.9 E-04
208-96-8	Acenaphthylene ^{d,g}	2.0 E-06
75-07-0	Acetaldehyde ^{e,h}	4.6 E-03
75-05-8	Acetonitrile ^{e,h}	1.1 E-04
107-13-1	Acrylonitrile ^{e,h}	1.3 E-04
7429-90-5	Aluminum ^{f,h}	7.7 E-05
7664-41-7	Ammonia ^{d,g}	1.3 E-02
120-12-7	Anthracene ^{e,h}	2.0 E-07
7440-36-0	Antimony ^e	4.7 E-05
7440-38-2	Arsenic ^{e,h}	1.2 E-06
7440-39-3	Barium ^f	1.4 E-05
71-43-2	Benzene ^{e,h}	2.2 E-04
56-55-3	Benzo[a]anthracene ^{e,g}	1.3 E-07
205-99-2	Benzo[b]fluoranthene ^{e,h}	2.9 E-07
207-08-9	Benzo[k]fluoranthene ^{e,h}	2.5 E-07
191-24-2	Benzo[g,h,i]perylene ^{e,h}	1.8 E-06
50-32-8	Benzo[a]pyrene ^{e,h}	4.7 E-07
192-97-2	Benzo[e]pyrene ^{d,h}	4.4 E-07
7440-43-9	Cadmium ^e	1.4 E-05
463-58-1	Carbonyl sulfide ^{e,i}	7.5 E-05
74-87-3	Chloromethane ^e	4.1 E-04
7440-47-3	Chromium ^e	3.4 E-06
218-01-9	Chrysene ^e	1.3 E-07
7440-48-4	Cobalt ^e	6.5 E-07
7440-50-8	Copper ^{f,h}	2.2 E-03
57-12-5	Particulate cyanide ^e	2.0 E-02
53-70-3	Dibenz[a,h]anthracene ^{e,h}	2.6 E-08
107-06-2	1,2-Dichloroethane ^{e,h}	8.8 E-04
--	Total dioxin/furan compounds ^e	7.0 E-10
111-90-0	2-(2-Ethoxyethoxy)ethanol ^{e,i}	1.3 E-05

Table 15.4.4-3 (cont.)

CASRN ^b	Pollutant	lb/lb NEW ^c
100-41-4	Ethylbenzene ^{e,g}	6.0 E-04
74-85-1	Ethylene ^{f,g}	1.6 E-01
117-81-7	bis(2-Ethylhexyl)phthalate ^e	6.0 E-03
206-44-0	Fluoranthene ^{e,h}	8.0 E-07
86-73-7	Fluorene ^{d,g}	6.0 E-07
50-00-0	Formaldehyde ^{e,h}	3.1 E-03
76-13-1	Freon 113 ^{f,h}	2.5 E-06
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin ^e	9.8 E-11
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran ^e	9.0 E-12
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran ^e	7.1 E-11
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin ^e	1.2 E-10
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin ^e	6.3 E-12
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin ^e	5.3 E-12
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran ^e	2.7 E-11
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran ^e	5.9 E-11
74-90-8	Hydrogen cyanide ^{e,h}	3.4 E-03
193-39-5	Indeno[1,2,3-cd]pyrene ^{e,g}	7.4 E-07
7439-92-1	Lead ^{e,h}	9.9 E-05
7439-96-5	Manganese ^{e,h}	1.0 E-05
75-09-2	Methylene chloride ^{e,h}	5.9 E-04
1634-04-4	Methyl tert-butyl ether ^{e,i}	7.4 E-06
91-20-3	Naphthalene ^{e,g}	1.2 E-05
7440-02-0	Nickel ^e	8.3 E-06
7697-37-2	Nitric acid ^{f,h}	1.2 E-02
1843-05-6	Octabenzene ^d	2.7 E-05
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin ^e	5.6 E-10
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran ^e	1.4 E-11
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin ^e	5.0 E-11
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran ^e	7.5 E-11
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran ^e	3.0 E-11
85-01-8	Phenanthrene ^{e,h}	1.4 E-06
108-95-2	Phenol ^{e,h}	1.8 E-05
129-00-0	Pyrene ^{d,h}	2.0 E-06

Table 15.4.4-3 (cont.)

