

CLEARED

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DoW Blast Overpressure Reference and Information Guide (D-BOP RIG) 2.0

July 2026

DoW Requirements for Managing Brain Health Risks from Blast Overpressure (BOP) / D-BOP RIG

- Specifies recommended stand-off distances for those (1) involved in training (e.g., instructors, range safety officers) and (2) involved in operations of the weapon system (e.g., assistant gunners, spotters and loaders) if there are options pertaining to their proximity to the weapons system, with consideration given to safe training and operations
- The stand-off distances and contour maps will continue to be updated as additional characterizations are completed, including additional weapons systems and/or variations in ammunition or charges, configuration (e.g., non-open terrain, shipboard)
- Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations

As Low as Reasonably Achievable (ALARA)

1 Minimize number of **personnel** in vicinity of BOP event

2 Increase **standoff distances** from weapons

3 Minimize the duration of **live-fire events**

4 Adhere to the **maximum allowable number of rounds (ANOR) that may be fired** during each event or time-period

5 Ensure appropriate **use of personal protective gear and equipment (PPE)**

6 **Train and educate others** on BOP hazards and risk management actions

Avoid unnecessary exposure

Fewer personnel

Increased distances

Shorter durations

Limit number of rounds

Use PPE

Educate others

Summary of Major Changes Since Last Publication

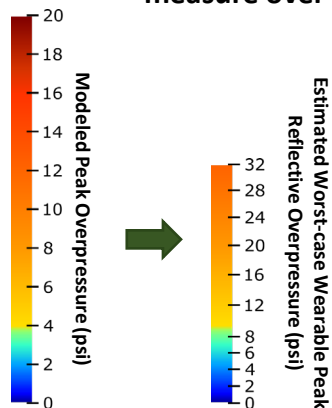
- **Incorporated enhanced mapping data for 4 additional weapons systems:**
 - M2A4 Bradley Fighting Vehicle (25 mm Chain Gun)
 - M1A2 Abrams Tank (120 mm Smoothbore Gun)
 - M67 Fragmentation Hand Grenade
 - Stun Grenade
- **Integrated updated maps for previously included weapons systems:**
 - M3 MAAWS
 - Updated contour map from extending 6 m to the right to 8 m to the right
 - M2A1 Machine Gun
 - Updated contour map to include personnel and simulation slice height to be at head level
 - M777 Howitzer
 - Replaced original contour with two distinct contour maps
 - M109A6/A7 Paladin
 - Updated the top-down contour image
 - 81 mm M252 Mortar
 - Updated contour map simulation slice height from 1.36 m to 1.15 m to remain consistent with other mortar contour maps

Summary of Major Changes Since Last Publication Cont.

- **Refined** how details were presented for each weapons system to **improve consistency**
- **Recategorized** weapons systems slightly to allow for **incorporation of additional data sets**
- **Added an acronym table** at the end of the guide
- **Updated pressure scales** to better represent pressures measured by **wearable blast sensors**
 - While the pressure scales were updated, the source data and contour maps for most weapons systems previously included in the D-BOP RIG 1.0 did not change (i.e., the updated pressure scale should not be interpreted to suggest that the weapons are producing higher overpressure)
 - Even with the updated pressure scale, many weapons systems did not require an update to the stand-off distances published in D-BOP RIG 1.0 as they were determined conservatively

Pressure Scale Update Details

- The contour maps within this guide were created through robust modeling based on the blast generated by the weapon itself versus the pressures measured on individual Service members
- The **pressure scale** previously used in **D-BOP RIG 1.0** represents **modeled peak overpressure levels** (similar to those that would be measured by a pencil probe, the gold standard in measuring blast)
 - Due to the **complex and orientation-dependent** nature of measuring blast, **these values may differ from those measured by a wearable blast sensor**
 - **Reflective interactions** from the body and environment can cause wearable blast sensors to **measure over double** what would be measured by a pencil probe



- Therefore, the pressure scales were updated to better estimate **worst-case wearable peak reflective overpressure levels**
- The length of the pressure scale was also adjusted to include only the portions of the modeled contours that may be measured by wearable blast sensors
- This change was made with the goal of **ensuring the values in the contour maps better represent the values that Service members may see** on the devices used to measure exposures during training (wearable blast sensors)
- When interpreting the contour map color range, **please note that green is not meant to automatically signify safety or below a potential level of concern**

Contents—Examined Weapon Systems

Shoulder Launched Munitions

- M3 Mult-Role Anti-Armor Anti-Personnel Weapon System (MAAWS) (Carl Gustaf)
- M136A1 AT4 Confined Space (AT4-CS)
- M72 Light Anti-Tank Weapon (LAW)

.50 Caliber Weapons

- M107 Sniper Rifle
- M2A1 Machine Gun
- MK 15 Mod 1 Sniper Rifle
- GAU21 Machine Gun

Indirect Fire Systems

- 105 mm M119 Howitzer
- 155 mm M777 Howitzer
- 120 mm M120 Mortar
- 81 mm M252 Mortar
- 60 mm M224 Mortar

Explosive Breachers

- Breacher (Door)

Fighting Vehicles

- M109A6/A7 Paladin (155 mm Howitzer)
- M2A4 Bradley Fighting Vehicle (25 mm Chain Gun)
- M1A2 Abrams Tank (120 mm Smoothbore Gun)

Grenades

- M67 Fragmentation Hand Grenade
- Stun Grenade

How to Use This Guide

This guide leverages data collection efforts performed by the USUHS CONQUER program.

