



# TECH *b.e.a.t*

Dedicated to Reporting Developments in Technology for Law Enforcement, Corrections, and Forensic Sciences

## 30 Years, 3,000 Saves

**O**n December 23, 1975, Seattle Police Department patrolman Raymond T. Johnson stood in the checkout line at a local market when a robbery suspect entered the store and brandished a weapon. Johnson lunged for the suspect's gun. In the violent struggle that ensued, the suspect emptied his .38-caliber pistol, striking Johnson in the left hand and twice in the chest before fleeing.<sup>1</sup> Officer Johnson survived with severe hand injuries, chest bruises, and a unique distinction—the first law enforcement officer saved in a field test of a new generation of soft body armor being conducted by the Office of Justice Programs' National Institute of Justice (NIJ).

Johnson was wearing body armor made with Kevlar®, an extraordinarily strong fabric developed by DuPont. NIJ, in partnership with the U.S. Army, had begun a program at the beginning of the 1970s to develop lightweight body armor woven from Kevlar. Field testing began in the summer of 1975, with 5,000 armors provided to 15 urban police departments. Less than 6 months later, Johnson was the first officer saved by one of the field test armors. In all, 17 other armor-wearing officers were saved during the 1-year field test.

Around the same time, NIJ developed a performance standard for body armor in collaboration with the National Institute of Standards and Technology (NIST) (then known as the National Bureau of Standards)<sup>2</sup>, followed by a voluntary testing program. The standards and testing program, which exists to this day, enables body armor manufacturers to certify the performance and safety of new body armor.<sup>3</sup> The NIJ standard establishes minimum performance requirements for armor and the testing program tests armor against the standard.

Fast forward 28 years, to the night of June 23, 2003. Forest Hills, Pennsylvania, police Officer Edward Limbacher, wearing body armor constructed primarily of a fiber called Zylon®, threw open the side door of an unmarked Econoline van and stepped out to move in on a drug suspect. The suspect fired, striking Limbacher in the arm and abdomen with .40-caliber rounds, then ran. The shot to the abdomen penetrated the body armor

Limbacher was wearing. He survived, but sustained severe injuries.<sup>4</sup>

The Forest Hills shooting was the first case ever reported to NIJ in which body armor compliant with the NIJ standard failed to prevent penetration from a bullet it was designed to defeat.

In the 28 years between those two incidents and in the time since, at least 3,000 officers survived shootings or other incidents because they were wearing body armor meeting NIJ performance standards.<sup>5</sup> But the Forest Hills incident caused great concern within the law enforcement community and within the U.S. Department of Justice: Are we keeping our officers safe?

### The Body Armor Initiative

In November 2003, in the aftermath of the Forest Hills incident, former Attorney General John Ashcroft announced the Department of Justice's Body Armor Safety Initiative<sup>6</sup> to address the reliability of body armor used by law enforcement and to review the process by which body armor is certified.

As part of the initiative, NIJ tested ballistic-resistant vests (both new and used) made with Zylon.<sup>7</sup> NIJ also tested upgrade kits distributed by the manufacturer of the armor in the Forest Hills incident to retrofit some models of its Zylon-based vests. And NIJ began a review of its standards and testing program for ballistic-resistant vests, which has resulted in interim changes to the standards and testing process. Read on for results of these tests and a summary of changes to the standards and testing program.

### Why did the vest fail?

Even before the announcement of the Attorney General's initiative, NIJ staff contacted representatives of the Forest Hills Police Department and the Allegheny County Police Department (the agency handling the criminal investigation of the shooting) to examine the vest, the

## 2 SURVIVOR STORIES

*In 1975, a Seattle lawman became the first law enforcement officer saved by a new kind of soft body armor being field tested by the National Institute of Justice (NIJ). Thirty years later, an Atlanta police officer became save number 3,000. Here are their stories.*

### SAVE NUMBER 1

On the afternoon of December 23, 1975, Seattle Police Department patrolman Raymond T. Johnson, wearing a winter coat over his uniform, stood in the checkout line at a local market as a man entered the store and drew a gun, intending to rob the store. Seeing Johnson, the suspect ordered him to hand over his service revolver and moved to take it away from him. Johnson lunged for the suspect's gun. As the two grappled, the suspect fired his .38 caliber pistol, striking Johnson in the hand. Johnson broke the suspect's finger as they wrestled for the gun. The suspect broke free, stepped back, switched the gun to his left hand, and shot Johnson in the chest. When Johnson kept coming, the suspect, wide-eyed in disbelief, fired again, striking Johnson directly over the heart. Still Johnson charged. They fell to the floor in a battle for the gun. The suspect fired his last shot, just missing Johnson's head. Johnson managed to tear off the suspect's ski mask as he broke free and fled. Officer Johnson survived with severe hand injuries, chest bruises, and a unique distinction—the first law enforcement officer saved by a new generation of soft body armor being field tested by the National Institute of Justice.