CASRN ^b	Pollutant	lb/lb NEW ^c
7440-22-4	Silver ^f	9.4 E-06
100-42-5	Styrene ^e	6.7 E-04
7664-93-9	Sulfuric acid ^f	1.2 E-02
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin ^e	6.8 E-11
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran ^e	4.9 E-11
108-88-3	Toluene ^{e,h}	8.7 E-06
71-55-6	1,1,1-Trichloroethane ^e	5.7 E-05
75-69-4	Trichlorofluoromethane ^f	1.0 E-03
540-84-1	2,2,4-Trimethylpentane ^{d,i}	2.3 E-04
75-35-4	Vinylidene chloride ^{e,h}	9.4 E-06
106-42-3, 108-38-3	m-Xylene, p-Xylene ^{e,h}	5.7 E-04
95-47-6	o-Xylene ^{e,h}	6.3 E-04
7440-66-6	Zinc ^f	3.8 E-04

^a Factors represent uncontrolled emissions. References 7, 8, and 10.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for each configuration tested is identified in Table 15.4.4-1.

^d Hazardous air pollutant under CAA Section 112(b).

^e Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

^f Reportable chemical under EPCRA Section 313.

^g EMISSION FACTOR RATING A.

^h EMISSION FACTOR RATING B.

ⁱ EMISSION FACTOR RATING D.

References For Section 15.4.4

1. *Report No. 1 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, March 2001.
2. *Training Munitions Health Risk Assessment No. 39-EJ-1485-00, Residential Exposure from Inhalation of Air Emissions from the 155-mm Propelling Charge (M3 series)*, Department of Defense Identification Code: D540, U.S. Army Center for Health Promotion and Preventive Medicine, Environmental Health Risk Assessment Program, June 2001.
3. *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.

4. *Hazard Classification of United States Military Explosives and Munitions*, U.S. Army Defense Ammunition Center, Logistics Review and Technical Assistance Office, McAlester, OK, Revision 11, February 2001.
5. *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*, MACTEC Federal Programs, Inc., Research Triangle Park, NC, July 2006.
6. 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.
7. *Report No. 5 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, September 2003.
8. *Detailed Test Plan No. 5 for the Firing Point Emission Study, Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, August 2001.
9. 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, January 2005 and June 2005.
10. *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 5 Testing Conducted at Aberdeen Proving Ground, Maryland*, MACTEC Federal Programs, Inc., Research Triangle Park, NC, July 2006.

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15.4.5 D541, M4A2 155-mm Propelling Charge, Zone 7

15.4.5.1 Ordnance Description^{1,2}

The M4A2 155-mm Propelling Charge, Zone 7 (DODIC D541) is a separate, white bag loaded charge used in 155-mm howitzers for firing into zones 3 through 7. The charge is used to fire various projectiles at down-range targets. Note that emission factors presented herein include only those associated with the firing of the propelling charge; emissions associated with the explosion of the propelled projectile are not addressed in this section.

The M4A2 155-mm Propelling Charge, consist of propellant including a base charge and four increments denoted as charge zone 4, charge zone 5, charge zone 6, and charge zone 7. The increments contain unequal amounts of propellant and from one to four of the increments may be used, depending upon the target range, projectile selected, and cannon used. The bags are fastened together with four cloth straps sewn to the base and tied on top of the charge zone 7 increment. Unnecessary charge increments are removed prior to loading the howitzer.

The M4A2 155-mm Propelling Charge contains an igniter charge in a red cloth bag sewn to the rear of the base charge. The igniter charge consists of a clean burning igniter. A flash reducer pad is assembled at the front end of the base increment.

15.4.5.2 Emissions And Controls¹⁻⁵

The primary emissions from the ignition of the M4A2 155-mm Propelling Charge are carbon dioxide (CO₂) and carbon monoxide (CO). 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 detonated in the field, there are no controls associated with its use.