Title:

Weapon system name and type

M3 Multi-Role Anti-Armor Anti-Personnel Weapon System (MAAWS) (Carl Gustaf)



STANDING

Posture

DoW Personal Protective Equipment Guidance:

- Personal protective equipment (PPE) level, and protections associated with each PPE level
- PPE levels, as defined by the Range Safety Regulation, can be found at the end of this guide
- Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations

DoW Personal Protective Equipment Guidance

Hearing Protection: Double-hearing protection (properly inserted earplugs and properly fitting earmuffs) must be worn within a 9 m radius. Approved single-hearing protection must be worn within 319 m for all anti-tank rockets, and within 460 m while firing HE, HEAT, TP, Smoke, and Illumination.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) for all personnel within 20 m.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 84 mm Recoilless Rifle
Ammunition Information: 84 mm HEAT TP 552 (DODIC: C386)



Minimum Stand-off Distance:
Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4 psi: 20 ft (6 m) or approximately the length of a shipping container (side on)

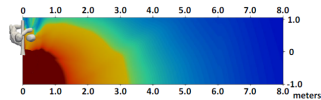
Approx. 20 ft (6 m) side on

Blast Overpressure Measurement Data

Horizontal slice at height = 1.6 m



Estimated Worst-Case Blast Peak Reflective Overpressure (psi)



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Pressure Scale:

Estimates worst-case values that may be measured by wearable blast sensors

Graph:

A bird's eye view of BOP zones color-coded based psi levels around the weapon

Output graph key; Grid is in meters

Data Collection Information and Recommended Stand-off Distances:

- Weapon description, ammunition, and configuration information for which BOP data was collected
- Minimum standoff distance for personnel in vicinity of the stationary weapon system based off 4 psi contour
 - More information on the 4 psi interim BOP exposure safety guideline can be found in the BOP Policy Memorandum linked on the Reference slide

Shoulder Launched Munitions



**M3 Multi-Role Anti-Armor Anti-Personnel
Weapon System (MAAWS) (Carl Gustaf)**



M136A1 AT4 Confined Space (AT4-CS)



M72 Light Anti-Tank Weapon (LAW)

M3 Multi-Role Anti-Armor Anti-Personnel Weapon System (MAAWS) (Carl Gustaf)



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Double-hearing protection (properly inserted earplugs and properly fitting earmuffs) must be worn within a 9 m radius. Approved single-hearing protection must be worn within 319 m for all anti-tank rockets, and within 460 m while firing HE, HEAT, TP, Smoke, and Illumination.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) for all personnel within 20 m.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 84 mm Recoilless Rifle

Ammunition Information: 84 mm HEAT TP 552 (DODIC: C386)



Minimum Stand-off Distance:

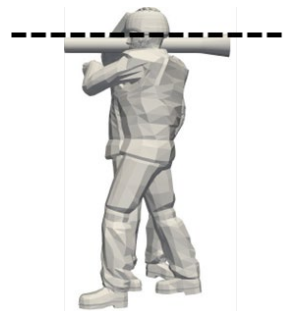
Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4 psi:

20 ft (6 m) or approximately the length of a shipping container (side on)

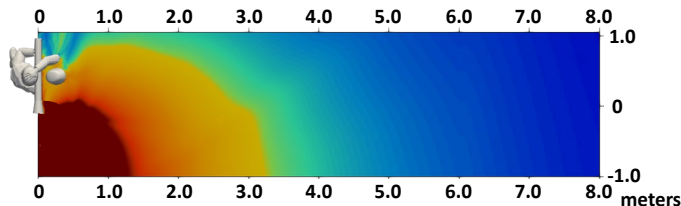
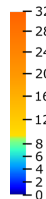
Approx. 20 ft (6 m) side on

Blast Overpressure Measurement Data

Horizontal slice
at height = 1.6 m



Estimated Worst-case Wearable Peak
Reflective Overpressure (psi)



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

M136A1 AT4 Confined Space (AT4-CS)



STANDING

DoW Personal Protective Equipment Guidance

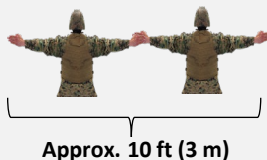
Hearing Protection: Double-hearing protection (properly inserted earplugs and properly fitting earmuffs) must be worn within a 100 m radius. Approved single-hearing protection must be worn within 205 m for all anti-tank rockets.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) for all personnel within 20 m.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 84 mm Recoilless Rifle

Ammunition Information: 84 mm AT4-CS-RS (DODIC: CA30)



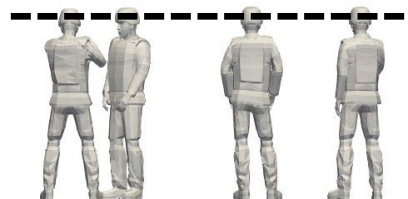
Minimum Stand-off Distance:

Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4 psi:

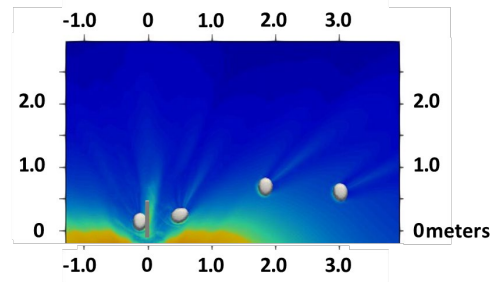
10 ft (3 m) or approximately 2 full arm spans

Blast Overpressure Measurement Data

Horizontal
slice at
height =
1.75 m



Estimated Worst-case Wearable Peak
Reflective Overpressure (psi)



