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

October 2024

DoD 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 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

- Avoid unnecessary exposure
- Fewer personnel
- Increased distances
- Shorter durations
- Limit number of rounds
- Use PPE
- Educate others

Contents—Examined Tier 1 Weapon Systems

How to use this guide

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

Title:
- Weapon system name and type

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

STANDING

Position

DoD Personal Protective Equipment Guidance

- *Personal protective gear and equipment (PPE) level.* Protections associated with each PPE level

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.

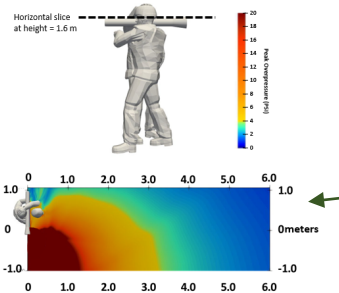
Data Collection Information and Recommended Stand-off Distances

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

Approx. 15/16 ft

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 approximately the length of a HMMWV

Blast Overpressure Measurement Data



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

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.

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)

STANDING

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.

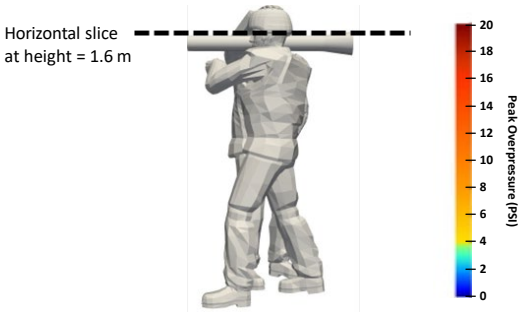
Data Collection Information and Recommended Stand-off Distances

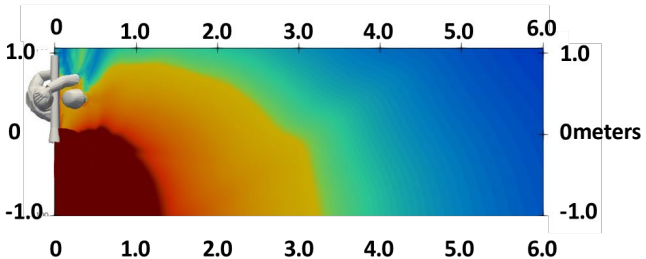
Weapons System: M3 MAAWS (Carl Gustav)
Ammunition: DODIC: A557
Round Type: 84mm HEAT TP 552
Data Collection: 1 shot
BOP Sensor: 5.2 ft above ground

Approx. 15/16 ft

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

Blast Overpressure Measurement Data





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

STANDING

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.

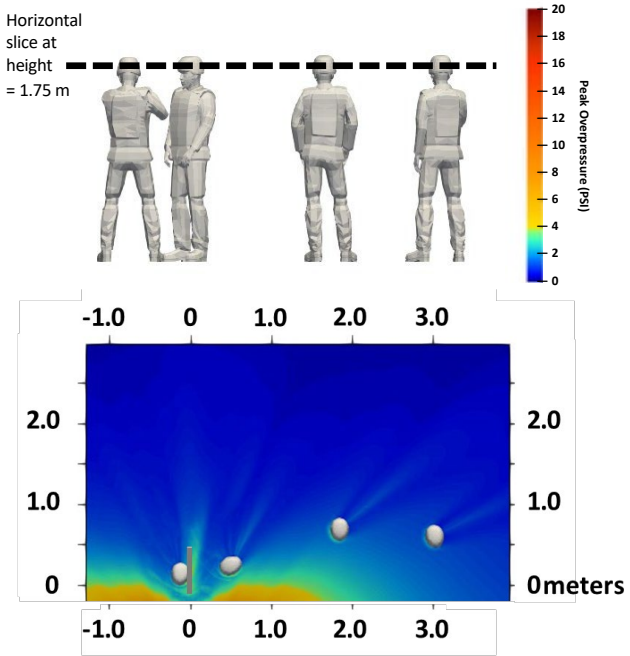
Data Collection Information and Recommended Stand-off Distances

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

Approx. 10 ft

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

Blast Overpressure Measurement Data



M72 Light Antitank Weapon (LAW)

STANDING

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 20m 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.