Table 15.4.5-1 presents emission factors for CO₂, criteria pollutants, methane, and total suspended particulate (TSP). Table 15.4.5-2 presents emission factors for hazardous air pollutants and toxic chemicals. 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).

15.4.5.3 Updates Since August 2004

Section 15.4 was created during August 2004. Revisions to this section since that date are summarized below.

Revision 2, July 2006

- Section 15.4.3, which presents emission factors for DODIC D533, M119A2 155-mm Propelling Charge, Zone 7, was added.
- Section 15.4.4, which presents emission factors for DODIC D540, M3 and M3A1 155-mm Propelling Charges, was updated to include additional test data.
- Section 15.4.5, which presents emission factors for DODIC D541, M4A2 155-mm Propelling Charge, Zone 7, was added.

Revision 1, July 2006

- The methodology used to assign emission factor ratings was revised as described in the associated background documents.
- The formatting for Table 15.4.1-1 was revised.
- Section 15.4.4, which presents emission factors for DODIC D540, M3 and M3A1 155-mm Propelling Charges, was added.

Table 15.4.5-1 EMISSION FACTORS FOR THE USE OF D541, M4A2 155-MM PROPELLING CHARGE, ZONE 7 – CARBON DIOXIDE, CRITERIA POLLUTANTS, METHANE, AND TOTAL SUSPENDED PARTICULATE^a

EMISSION FACTOR RATING: A (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
124-38-9	CO ₂	4.7	3.5 E-01
630-08-0	CO	6.0	4.5 E-01
7439-92-1	Lead (Pb) ^f	3.6 E-03	2.7 E-04
74-82-8	Methane	3.6 E-02	2.7 E-03
--	Oxides of nitrogen (NO _x)	7.9 E-02	5.9 E-03
--	PM-2.5 ^{d,f}	1.4 E-01	1.0 E-02
--	PM-10 ^{e,f}	3.2 E-01	2.4 E-02
12789-66-1	TSP ^f	4.2 E-01	3.2 E-02

^a Factors represent uncontrolled emissions. References 1, 2, and 3.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 13.32 pounds per item. Reference 2.

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

^e PM-10 = particulate matter with an aerodynamic diameter equal to or less than 10 µm.

^f EMISSION FACTOR RATING B.

Table 15.4.5-2 EMISSION FACTORS FOR THE USE OF D541,
M4A2 155-MM PROPELLING CHARGE, ZONE 7 –
HAZARDOUS AIR POLLUTANTS AND TOXIC CHEMICALS^a

EMISSION FACTOR RATING: B (except as noted)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
83-32-9	Acenaphthene ^d	3.4 E-07	2.5 E-08
208-96-8	Acenaphthylene ^{d,g}	7.8 E-07	5.8 E-08
75-07-0	Acetaldehyde ^e	1.3 E-05	1.0 E-06
75-05-8	Acetonitrile ^e	1.7 E-04	1.3 E-05
7429-90-5	Aluminum ^{f,h}	2.3 E-03	1.7 E-04
7664-41-7	Ammonia ^{d,g}	1.4 E-01	1.0 E-02
120-12-7	Anthracene ^e	1.7 E-07	1.3 E-08
7440-39-3	Barium ^{f,i}	1.3 E-04	9.5 E-06
71-43-2	Benzene ^e	1.9 E-04	1.4 E-05
56-55-3	Benzo[a]anthracene ^{e,g}	1.5 E-07	1.1 E-08
205-99-2	Benzo[b]fluoranthene ^e	1.6 E-07	1.2 E-08
191-24-2	Benzo[g,h,i]perylene ^e	1.3 E-06	1.0 E-07
192-97-2	Benzo[e]pyrene ^d	2.9 E-07	2.2 E-08
7440-47-3	Chromium ^{e,i}	3.4 E-05	2.6 E-06
18540-29-9	Hexavalent chromium ^{e,h}	1.2 E-05	9.2 E-07
218-01-9	Chrysene ^{e,h}	1.8 E-07	1.4 E-08
7440-50-8	Copper ^f	4.6 E-02	3.4 E-03
57-12-5	Particulate cyanide ^{e,h}	3.9 E-03	2.9 E-04
75-71-8	Dichlorodifluoromethane ^f	6.4 E-06	4.8 E-07
--	Total dioxin/furan compounds ^{e,h}	1.4 E-09	1.0 E-10
74-85-1	Ethylene ^{f,g}	1.8 E-04	1.4 E-05
117-81-7	bis(2-Ethylhexyl)phthalate ^{e,h}	8.2 E-05	6.1 E-06
206-44-0	Fluoranthene ^e	7.6 E-07	5.7 E-08
86-73-7	Fluorene ^{d,g}	7.8 E-07	5.8 E-08
50-00-0	Formaldehyde ^e	6.5 E-05	4.9 E-06
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin ^{e,h}	1.1 E-10	8.5 E-12
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran ^{e,h}	2.5 E-11	1.9 E-12
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin ^{e,h}	4.6 E-12	3.5 E-13
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin ^{e,h}	5.8 E-12	4.3 E-13
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran ^{e,i}	2.1 E-12	1.5 E-13