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

M72 Light Anti-Tank Weapon (LAW)



STANDING

DoW Personal Protective Equipment Guidance

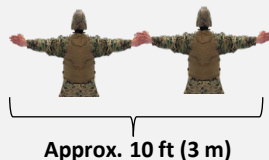
Hearing Protection: Double-hearing protection (properly inserted earplugs and properly fitting earmuffs) must be worn within a 19 m radius. Approved single-hearing protection must be worn within 390 m for all anti-tank rockets.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) for all personnel within 20 m.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 66 mm Anti-Tank Launcher

Ammunition Information: 66 mm HEAT



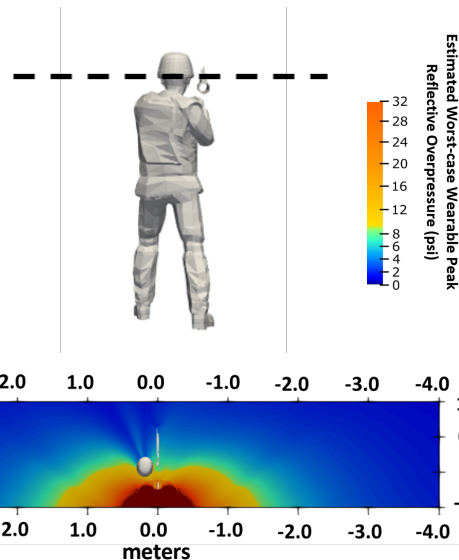
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

10 ft (3 m) or approximately 2 full arm spans

Blast Overpressure Measurement Data

Horizontal
slice at height
= 1.68 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

. 50 Caliber Weapons



M107 Sniper Rifle



M2A1 Machine Gun



MK 15 Mod 1 Sniper Rifle



GAU-21 Machine Gun

M107 Sniper Rifle



PRONE

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection will be worn within 55 m to the side and 12 m to the rear of the weapon.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel on range.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: .50 cal blow-back operated semi-automatic sniper rifle with dual chamber detachable muzzle brake

Ammunition Information: .50 cal BMG M33 Ball (DODIC: A557)



Approx. 7 ft (2.1 m)

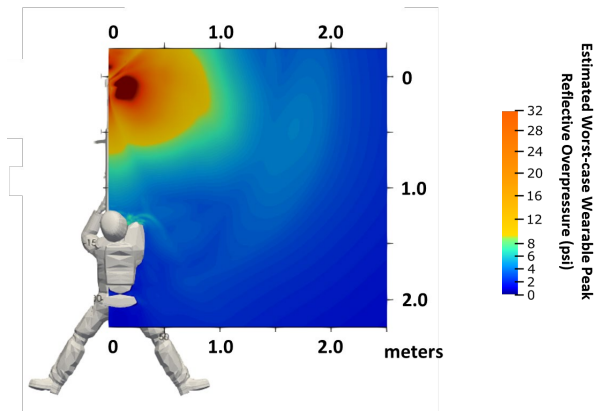
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

7 ft (2.1 m) or approximately a full arm span

Blast Overpressure Measurement Data

Horizontal slice at
height = 0.32 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

M2A1 Machine Gun



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection will be worn within 55 m to the side and 12 m to the rear of the weapon.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel on range.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: .50 cal semi-automatic machine gun

Ammunition Information: .50 cal M8 API (DODIC: A531)



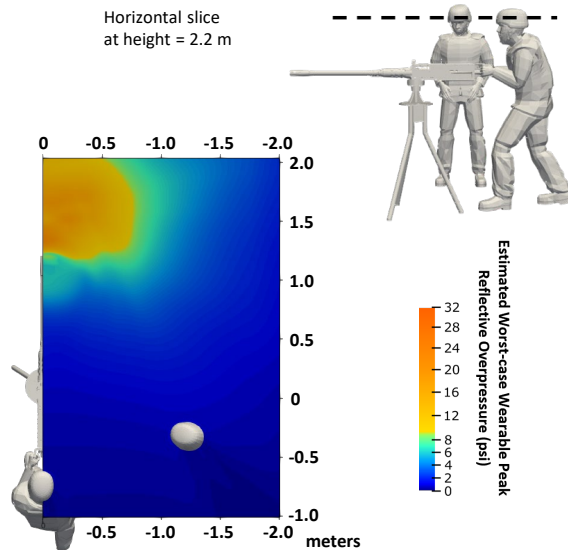
Approx. 7 ft (2.1 m)

Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

7 ft (2.1 m) or approximately a full arm span

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

MK 15 Mod 1 Sniper Rifle



PRONE

DoW Personal Protective Equipment Guidance

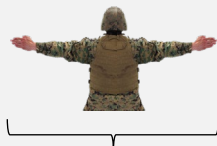
Hearing Protection: Approved single-hearing protection will be worn within 55 m to the side and 12 m to the rear of the weapon.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel on range.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: .50 cal bolt action sniper rifle

Ammunition Information: .50 cal BMG M33 Ball (DODIC: A557)



