TIME-DEPENDENT EFFECTS OF HUMAN BLOOD ON THE MICROSCOPIC COMPARISON OF FIRED BULLETS

by

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PREFACE

This dissertation consists of five chapters, each of which focuses on various aspects of the forensic discipline of Firearms and Toolmarks. This dissertation for the most part attempts to highlight the exposure of projectiles to blood and the degradation over time of the fine detail, which is necessary for microscopic examination. This study should be of interest to students and qualified role-players in forensic science, the criminal justice system, the law community and the general population globally.

Chapter 1 identifies the research problem and the necessary steps that were taken to ensure that the research methodology applied is relevant and reliable. Chapter 2 focuses on various factors that have to be considered in damage to bullets and investigation procedures that should be followed to ensure that physical evidence is preserved for submitting to a forensic science laboratory.

Chapter 3 investigates the degradation effects of fired bullets exposed to various materials in a laboratory environment and the timelines associated with the degradation effects. Chapter 4 evaluates the examination procedures for fired bullets and the contributing factors that may influence the striation marks on bullets needed for microscopic examination. It also examines the scientific method used for firearm identification, and explores the admissibility of physical evidence in a court of law. The final chapter, Chapter 5 discusses the findings and recommendation of this research study.

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CHAPTER 1

GENERAL ORIENTATION

1.1 INTRODUCTION

From the earliest times, Eckert (1997:3) explains, the primary tool in the investigation of crime has been the observation and interpretation of physical evidence. Lee (1994:3) concurs with Eckert and outlines the major objectives of crime scene investigation as the recognition, identification, collection, interpretation and reconstruction of all relevant physical evidence.

"The discovery of physical evidence is the basis of further forensic investigation" (Lee, 1994:79). This dissertation explored firearms evidence in particular. "Firearm evidence is unique in the category of physical evidence and has the potential to individualise its origin" (Eckert, 1997:7). Anecdotal findings are addressed which suggest a linkage between the exposure of projectiles to blood and the degradation of the fine detail necessary for microscopic identification and comparison, which has been a long-time concern in the forensic discipline of firearms.

1.2 PROBLEM STATEMENT

"Firearms examination in the most basic sense involves links made between firearms and fired bullets found at crime scenes" (Nichols, 2003:466). Analysing class and individual characteristics on bullets allows the firearms examiner to identify a firearm from which a bullet has been fired. The bullet is normally the component that remains behind at the crime scene, which also refers to the victim's body.

Therefore, it is to no surprise to the scientific community that bullets found at crime scenes are likely to have been exposed to and/or submerged in blood. This, however, is problematic to the firearms examiner. Fired bullets are often received as evidence by a forensic laboratory. The casework experience of the researcher in shooting incidents (e.g. case file numbers 2003-5439, 2004-4111 and 2006-3577) suggests that exposure to blood of fired bullets over time has a degradation effect or obscures the striation marks needed for microscopic comparison.

In the investigation of a double homicide (case file number 2002-2366), the researcher screened fired bullets recovered during an autopsy and noted the condition. The bullets had been packaged in containers and submitted to the Forensic Science Laboratory in Somerset West. Seven months later, the bullets were examined and degradation of the striation marks was noted, as was the fact that biohazardous material used in the laboratory had a direct impact on the microscopic examination.

Scanlan (2005) supports the researcher's experience that determined that blood does in fact cause damage to bullets to the extent where no firearm analysis can be completed. He also concluded that the damage is more severe the longer the bullets are exposed to blood. This also became evident in studies conducted by Thomas (2005:14) and Wilson (2006:1). The sample bullets were exposed to blood, air-dried at room temperature and compared to control samples over time. Both researchers found that dried blood had little effect on bullets in a controlled environment.

The researcher found that some bullets that had been exposed to blood for longer periods were more damaged than those exposed over shorter periods of time. If this is the case, then bullets are being preserved incorrectly once they have been collected at crime scenes or from autopsies. This is based on the theory that blood causes bullet damage.

1.3 AIM OF THE RESEARCH

The main aim was to study the effect that blood has on fired bullets to the point where it interferes with microscopic comparison. This aim included a secondary aim, which focused on the amount of time bullets have been exposed to blood. To get to the root of the problem, variables such as the origin of the fired bullet, impact damage, the environment, and the collection and preservation of bullets were investigated.

1.4 PURPOSE OF THE RESEARCH

To address the aims of the research and answer the questions that arise, the study had several purposes, which were based on the guidelines developed by Denscombe (2002:25-27). The purposes are listed as follows:

- This research aims to determine the length of time for which a bullet can be exposed to blood before any class and/or individual characteristics on it are degraded to the point where a positive identification can no longer be made.

- The methods by which blood-exposed bullets are collected and packaged at the crime scene were investigated. The aim was to determine the strengths and weaknesses of the methods so as ultimately to make recommendations for improvement.

- The researcher explored how investigators internationally collect bullets exposed to blood from crime scenes. To accomplish this, the researcher read extensively to explore the field.

- The researcher applied the findings to develop best practices. This study may be used as a reference guide to enhance the preservation of evidence and ultimately improve the condition of fired bullets for microscopic examination.

- The findings of this study should be valuable to students and qualified role-players in forensic science, the criminal justice system and the general population globally.

1.5 RESEARCH QUESTIONS

Research questions specify exactly what is to be investigated. They are not the broad goals of the research that are directly investigated by the researcher, but specific things that must be observed, measured and interrogated to shed light on the broader topic. Research questions express the basis for the design (Denscombe, 2002:31).

The following research questions were developed to gather information in the investigation process:

- What factors have to be considered in damage to bullets?

- Is the length of time that bullets are exposed to blood a factor in damage?
- What scientific method is applied to the microscopic examination of fired bullets and is it admissible in a court of law?

1.6 KEY THEORETICAL CONCEPTS

A process was followed to identify and define key theoretical concepts that are used throughout this study. The purpose is to eliminate any confusion on the part of other researchers or readers that may arise in the future:

- *Identification* is the process of comparing two similar objects and concluding that both have a common origin. In the case of firearms examination, this is to "determine that two projectiles were fired from the same firearm" (Miller & McLean, 1998:15).

- *Striation Marks* can be defined as parallel surface contour variations on the surface of an object caused by the combination of force and motion, where the motion is approximately parallel to the place being marked. These striations are accidental in nature and unique to a common origin (a particular firearm or tool), also known as striae (Chayko & Gulliver, 1999:501).

- *Time-Dependent Effects* are defined by the Canadian Oxford Dictionary (2001:1519) as the indefinite and continuous duration of existence seen as a series of events progressing from the past through the present and into the future. The effects speak to the variation of an item being observed during the series of events.

- *Projectile* is defined by Wallack (1985:26) as a solid projectile comprised normally from metal and often in the shape of a pointed cylinder or ball discharged from a firearm or air gun. A bullet is a component of a cartridge, which also includes a case, gunpowder and a primer. However, a projectile refers to any object that can be propelled through the air by an exertion of force that has the potential to damage an individual, animal or object it contacts depending on its size, shape, speed and hardness.

- *Microscopic Comparison* is the comparison of two or more items using a comparison microscope (Moran, 2001:41). The comparison microscope is essentially two microscopes connected to an optical bridge. Cook (1985:46) describes the comparison microscope as having a bridge, which allows the forensic examiner to observe two objects simultaneously with the same degree of magnification. This instrument can have a monocular or binocular eyepiece.

1.7 RESEARCH DESIGN AND APPROACH

Mouton (2001:51) describes empirical research as the study of a physical object. Empirical research is the production of knowledge based on experience or observation. "Empirical research involves the idea of getting out of the armchair or going out of the office and purposefully seeking the necessary information out there" (Denscombe, 2002:6). Empirical design was best suited for this research project. It gave the researcher the opportunity to conduct an in-depth study involving the forensic science community. The researcher also gained insight into time-dependent effects of human blood on microscopic comparisons of fired bullets.

A qualitative approach was used which found to be best suited for this study. "Qualitative data is descriptive" (Breakwell, Hammond & Fie-Schaw, 1995:259). Welman and Kruger (1999:196) highlight the advantage of this approach, which allowed the researcher to ask a series of unstructured and in-depth questions through interviews. The researcher received first-hand information from qualified forensic examiners and technologists. As stated by Welman and Kruger (1999:197), this is a better option than relying on interpretation, or speculative explanations of the matter at hand.

In addition, the researcher had the opportunity to interact with firearms examiners and to ask questions about sensitive issues that are of concern to the scientific community. This approach established timelines along with considerable changes that occur which, it is hoped, would assist in finding a resolution to the problem.

1.8 TARGET POPULATION AND SAMPLING

The Statistics Glossary website (http//www.stats.gla.ac.uk/steps/html#targpop) accessed on 11/27/07 defines the target population as the entire group a researcher is interested in. The group refers to the target population from whom the researcher wishes to draw findings. As outlined by Welman & Kruger (1999:47), the target population is the population that meets the sampling criteria.

The target population for this study according to this definition are qualified forensic firearms examiners and technologists. Welman and Kruger (1999:47) explain that it is a process whereby researchers may rely on data collected from a sample of the target population. The findings of the representative samples can be applied to the larger population. The portion of the population selected is used to represent the entire target population.

