Drilling Toolmarks Discovered on the Underside of an Explosively Formed Projectile Liner

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ABSTRACT

Common toolmarks present on EFP liners could not be identified. However, some atypical toolmarks believed to be from a drill bit were found which allowed the identification of three explosively formed projectiles (EFPs) to one another.

Introduction

Currently, the ANSI National Accreditation Board (ANAB) accredits a number of laboratories in the discipline of Firearm and Toolmark Examinations [1]. In this discipline, it is rare to find a laboratory that examines only non-firearm toolmarks. This is especially true in the United States due to the number of gun-related crimes which require forensic examination for investigative and/or prosecutorial purposes.

However, the Terrorist Explosive Device Analytical Center (TEDAC) is such a laboratory. Started by the Federal Bureau of Investigation in 2003, TEDAC serves as "the single interagency organization to receive, fully analyze, and exploit all terrorist improvised explosive devices , or IEDs†, of interest to the United States" [2, 3]. TEDAC is located on the Redstone Arsenal near Huntsville, Alabama, with the mission "to directly contribute to the eradication of the IED threat" [4].

In pursuit of this goal, the TEDAC Toolmark Group performs forensic toolmark examinations on a wide variety of items to maximize the investigative potential of any toolmarks that are present. All of these items are directly related to IED components and/or attacks involving IEDs, whether as parts from an exploded device, from an undetonated recovered device, or as a component of a switching system or other IED-associated component. Locating and identifying toolmarks on two or more items serves to link those items to a common source, maker, or network. Previous associations made through biometric analyses (latent fingerprints and DNA) may serve to further link a device or component to an individual or group.

Items processed by the Toolmark Group encompass such a wide variety of materials because the device fabricators, "bomb-makers," are likely to use materials they have readily available. Hence, the name 'improvised' explosive device: they will use whatever they have access to that will accomplish their mission. Submitted items include pieces of plastic, vinyl, and rubber hoses; metal plates and rings; PVC pipe sections; wood; foam; copper wires and their insulation; and Explosively Formed Projectile (EFP) liners.

All of these materials have a manufacturing source where toolmarks of origin may be imparted, such as draw/extrusion marks in pipe or copper sheet, or mold marks in plastic items used to house electronic components. While these toolmarks are often identifiable, they may be of limited value due to a lack of knowledge concerning the persistence of the toolmarks in a manufacturing run/cycle, the number of items produced in a time period, and distribution methods/networks. These manufacturing marks may be likened to bunter marks on cartridge cases or striated marks on unfired small arms primers. When it can be determined that toolmarks have originated from the bomb-makers, rather than from the original manufacturing process, recovery personnel, or render-safe procedures, the information gathered has a much higher intelligence value.

IEDs have four principal components: 1) a power source, 2) a trigger or switching system, 3) a detonator/initiator, and 4) a main explosive charge. Many IEDs also include a container, which serves to contain and direct the force of the blast, and to provide primary fragmentation. Anti-personnel IEDs can have ball bearings, nuts, bolts, or other potential projectiles incorporated within the device. Explosively Formed Projectile IEDs contain an EFP liner, typically made of copper, which forms the projectile portion of the device. EFP Liners may

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†The US Weapons Technical Intelligence Handbook defines an IED as: "a device placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic, or incendiary chemicals and designed to destroy, incapacitate, harass, or distract. They may or may not incorporate military stores, but are normally devised from nonmilitary components [2].

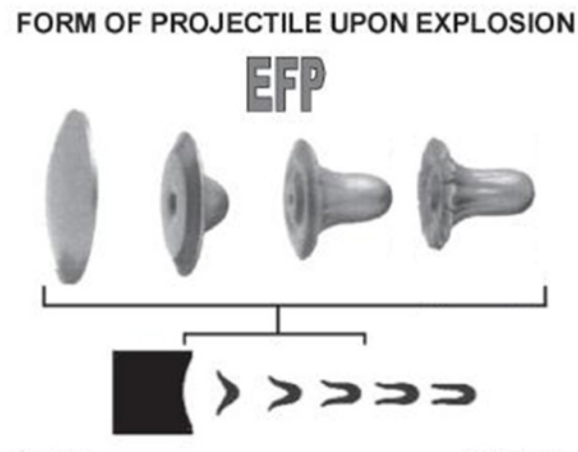

Figure 1: Action of an EFP

Figure 2: Toolmaks on the convex surface of an EFP liner

also be composed of steel, aluminum, and brass. **Figure 1,** from the National Ground Intelligence Center, describes how an EFP performs.

Materials and Methods

During the recent examination of an EFP liner, toolmarks were noted on the convex side of the liner (**Figures 2-5**).

These toolmarks were roughly equidistant from one another, bore a shiny appearance, and did not appear to be 'aged' like the patina on the remainder of the liner's surface. At the least, this suggested that they may have been produced more recently than the original copper sheet material.