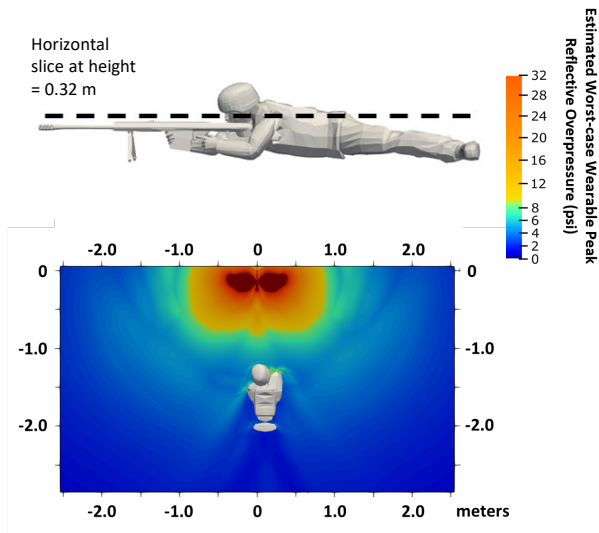
Approx. 7 ft (2.1 m)

Minimum Stand-off Distance:

Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4 psi: **7 ft (2.1 m) or approximately a full arm span**

Blast Overpressure Measurement Data

Horizontal
slice at height
= 0.32 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

GAU-21 Machine Gun



DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection will be worn within 55 m to the side and 12 m to the rear of the weapon.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel on range.

Data Collection Information and Recommended Stand-off Distances

Weapons Description: .50 cal automatic machine gun

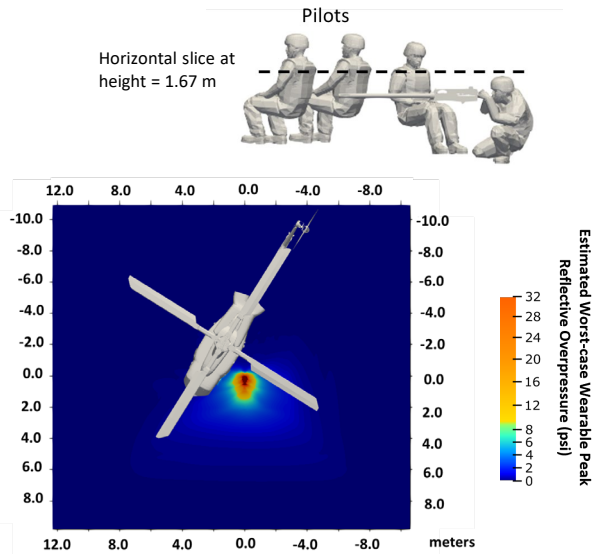
Ammunition Information: .50 cal BMG M33 Ball (DODIC: A557)

Minimum Stand-off Distance (Ground):

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

Measurements where personnel may be located are < 4 psi; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Indirect Fire Systems



105 mm M119 Howitzer



155 mm M777 Howitzer



120 mm M120/121 Mortar



81 mm M252 Mortar



60 mm M224 Mortar

105 mm M119 Howitzer



STANDING

DoW Personal Protective Equipment Guidance

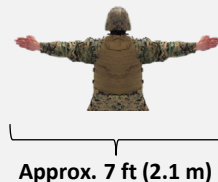
Hearing Protection: Approved double-hearing protection is required within 9 m, and single-hearing protection is required within 165 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel immediately engaged in firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: Indirect Fires System Artillery Cannons

Ammunition Information: M1 projectile, 105 mm HE M67 propellant system (DODIC: C436), fired at Charge 6



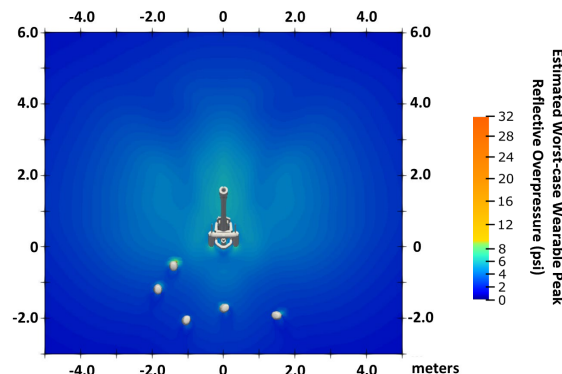
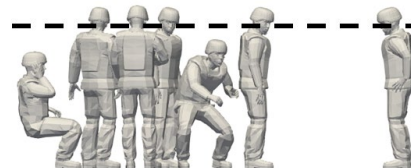
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

7 ft (2.1 m) or approximately a full arm span

Blast Overpressure Measurement Data

Horizontal slice
at height = 1.6 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

155 mm M777 Howitzer

2 LIMA Charge



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved double-hearing protection is required within 9 m, and single-hearing protection is required within 235 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel immediately engaged in firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: Towed 155-mm lightweight artillery system

Ammunition Information: Round fired w/ M231 MACS (DODIC: DA12), 2 LIMA Charge

Configuration Information: 14 degree barrel angle



Approx. 20 ft (6 m) side on

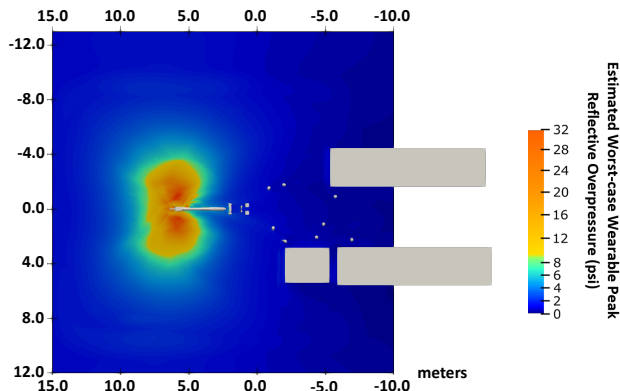
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

23 ft (7 m) or slightly more than the length of a shipping container (side on)