Johnson was wearing body armor made with Kevlar®, an extraordinarily strong fabric developed by DuPont. NIJ, in partnership with the U.S. Army, had begun a program at the beginning of the 1970s to develop lightweight body armor woven from Kevlar. Field testing began in the summer of 1975, with 5,000 armors provided to 15 urban police departments. Less than 6 months later, Johnson was the first officer saved by one of those armors. In all, 17 other armor-wearing officers were saved during the 1-year field test.

The disbelieving criminal fled the scene of the shooting. Officer Johnson was transported and hospitalized for several days for treatment of severe backface signature contusions and the gunshot wound to his left hand. Based on information provided by Officer Johnson the suspect was identified and arrested. He was convicted on charges of 1st degree assault on Officer Johnson and was sentenced to prison. Officer Johnson returned to duty and completed his police career. Officer Johnson is now retired.

### SAVE NUMBER 3,000

In the predawn hours of October 8, 2005, Officer Corey B. Grogan of the Atlanta Police Department was in the zone 4 district house taking a report from a walk-in complainant, when Lt. John Demmit requested he assist in the service of an arrest warrant. The warrant was for an individual known to the police with a prior criminal conviction. The warrant charged three counts of aggravated assault that occurred in

Douglasville. Three officers from Douglasville teamed up with several Atlanta officers to serve the warrant.

The original plan was to cordon off the residence where the suspect was known to be. The lieutenant and Officer Grogan approached the front door and knocked but got no response. Light in a back room appeared to be from a television.

Lt. Demmit pulled the officers back to a driveway area, developed an entry plan, and briefed all personnel as to their individual responsibility. The lieutenant took the point and carried a ballistic shield with Officer Grogan second in the stack. The door was hit and forced open. Lt. Demmit was the first in and announced police presence and the purpose for the entry. Officer Grogan heard Lt. Demmit give verbal commands to someone to show their hands. He turned and observed a male lying on a couch covered with a blanket. This individual opened fire on the officers.

Officer Grogan reached to pull Lt. Demmit back out the door. He was going to the ground when he felt something impact his chest and something hot graze his face. Officer Grogan exited the house and moved toward cover behind a vehicle that was parked in the front yard. Firing continued inside the residence. When the gunfire subsided, Officer Grogan withdrew across the street to gain better cover where he found Lt. Demmit and Officer A. Nixon. Grogan requested that Lt. Demmit look at his face because he thought he had been shot as the burning sensation continued. He was told that his face had scratch marks.

A SWAT team responded. On entry they found the suspect deceased. He had been justifiably killed during the shootout with the officers. Investigators discovered weapons and a quantity of methamphetamines in the shooter's house. A female friend of the shooter suffered a nonlifethreatening gunshot wound to the leg during the exchange of gunfire. She was transported and treated for her injury.

When order was restored, Officer Grogan and Lt. Demmit were examined by Atlanta Fire Department EMS personnel. It was determined that in addition to the grazing wound to his face, Officer Grogan had been hit twice in the chest with bullets from the shooter's .45 caliber semiautomatic pistol. The rounds hit center upper left torso and were stopped by his protective body armor. Lt. Demmit suffered fragmentation wounds to his face after a bullet struck and shattered his radio microphone. The officers were transported to a trauma center where they were examined, treated, and released. Lt. Demmit and Officer Grogan have returned to duty.

These survivor stories are courtesy of the IACP/DuPont™ Kevlar® Survivors' Club®, [www.dupont.com/kevlar/lifeprotection/survivors.html](http://www.dupont.com/kevlar/lifeprotection/survivors.html).

weapon, and the ammunition used in the shooting in order to determine why the vest failed. The examination found that:

- The bullet velocity from the gun used in the shooting was not greater than the bullet velocity NIJ uses in compliance testing for the type of vest Limbacher was wearing.
- The physical properties of the bullets used in the shooting were similar to bullets used in NIJ's compliance testing of the type of vest Limbacher was wearing, although there were some differences in bullet geometry and in how the bullet deformed on impact.
- The tensile strength of Zylon yarns removed from the back panel of Limbacher's vest was up to 30 percent lower than Zylon yarns from new armor that the manufacturer provided for this study. (The front panel, which was penetrated in the incident, was being held as evidence in the criminal case against the shooter, so it was not available for testing.)