On the North Arizona University website (www.jan.ucc.nau.edu, 11/27/07) various research sampling is describes. Purposive sampling as giving the researcher the opportunity to handpick subjects to participate in a study based on the identified variables under consideration. Based on the elements being investigated, fired bullets exposed to blood are not found at all crime scenes. Cases had to be selected based on the type of evidence (e.g. bullets exposed to blood) submitted in each case. This sampling method is normally used in qualitative studies to study the experience of a specific population.

To ensure that the sample of the population is representative of the target population, the researcher decided to set the criteria for sampling as follows:

- Qualified forensic firearms examiners and technologists
- Those who successfully completed a competency test
- Those who do an annual proficiency test

The researcher’s sample target population was one of the disciplines within the Centre of Forensic Sciences, Ontario, Canada. The researcher is the technical manager of the Firearms and Toolmarks section, which took part in this study. As a matter of convenience, the researcher had contact with the respondents on a daily basis and drew on their experience. The fifteen examiners and technologists were all aware that the researcher was conducting the research. The advantage of this study is that the findings and recommendations of this study can be applied globally.

Although the researcher restricted the sample population to a very specific population, all available subjects were used. The researcher also selected the Firearms section due to the nature of the problem statement. To determine time-dependent effects on fired bullets exposed to blood, the researcher had to use the discipline ultimately responsible for examining fired bullets.

There are ten forensic scientists and five technologists in the Firearms and Toolmarks section. The researcher selected names at random from a list, which was regarded as a representative sample of the qualified scientists. The technique chosen to select the forensic sciences is that of simple random sampling. Simple random sampling as defined by Kruger and Welman (1999:53) is that each individual within the selected group has the same chance of being included in the study. Consecutive numbers were assigned to each of the forty-five names and thrown into a hat and selected, which ensured that each scientist had an equal opportunity to be selected for this study.

A request for a staff development form was authorised by Gareth Jones, the Section Head of the Organisational and Development Section at the Centre of Forensic Sciences, which ultimately authorises the scientists to be interviewed.

1.9 DATA COLLECTION

In this section the specific data collection techniques are identified which were used throughout this study.

1.9.1 Literature

The purpose of this study was two-fold. The first reason was to find answers to the researcher's research questions and the second was to determine previous findings relating to the problem statement of this study.

A thorough literature review revealed that no previous research had been conducted on the same topic. A search of the libraries of the Universities of Toronto and South Africa revealed no such topic. Extensive reading was done using the journal catalogue of the Association of Firearm and Toolmark Examiners (AFTE), a professional association in the United States of America. Although no such topic exists in the field, the literature review did reveal relevant research studies that were conducted. In all these studies bullets were exposed to liquid human blood in controlled environments.

Miller (2001:125) used a comparison microscope in his experimental research study and explains the process by which striation marks are produced in the firing process. He demonstrated in his studies that striation marks are of the utmost important to firearm examiners when they conduct microscopic comparisons on bullets.

The literature works that the researcher found to be applicable to this study were reviewed and studied to determine whether or not they could answer any of the research questions.

1.9.2 Semi-structured interviews

The most appropriate data collection technique for this research study was semi-structure interviews. The Canadian Oxford Dictionary (2003:738) defines interviews as a session of questions between two or more people. Interviews are an essential part of qualitative research (Breakwell et al., 1995:230).

Welman and Kruger (1999:196) describe semi-structured interview as a technique where the researcher has planned in advance the main areas that need to be covered. It also gives the researcher the flexibility to change the exact wording and order of the research questions. In preparation for this study a series of questions were prepared in advance which would get to the root of the problem. This allowed the researcher to keep the flow going by asking relevant questions if the interviewee diverged from the topic.

The researcher's interview schedule for this study included:

- Introductory comments.
- A list of topic headings and key questions to ask under the headings. The purpose of the questions was to find answers to the research questions, and in that way to get to the root of the problem statement.
- A set of associated prompts.
- Closing comments.

Welman and Kruger (1999:197) explain the process on setting the standards for interviews. The researcher was not biased in any way; no approval or disapproval was shown to responses from the interviewees. In addition, the interviewer ensured that frankness and honesty were the order of day. It was also made clear that the researcher was interested in the participants and did not generalise in the representative sample group.

On the management help website (www.managementhelp accessed on 11/23/07) the researcher found a list of steps that need to be followed to prepare for an interview. Confidentiality is an important aspect of conducting interviews. To ensure that the participants responded freely and honestly, the interviewer guaranteed anonymity. The interviewees were referenced as Respondents to protect their identity. The interviewer was mindful that in order to get the best results from the participants there was a mutual understanding and respect between the parties. A systematic approach was used to deal with difficult questions in the middle or towards the end of the interview session and the participant was given time to be more comfortable and at ease.

The researcher included in part of the closing comments complete confidentially of the responses and the names of the interviewees. The names of the interviewees were not used unless permission was granted, which was integrated into the interview schedule.

1.9.3 Case study

Another data-collecting technique the researcher used to gather information was cases from previous examinations. Information gathered from case files at the laboratory was integrated with information obtained from the interviews and the literature study. A case study was used to combine different methods to compile a holistic understanding of the research problem. “The information gathered from the conclusion of reports was an accurate reflection of reality” (Welman & Kruger, 1999:191).

Permission was granted from the Organisational Development Unit of the Centre of Forensic Sciences to review the case files for research purposes. The authorisation for development was included in this study.

Information was retrieved from case files. Case files were randomly selected (20 in total) over a one-year period from the Storage facility of the laboratory. The case files were selected from amongst approximately two thousand case files. They were representative samples of crimes committed in the province of Ontario, Canada, in which bullets had been exposed to blood. A guided list of questions (relevant to the questions for the interview schedule) was used to review and check these case files. This ensured consistency throughout the case file review.

The cases were randomly requested from the archives and screened to determine whether they had the right evidence (bullets covered in blood). If they did, they were retained, and if not, they were returned to Storage. The case files were examined by gathering information from the submission sheet to determine timelines. Worksheets from the examiners were studied to determine the condition that the bullets were in at the time of the examination. The results and conclusions (scientific opinion) of the examiner on the final report were also screened.

The following guided questions were used for the case file reviews

- What was the date on which the crime was committed?
- What was the environment in which the bullet was found?
- What was the overall condition of the bullet?
- When and how was the bullet collected and packaged?
- When was the bullet submitted to the laboratory?
- Had the bullet been exposed to blood at the crime scene?
- Was it cleaned on collection and packaging?
- When was the bullet first examined by the scientist/technologist?
- How were the bullets packaged that had been exposed to blood?
- How were bullets packaged that had not been exposed to blood?
- Did the examiner clean the bullet?
- What chemical solution was used for cleaning?
- What were the microscopic findings?
- What were the scientific opinions of the scientist/technologist?
- What was the time period between collection and actual examination?

1.9.4 Personal experience

The researcher of this study was a crime detective for seven years in the Criminal Investigation Department of the South African Police. He investigated in excess of 4 000 cases, ranging from petty crime such as assault to high profile murder cases.

In addition, the researcher is a qualified scientist and a certified international auditor in the forensic field of firearms, toolmarks, physical matches and crime scene reconstruction. The researcher has four years' experience in examining firearm-related cases in a laboratory environment. He spent another four years as the technical manager of the Firearms and Toolmarks section in Canada.

The experience of the researcher includes the examination of more than 2 000 forensic firearm-related cases, attending more than 500 crime scenes and testifying more than fifty times as an expert witness. The researcher has been qualified to testify in the criminal and civil courts of South Africa and Canada.

1.10 DATA ANALYSIS PROCEDURE

The data analysis procedure consisted of the data collection methods described previously in this study and a section to address validity and reliability. Information was analysed and retrieved from the interviews and case studies (Welman & Kruger, 1999:201). The data analysis spiral from Leedy and Ormrod (2005:151) was adopted to guarantee that all data were captured accurately and common trends and patterns were identified. The phases are illustrated as follows:

- *Phase 1*

  Data analysis already started with the analysis of raw data collected from the interviews. To keep track of the thirty interviews that were conducted, the researcher decided to break up the data into manageable themes.
- *Phase 2*

  Common themes were organised in order to establish a direct and systematic approach to analysing the data (Welman & Kruger, 1999:202).
- *Phase 3*

  At the end of each day the data collected from the interviews were screened to get an overall sense of the information collected.
- *Phase 4*

  Themes were selected to categorise the data with the aim of identifying any patterns, trends and associations. The categorisation of the data allowed the researcher to correlate data at a very early stage.
- *Phase 5*

  A table was used to categorise the following themes bullet condition, location, packaging, time period from when the bullet was identified to when it was examined by the scientist, microscopic findings and the personal opinion of the scientist as to whether he/she believed the findings had a direct impact due to the fact that the bullets had been exposed to blood.

This also allowed for the quick determination of the frequency of the facts and could provide feedback on the tenability or untenability of the originally formulated research problem (Welman & Kruger, 1999:201). It supported or refuted information gathered in the interview process. A more complete report was produced by this analysis procedure.

1.11 THODS USED TO ENSURE VALIDITY

A substantial approach relates to the measurement of tangibles including dimensions, counts and relationships between phenomena. Anything that can be physically measured is usually used in quantitative research versus the insubstantial approach, which deals with the measurement of intangibles including concepts, ideas, opinions, feelings, etc., that is, anything that cannot be physically measured is usually used in qualitative research (Leedy, 1993:32).