Blast Overpressure Measurement Data

Horizontal
slice at height
= 1.6 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

155 mm M777 Howitzer

5 HOTEL Charge



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved double-hearing protection is required within 22 m, and single-hearing protection is required within 611 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel immediately engaged in firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Type: Towed 155-mm lightweight artillery system

Ammunition Information: M795 HE (DODIC: D529) fired w/ M232 MACS (DODIC: DA13), 5 HOTEL Charge

Configuration Information: 30 degree barrel angle



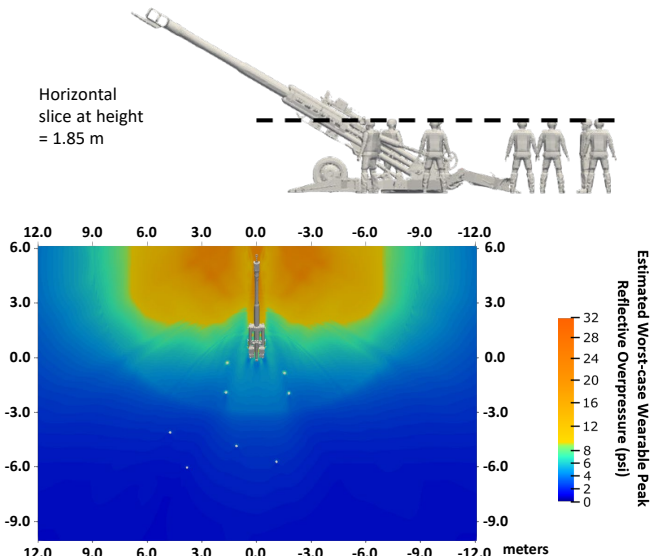
Approx. 40 ft (12 m)

Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

40 ft (12 m) or slightly more than a deployed M777

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

120 mm M120/121 Mortar



KNEELING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved double-hearing protection is required within 21 m, and single-hearing protection is required within 375 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel who take part in mortar firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 120 mm Ground Mounted Mortar

Ammunition Information: 120 mm M933 HE Cartridge, M230 Propelling Charge, fired with Charge 3



Approx. 10 ft (3 m)

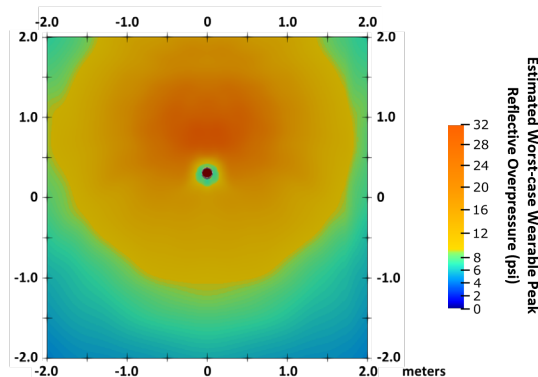
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

13 ft (4 m) or slightly more than 2 full arm spans

Blast Overpressure Measurement Data

Horizontal slice
at height = 1.6m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

81 mm M252 Mortar



KNEELING

DoW Personal Protective Equipment Guidance

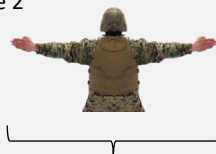
Hearing Protection: Approved double-hearing protection is required within 6.5 m, and single-hearing protection is required within 115 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel who take part in mortar firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 81 mm Ground Mounted Mortar

Ammunition Information: 81 mm M889A2 HE Cartridge (DODIC: CA43), M223 Propelling Charge, fired with Charge 2



Approx. 7 ft (2.1 m)

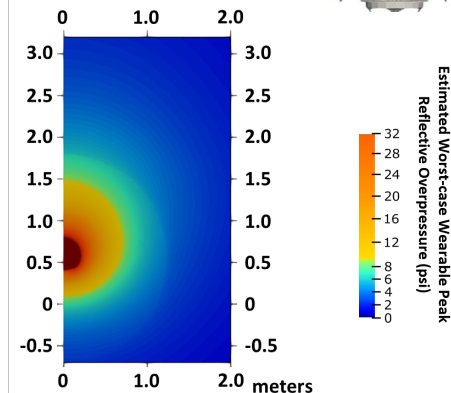
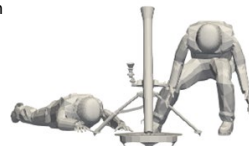
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

7 ft (2.1 m) or approximately a full arm span

Blast Overpressure Measurement Data

Horizontal slice
at height = 1.36m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

60 mm M224 Mortar



KNEELING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved double-hearing protection is required within 4.4 m, and single-hearing protection is required within 78 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel who take part in mortar firing.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 60 mm Ground Mounted Mortar

Ammunition Information: 60 mm M1061 HE Cartridge (DODIC: BA29), 2 Propelling Charges, fired with Charge 2



Approx. 3 ft (0.9 m)

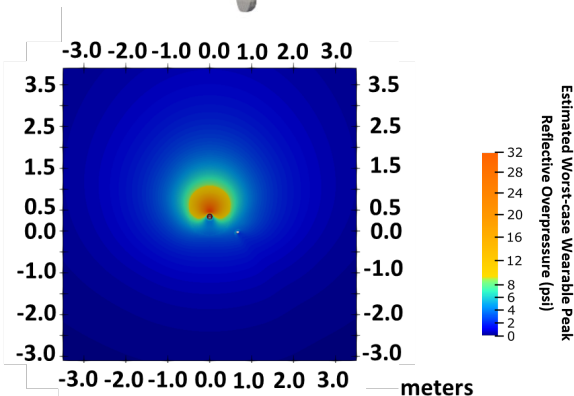
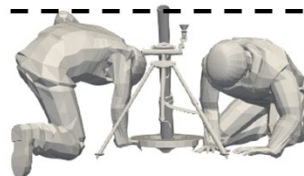
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