Initially, the marks were thought to be created by the chuck of a machining center where the liner would be mounted for lathe-trimming of the edge. However, this liner did not bear

Figure 3: EFP toolmark (image taken using Alicona® Infinite Focus Sl microscope)

Figure 4: EFP toolmark

Figure 5: EFP toolmark

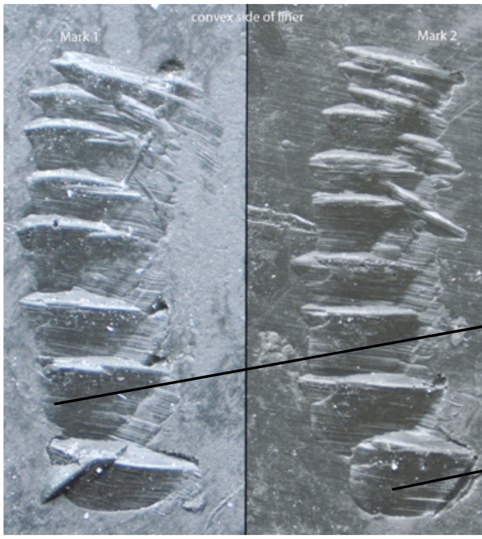

Figure 6: Two of the EFP toolmarks (taken on Leeds Forensic Systems LCF toolmark microscope)

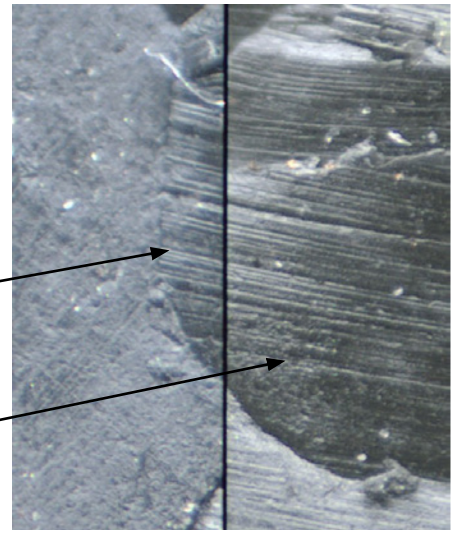

Figure 7: Corresponding detail in EFP toolmarks

any marks to indicate it had been trimmed, and the toolmarks were quite deep. Paired with the depth and shape of these toolmarks, and the absence of any lathe toolmarks, further investigation was warranted.

Due to their size and shape, EFP liners are not particularly suited to being placed directly on the comparison microscope. Casting material is routinely used to capture the detail within toolmarks, so casts were made for comparison. If in fact these toolmarks were from a three-sided chuck device, then they should not be identifiable to one another, as each chuck 'element' would act as an individual tool. Soon after placing the casts on the microscope, it was clear that these were three toolmarks that had been separately created by the same tool (**Figures 6 and 7**).

Prior to submission to the laboratory, this unusually marked liner had been removed from a device that also bore a design different than that normally seen. This IED was composed of a PVC body packed with explosive material, a metal base plate with a hole for a detonator/blasting cap, the copper liner in the opposite end, and a metal retaining ring which held the liner in place. The retaining ring was held in place by three rivets, which were equally spaced around the circumference of the IED. Most EFPs are not of this construction. It is more common for the liner to be held in place by compression, by an epoxy-like material, or by metal tabs that are welded to the side of the container, then folded over the EFP liner.

Once this unusual design was noted, our initial theory as to the creation of the toolmarks was that they were possibly created during the disassembly process when render-safe personnel 'drilled out' the rivets, and allowed the drill bit to make glancing contact with the convex underside of the liner. As the drill bit punched-through the rivet, it continued to rotate and move forward, making multiple, glancing contacts with the underside of the liner.

At this point in the case, it was noted that two additional IEDs had been submitted that had not yet been disassembled. These exhibits also were held together with rivets through a retaining ring, but no further examination had been done. A quick look at the underside of the EFP liners (in situ) revealed the same type of toolmarks that were observed on the liner of the disassembled device.

With this discovery, it was now clear that these toolmarks were likely created during the assembly process. Casts of these toolmarks were compared to the previously created casts from the disassembled device and were found to be identifiable. The toolmarks present on the three EFP liners had all been produced by the same drill bit (**Figures 8-11**).

A literature search revealed only two articles that dealt specifically with toolmarks created by drill bits [4, 5]. Both of these articles dealt with the identification of drill bit toolmarks in a blind hole, where the user had stopped the drilling process before perforation of the substrate.