Validity deals with the credibility of the tool to measure the phenomena (Leedy, 1993:32). The measures used in this study have all been validated through research reported in published literature, which have been referenced. To insure that the interviews conducted were valid, the researcher allowed the interviewees to review the recorded notes from the interview. Thus any discrepancy in note taking could be pointed out and corrected.

To ensure that the information gathered from the interviewees was accurate, the researcher drafted a brief summary of the content (addressing the key research questions). He compared it with other responses that were gathered and carefully inspected the results in terms of the usefulness of the information in addressing the research problem. This also ensured that the questions asked during the interview were valid. As described by Leedy and Ormrod (2005:28), the validity of an instrument relates to the extent to which the instrument measures what it is suppose to measure.

This assures that the information is accurate when the reference list has been completed. The information gathered from the case files all related to fired bullets exposed to blood, together with timelines from the time the evidence was collected until it was examined. The amount of information gathered was useful for determining a time frame for when damage occurs to fired bullets exposed to blood.

1.12 METHODS USED TO ENSURE RELIABILITY

"Reliability is the ability of the tool to consistently measure the phenomena it was designed to measure" (Leedy, 1993:32). The interview schedule and the case file review guidelines were drafted in line with the main research questions to ensure consistency and that the questions were answered for which they were designed.

The interview scheduled was complied by making the research questions subheadings. This was done to ensure that important questions that the researcher developed to address the research problem were actually answered. The interview schedule template used ensured that all the questions were the same for all the interviewees. The guided questions created for the case file review were placed next to each case file and ticked off during the review process to ensure that each question had been addressed.

1.13 ETHICAL CONSIDERATIONS

As outlined in the Association of Firearm and Toolmark Examiners' restricted website for members only, the researcher (the person conducting the research) pledged to conduct a full and fair investigation of the facts outlined in this research proposal. The researcher further pledged to render an opinion strictly in accordance with the information obtained from the facts (www.afte.org, 11/27/07).

After studying the policies and procedures outlined in the electronic document of the Association of Firearm and Toolmark Examiners (www.afte.org, 11/27/07), and by UNISA (www.unisa.za accessed 2/11/07). The researcher further ensured that the opinions rendered were impartial, objective and would only be in the researcher's field of competency. The policies and procedures of the ethical code of UNISA render general standards, which the researcher strived to meet at all times (www.unisa.ca.za , 2/11/07).

Leedy and Ormrod (2005:101) discuss guidelines pertaining to ethical behaviour when human objects are involved. They list the guidelines for ethical considerations as follows:

- Protection of human harm – researchers should not subject participants to physical or human harm. This study was conducted in a Forensic Science laboratory, which is governed by a Health and Safety policy to protect participants from harm, such as biohazardous or chemical materials.
- Informed consent – the nature of the study must explain to participants, and they must be given the choice of participating or not. Informed consent is a voluntary decision to proceed with a matter. The right of informed consent has a partner of sorts the right of informed refusal. In other words, researchers have the same legal and ethical obligation to respect "no" as they do "yes." The researcher of this study included an informed consent box at the bottom of the interview schedule, which the interviewee could sign. “This includes the right to full disclosure of this research study to interviewees” (Mouton, 2001:243).
- Right of privacy – researchers must respect the privacy of participants. In this study, the term respondent was used together with a letter of the alphabet to replace the interviewees’ names.
- Honesty with professional colleagues – Results from the study should be reported to participants. The researcher, through the results and conclusion of the dissertation, will reported these facts and opinions accurately in a PowerPoint presentation to professional colleagues in South Africa.
- Internal review boards (IRB) – as in the United States there is an IRB, which assesses every research proposal submitted by any entity (e.g. universities, laboratories, colleges, etc.).

1.14 RESEARCH STRUCTURE

The following format was chosen for this dissertation:

- Chapter 2 Discusses firearms evidence in general, the processes around the origin of the fired bullet and various factors that may contribute to bullet damage. The chain of custody is explored in great detail to ensure that the credibility of evidence is maintained throughout the investigation process. The chapter also discusses the concepts of bullet collecting, different packaging conditions and how these may influence the examiner's ability to conduct microscopic examinations.

- Chapter 3 This chapter addresses timelines, types of examinations performed by the firearms section and other forensic disciplines that may have an impact on firearms examinations. Case submission guidelines to the laboratory are reviewed and the case file review results are listed and discussed. Corrosion is discussed and a close look is given at how it affects bullets.

- Chapter 4 Various factors that contribute to bullet damage are highlighted. The scientific approach to the forensic firearms discipline is reviewed. The method used by examiners to identify firearms is discussed in great detail. The general processes and challenges examiners face are reviewed to identify variables that fired bullets are exposed to in the Firearms Section of a laboratory.

- Chapter 5 All the findings reached in this study are summarised and the researcher makes recommendations.

CHAPTER 2

THE CRIME SCENE

2.1 INTRODUCTION

The researcher started his investigation prior to bullets being submitted to the Centre of Forensic Science (CFS) crime laboratory. A wide variety of variables that can affect the condition of bullets before they are exposed to blood were first considered and scrutinised in great detail. Firearm evidence was examined in general and the principles of the Locard theory (see Section 2.5) were applied to crime scene investigations.

The proper recording of the condition and location of evidence at a crime scene is a vital element in maintaining the chain of custody and, more importantly, for courtroom proceedings. Search patterns are discussed which ensure that firearm-related evidence is not overlooked at crime scenes. This chapter also discusses ways of collecting bullets and different packaging conditions, and how these may influence the examiner's ability to conduct microscopic examinations.

2.2 CRIME SCENE

McClintock (2001:32) defines a crime scene in the broader sense to include more than the direct location of where the crime was committed. It may include other physical locations where evidence has been generated. The Canadian Oxford Dictionary (1998:333) defines a crime scene as the place where an unlawful offence has been planned and/or committed. For example, the place where the firearm was dumped may be a different location to where the victim was found, or it could be where the suspect purchased the firearm prior to committing the murder. Respondent A (personal interview, November 12, 2007) claims that all of these places are part of the crime scene and may contain evidence that could help solve the crime.

According to Owen (2000:26) forensic investigations start with the examination of the scene where the crime was committed. This is where investigators will find the first clues and evaluate their initial impressions concerning the nature of the crime, the cause of death and identity of the criminal(s).

2.3 FORENSIC SCIENCE

Meyers (2004:viii) defines forensic science as scientific knowledge for use by the law and the courts. Forensic science is the application of a broad spectrum of science used to provide impartial or unbiased scientific evidence for use in the legal system. According to criminal justice researchers, "police are on average about three times more likely to solve cases when scientific evidence is gathered and analyzed" (Campbell, 2000:18). Forensic science thus becomes a crucial component of the investigation process.

2.3.1 Forensic Investigation vs. Criminal Investigation

Van der Westhuizen (1996:354) defines criminal investigation, as a lawful fact-finding or information gathering process within the criminal justice system with the objective of reconstructing an unlawful act. The related term forensic investigation refers more specifically to the scientific collection of physical evidence in criminal cases. Owen (2000:8) describes forensic investigation as the application of various scientific methods and techniques within the legal system. The researcher is of opinion that forensic investigation should be seen as an investigative aid within the criminal justice system to solve crime.

2.3.2 Identification

Campbell (2000:52) correctly notes that in many cases the objective is not to group evidence, but to identify evidence. Meyer (2004:viii) defines identification as individualisation pertaining to forensic science as a causal identity (i.e. restoration of a obliterated serial number). Respondent C (personal interview, June 9, 2007) highlights the fact that one of the types of examination that is performed at a Forensic

Science Laboratory is the restoration of obliterated serial numbers on firearms. This is common as investigators attempt to track down the rightful owner.

2.4 ORIGIN OF BALLISTICS

Ballistics is the study and science of the passage of projectiles in motion and may be divided into three subsets. According to Dodd (2006:1) the three subsets of ballistics are internal, external and terminal.

2.4.1 Internal Ballistics

Heard (1997:65) defines internal ballistics as the study of what happens inside the weapon from the moment the firing pin strikes the primer to the time the bullet exits the barrel. It is mainly concerned with the propellant pressure that forces the bullet from the cartridge case down the barrel of the weapon.

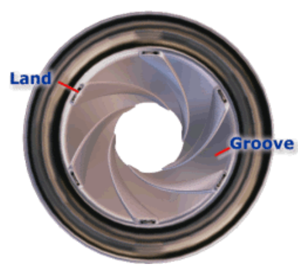


Figure 2.1 Rifling inside a barrel

(Wilson, 2006:1)

The motion of the bullet down the barrel of a weapon is a process in which rifling marks, illustrated in Fig. 2.1, which “consist of lands and grooves” (Wilson, 2006:1), are impressed on the bullet. Fig. 2.2. shows a pristine bullet containing rifling impressions (Thomas, 2005:18). According to Warlow (2005:115), finding these markings with other features will allow the firearms examiner to provide police agencies with valuable information.

Figure 2.2 Rifling impressions on a fired bullet

(Thomas, 2005:18)

2.4.2 External ballistics

Wilber (1977:101) describes external ballistics as the actual path that the bullet follows before it impacts the target, also known as trajectory. This phase of firearms examination starts when the bullet exits the muzzle of the firearm. Most people believe that the path of a bullet is straight, which is in fact untrue. Fig. 2.3 shows the principle aspects of the trajectory of the flight of a bullet, which is parabolic in shape.

