HANDHELD BALLISTIC SHIELDS:
What is the BFD with Backface Deformation?

By Boydd Products, Inc. 9/01/2025

When selecting ballistic shield protection for officers, stopping the bullet is only part of the equation. An often overlooked but critical factor is ballistic backface deformation and what happens inside ballistic armor when a shield takes a hit.

What Is Backface Deformation?

Backface deformation occurs when a projectile strikes ballistic armor and, while it doesn't penetrate, the captured energy causes an expansion or bulge on the rear side facing the officer. This deformation can transmit blunt force trauma to the body, potentially leading to serious injuries even if the armor stops the round.

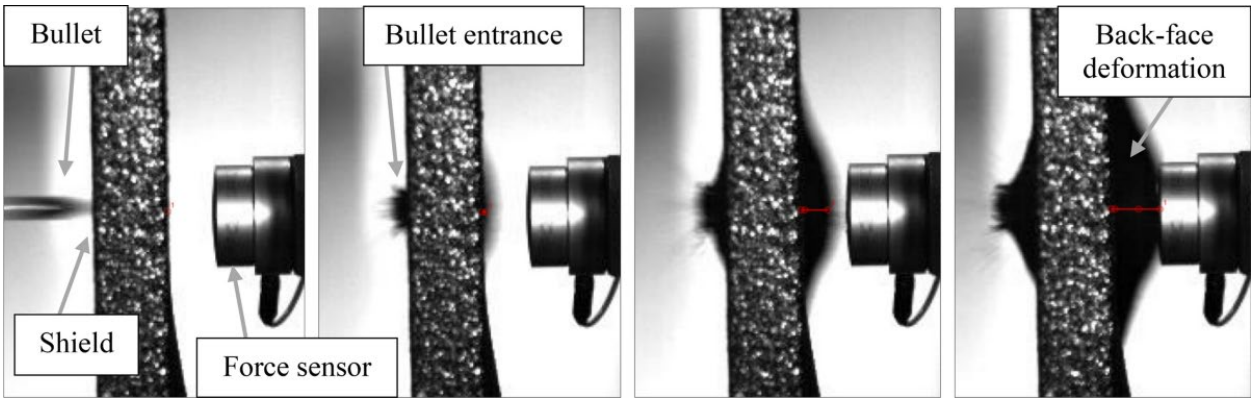


Illustration: de Lange, J.E., Burrows L.J., Binette J.S., & Quenneville C.E. (2023). Behind shield blunt trauma: characterizing the back-face deformation with a focus on upper limb loading. Annuls of Biomechanical Engineering, 51(6) 1331-1342.

Why It Matters in the Field

The consequences of backface deformation can include:

- Bone Fractures
- Muscle/Organ Damage and Contusions
- Temporary Incapacitation
- Increased Risk of Injury if Shield is Dropped Due to Trauma to the Support Arm
- Biomechanical Inability to Stay in the Fight

This is why agencies should not only focus on whether shield armor stops a round, but also on how it disperses the energy to protect the wearer from blunt force trauma.

How It is Measured

The NIJ (National Institute of Justice) sets limits on allowable backface deformation (BFD) specifically for torso-worn body armor. These limits do not apply to ballistic shields, as

shields are typically handheld and not pressed directly against the body or vital organs like body armor is. In standardized NIJ testing for torso armor, the armor is placed over a clay backing that simulates human tissue. After a ballistic impact, the depth of the indentation (measured in millimeters) indicates how much force is transferred to the body.

Photo by Boydd Products

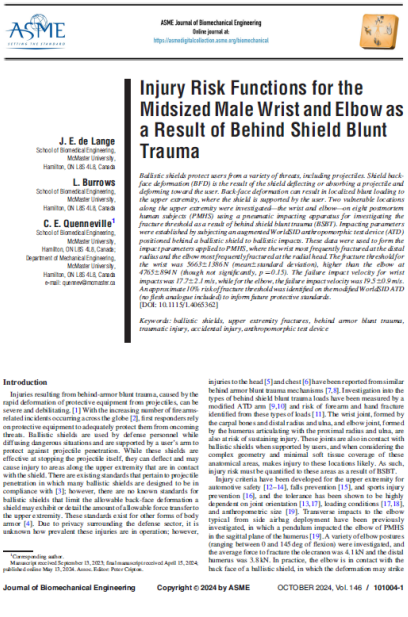
The energy from the impact causes the armor to expand to a specific depth prior to retraction. Some armor companies may display the retracted bulges on the back of previously tested armor to demonstrate the armor's backface deformation (BFD) performance. Do not be misled, these bulges (formed after the armor has already been shot) are not accurate indicators of how far the material would actually push into clay or a body during an impact. BFD depth can vary significantly depending on the armor's material and manufacturing methods. The NIJ currently allows a maximum backface deformation (BFD) of 44mm for torso-worn body armor. In real-world applications lower deformation is always preferred.

