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

May 2024
• 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 will 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)
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 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
## Examined Tier 1 Weapon Systems

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How to use this guide

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

Title:
- Weapon system name and type

DoD Personal Protective Equipment Guidance
- Personal protective gear and equipment (PPE) level.
  Protections associated with each PPE level

Data Collection Information and Recommended Stand-off Distances:
Weapon system, ammunition, and sensor information under which BOP data was collected.

Minimum standoff distance for personnel in vicinity of the stationary weapon system based off 4psi contour.

Graph: A bird’s eye view of blast overpressure zones color-coded based on pounds per square inch (psi) levels collected around the weapon.

Output graph key; Grid is in meters
Shoulder Launched Munitions

M3 Multi-role Anti-Armor Antipersonnel Weapon System (MAAWS) (Carl Gustav)

M-136A1 AT4 Confined Space (AT-4CS)

M72 Light Antitank Weapon (LAW)
M3 Multi-role Anti-Armor Antipersonnel Weapon System (MAAWS) (Carl Gustav)

DoD Personal Protective Equipment Guidance

**Hearing protection**  Within a 100-m radius must wear properly inserted foam earplugs as well as earmuffs (double hearing protection), single hearing protection within 500m while firing HE, HEAT, TP, smoke, and illumination.

**Eye protection**  all personnel on the range.

**Helmet and flak jacket**  required when firing.

Data Collection Information and Recommended Stand-off Distances

**Weapons System:** M3 MAAWS (Carl Gustav)

**Ammunition:** DODIC: A557

**Round Type:** 84mm HEAT TP 552

**Data Collection:** 1 shot

**BOP Sensor:** 5.2 ft above ground

**Minimum Stand-off Distance:**
Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4psi: 16 ft or approximately the length of a HMMWV
DoD Personal Protective Equipment Guidance

**Hearing protection**  Double hearing protection must be worn within a 100m radius (inserted foam earplugs as well as earmuffs), single hearing protection will be worn by personnel within 390m of the firing point.

**Eye protection**  All personnel on the range.

**Helmet and flak jacket**  Required when firing.

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Data Collection Information and Recommended Stand-off Distances

**Weapons System:** M136A1 AT4 Confined Space (AT4CS)  
**Round Type:** 84mm AT4CS-RSTP 552  
**Data Collection:** 1 shot  
**BOP Sensor:** 5.2 ft above ground

**Minimum Stand-off Distance:**  Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4psi:  
10 ft or approximately 2 people 2-arms length

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Blast Overpressure Measurement Data

Horizontal slice at height = 1.75 m
**DoD Personal Protective Equipment Guidance**

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point. Gunners and other personnel within 20 m will wear personal protective gear such as improved body armor. Sleeves should be down and collars up.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

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**Data Collection Information and Recommended Stand-off Distances**

**Weapons System:** M72 LAW - Standing

**Round Type:** 66mm HEAT

**Data Collection:** 1 shot

**BOP Sensor:** 5.2 ft above ground

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

10 ft or approximately 2 people 2-arms length

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**Blast Overpressure Measurement Data**

Horizontal slice at height = 1.68 m
.50 Caliber Weapons

- M107 Sniper Rifle
- M2A1 Machine Gun
- MK 15 MOD 1
- GAU-21 Machine Gun
DoD Personal Protective Equipment Guidance

**Hearing protection** 180 ft to the side of the weapon, and 39 ft to the rear.

**Eye protection** for those on the range.

Data Collection Information and Recommended Stand-off Distances

**Weapons System:** .50 cal blow-back operated semi-automatic sniper rifle with dual chamber detachable muzzle brake

**Ammunition:** DODIC: A557

**Round Type:** .50 BMG – M33 Ball with Propellant: WC 860

**Data Collection:** 10 shots

**BOP Sensor:** 0.3 ft above ground

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

7 ft or approximately 2-arms length

Blast Overpressure Measurement Data

Horizontal slice at height = 0.32 m
DoD Personal Protective Equipment Guidance

**Hearing protection**: Single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection**: All personnel on the range.

**Helmet and flak jacket**: Required when firing.

Data Collection Information and Recommended Stand-off Distances

**Weapons System**: .50 caliber semi-automatic machine gun

**Round Type**: .50 cal M8 API

**Data Collection**: 4 firing bursts

**BOP Sensor**: 5.2 ft above ground

**Minimum Stand-off Distance**: Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: 7 ft or approximately 2-arms length

Blast Overpressure Measurement Data

Horizontal slice at height = 2.0 m

Peak Overpressure (PSI)
DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection** all personnel on the range.

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Data Collection Information and Recommended Stand-off Distances

**Weapons System:** .50 cal bolt action sniper rifle

**Round Type:** .50 cal M33 Ball

**Data Collection:** 8 shots

**BOP Sensor:** 4” above ground

**Minimum Stand-off Distance:**

Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **7 ft or approximately 2-arms length**

---

Blast Overpressure Measurement Data

*Horizontal slice at height = 0.32 m*

- Peak Overpressure (PSI)
GAU-21 Machine Gun

DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection** all personnel on the range.