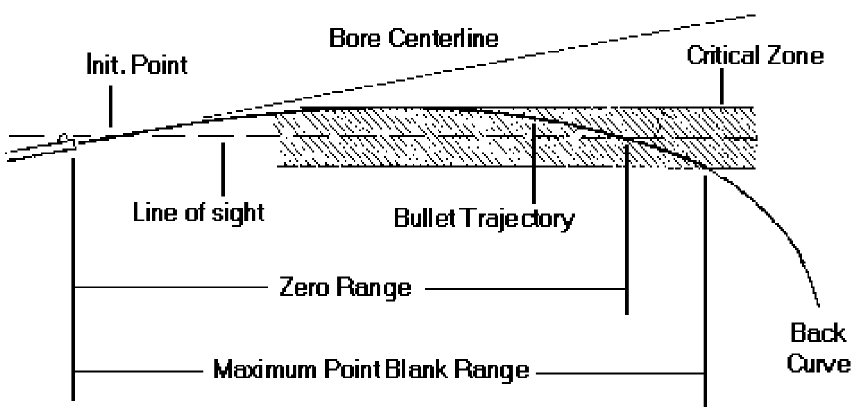


Figure 2.3 The barrel's angle in relation to the flight path of a bullet

(www.frfrogpad.com accessed 2/11/2008)

2.4.3 Terminal ballistics

Warlow (2005:169) states that the damage to a bullet depends on the bullet mass, velocity, design, construction and the nature of the target. Terminal ballistics ultimately deals with what takes place when the bullet strikes the target and the effects this has on one another. During this brief period of interaction with the target, the bullet suffers some degree of deformation and accumulates deposits. Fig. 2.4 illustrates various degrees of damage to a fired bullet. Heard (1997:131) and Respondent F (personal interview, October 10, 2007) agrees that damaged bullets or fragments of damaged bullets influence microscopic examinations.

Figure 2.4 Multiple fragments from a bullet retrieved after striking a target (www.firearmsid.com, accessed 11/27/2007)

2.5 THE LOCARD PRINCIPLE

Haag (2005:9) explains that the Locardian theory is that when two items come into contact with one another, there will be an exchange. This theory is essentially applied to crime scenes: every contact leaves a trace. This can be anything left behind at a crime scene or taken from the crime scene. Campbell (2000:28) explains that the perpetrator will take away traces of the victim and the crime; the victim will retain traces from the perpetrator and the crime scene.

This can be simplified by using the example of handling a firearm. When a firearm is handled with the bare hands, fingerprints and body fluid (e.g. sweat) are transferred to the firearm, leaving a trace of the handling. McClintock (2001:33) gives a few examples: cat hairs clinging to trousers, finger marks left on a clean glass, the impression that boots make in snow or on damp ground.

In relation to firearms identification, this refers to the “Transfer of marks when the bullet comes into contact with the inside of the barrel in the firing process” (Siegal, Saukko & Knupper, 2000:412), and when the bullet comes into contact with the target. Respondent D (personal interview, November 14, 2007) believes that this material from the barrel and the material from the target or anything that remains on the bullet are regarded as trace materials. This is an important theory and relates to the significant events at the crime scene.

2.6 EVIDENCE

Evidence is anything that helps to establish the facts of the crime under investigation (Axelrod & Antinozzi, 2003:145). McClintock (2001:33) believes that physical evidence is the most powerful type of evidence. Unlike eyewitness identifications and witness statement type of evidence, physical evidence is unaffected by emotion, prejudice or personal impressions. Campbell (2000:16) lists four types of evidence that may be admitted at a trial:

- Testimony, statement from competent, sworn witnesses.
- Direct evidence, which refers to the observation of eyewitnesses.
- Circumstantial evidence, which is any point that tends to prove or disprove a point at issue.
- Real or physical evidence, sometimes called hard evidence, which refers to any tangible article, weapon, bloodstains, etc.

2.6.1 Firearm evidence

Crime involving the use of firearms represents a significant area of police investigation. Fisher (2000:277) emphasises that firearm evidence is typically involved in violent crimes, such as murder, attempted murder, assault and rape, notwithstanding the fact that it may be involved in any other crime. Axelrod and Antinozzi (2003:148) note that bullets, bullet holes and fired cartridge cases are often submitted to crime laboratories as firearm evidence. He further identifies firearm evidence as:

- Firearms and firearm components.
- Tools and toolmarks, which may include:
    - Pliers
    - Hammers
    - Scissors
    - Crowbars
    - Human bones
    - Bolts
    - Screens

The researcher developed a list of typical questions that must be considered when firearm evidence is involved:

- What type of firearm was used?
- Did a specific weapon fire the bullet in question?
- How many firearms were used at the crime scene?
- Where was the shooter at the time of the firearm discharge?
- At the time of firearm discharge what was the distance between the shooter and the victim?
- Is the firearm classified as a firearm under the Firearms Act?
- Is the firearm operational as designed by the manufacturer?

Axelrod and Antinozzi (2003:149) discuss blood and body fluids, which are now more important than ever because of DNA analysis. This information can provide positive identification of the human source of evidence. The researcher found that some bullets exposed to blood for longer periods, for example in case file 2004-4111, show a degradation effect on the striation marks. This is a challenge to investigators in the collection of evidence.

The responsibility of providing evidence in a court of law rests with the prosecution. The prosecutor may supply the witness testimony under oath, by documentary evidence or by the exhibition of evidence as long as the rules of relevancy apply, which determine the admissibility of evidence in criminal cases. According to these rules, evidence is anything that might establish the guilt or innocence of a person. The most important exception is hearsay. In this instance crime scene recording techniques are regarded as relevant and admissible in a court of law.

2.6.2 Trace Evidence

“The variety of trace evidence is almost endless and includes a liquid, print and any object” (Marais, 1992:6). Fisher (2000:161) defines trace evidence as a generic term for small, often microscopic materials. Some of the more common types of trace materials frequently found on fired bullets by the researcher in criminal investigations include fibres, blood, wood and assorted microscopic debris. Human blood as a trace material will be discussed in more detail.

Eckert (1999:12) describe the cellular elements of blood. These include red blood cells, white blood cells and platelets, which make up 45% of the volume of blood. The remaining 55% is comprised of the liquid portion of blood, called plasma. Blood plasma consists of water, salts and proteins, as well as other components that are transported by the blood. Water makes up approximately 9% of the plasma and dissolved in it are numerous solids and gases (Eckert, 1999:12).

Figure 2.5 Human blood adhering to the surface of a recovered lead bullet

(Thomas, 2005:11)

The researcher found that recently there has been an increase in the number of requests for DNA analysis to be done on blood found on bullets. Respondent H (personal interview, November 3, 2007) believes that this is why bullets at a scene are often packaged without removing blood from them as shown in Fig. 2.5. The researcher found that due to backlogs, some cases are not examined until many weeks or months after being submitted to the laboratory.

“Dried blood, as opposed to wet blood, has a slower rate of denaturation, and therefore preserves the quality of the DNA better” (Thomas, 2005:10). “Dried blood does not degrade the surface of the bullets and such samples cannot be used to determine the amount of degradation that occurs after the bullets have been covered in blood for six to eight weeks” (Wilson, 2006:3).

2.7 CHAIN OF EVIDENCE

Chain of custody ultimately applies to the handling and documentation of evidence. According to Siegal et al. (2000:409), the chain of custody process is used to authenticate evidence. Continuity accounts for the custody of evidence from the time it is identified at the scene until its presentation as evidence in court. In the case of a firearm seized at the scene the make, model, serial number and condition must be documented together with the name of the person who collected and packaged the firearm. Respondent A (personal interview, November 12, 2007) notes that all transfers, such as the date, time and person who handled the firearm must be documented throughout the investigation.

“If continuity is broken, if one link of the chain of custody is lost or weak, the value of the evidence is called into question and may be pronounced inadmissible” (Greenshield & Scheurman, 2001:19). The authors here refer to the transfer and handling of evidence. In the case of the firearm seized, if the condition of the firearm change (e.g. the firing pin breaks) and the change cannot be explained, one may conclude that the evidence was tampered with and may result in the evidence not being admitted in court. Any weak link in the chain admits the possibility of accidental contamination or deliberate tampering, and provides the basis for the defence’s argument of reasonable doubt (Axelrod & Antinozzi, 2003:150).

2.8 RECORDING THE CRIME SCENE

Before the investigator begins examining the crime scene, as much information as possible must be gathered. Garrison (1996:168) addresses the proper recording of the condition; position and location of bullets found at crime scenes and explains how essential this is to crime scene shootings and more importantly to courtroom proceedings.

A slow and methodical approach is recommended. Investigators have a limited amount of time to work a crime scene in its untouched state. Saferstein (2004:10) states that it is important that the original state of a crime scene must not be lost, and discusses various methods that can be used to record a crime scene. Photography, sketches and notes/narratives are the three methods of recording crime scenes.

2.8.1 Narrative

A narrative is a running description of the crime scene. At no time must evidence be collected during the draft of the narrative. Nothing should be insignificant if it catches the eye. Photographs and sketches should be used to supplement the narrative, not substitute the narrative (Wade, 2003:25). The narrative should include the following:

- Case number (identifier).
- Date, time and location.
- Weather and light conditions.
- Identity and assignment of personnel.
- Condition and position of evidence.