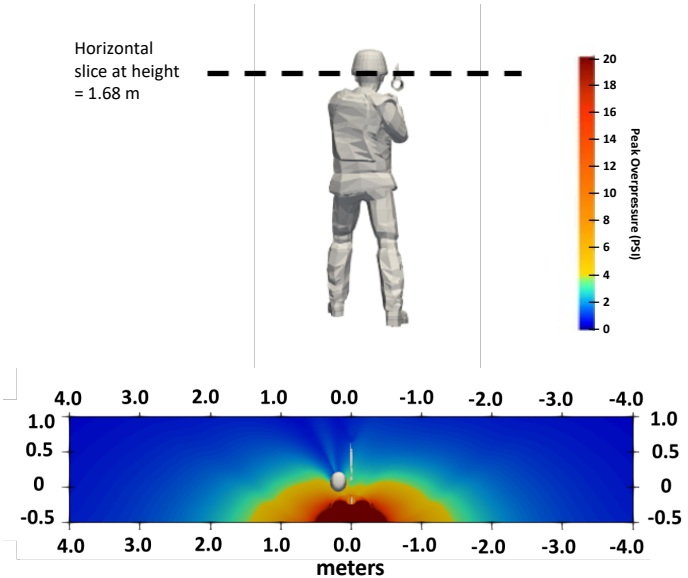
Data Collection Information and Recommended Stand-off Distances

Weapons System: M72 LAW - Standing
Round Type: 66mm HEAT
Data Collection: 1 shot
BOP Sensor: 5.2 ft above ground

Approx. 10 ft

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

Blast Overpressure Measurement Data



. 50 Caliber Weapons

M107 Sniper Rifle

M2A1 Machine Gun

MK 15 MOD 1

GAU-21 Machine Gun

M107 Sniper Rifle

PRONE

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.

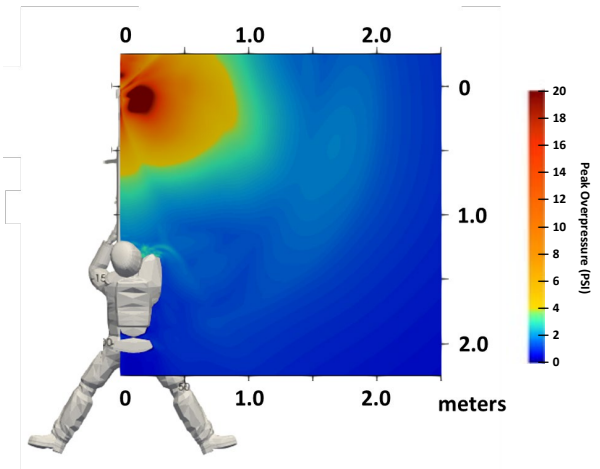
Data Collection Information and Recommended Stand-off Distances

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



M2A1 Machine Gun

STANDING

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

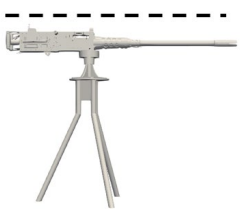
Weapons System: .50 caliber semi-automatic machine gun
Round Type: .50 cal M8 API
Data Collection: 4 firing bursts
BOP Sensor: 5.2 ft above ground

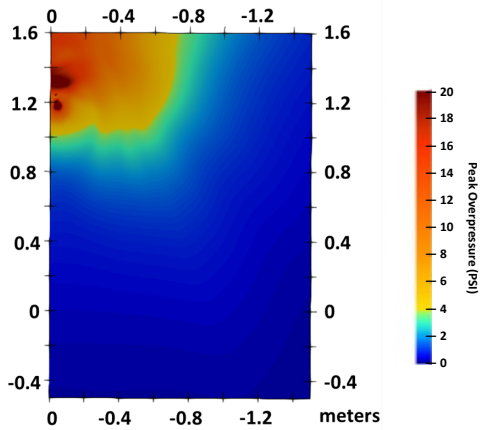
Approx. 7 ft

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





MK 15 MOD 1

PRONE

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.

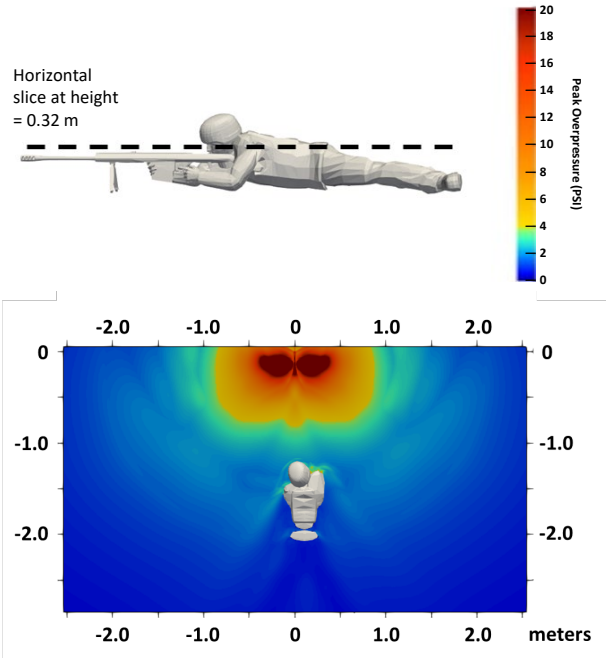
Data Collection Information and Recommended Stand-off Distances