What about Handheld Shields?

Since ballistic shields are not classified as torso-worn armor, they are not required to undergo backface deformation (BFD) testing. Instead, they are more commonly independently tested to NIJ Standard 0108.01, which involves a straightforward five-shot spread at 0-degree obliquity for perforation. Is "good enough" truly good enough? Perhaps consider the following study.

Behind the Shield Blunt Trauma - The Published Study

In a recent study published by the ASME Journal of Biomechanical Engineering (Injury Risk Functions for the Midsized Male Wrist and Elbow as a Result of Behind Shield Blunt Trauma) lead by Biomechanical Engineer, Dr. J.E. de Lange (M.A.Sc., Ph.D., P.Eng.) data was collected for developing injury thresholds using post-mortem human limbs under loading conditions similar to those recorded in a previous live-fire ballistic shield study. BABT (Behind Armor Blunt Trauma) results indicate the forearm is most susceptible to injury. "The significantly lower forearm fracture threshold in comparison to the wrist and elbow under similar loading conditions indicates it may be the most vulnerable location for injury resulting from behind shield blunt trauma. This study also notes, "It is important that ballistic shields protect users from both



ASME Journal of Biomechanical Engineering
Online journal at:
https://asmedigitalcollection.asme.org/biomechanical

Injury Risk Functions for the Midsized Male Wrist and Elbow as a Result of Behind Shield Blunt Trauma

J. E. de Lange
School of Biomedical Engineering, McMaster University, Hamilton, ON L8S 4L8, Canada

L. Burrows
School of Biomedical Engineering, McMaster University, Hamilton, ON L8S 4L8, Canada

C. E. Quenneville[1]
School of Biomedical Engineering, McMaster University, Hamilton, ON L8S 4L8, Canada;
Department of Mechanical Engineering, McMaster University, Hamilton, ON L8S 4L8, Canada
e-mail: quennev@mcmaster.ca

Ballistic shields protect users from a variety of threats, including projectiles. Shield back-face deformation (BFD) is the result of the shield deflecting or absorbing a projectile and deforming toward the user. Back-face deformation can result in localized blunt loading to the upper extremity, where the shield is supported by the user. Two vulnerable locations along the upper extremity were investigated—the wrist and elbow—on eight postmortem human subjects (PMHS) using a pneumatic impacting apparatus for investigating the fracture threshold as a result of behind shield blunt trauma (BSBT). Impacting parameters were established by subjecting an augmented WorldSID anthropomorphic test device (ATD) positioned behind a ballistic shield to ballistic impacts. These data were used to form the impact parameters applied to PMHS, where the wrist must frequently fractured at the distal radius and the elbow most frequently fractured at the radial head. The fracture threshold for the wrist was 3663 ± 1386 N (mean ± standard deviation), higher than the elbow at 4703 ± 894 N (though not significantly, p = 0.13). The failure impact velocity for wrist impacts was 17.7 ± 2.1 m/s, while for the elbow, the failure impact velocity was 19.5 ± 0.9 m/s. An approximate 10% risk of fracture threshold was identified on the modified WorldSID ATD (no flesh analogue included) to inform future protective standards.
[DOI: 10.1115/1.4065362]

Keywords: ballistic shields, upper extremity fractures, behind armor blunt trauma, traumatic injury, accidental injury, anthropomorphic test device