NIJ developed a detailed test plan simulating the Forest Hills incident to isolate the factors deemed most likely responsible for the vest failure. Test designers identified five potential causal factors: ballistic material tensile strength, bullet type, the gun barrel twist, the shot angle, and the location of the shot on the armor.

NIJ obtained and tested 32 ballistic panels of the type worn in the Forest Hills incident. Half of the panels were tested "new" and the other half were artificially aged for 5 months in a chamber exposing the panels to controlled temperature and humidity conditions, until the tensile strength of fibers in the vests matched those of fibers from the rear panel of the Forest Hills vest.

Each of the 32 panels was shot 6 times. None of the 192 shots penetrated the panels. NIJ is continuing efforts to determine the cause of the Forest Hills failure, but is still unable to draw a definitive conclusion.

## Testing the Upgrade Kits

As part of the Attorney General's initiative, NIJ was directed to test any upgrade kits offered by body armor manufacturers to retrofit existing vests. The tests would determine if the upgrade kits met the NIJ performance standard when used with the original vest they were designed to supplement. One manufacturer, Second Chance Body Armor, Inc. (the manufacturer of the body armor worn in the Forest Hills incident) offered an upgrade kit to users of some models of Zylon-based body armor—an additional ballistic panel inserted into the armor. At NIJ's request, Second Chance provided 50 sets of armors and matching upgrade kits for three soft armor protection levels—Level IIA, Level II, and Level IIIA.<sup>8</sup> The samples provided included both new and used upgrade

kits, and the majority of the armors had been previously worn.

NIJ's testing found that the upgrade kits provided added protection when used with the existing used body armor. However, the level of protection did not meet existing NIJ performance standards for new body armor.

Also, the vest/upgrade kit combinations in all three protection levels experienced excessive "backface signatures." This means that the bullets did not penetrate the vest, but the impact of one or more bullets created a "dent" of more than 44 mm (almost 2 inches) into the clay in back of the vests during testing, a depth that may cause serious injury. Six of eight Level IIA armors, two of eight Level II armors, and five of eight Level IIIA armors ultimately tested experienced excessive backface signatures during testing.

Further, two of the eight Type IIIA vests/upgrade kits (designed to offer protection against high-velocity 9 mm and .44-caliber Magnum bullets) experienced penetrations.

Despite safety questions raised by these test results, it is important to note that the upgrade kits did add some measure of protection. NIJ encouraged officers to wear their Zylon-containing armor and upgrade kits until they were replaced.

## Testing Used Armor

Heat, moisture, ultraviolet and visible light, detergents, friction, and mechanical damage may all contribute to the degradation of fibers used in the manufacture of body armor. Body armor manufacturers design their armor and provide care instructions to minimize the effects of these degrading properties.

Because the evidence showed an unexpected degradation rate in Zylon-based armor, NIJ conducted ballistic and mechanical properties testing on 103 additional used Zylon-containing body armors. Law enforcement agencies across the United States provided these vests to NIJ. Sixty of these used armors (58 percent) were penetrated by at least one round during a six-shot test series. Of the armors that were not penetrated, 91 percent had backface deformations in excess of that allowed by the NIJ standard for new armor. Only four of the used Zylon-containing armors met all performance criteria expected under the NIJ standard for new body armor compliance. Although these results do not conclusively prove that all Zylon-containing body armor models have performance problems, the results show that used Zylon-containing body armor may not provide the intended level of ballistic resistance.

In addition, armors were visually inspected and given one of four condition ratings from "no visible signs of wear" to "extreme wear and abuse." Testers found no

correlation between the level of visible wear of the body armor panels and the ballistic performance of those panels. This is important because even used Zylon body armor that appears to be in good condition may not provide an acceptable level of performance.

## Exploring Fiber Degradation

With funding provided by NIJ, polymer scientists at NIST are probing down to the molecular level to learn more about how Zylon degrades. They are examining the chemical changes that occur as the fibers degrade, the trace contaminants on fibers that may contribute to degradation, the moisture content of fibers, and mechanical strength differences among individual fibers and what causes those differences.

Initial findings have isolated the ballistic performance degradation to the breakage of a small part of the Zylon fiber molecule. Breakage of this part of the molecule, called the oxazole-ring, occurs as a result of exposure to both moisture and light. When there was no potential for external moisture to contact Zylon yarns, there was no significant change in the tensile strength of these yarns. Therefore, it appears that external moisture is necessary to facilitate the degradation of Zylon fibers.