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**Data Collection Information and Recommended Stand-off Distances**

**Weapons System**: .50 caliber automatic machine gun

**Round Type**: .50 BMG M33 Ball w/ WC 860 Propellant

**Data Collection**: 8 firing bursts

**BOP Sensor**: 3.3ft above ground

**Minimum Stand-off Distance (Ground)**:
Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: Measurements are < 4 pounds per square inch; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements

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**Blast Overpressure Measurement Data**

Horizontal slice at height = 1.67 m

Peak Overpressure (PSI) 14
Indirect Fire System – Howitzers

- M109 A6/A7 155MM Paladin Howitzer
- M119A1-A3 105MM Howitzer
- M777A2 155MM Howitzer
DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within 800m.

**Eye protection** all personnel on the range.

Data Collection Information and Recommended Stand-off Distances

**Weapons System:** M72 LAW Light Antitank Weapon

**Round Type:** 66mm HEAT

**Data Collection:** 1 shot

**BOP Sensor:** 2.3 ft above ground

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

**Measurements are < 4 pounds per square inch; 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

[Graph showing blast overpressure measurements]
M119A1-A3 105MM Howitzer

DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 800m.

**PPE:** all personnel immediately engaged in firing will wear body armor and helmet, hearing/eye protection.

Data Collection Information and Recommended Stand-off Distances

**Weapon Type:** Indirect Fires System Artillery Cannons

**Round Type:** M1 projectile, 105mm HE M67 propellant system charge-6

**Data Collection:** 1 shot

**BOP Sensor:** 5.2 ft above ground

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

**Measurements are < 4 pounds per square inch;** 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 = 1.6 m
DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 800m.

**PPE:** all personnel immediately engaged in firing will wear body armor and helmet, hearing/eye protection.

Data Collection Information and Recommended Stand-off Distances

**Weapon Type:** Indirect Fires System Artillery Cannons

**Round Type:** Round fired w/ 2M231 charges (“2LIMA”)

**Data Collection:** 1 shot

**BOP Sensor:** 5.2 ft above ground

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

- Measurements are < 4 pounds per square inch; 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 = 1.85 m
## Indirect Fire System – Mortars

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<tr>
<th>Mortar Type</th>
<th>Description</th>
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<td>M252 81 MM Mortar</td>
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<tr>
<td>M224 60 MM Mortar</td>
<td></td>
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</table>
**M224 60 MM Mortar**

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**DoD Personal Protective Equipment Guidance**

*Hearing protection* single hearing protection will be required within 200m.

**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

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**Data Collection Information and Recommended Stand-off Distances**

**Charge Type:** M224 60 MM Mortar

**Round Type:** M1061 (B29) HE mortar cartridge, 2 propelling charges

Round fired with Charge 2

**Data Collection:** 1 shot

**BOP Sensor:** 3.2 ft above ground

**Minimum Stand-off Distance:**

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: 3 ft or approximately 1 arm length

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**Blast Overpressure Measurement Data**

Horizontal slice at height = 0.8 m

![Blast Overpressure Measurement Data Graph](image)

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M252 81 MM Mortar

DoD Personal Protective Equipment Guidance

**Hearing protection** hearing protection will be required within 200m.

**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

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**Data Collection Information and Recommended Stand-off Distances**

**Charge Type:** M252 81 MM Mortar

**Round Type:** M889A2 HE mortar cartridge, M223 propelling charge

Round fired with Charge 2

**Data Collection:** 1 shot

**BOP Sensor:** 5.2 ft above ground

**Minimum Stand-off Distance:**

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

7 ft or approximately 2-arms length
M120/121 120 MM Mortar

DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 200m.

**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

Data Collection Information and Recommended Stand-off Distances

**Charge Type:** M120/121 120 MM Mortar  
**Round Type:** M933 HE mortar cartridge, M230 propelling charge  
**Round fired with Charge 3**  
**Data Collection:** 1 shot  
**BOP Sensor:** 5.2 ft above ground

**Minimum Stand-off Distance:**  
Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:  
**13 ft or slightly more than 2 people 2-arms length**

Blast Overpressure Measurement Data

Horizontal slice at height = 1.6m

- Peak Overpressure (PSI) 22
Explosive Breachers

Breacher Door

Breacher Wall
Exterior Beaching: Water Door Charge 0.11 lb N.E.W.

DoD Personal Protective Equipment Guidance

**PPE:** IBA, helmet, and hearing and eye protection will be worn by personnel within the SDZ but outside the missile-proof shelter.

Data Collection Information and Recommended Stand-off Distances

**Charge Type:** Explosive Breaching

**Charge Type:** Door water charge w/ NEW: 0.11lbs

**Data Collection:** 1 blast

**BOP Sensor:** 5.24 ft above ground

**Minimum Stand-off Distance:**
Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **13 ft or slightly more than 2 people 2-arms length**
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-7¼“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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