4 ft (1.2 m) or slightly more than 1 arm length

Blast Overpressure Measurement Data

Horizontal slice
at height = 0.8 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Explosive Breachers



Breacher Door

DoW Personal Protective Equipment Guidance

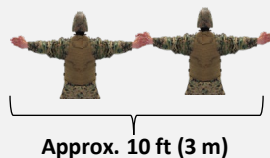
Hearing Protection: The use of double-hearing protection during explosives training and operations is strongly encouraged.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) will be worn by personnel in the SDZ.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: Explosive Breaching

Explosive Description: Door water charge w/ NEW: 0.11lbs

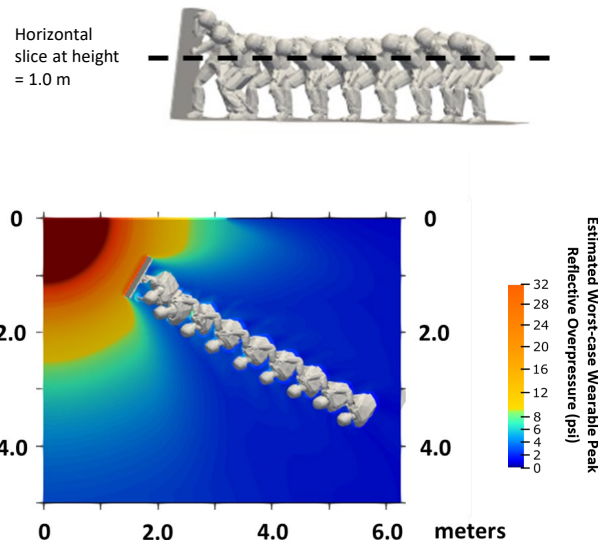


Minimum Stand-off Distance:

Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

13 ft (4 m) or slightly more than 2 full arm spans

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Fighting Vehicles



M109A6/A7 Paladin (155 mm Self-Propelled Howitzer)



M2A4 Bradley (25 mm Chain Gun)



M1A2 Abrams Main Battle Tank (120 mm Smoothbore Gun)

M109A6/A7 Paladin (155 mm Self-Propelled Howitzer)



DoW Personal Protective Equipment Guidance

Hearing Protection: Approved double-hearing protection is required within 34 m, and single-hearing protection is required within 611 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) required for all personnel on the range.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 155 mm Self-Propelled Howitzer

Ammunition Information: 155 mm M1122 HE (DODIC: DA51) fired w/ M231 MACS (DODIC: DA12), 2 LIMA Charge



Approx. 20 ft (6 m) side on

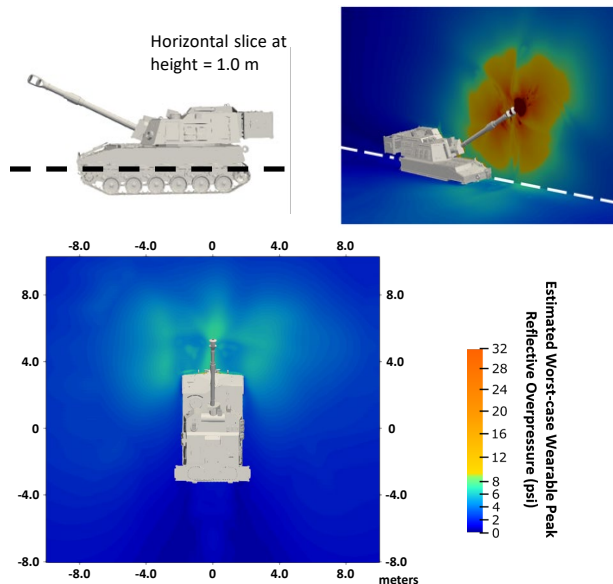
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

20 ft (6 m) or approximately the length of a Paladin (side on)

Note: Measurements are < 4 psi at operator locations within Paladin

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

M2A4 Bradley (25 mm M242 Bushmaster)



DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection, headsets, or CVC helmets with active noise reduction required for all vehicle occupants.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel within the danger area.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 25 mm M242 Bushmaster Chain Gun

Ammunition Information: 25 mm M910 TPDS-T (DODIC: A940)

Configuration Information: 4.1 degree barrel angle, hatches open



Approx. 10 ft (3 m)

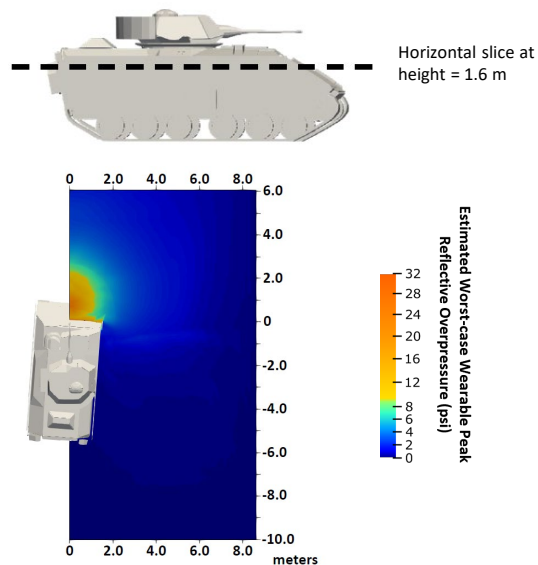
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

13 ft (4 m) or slightly more than 2 full arm spans

Note: Measurements are < 4 psi at operator locations within Bradley

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

M1A2 Abrams Main Battle Tank (120 mm M256 Smoothbore Gun)



DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection, headsets, or CVC helmets with active noise reduction required for all vehicle occupants. Approved single hearing protection for all personnel within 501 m.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) recommended for all personnel within the danger area.