2.8.2 Video recording

Another method of recording the crime scene is video recording. Light-weight video cameras are ideally suited for making a video recording. Video recording can provide a perspective of the crime scene layout, which cannot be perceived as easily in photographs and sketches. This is an additional method of recording the crime scene, which is of great value to crime scene investigators. It is a more natural viewing medium to which the court can readily relate, especially in demonstrating the structure of the crime scene and how the evidence relates to the crime (www.crime-scene-investigators.net, 11/27/07).

"If videotapes are to be used as evidence in court, they should not be edited or erased" (Fisher, 2004:86). The entire tape must be unedited if it is to be acceptable in court. Paciocco and Steusser (1996:1) views video recording as a tool that accommodates evidence in the presentation and consideration of any information to assist the jury and/or judge to come to an accurate factual determination. Video recording assist as a visual aid. According to Paciocco and Steusser (1996:2), video recording evidence will be admissible in the court of law as long as the trier of fact can consider it.

2.8.3 Investigative photography

Photography is a valuable tool for recording crime scenes (Staggs, 1997). A comprehensive photographic record of the firearm evidence should be made (Warlow, 2005:219). "The most important prerequisite for photographing a crime scene is for it to be in an unaltered condition" (Saferstein, 2004:36). Unless there are injured parties, objects should not be removed. The photographs should clearly and accurately illustrate the scene as it was found. Detailed photographs must be taken of all physical evidence in the condition in which they were found, prior to it being collected.

Fisher (2004:84) outlines the criteria for photographs to be admissible in court. The investigating officer must be able to testify that the photograph illustrates the area shown. To be accurate it must also accurately present the subject matter in colour, scale and form. In the author's experience, courts may not allow even minor modifications of photographs, and in such cases duplicate photos must be taken, first of the scene as it was and then with the scale shown.

2.8.4 Crime scene sketches

Photographs are not sufficient for recording a crime scene adequately. The sketch establishes a permanent record of items, conditions, distance and size relationships.

Fisher (2004:86) defines a sketch as not being an architectural drawing, instead it is simply an illustrative diagram or drawing that accurately depicts the appearance of a crime scene. A sketch is usually made as if the scene were being viewed from straight down or from straight ahead. Sketches supplement photographs and play an important role in shooting crime scenes.

Sketches are normally not drawn to scale. However, the sketch should include measurements and details so that a drawn-to-scale diagram can be produced if necessary. Fisher (2004:88) notes that the people who draw the sketch must be able to provide witness testimony that the sketch is a true representation of the scene.

2.9 CRIME SCENE SEARCHES

One of the major activities by police at the crime scene is to look for items of evidence that have some probative value in the crime at hand (Siegal et al., 2000:409). First and foremost, the crime scene needs to be secured and protected. Wade (2003:49) provides guidelines to secure and protect the scene:

- Take control.
- Determine the extent to which the crime scene should be protected.
- Continue taking notes.
- Keep unauthorised personnel out.
- Record the time and names of personnel who enter and leave the crime scene.

Fisher (2004:77) highlights the process to the general approach of searching a crime scene. Before entering, a crime scene the investigator has to decide what search pattern will be used at the scene. Failure to recognise an item as evidence or failure to properly collect items will be detrimental to an investigation. Fig. 2.6 gives two examples of search patterns that can be used at crime scenes. The best search method is normally the most time consuming. Axelrod and Antinozzi (2003:138), Crime Scene Searches Study Guide (2003:14) and Fisher (2004:77) are all investigation texts, which recommend a variety of search patterns strip or lane search, grid search, spiral search and quadrant search. Some search patterns are good for outdoor scenes and others more appropriate for indoor scenes. The important factor to consider and remember before starting a search plan is the fact that thoroughness is extremely important.

2.9.1 Strip or lane search method

Fisher (2004:78) describes this method as commonly used to cover large or open areas as seen in Fig 2.6 (a). Personnel line up shoulder-to-shoulder, usually an arm's length away from each other, and move slowly along, examining parallel strips of terrain. When a suspected object, such a cartridge case or bullet is located, the location and condition must be recorded. Personnel should try to keep the line straight and move forward together to avoid missing areas. This is one of the disadvantages of a strip search method. The advantage of this type of search is the fact that a large area can be covered.

2.9.2 Grid search method

Axelrod & Antinozzi (2003:139) defines grid search as a variation of the strip search method and is best used outdoors. Personnel search a trip along one axis, east to west, and then come back and cover the same area on a north-to-south axis. The disadvantage of such a search is that it is time consuming, but provides a double check of the search area. It is particularly useful in rough terrain where fired bullets and cartridge cases are hard to see.

2.9.3 Zone or sector search method

"The area to be searched is divided into zones or sectors" (Crime Scene Searches Study Guide, 2003:14). Each person is assigned a sector to do a thorough search. The researcher believes that good coordination is key to ensure that a complete search of the scene is conducted. Two people searching a room can use this method. Divide the room into two halves, after conducting a through search, they can switch halves. The disadvantage that the researcher has noted is contamination or the transfer of debris or evidence between sectors by the searchers.

2.9.4 Clockwise search method

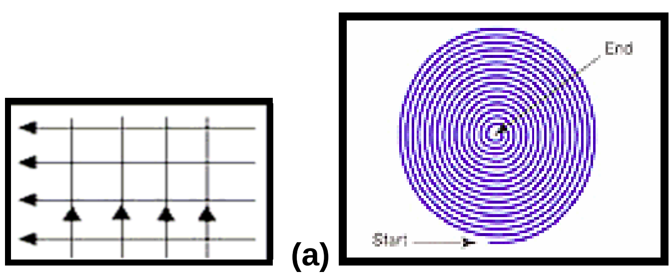
This search pattern involves two agents working together. On agent searches in a clockwise direction, searching the area from waist height up to the ceiling. The second agent searches counter-clockwise from waist height down to the floor. Once one pass has been completed, the roles are reversed and the process is repeated.

2.9.5 Point-to-point search method

Even though this is not very systematic, it can be used in small confined areas. This method is commonly used in firearm-related evidence and gives direction to the location of the firearm, expended cartridge cases and positions of bullet holes.

2.9.6 Spiral search method

This method, illustrated in Fig 2.6 (b), is typically used for outdoor scenes. Saferstein (2004:41) notes that a single searcher who walks in a slightly decreasing, less-than-concentric circle from the outermost boundary towards the centre usually uses this search pattern. The process should not be reversed. It can be used for underwater searches.



(a) (b)

Figure 2.6 (a) Variation of strip search methods best used outdoors (b) Conducted by a single searcher walking in a slightly decreasing circle

Firearm evidence based on the author’s experience is easier to find using the point-to-point search pattern. This search pattern allows the searcher to move from one point to another based on the evidence at hand. For example the location of the bullet will provide information on where the shooter may have been standing at the time of discharge. Marais (1992:9) points out that the identification of larger items is normally not a problem, but a more thorough search has to be conducted for smaller evidence (e.g. blood stains, hairs or fibres).

2.10 COLLECTION OF EVIDENCE

Once the crime scene has been searched, photographed and sketched, the process of collecting evidence should begin. Physical evidence must be handled and processed in a way that prevents any change from taking place between the time it is removed from the crime scene and the time it is received at the laboratory (Saferstein, 2004:43). Thomas (2005:5) discusses the importance of preserving the quality of all firearm evidence found at a crime scene in order to assist investigators to solve the crimes.

Fisher (2004:387) explains that in any case, well-preserved, uncontaminated evidence is vital to uphold the law's requirement for "proof beyond all reasonable doubt". Consequently, the most vulnerable evidence is collected first. Byrd (2001:3) discusses the responsibility of investigators who are responsible for collecting a vast amount of evidence and coordinating information from variety of sources, including the witnesses, suspects, officers, forensic pathologists and the crime laboratory, amongst others.

Evidence that is not protected from spoilage may not be in a condition to provide useful information. The methods by which evidence should be protected vary significantly and depend entirely on the type of evidence that has been identified (Fisher, 2004:379).

2.10.1 Firearms

"The most important consideration when handling a weapon is safety" (Respondent B, personal interview, November 12, 2007). Saferstein (2001:439) lists the most important considerations for the collection of firearms and the key factors that should be documented:

- The weapon's hammer and safety position.
- The location of the weapon and ammunition.
- The capacity of the magazine.
- The condition of the weapon.
- In the case of the revolver the chamber position should be marked in line with the barrel.
- Detailed notes must be taken of the condition of the firearm.

2.10.2 Bullets and cartridge cases from the victim

The protection of class and individual markings on bullets and cartridge cases must be the primary concern of the field examiner (Saferstein, 2001:439). When assisting with a post-mortem examination or handling bloodstained bullets it is imperative that surgical gloves be worn (Warlow, 2005:232). The following guidelines are listed on how bullets/projectiles must be processed for submission to the laboratory:

- Bullets and bullet fragments should be retrieved by hand or with plastic forceps; do not use metal forceps or other sharp tools.
- Retrieve as many shotgun pellets as possible; plastic forceps may be used to recover these.
- If a bullet is embedded in bone, remove that portion of bone.
- Remove any trace evidence from the projectile prior to rinsing.
- Blood should be removed from bullets, wadding and pellets as soon as is practicable, by rinsing with water and air-drying completely prior to packaging.
- Do not mark the bullet.