Table 15.4.5-2 (cont.)

CASRN ^b	Pollutant	lb per item	lb per lb NEW ^c
74-90-8	Hydrogen cyanide ^e	5.0 E-02	3.7 E-03
7439-92-1	Lead ^e	3.6 E-03	2.7 E-04
7439-96-5	Manganese ^e	1.0 E-04	7.5 E-06
91-20-3	Naphthalene ^{e,g}	6.7 E-06	5.0 E-07
7440-02-0	Nickel ^{e,i}	8.4 E-05	6.3 E-06
7697-37-2	Nitric acid ^{f,h}	2.2 E-03	1.6 E-04
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin ^{e,h}	1.2 E-09	8.9 E-11
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran ^{e,h}	4.3 E-11	3.2 E-12
85-01-8	Phenanthrene ^e	1.2 E-06	9.2 E-08
108-95-2	Phenol ^e	1.6 E-05	1.2 E-06
129-00-0	Pyrene ^d	1.6 E-06	1.2 E-07
100-42-5	Styrene ^{e,h}	4.7 E-05	3.5 E-06
108-88-3	Toluene ^e	2.7 E-05	2.0 E-06
540-84-1	2,2,4-Trimethylpentane ^{d,i}	6.0 E-04	4.5 E-05
7440-62-2	Vanadium ^{f,i}	6.0 E-05	4.5 E-06
7440-66-6	Zinc ^{f,h}	6.0 E-03	4.5 E-04

^a Factors represent uncontrolled emissions. References 1, 2, and 5.

^b CASRN = Chemical Abstracts Service Registry Number.

^c NEW = net explosive weight. The NEW for this ordnance is 13.32 pounds per item. Reference 5.

^d Hazardous air pollutant under CAA Section 112(b).

^e Reportable chemical under EPCRA Section 313 and a hazardous air pollutant under CAA Section 112(b).

^f Reportable chemical under EPCRA Section 313.

^g EMISSION FACTOR RATING A.

^h EMISSION FACTOR RATING C.

ⁱ EMISSION FACTOR RATING D.

References For Section 15.4.5

1. *Report No. 5 for the Firing Point Emission Study Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, September 2003.
2. *Detailed Test Plan No. 5 for the Firing Point Emission Study, Phase II*, Military Environmental Technology Demonstration Center, U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD, August 2001.
3. *Hazard Classification of United States Military Explosives and Munitions*, U.S. Army Defense Ammunition Center, Logistics Review and Technical Assistance Office, McAlester, OK, Revision 11, February 2001.

4. *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 5 Testing Conducted at Aberdeen Proving Ground, Maryland, MACTEC Federal Programs, Inc., Research Triangle Park, NC, July 2006.*
5. 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, January 2005 and June 2005.