Data Collection Information and Recommended Stand-off Distances

Weapon Description: 120 mm M256 Smoothbore Gun

Ammunition Information: 120 mm M865 TPCSDS-T (DODIC: C785)

Configuration Information: 0.2 degree barrel angle, 6.53 degree azimuth, hatches open



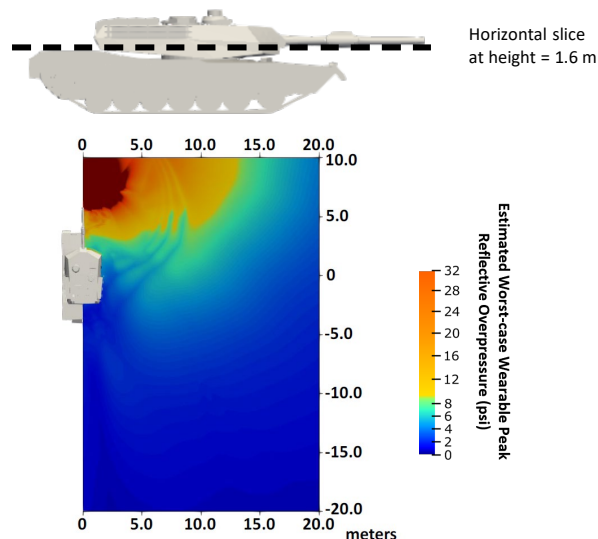
Minimum Stand-off Distance: **Approx. 66 ft (20 m)**

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

66 ft (20 m) or approximately the size of a large articulating bus

Note: Measurements are < 4 psi at operator locations within Tank

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Grenades



M67 Fragmentation Hand Grenade



Stun Grenade

M67 Fragmentation Hand Grenade



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Approved single-hearing protection is required for all participating personnel when throwing bays are used, and is recommended for all personnel participating in tactical exercises.

PPE: Body armor and helmet, hearing and eye protection (PPE Level 1) for all personnel within the 150 m danger area.

Data Collection Information and Recommended Stand-off Distances

Explosive Description: Composition B, NEW: 6.5 oz (DODIC: G881)

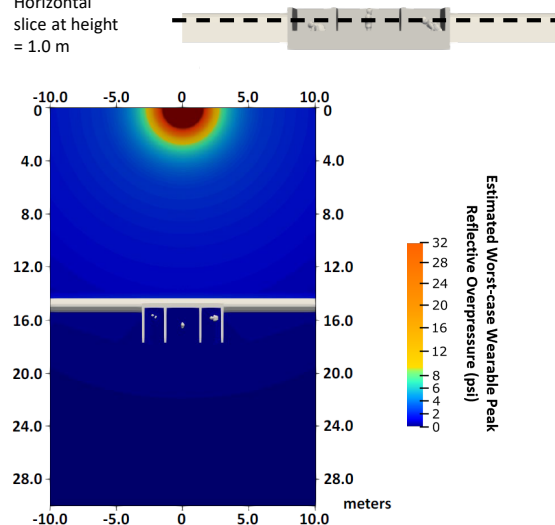
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

Measurements are < 4 psi at operator locations, but stand-off distances should not be derived from this contour map as the 4 psi contour around point of detonation (~5.5 m) is within the wounding radius of the grenade. Information on safe viewing positions and protective measures for observers can be found in the Range Safety Regulation. Otherwise, maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements

Blast Overpressure Measurement Data

Horizontal
slice at height
= 1.0 m



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Stun Grenade



STANDING

DoW Personal Protective Equipment Guidance

Hearing Protection: Properly fitted single-hearing protection is required during training at all times when detonating a stun grenade.

PPE: Combat uniform or standard utility uniform, hearing and eye protection (PPE Level 0) for all personnel within the 24 m SDZ.

Data Collection Information and Recommended Stand-off Distances

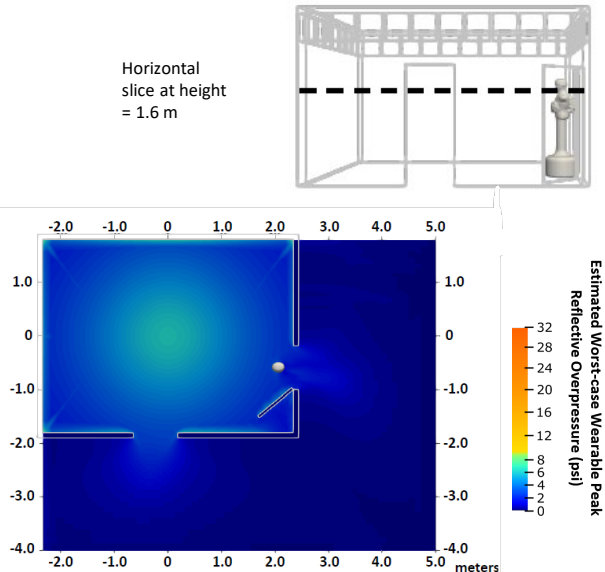
Explosive Description: 1 banger

Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4 psi:

Measurements are < 4 psi at operator locations, but stand-off distances should not be derived from this contour map as the 4 psi contour around point of detonation (~1.5 m) is within the SDZ of the grenade. Additionally, pressures may reach/exceed 4 psi near the walls of the enclosure. Information on safe viewing positions and protective measures for observers can be found in the Range Safety Regulation. Otherwise, maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements

Blast Overpressure Measurement Data



Note: Refer to individual ammunition and weapons system-specific technical and operations manuals for more specific recommendations.