Weapons System: .50 cal bolt action sniper rifle
Round Type: .50 cal M33 Ball
Data Collection: 8 shots
BOP Sensor: 4” above ground

Approx. 7 ft

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



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.

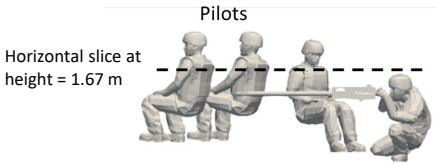
Eye protection all personnel on the range.

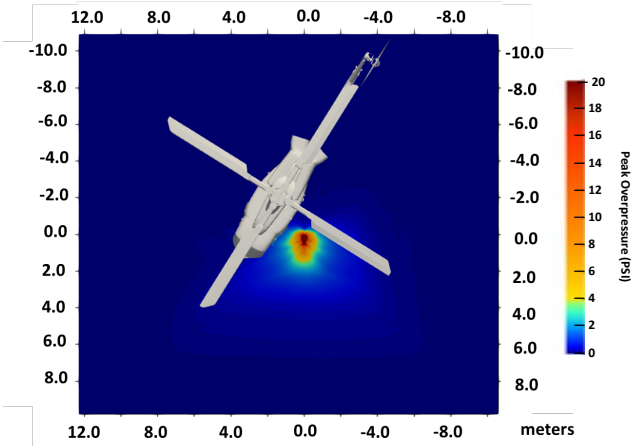
Data Collection Information and Recommended Stand-off Distances

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**

Blast Overpressure Measurement Data





Indirect Fire System – Howitzers


M109 A6

M109 A6/A7 155MM Paladin Howitzer


M119 A3

M119A1-A3 105MM Howitzer


M777 A2

M777A2 155MM Howitzer

M109 A6/A7 155MM Paladin Howitzer

DoD Personal Protective Equipment Guidance

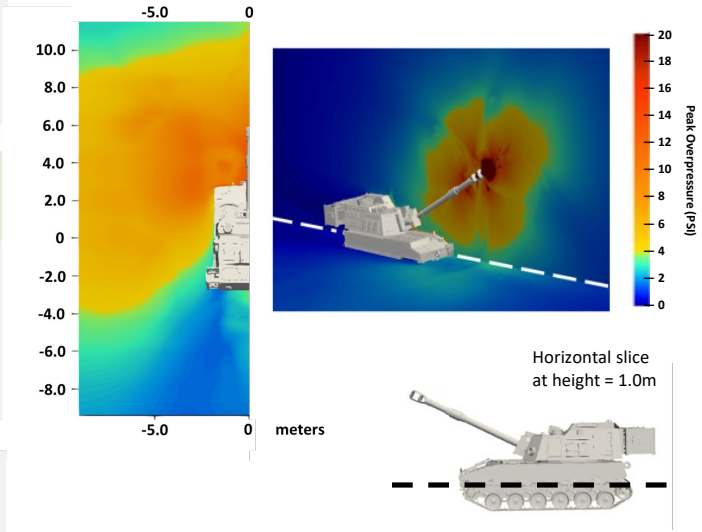
Hearing protection will be required within 800m.

Eye protection all personnel on the range.

Data Collection Information and Recommended Stand-off Distances

Weapons System: M109 A6/A7 Paladin Howitzer
Round Type: 155mm M1122 HE; Propelling Charge: 2 M231 Charges
Data Collection: 12 shots
BOP Sensor: For data collection, sensors were generally placed at 0.1, 1 and 1.6 m above ground - please note that the 1.0 m on the map refers to the height of the horizontal section in the computational model
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