In addition to this work, NIJ is funding research on other ballistic materials to better understand how and why ballistic-resistant materials degrade over time.<sup>9</sup>

## Improving the NIJ Standard and Compliance Testing Program

NIJ has undertaken a complete review of its performance standard for ballistic-resistant armor and the compliance testing program. It solicited input from law enforcement; corrections; fiber, fabric, and armor manufacturers; and standards and testing organizations.

NIJ's 2005 Interim Requirements for Bullet-Resistant Body Armor, issued in August 2005, take into account the possibility of ballistic performance degradation over time. These interim requirements will help ensure that officers are protected by body armor that maintains its ballistic performance during its entire warranty period.

Under the 2005 interim requirements, NIJ will not deem armor models containing PBO (the chemical basis of Zylon) to be compliant unless their manufacturers provide satisfactory evidence to NIJ that the models will maintain their ballistic performance over their declared warranty period.

NIJ recommends that agencies that purchase new ballistic-resistant body armor select body armor models that comply with the NIJ 2005 Interim Requirements. A

list of models that comply with the requirements is maintained at [www.justnet.org/BatPro](http://www.justnet.org/BatPro).

NIJ is also encouraging manufacturers to adopt a quality-management system to ensure the consistent construction and performance of NIJ-compliant armor over its warranty period. In the future, NIJ will issue advisories regarding body armor materials that appear to create a risk of death or serious injury as a result of degraded ballistic performance. Any body armor model that contains any material listed in such an advisory will be deemed no longer compliant with the NIJ standard unless the manufacturer satisfies NIJ that the model will maintain ballistic performance over the declared warranty period. On August 24, 2005, NIJ identified poly-p-phenylene benzobisoxazole (commonly known as PBO or Zylon®) as a material that appears to create a risk of death or serious injury as a result of degraded ballistic performance when used in body armor.

## Life Vests

There are at least 3,000 other stories like Seattle Police Officer Raymond T. Johnson's. That's 3,000 families spared the anguish of the death or debilitating injury to a loved one in the line of duty. And cases like that of Forest Hills Officer Limbacher's are rare—a testament to the reliability of soft body armor. Even so, that single failure prompted NIJ to review its body armor program and to conduct an intensive examination of why that failure occurred. Through this review and research, NIJ remains committed to working for the safety of law enforcement officers.

The evidence is clear: An officer not wearing armor is 14 times more likely to suffer a fatal injury than an officer who is. Therefore, the most important message for the law enforcement community is that officers should continue to wear their body armor.

At least 3,000 officers would second that advice.

***Status reports on the Attorney General's Body Armor Safety Initiative and other updates on the activities in support of the Initiative are posted on the Bulletproof Vest Partnership/Body Armor Safety Initiative Web site at <https://vests.ojp.gov>.***

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## Endnotes

1. The suspect was arrested 6 weeks later and charged with first-degree assault and attempted robbery. He was convicted and sentenced to 15 to 30 years.

2. Commercial body armor was being manufactured and sold even as NIJ's field test began, accelerating the need for a standards program. In fact, the first documented "save" unrelated to NIJ's field test occurred in May 1973 in Detroit, Michigan.
3. More information about NIJ's body armor standards and testing program can be found at NIJ's National Law Enforcement and Corrections Technology Center Web site, Justnet, at <http://www.justnet.org/testing/bodyarmor.html>.
4. The suspect was arrested later that night. In April 2004 he was convicted of 2 counts of attempted homicide, 11 counts of aggravated assault, and 9 counts of reckless endangerment related to the June 23 incident.
5. In 1987 DuPont and the International Association of Chiefs of Police created the IACP/DuPont™ Kevlar® Survivor's Club®, which recognizes law enforcement and corrections officers who survive life-threatening or disabling events because they were wearing personal protective body armor. In March 2006, the IACP recognized Atlanta Police Department Officer Corey B. Grogan as the 3,000th documented save. A Web site, <http://www.dupont.com/kevlar/lifeprotection/survivors.html>, keeps a tally of survivors, maintains a database of survivor stories, and provides criteria and instructions for membership.
6. A Web site supporting the Body Armor Safety Initiative is at <https://vests.ojp.gov/index.jsp>.
7. Zylon fiber is manufactured by Toyobo Co., Ltd. of Japan.
8. For a description of the protection levels, see NIJ's *Ballistic Resistance of Personal Body Armor*, NIJ-Standard-0101.04, <http://www.ojp.usdoj.gov/nij/pubs-sum/183651.htm>.
9. The most recent NIJ solicitation for concept papers, "Officer Safety Equipment," is at <http://www.ncjrs.gov/pdffiles1/nij/sl000720.pdf>.



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