In order to get a better understanding of the marks encountered in this case, additional research was done on the manufacturing of drill bits. Drill bits are typically produced from high-speed steel, starting out as a steel blank. Once sized to an appropriate diameter, an abrasive wheel produces helical grooves, called

Figure 8: Corresponding detail in EFP toolmarks

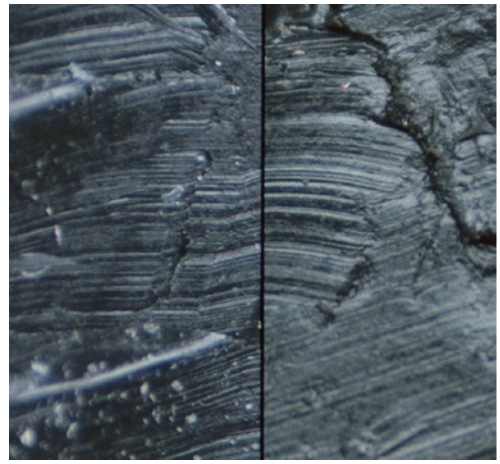

Figure 10: Corresponding detail in EFP toolmarks

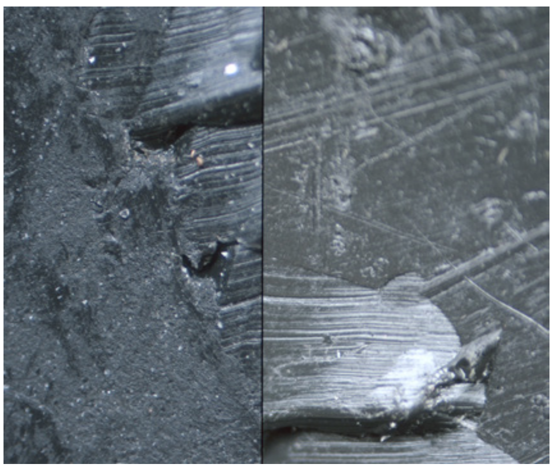

Figure 9: Corresponding detail in EFP toolmarks

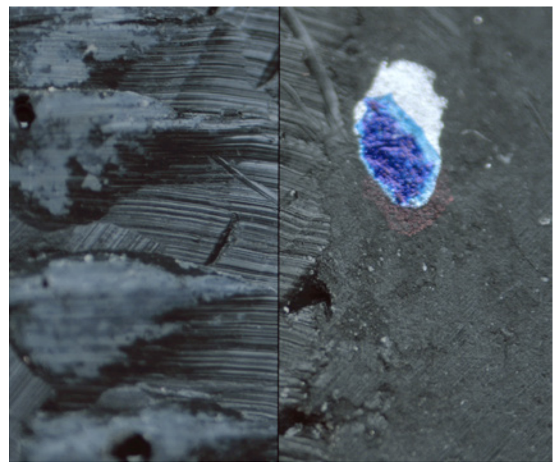

Figure 11: Corresponding detail in EFP toolmarks

flutes, along the length of the bit. Flutes help to remove the cut-away material (swarf) from the hole, and are essential for deep hole drilling. As material is sliced away by the cutting edges of the bit, the twisting motion of the bit moves the material toward and into the flutes for removal. Some bits are manufactured with a central hole through the bit that allows fluid to be pumped through the bit. This fluid cools the cutting edges of the bit and helps to flush material from the hole.

Most commonly, bits have two (2) ground finished/sharpened edges at the tip of the bit. This type of working surface produces individual characteristics. Drill bits that have dulled are replaced or sharpened by an abrasive wheel or by filing (**Figure 12**).

Results and Conclusions

The discovery and comparison of these uncommon toolmarks provided a means by which these devices could be linked to one another. All of the toolmarks present on the underside of the EFP liners examined could be identified as having originated from the same source tool.

Lessons learned from this examination include:

1. Working theories are works in progress. Until evidence is discovered that confirms a theory, the theory must remain fluid enough in the mind of the examiner to be modified as the examination progresses.

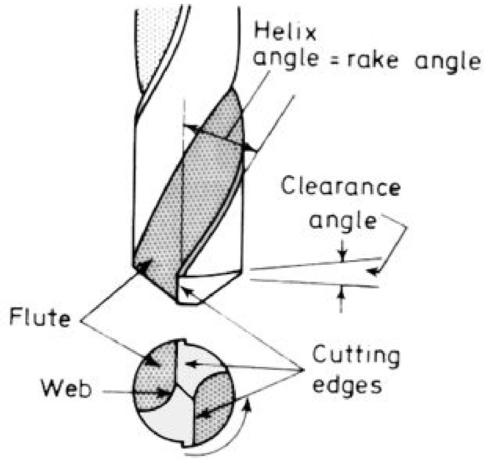

Figure 12: Diagram of a drill bit tip (Source: web.mit.edu)

2. Toolmark examinations are often detailed and time consuming. Examiners should be encouraged to never give up until all options are exhausted and all comparisons are made.

References

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