2.10.3 Bullets and cartridge cases from the scene

Webster (2005:17) outlines how bullets and cartridge cases should be retrieved from a crime scene. Extreme caution should be exercised when collecting bullets and cartridge cases to ensure that the marks on them are preserved.

- Identify each piece of evidence collected from the crime scene.

- Describe the location where the items were collected and the condition that they were found in.
- Be able to demonstrate that the evidence collected and the evidence presented to the courts is the same.
- Be able to explain any changes that the evidence may have undergone from the time it was collected.
- If the bullet is embedded, cut out the area containing the bullet.
- Do not recover bullets with any type of tool (exception plastic forceps).
- If DNA analysis is not required, blood should be removed from bullets as soon as is practicable, by rinsing with water and air-drying completely prior to packaging.
- Submit all fragments found at the scene.
- Do not mark any part of a cartridge case, mark the container.
- Package each cartridge case in a separate container (e.g. envelope, plastic box).
- Fired ammunition and components found are only accepted in cases of personal injury or matters of public safety

2.11 PACKAGING OF EVIDENCE

Evidence is ultimately packaged to prevent destruction and contamination (Siegal et al., 2000:415). “Evidence packaging is a crucial component in the submission process and is vital in maintaining chain of custody and the preservation of evidence” (Respondent A, personal interview, November 12, 2007). Saferstein (2004:90) provides brief instructions on packaging of firearms-related evidence:

- Toolmarks on objects should be protected from contamination and moisture.
- Clothing containing biological stains should be air-dried and wrapped separately.
- Firearms should be fixed inside containers.
- Cartridge cases and bullets should be packaged separately.
- Live ammunition should be packaged in cushioning material.
- Use clean and unused containers.
- Label all containers with a unique number and agency number.

- Package all items separately.
- Give a contents description.

Ethridge (2005:23) concurs that it is essential to prevent contamination, loss or alteration, and to maintain the integrity of evidence. He further highlights the importance of securing evidence to prevent physical contact with other pieces of evidence, as well as the evidence packaging.

2.11.1 Containers

Wilson (2006:2) notes that when forensic laboratories receive bullets covered in blood, they are typically wrapped in paper towels, plastic zip-lock bags, plastic containers, glass containers or paper envelopes. The researcher concurs that these types of packaging are typical of the way that projectiles are received at a laboratory. In CFS Case file number 2006-3577, the researcher documented two types of packaging. One bullet was packaged in a plastic container and the other in a white envelope. The fired bullets had different degrees of damage. The type of packaging could have been one of the contributing factors towards the differences.

Wilson (2006:3) found that fired bullets packaged in ordinary plastic containers and plastic zip-lock bags had the most damage, while very little change was observed in bullets that were in a specimen cup wrapped in a paper towel or in envelopes - these bullets were still covered in dried blood. The researcher observed various degrees of damage caused by various types of containers that ranged from pitting of the lands and grooves, discoloration of the metal and the deformation of striation marks.

2.11.2 Unique identifier

Saferstein (2001:439) notes the importance of the proper packaging of bullets and cartridge cases. Each container must be labelled uniquely and all fired bullets and cartridge cases must be packaged separately to avoid any confusion. This will ensure that the chain of custody of all evidence collected is tracked. Fisher (2000:285) highlights trace evidence that a fired bullet commonly retains. Traces of wood, fibres, paint, building material, blood and hair must be looked for and preserved.

"Bullets recovered at the crime scene must be inscribed with the investigator's initials, either on the base or the nose of the bullet" (Saferstein, 2006:480), as illustrated in Fig. 2.7. Respondent G (personal interview, October 23, 2007) identifies this as an important factor to consider when marking fired bullets; the complete circumference is of value for firearms examiners.

The researcher found in SAPS Case file number 2001-10213 two bullets submitted from the crime scene where the striations marks had been obliterated by the investigator's initials. *When there is more than one bullet a number should accompany the bullet (Saferstein, 2001:440).* Protection of class and individual characteristics must be the primary concern of field investigators (Saferstein, 2006:280).

Figure 2.7 Recovered evidence must be marked on the base or nose of the bullet. When there is more than one bullet a number should accompany the bullet

(Saferstein, 2001:440)

2.11.3 Transmittal letter

All evidence that is submitted to a crime laboratory needs an accompanying submission form or covering letter. "In the absence of a standard evidence transmittal form, you may use the following sample to submit evidence" (Ethridge, 2005:78)

- A brief description of the facts of the case.
- The laboratory examination requested.
- The submitting case number.

- A brief description of the evidence and the indicated source.
- The investigating officer's contact number and mailing address.

Webster (2005:5) gives general guidelines for bullets submitted to the laboratory and the contents that also have to be included in a submission form or letter

- Seal numbers of containers.
- Notification of any hazardous materials.
- Important information that the examiner must be made aware of.

2.12 FACTORS TO BE CONSIDERED IN BULLET DAMAGE AT THE CRIME SCENE

Various factors were considered in this Chapter that could cause bullet damage:

- Warlow (2005:169) defines terminal ballistics as the first major factor to be considered in bullet damage. This may vary and depend on bullet mass, velocity, design, construction and the nature of the target.
    - Bullets retrieved at autopsies are frequently found to be significantly deformed and/or mushroomed.
    - The bullet may fragment into two or more pieces, which can limit or impact the microscopic examination.
    - Bullet ricochet occurs when a bullet is deflected off a surface
- Saferstein (2004:43) highlights the collection and the packaging of evidence, which play a vital role in bullet damage. Changes to fired bullets can arise from contamination, removal of bullets from targets, breakage of containers, accidental scratches or improper or careless packaging. The impact of improper collection and packaging of evidence cannot be over-emphasised. Wilson (2006:3) more specifically found that the major degradation of striation marks observed was due to the different types of packaging that were used.
- Wilson (2006:4) studied bullets exposed to blood and found that it has a corrosive effect on striation marks in bullets. Thomas (2005:20) carried out experiments on bullets exposed to dried blood and found some discolouration over an 18-week period.

2.13 SUMMARY

All the evidence at the crime scene has the potential to solve the crime. This is one of the primary challenges to investigators. However, with the assistance of forensic science, police are three times more likely to solve cases. Application of the forensic discipline of firearms has become routine in criminal investigations.

The important rule to remember in any search pattern is thoroughness. Following the initial search, photographing and sketching of the crime scene, the evidence can be collected. Physical evidence should be handled as little as possible. Too much handling may result in the degradation of valuable evidence that could help to solve the crime.

Contamination is a concern in the proper preservation of evidence. It is important that items should be packaged separately in individual containers. There are several elements of crime scene investigation techniques that must be followed to ensure that evidence is identified, collected and packaged correctly for laboratory examination.

It appears that many factors have to be considered in bullet damage, from the time the bullet leaves the muzzle of the firearm until it strikes its target. Terminal ballistics is important and must be understood. The general rule is that firearms and ammunition should be left untouched at the crime scene. The following factors were clearly identified as variables that might influence the condition of the bullet:

- Bullet impact.
- Collection of bullets.
- Packaging of bullets.
- Trace evidence, including blood.

The following chapter deal with the processing of cases at the laboratory.

CHAPTER 3

PROCESSING CASES AT THE LABORATORY

3.1 INTRODUCTION

“Laboratories in general promote the use of consistent and approved procedures in the acquisition and transmittal of evidentiary items for forensic analysis” (Ethridge, 2005:1). This chapter discusses processing timelines when items are submitted to a forensic laboratory and the types of examinations performed by the firearms section.

Case submission guidelines from laboratories abroad were reviewed and are discussed in detail. This chapter also focuses on previous laboratory experiments regarding bullet exposure to blood and the possible chemical reactions that could cause damage to bullets. This will determine whether or not the length of time blood is exposed to bullets is a factor that must be considered.

3.2 SERVICES OF A FIREARMS AND TOOLMARKS SECTION

The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATFE) Handbook of Forensic Services (Wade, 2003:46) lists the services that are provided by the firearms section of a crime laboratory:

- Conducting trigger-pull tests – determining the amount of force needed to discharge a firearm.
- Assessing the mechanical condition of a firearm – determining whether a firearm functions as designed or whether there are any defects present.
- Accidental discharge test – determining whether a firearm can fire without direct application of pressure on the trigger.
- Gunshot residue examinations – determining whether gunpowder or lead residues have been deposited on clothing and other items through physical and chemical examinations.
- Shot pattern examinations – determination of the distance of a shooter from a target through analysis of the change in the spread of shot pellets following the discharge of a shotgun.

- Trajectory analysis examinations – determining the angle and direction of fire and the location or positioning of a shooter through geometric measurement and analysis of bullet holes.
- Serial number restorations – the restoration of obliterated or altered serial number characters on firearms, vehicles or other equipment through the application of chemical, thermal and magnetic techniques to the altered surfaces.
- Toolmarks examination – determining whether a given tool made a toolmark impression.

Miller and McLean (1998:20) claims that in addition to these services, firearms examiners perform microscopic comparisons to:

- Compare fired bullets and/or cartridge cases to each other, which can determine how many firearms, were used in the crime.
- Identify the calibre and manufacturer of ammunition components - this also includes the examination of various shotshell components.
- Determine the make and model of the firearm that may have fired a particular bullet or cartridge case.