M119A1-A3 105MM Howitzer

STANDING

DoD Personal Protective Equipment Guidance

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

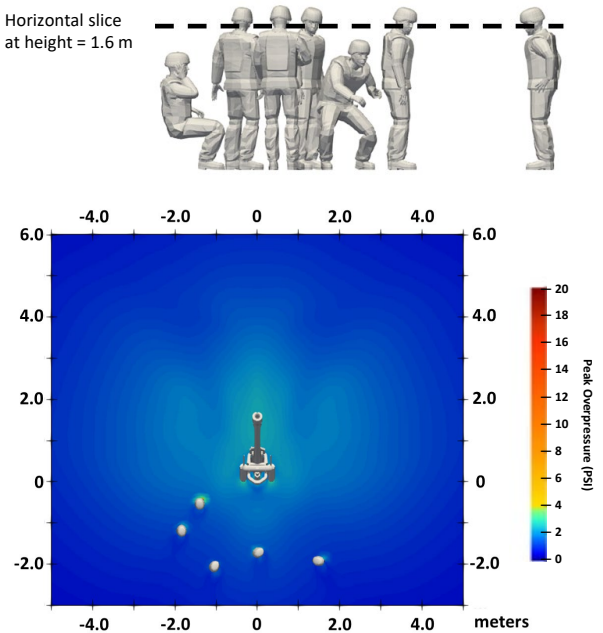
PPE: all personnel immediately engaged in firing will wear body armor and helmet, hearing/eye protection.

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



M777A2 155MM Howitzer

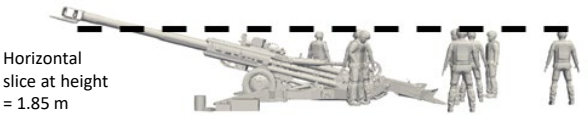
STANDING

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.

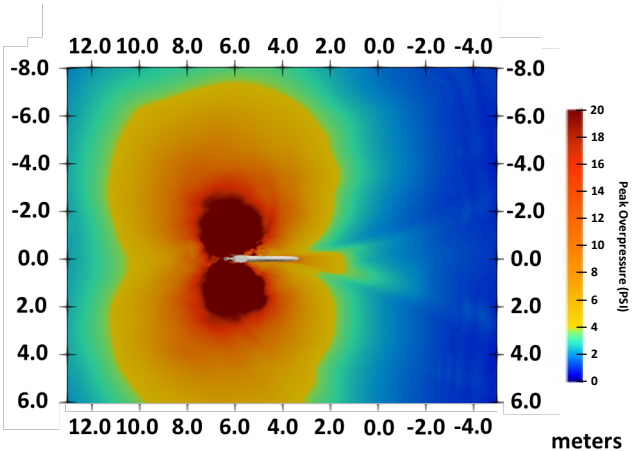
Blast Overpressure Measurement Data



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



Indirect Fire System – Mortars

M120/121 120 MM Mortar

M252 81 MM Mortar

M224 60 MM Mortar

M224 60 MM Mortar

KNEELING

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).

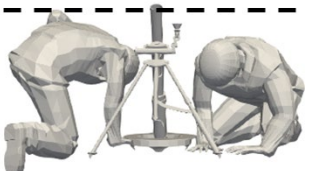
Data Collection Information and Recommended Stand-off Distances

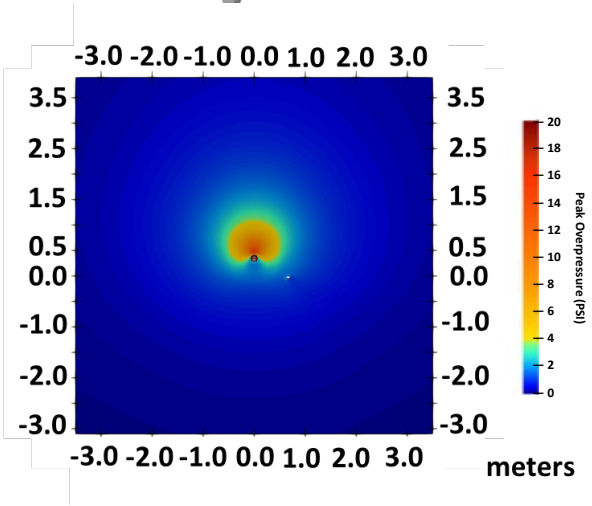
Charge Type: M224 60 MM Mortar
Round Type: M1061 (B29) HE mortar cartridge, 2 propelling charges
Round fired with Charge 2
Data Collection: 1 shot
BOP Sensor: 3.2 ft above ground

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**

Blast Overpressure Measurement Data

Horizontal slice
at height = 0.8 m





M252 81 MM Mortar

KNEELING

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).