Introduction

Injuries resulting from behind-armor blunt trauma, caused by the rapid deformation of protective equipment from projectiles, can be severe and debilitating. [1] With the increasing number of firearms-related incidents occurring across the globe [2], first responders rely on protective equipment to adequately protect them from oncoming threats. Ballistic shields are used by defense personnel while diffusing dangerous situations and are supported by a user's arm to protect against projectile penetration. While these shields are effective at stopping the projectile itself, they can deflect and may cause injury to areas along the upper extremity that are in contact with the shield. There are existing standards that pertain to projectile penetration in which many ballistic shields are designed to be in compliance with [3]; however, there are no known standards for ballistic shields that limit the allowable back-face deformation a shield may exhibit or detail the amount of allowable force transferto the upper extremity. These standards exist for other forms of body armor [4]. Due to privacy surrounding the defense sector, it is unknown how prevalent these injuries are in operation; however, injuries to the head [5] and chest [6] have been reported from similar behind armor blunt trauma mechanisms [7,8]. Investigation into the types of behind shield blunt trauma loads have been measured by a modified ATD arm [9,10] and risk of forearm and hand fracture identified from these types of loads [11]. The wrist joint, formed by the carpal bones and distal radius and ulna, and elbow joint, formed by the humerus articulating with the proximal radius and ulna, are also at risk of sustaining injury. These joints are also in contact with ballistic shields when supported by users, and when considering the complex geometry and minimal soft tissue coverage of these anatomical areas, makes injury to these locations likely. As such, injury risk must be quantified to these areas as a result of BSBT.

Injury criteria have been developed for the upper extremity for automotive safety [12–16], falls prevention [15], and sports injury prevention [14], and the tolerance has been shown to be highly dependent on joint orientation [13,17], loading conditions [17,18], and anthropometric size [19]. Transverse impacts to the elbow typical from side airbag deployment have been previously investigated, in which a pendulum impacted the elbow of PMHS in the sagittal plane of the humerus [19]. A variety of elbow postures (ranging between 0 and 145 deg of flexion) were investigated, and the average force to fracture the olecranon was 4.1 kN and the distal humerus was 3.8 kN. In practice, the elbow is in contact with the back face of a ballistic shield, in which the deformation may strike

[1]Corresponding author.
Manuscript received September 15, 2023; final manuscript received April 15, 2024; published online May 15, 2024. Assoc. Editor: Petre Clipcan.

projectile penetration and injuries resulting from behind shield blunt trauma. Currently used shields that pass standards regulations on projectile penetration may not be adequate in minimizing upper extremity fracture risk. Results from this study can be used to develop a new standard to assess whether or not shields are adequate at minimizing upper extremity fractures, providing important protection for armed forces."

Be Forward Thinking

When evaluating ballistic shields for your department:

- **Inquire whether Backface Deformation** (BFD) testing has been conducted at the forearm point of contact with the specific shield model you plan to purchase. Many manufacturers may be unaware of the ASME study or may opt not to conduct BFD testing, as ballistic shields are generally not classified as "torso-worn" armor. If testing has been performed, request official results from an accredited independent ballistic laboratory. If not, and you have concerns, you might consider asking the manufacturer to submit the shield for testing before completing your purchase.
- **Look for shields with adequate standoff distance or padding** at the point of contact with the user's forearm.
- **Consider shields tested to more stringent standards** such as ASTM E3141M-24 / ASTM E3347M-25 which require multiple calibers and additional shots to include zero-degree and thirty-degree cluster shots.
- **Evaluate bolt free solutions and modular shield systems**. These systems eliminate common hardware related weak points and can reduce replacement costs over time.
- **If the shield includes hardware** bolted into or through the ballistic resistant armor panel, insist on verifying bolt impact test results for that specific model and protection level. Many products are tested before any holes are drilled or hardware is installed, which is common in independent lab testing. However, this can compromise officer safety by leaving hardware performance unverified and increasing the risk of secondary projectiles.
- **For shields with viewports**, request certified test data from an accredited lab. Pay attention to the number of impacts the viewport withstood and the calibers used. Some viewports are only rated for a single shot, while others may withstand multiple hits.

Final Word

In high-risk situations, stopping the projectile is only the first step, survivability also hinges on minimizing the physical trauma caused by the impact. To improve officer safety and minimize the risk of biomechanical injuries caused by blunt trauma behind the shield, agencies should prioritize ballistic shield solutions that combine proven penetration resistance with low backface deformation and reliable ballistic hardware performance.

Collaborating with manufacturers who focus on these critical factors is key to ensuring comprehensive protection.

About Boydd Products

Boydd Products, Inc. is emerging as a leading innovator in armor support systems dedicated to improving performance, safety, and reliability for professionals in high stress environments. With a focus on practical design and improved features, Boydd Products delivers advanced solutions that address real world challenges and enhance survivability under extreme conditions. Inspired by a recent life saved, retired Police Sergeant Jim Boydd continues to lead the charge in new product innovation. If you want to learn more, contact Boydd Products or visit www.boyddproducts.com or www.advancedballisticshield.com