Methods and Acknowledgements

Field Data Collection

Funding Source: OASD Health Affairs/USUHS

Study Title: CONQUER; PI: CDR Josh L. Duckworth, MD

Award Numbers: HU0001-18-2-0006, HU0001-19-2-0049

Measurement & Recording Equipment

- PCB pencil gauges (Model 137B23B)
- Microphones (G.R.A.S.47BX-S7¼"CCP)
- BlackBox Biometrics (B3) Gen 7 Blast Gauge System
- Hi-Techniques Ruggedized Echelon Data Acquisition System (DAQ)
- Video: Sony DSC-RXOM2 Mini Cameras & CCB-WD1 Control Boxes; GOPRO MAX 360 Camera

Data Processing, Reporting & Visualization

- Validated high-fidelity simulations based upon data from both scientific instruments and blast gauges
- Second-Order Hydrodynamic Automatic Mesh Refinement Code (SHAMRC) simulations provided voxel-based maximum peak overpressure estimates to support blast overpressure contour visualization
- Two-dimensional slices of environmental overpressure, based upon high fidelity simulation data, provide visual estimates of maximum peak environmental overpressure.
- Three-dimensional contour plots, also based upon high fidelity simulation, provide visual estimates of maximum peak surface pressure on objects and service members.
- B3 Blast Gauge data as captured on engineering stake-mounted gauges were processed using Stata 17 (StataCorp, College Station, TX) for graphic display.

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- United States Marine Corps
- United States Special Operations Command

Acronym List

Acronym	Definition
ALARA	As Low As Reasonably Achievable
API	Armor-Piercing Incendiary
BMG	Browning Machine Gun
BOP	Blast Overpressure
cal	Caliber
CONQUER	Combat and Training Queryable Exposure/Event Repository
CS-RS	Confined Space-Reduced Sensitivity
CVC	Combat Vehicle Crewman
DODIC	Department of Defense Identification Code
DoW	Department of War
ft	Feet
HE	High Explosive
HEAT	High Explosive Anti-Tank
IBA	Interceptor Body Armor
LAW	Light Anti-Tank Weapon

Acronym	Definition
m	Meter
MAAWS	Multi-Role Anti-Armor Anti-Personnel Weapon System
mm	Millimeter
NEW	Net Explosive Weight
NHC	Noise Hazard Contour
oz	Ounce
PPE	Personal Protective Equipment
psi	Pounds per square inch
SDZ	Surface Danger Zone
TP	Training Practice
TPCSDS-T	Target Practice, Cone Stabilized, Discarding Sabot-Tracer
TPDS-T	Target Practice Discarding Sabot with Tracer
USUHS	Uniformed Services University of the Health Sciences

Personal Protective Equipment Levels

Personal protective level	Personal protection required
0 ¹	Army combat uniform or standard utility uniform, hearing and eye protection
1 ¹	Body armor and helmet, hearing and eye protection
2 ¹	Body armor with front and back enhanced small arms protective insert plates and helmet, hearing and eye protection
3	Body armor with front, back, and side enhanced small arms protective insert plates and helmet, hearing and eye protection

Note.

¹ Eye protection is encouraged. Based on risk assessment, the unit commander may require ballistic or laser eye protection.

PPE Levels as defined in: Department of the Army and the U.S. Marine Corps. 2025. Regulation 385-63/MCO 3570.1D, Range Safety. <https://armypubs.army.mil>

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- AT4: https://odin.t2com.army.mil/WEG/Asset/AT-4_Swedish_84mm_Single-Use_Anti-Tank_Recoilless_Rifle
- LAW: <https://www.nammo.com/product/our-products/shoulder-fired-systems/m72-series/m72-anti-structure-munition-a12/>
- M107: <https://www.dvidshub.net/image/4846269/m107-50-caliber-sniper-rifle>
- M2A1: https://www.army.mil/article/92130/m2a1_machine_gun_features_greater_safety_heightened_lethality
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- 60 mm Mortar: <https://www.asiapacificdefensejournal.com/2019/03/philippines-receives-60mm-mortars.html>
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- M109A6/A7 Paladin: <https://www.defensedaily.com/state-department-approves-1-3-billion-howitzer-deal-saudi-arabia/international/>
- M2A4 Bradley: https://odin.t2com.army.mil/WEG/Asset/M2_Bradley_American_Infantry_Fighting_Vehicle
- M1A2 Abrams: <https://odin.t2com.army.mil/WEG/Asset/318957732468f616f5ad6c99dddeaa0f>
- Bus: <https://bus-news.com/miami-dade-transit-orders-100-nfi-electric-buses/>
- M67 Fragmentation Grenade: <https://odin.t2com.army.mil/WEG/Asset/9de20d2969b5596dbe7cc62793f84c5b>
- Stun Grenade: <https://combatoperators.com/weapons/grenades/xm84-m84-stun-grenade-design-use-and-potential-risks/>

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