3.3 RECEIVING EVIDENCE

Respondent D (personal interview, November 14, 2007) explains that the Centre Receiving Office (CRO) at the Centre in Canada processes all evidence submitted to the laboratory for examination. Respondent A (personal interview, November 12, 2007) concurs that the CRO at the Centre of Forensic Science and the South African Police Service Laboratories operate using the same concept. The core business is to process incoming evidence and distribute the evidence to the relevant disciplines for analysis.

3.3.1 Receiving Office

In February 2007, the researcher visited the Forensic Science Laboratory in Cape Town, South Africa and found that they have well-established procedures in place to process evidence. Respondent A (personal interview, November 12, 2007) who was the Assistant Section Head of the Ballistic Unit in South Africa, from 2004 to 2006 explains that the laboratory has a Receiving Office manned by three administrative workers. They are responsible to receiving the containers in which the evidence is packaged. Their duties include:

- Processing and entering evidence in an evidence register.
- Create case folders for each individual case.
- Transfer the evidence to a centralised storage facility at the laboratory.

The Forensic Science Laboratory's Ballistic Unit located in Pretoria hosted the International Forensic Technology Symposium (IFTS) in South Africa and invited attendees to visit their facility. The researcher visited the Laboratory in April 2007 and found that evidence received at the Laboratory was dealt with in a similar manner as explained by Respondent A (personal interview, November 12, 2007). The researcher also visited several crime laboratories in Canada and the USA in recent years, and found that most laboratories use a Laboratory Information Managements System (LIMS) as the single tool to process all evidence received at a laboratory.

Respondent E (personal interview, November 16, 2007) lists a series of steps that anyone should follow when processing evidence that relates to firearms:

- Read and understand the covering letter and determine what examination is requested.
- Correlate the information on the package and the information on the covering letter, e.g. ensure that the seal numbers correspond and are correct.
- Make the firearm safe, i.e. all ammunition must be removed from the firearm.
- Record the details and process the firearm in the Laboratory Information Management System (LIMS) or evidence register to track the transfer of evidence.

Ethridge (2005:44) agrees that a firearm must always be rendered safe before being processed for analysis. "Staff are required to check all firearms regardless of any information provided to the effect that the gun has been proven safe" (Webster, 2005:45). Wade (2005:7) outlines a similar approach for each discipline of the Alcohol Tabaco and Firearms Examiners (ATFE).

3.3.2 Challenges in the Centre Receiving Office

The challenge is to ensure that the case submission criteria for each section are met without compromising the evidentiary value of the evidence. Respondent F (personal interview, October 10, 2007) recounts her training at the Centre Receiving Office (CRO). She was trained to submerge all biohazardous bullets in water. According to Respondent I (personal interview, December 17, 2007) describe it as a direct violation of the case-accepted guidelines. Webster (2005:5) list the steps that need to be followed for biohazardous bullets:

- If the blood is required for DNA analysis it must be air-dried before it's packaged (exception items to Toxicology).
- If the blood is not required, the bullet must be rinsed with water and dried.
- Use clean and unused containers to prevent contamination.
- Label all containers this will further assist continuity.

"Contrary to what some defense attorneys might claim evidence is rarely subjected to deliberate tampering" (Axelrod & Antinozzi, 2003:152). Respondent A (personal interview, November 12, 2007) found that on three occasions over the past twelve months the scientist examined evidence that were handled poorly by the CRO. In one instance, Respondent B (personal interview, November 12, 2007) received a bullet submerging in water from CRO. On further examination, the scientist assessed that the bullet was corroded and striation marks distorted. This made microscopic examination difficult. Respondent C (personal interview, June 9, 2007) experienced the same thing in a case she examined in 2006 where a greenish-brown discolouration was observed and the bullet was found to be of no microscopic value for identification.

3.3.3 Laboratory Information Management System (LIMS)

At the Centre of Forensic Sciences in Canada, Johnston (2007:2) explains the process once the packaging criteria have been met. The CRO technologist will proceed with the processing and input the evidence into the LIMS. Continuity and chain of custody are maintained throughout this system. Johnston (2006:8) further states that each registered user, who has a profile and a secret pin number to ensure secure transfers.

This is used to demonstrate the chain of custody of all evidence processed at the laboratory to the courts of law. “LIMS software is ultimately used for the management of evidence and to generate reports for statistical purposes” Respondent I (personal interview, December 17, 2007).

3.4 CASE PROCESSES

Siegal et al. (20004:09) explain that every country has a rule of law that requires evidence be preserved in the same condition as when it was first found at the scene. It does allow for some changes during the examination of evidence by the laboratory and normal degradation with time, which must be clearly documented in a scientific report (Respondent D, November 14, 2007).

“It is important that the changes be recorded in the examiner’s work notes and documented in the statement from the examiner” (Respondent B, personal interview, November 12, 2007) The Ballistic Unit in Cape Town designed a report template that examiners use to draft reports. The template makes provision for recording any changes that occur and to ensure that there is consistency in the evidence reported to clients. Respondent B (personal interview, November 12, 2007) further states that it is important to preserve the quality of all firearm evidence found at a scene in order to assist investigators to solve these crimes. If changes occur or evidence is damaged, all relevant role-players have to be notified through the report.

Respondent C (personal interview, June 9, 2007) highlights the fact that case processes are developed to streamline examinations and to ensure that evidentiary value is preserved. The preservation of fired bullets becomes a challenge when bullets exposed to blood from the crime scene are not examined in a timely manner.

3.4.1 Workload

In a Memorandum addressed to all police agencies (Prime, 2007) from the CFS Laboratory communicates the changes needed to be made to utilise resources in those cases that will have the greatest impact on clients and stakeholders. This acknowledged the fact that the Firearm section was experiencing difficulty in coping with their workload. It is only a small section, and some cases could not be examined immediately (Thomas, 2005:5).

In South Africa the "Forensic Science Laboratories (FSLs) have a backlog of 6 086 samples" (http//www.int.iol.co.za, 11/29/07). In this newspaper article Safety and Security Minister of South Africa Charles Nqakula stated that investigating officers could expect to wait an average of 102 days for the results from Biology, 56 days from Chemistry, 40 from Ballistics, and 35 days for questioned documents. This is a potential risk for bullets that are exposed to blood. "Timelines is a increase concern to firearms examiners" (Respondent A, personal interview, November 12, 2007).

3.5 CASE STUDIES

Information was gathered at the Centre of Forensic Sciences from twenty-one case files to review timelines (from the time the bullet was submitted until it was examined by the examiner). The condition of the bullet and the microscopic findings of examiners were essential components of the collection of this information.

3.5.1 Timelines and the degradation of marks

Timelines were reviewed for each bullet from the time the crime was committed until the bullet was examined by the examiner. Processing timelines ranged from three weeks to two years with varying results:

- Case file number 2005-75850 revealed that fired bullets were exposed to liquid blood for a period of three weeks and could not be identified with other bullets.

- In case file number 2006-3577, bullets exposed to blood after eight months indicated no value for microscopic identification.
- Case file 2004-8501 revealed that bullets that had been exposed to blood for a two-year period could still be used for microscopic comparison.

Respondent H (personal interview, November 3, 2007), Respondent I (personal interview, December 17, 2007) and Respondent G (personal interview, October 23, 2007) have the same view, the length of time bullets is unknown for how long bullets must be exposed to before damage occur. Arnold (1988:163) believes that there is no way of determining how long a bullet has to be exposed to any matter, due to the many conditions a bullet is subjected to (corrosion, abrasion, oxidation, etc.). Arnold (1988:163) did link a questioned bullet that was fired and recovered from an embankment. Ten years later, identification was made.

The study found that timelines vary significantly. Bullets are exposed to blood for as little as three weeks as long as two years, with varying results. Respondent E (personal interview, November 16, 2007) explains that due to the number of variables involved each bullet must be dealt with on a case-by-case basis.

3.5.2 Bullet condition

"The condition of the bullets and the amount of rifling left on the bullet is a major factor in microscopic comparisons" (Respondent B, personal interview, November 12, 2007). The worksheets reviewed from case files 2005-8623, 2006-2617, 2006-8296, 2006-8729, 2005-6041, 2005-7635, 1983-5999 and 1974-6111 revealed that bullets are received in various shapes, forms and sizes.

In case files 2006-2279 and 2005-7020 the researcher encountered bullets that were badly damaged (e.g. one or two lands and grooves). Chapter 2 discusses the transfer of marks when the bullet moves down the barrel of a firearm. The complete circumference of the bullet comes into contact with the barrel, and it is the complete circumference of the bullet that is a true representative of the barrel. If all the lands and grooves are not present, which was the problem in case files 2006-2279 and 2005-7020, the examiner may find it difficult to make microscopic findings.

Respondent H (personal interview, November 3, 2007) discussed bullet condition and found that bullets may also fragment into two or more pieces, which without doubt influences microscopic examination. Bullets retrieved at autopsies are significantly deformed and mushroomed. Case file 2006-3577 revealed a wide range of various conditions of bullets pristine, fragmented and badly deformed, etc., which are variables that affects on microscopic examination.

3.5.3 Microscopic results

Four types of results were observed in the reports of case files 2005-7585, 2005-6054, 2005-5576, 2005-3555, 2003-5451, 2003-9100 and 2006-2279:

- Identification – There were sufficient marks for an identification.
- Elimination – There were sufficient marks for an elimination.
- Inconclusive – There were not sufficient marks for an identification or elimination.
- No value – There are no marks of value for a microscopic examination.