Data Collection Information and Recommended Stand-off Distances

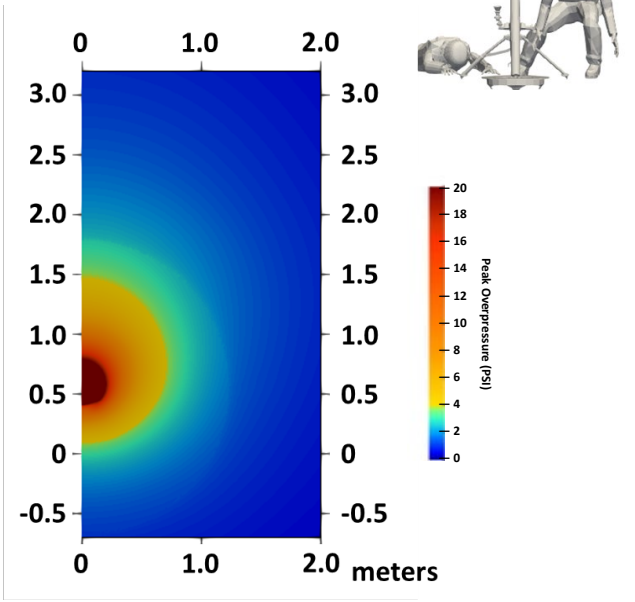
Charge Type: M252 81 MM Mortar
Round Type: M889A2 HE mortar cartridge, M223 propelling charge
Round fired with Charge 2
Data Collection: 1 shot
BOP Sensor: 5.2 ft above ground

Approx. 7 ft

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 = 1.36m



M120/121 120 MM Mortar

KNEELING

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

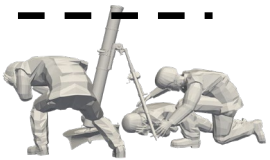
Charge Type: M120/121 120 MM Mortar
Round Type: M933 HE mortar cartridge, M230 propelling charge
Round fired with Charge 3
Data Collection: 1 shot
BOP Sensor: 5.2 ft above ground

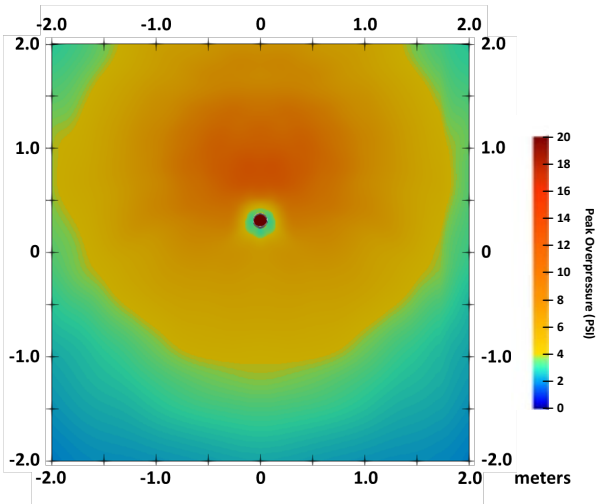
Approx. 10 ft

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





Explosive Breachers

Breacher Door

Breacher Wall

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

STANDING

DoD Personal Protective Equipment Guidance

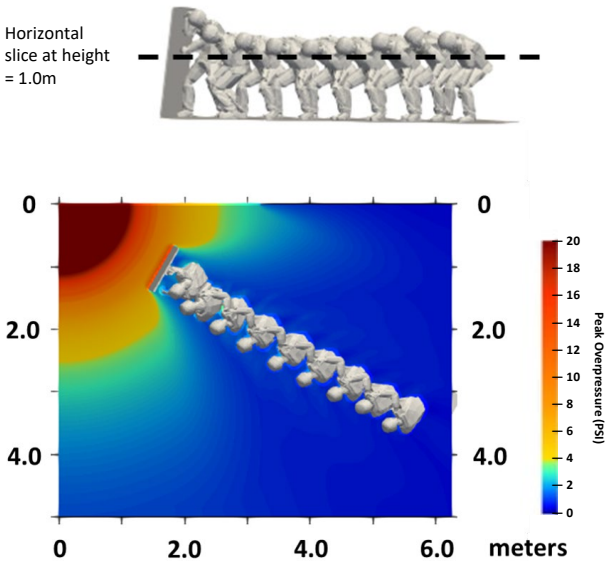
PPE: IBA, helmet, and hearing and eye protection will be worn by personnel within the SDZ but outside the missile-proof shelter.

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**

Blast Overpressure Measurement Data



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 AutomaticMesh 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.

Research Team Members

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- United States Army National Guard (Arkansas)
- United States Navy
- United States Marine Corps
- United States Special Operations Command