Microscopic results revealed that 50% of the 20 cases reviewed were identified to other bullets. These bullets had good quality marks even though they have been exposed to blood. Fig. 3.1 illustrates a comparison between two bullets. The sample on the left was taken after it had been exposed to blood for two weeks (Wilson, 2006:4).

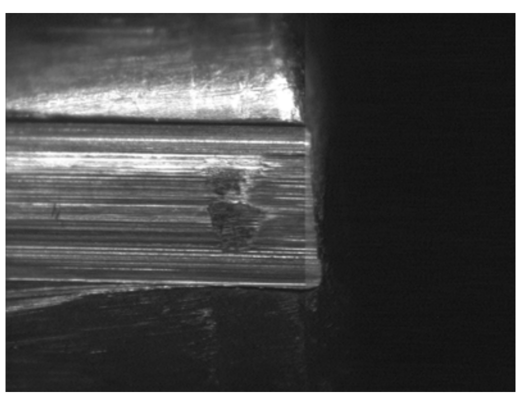


Figure 3.1 Sample of a photomicrograph with a dividing line in the centre. The sample on the left was taken after it had been exposed to blood for two weeks (Wilson 2006:4)

Thirty per cent of the results revealed that the examiner could not make an identification nor an elimination and twenty percent concluded that the bullet or bullet fragments were of no value for microscopic examination. In the reports of the scientists the reasons are listed either as damage or insufficient present for an identification or elimination. Fig. 3.2 illustrates a photo-microphotograph with a dividing line in the centre. The sample on the left was taken after it had been exposed to blood for four weeks (Wilson, 2006:4).

Figure 3.2 Sample of a photomicrograph with a dividing line in the centre. The sample on the left was taken after it had been exposed to blood for four weeks (Wilson 2006:4)

3.6 CORROSION

There are two possible causes of damage that has been observed on bullets that have been fired through bodies (Thomas, 2005:8). One possibility is deformation as the bullet travels through tissue, which relates to terminal ballistics. The other is damage from a chemical reaction causing corrosion.

Zumdahl (1998:469) explains that most bullets are made of metal and are prone to corrosion, a process that involves the oxidation of the metal. Considine (1984:293) defines corrosion as the electrochemical degradation of metals or alloys due to reaction with their environment; it is accelerated by the presence of acids or bases.

This means that degradation could change, alter and/or distort striation marks on fired bullets required for bullet comparison.

“Some factors that affect the rate of corrosion include the concentration of oxygen, the acidity, impurities and the presence of moisture” (Zumdahl, 1998:572). Thomas (2005:10) notes that all these elements are present in blood. There has been an increase in the number of requests for DNA analysis to be conducted on blood found on bullets. With cases being examined 19 months after they have been submitted, the degradation of striation marks due to corrosion is guaranteed.

3.7 BULLETS EXPOSED TO BLOOD

Ethridge (2005:23) discusses the importance of securing evidence, so as to prevent physical contact with other pieces of evidence as well as with the evidence packaging. Respondent B (personal interview, November 12, 2007) finds this a challenge when dealing with bullets exposed to blood. Investigators generally find it a challenge when faced with two types of physical evidence, namely blood and bullets.

Respondent F (personal interview, October 10, 2007) explains that as a bullet enters a victim’s body, it become deformed from the impact and covered in blood. The blood may or may not stay on the bullet, depending on where it is lodged in the body. Hunter (2006:17) notes that no crime scene investigator in the world would deny that the presence of blood is critical as evidence at crime scenes, hence the reluctance to remove blood from bullets for analysis.

Campbell (2000:29) explains that water or fluids make up 92% of our bodies and the analysis of certain types of body fluids – blood, saliva, sweat, semen and urine - can provide information about the person from which they came. “All blood has two major components, plasma and cells” (Hunter, 2006:17). These cellular elements, which include red blood cells, white blood cells and platelets, make up 45% of the total blood volume. The remaining 55% is comprised of the liquid portion of blood, called plasma. Plasma consists of water, salts and proteins, as well as other components that are transported by the blood.

Thomas (2005:14) experimented in a laboratory environment on the effects of dried blood on bullets by placing bullets in transparent containers. She exposed the bullets to liquid blood and left them to dry at room temperature. Controls were generated to compare the samples over a four-month period. Except for discoloration, no significant damage was observed over the entire four-month period.

Respondent B (personal interview, November 12, 2007) believes that by not removing blood from bullets, the striation marks on bullets are placed at risk for microscopic comparison. Respondent E (personal interview, November 12, 2007) concurs with Respondent B (personal interview, November 12, 2007). Both scientists had trouble in examining bullets exposed to blood to the point where the bullets where of no value for an identification.

3.8 SUMMARY

The Centre of Forensic Sciences follows stringent guidelines to ensure that evidence is packaged and sealed to secure it and its integrity. Even with the well-established procedures in place at the Centre regarding the handling and processing of evidence, this review found that there had occasionally been policy violations for processing bullets covered in blood.

Based on the case file review, CRO staff filled evidence containers with water if the bullets were exposed in blood. This is a strong contradiction to what Firearms examiners from the Centre of Forensic Sciences are communicating to clients and stakeholders, which is that water is extremely corrosive to bullets, which must at all times be air-dried before being submitted to the CRO. Thomas (2005:23) agrees with the Firearms examiners based on a study of bullets and recommends that bullets must be air-dried before being packaged.

The cases reviewed suggest that it can take as long as two years before a bullet may be examined by the Firearms section. Ultimately the prevention of contamination, loss or alteration and the preservation of fired bullets are essential to ensure that microscopic examinations are successful.

Preservation of blood evidence by leaving it on bullets is detrimental to the rifling marks on the bullets - the blood will be preserved for further analysis, but damage to the rifling marks is guaranteed. Timelines varied significantly and a closer look at the methods used for identification is discussed in Chapter 4.

CHAPTER 4

EXAMINATION OF FIRED BULLETS

4.1 INTRODUCTION

The type of examination that can be performed at the Laboratory's Firearms Section may vary. This depends on the particular evidence submitted and the purpose of the examination. Various types of projectiles are discussed together with the screening process to prepare bullets for microscopic comparison.

This chapter focuses on the examination process, the scientific method and firearm identification and its acceptability in a court of law. The factors that may cause damage in a laboratory environment are also explored and discussed. The theory of identification is explained so that investigators can gain a better understanding of how linkages are made.

4.2 THE SCIENTIFIC METHOD

"Forensic science in its broadest definition is the application of science to law" (Saferstein, 2001:1). The forensic science community applies the knowledge and technology of science to assist with the enforcement of the law. The scientific method is necessary to develop scientific knowledge and is applied when conducting forensic casework.

Miller & MacLean (1998:15) describe the scientific method as having seven steps:

- Stating the problem – purpose of the examination.
- Gathering information about the problem – case history.
- Forming a hypothesis – bullet in question was not fired from the firearm.
- Testing the hypothesis – analysis.
- Recording and analysing the data – document examination.
- Stating the conclusions – report the conclusions through a statement of analysis.
- Repeat the work – the examination is repeated by another qualified examiner and the same results must be reached.

4.3 SCREENING AND PREPARATION PROCESSES

Screening and preparation are important elements of the examination process to assess bullet damage. There are two main categories of projectiles, which are commonly known as pellets and bullets (Booker, 1980:159).

4.3.1 Pellets

Pellets are spherical balls commonly known as shot. This is the projectile component of a shotshell cartridge used in shotguns. “There are multiple pellets in one shotshell case that are held together by a wad” (Saferstein, 2004:439). These pellets disperse upon exiting the barrel of a firearm, leaving the wad to fall approximately 20 feet from the point of firing (www.forensicid.com, accessed 11/27/07).

Respondent G (personal interview, October 23, 2007) discussed pellets as a component of a shotshell cartridge that are not exposed to the inside surface of the barrel. They do not have individual marks on them and are therefore of no use for projectile comparisons. The barrels of most shotguns are smooth and do not leave characteristic striation marks and do not have the rifling lands and grooves, as do most barrels from rifles and handguns. Because of these two facts this study will not examine shotgun pellets.

4.3.2 Bullets

“As the projectile is accelerated down the barrel, the impressions from the lands and grooves are scraped into the surface of the bullet, known as rifling” (Rowe, 2000:330). Meyers (1993:281) specifies that these marks be used for microscopic examination.

Love (1980:32) studied the effect of blood on bullets by placing bullets in containers with human blood. He exposed the bullets by leaving half the containers outdoors and the other half in a refrigerator. After nine months the outdoor bullets showed major corrosive effects and were no longer identifiable. The refrigerator bullets were essentially unaltered. The one problem with this study is that no control samples were taken. However, this study, which was conducted over a period of one year, demonstrated that blood deposits on bullets have a degradation effect. In the investigation process of this study the researcher does note that other environmental factors could have played a role.

Scanlan (2005:43) gave a presentation at the conference of the American Academy of Forensic Sciences on the corrosive effects of blood on bullets. The author examined copper-jacketed bullets that had been sealed in specimen cups with blood. He determined that blood does cause damage to bullets to the point where no firearm analysis can be done and that this damage increases over time.

Research conducted by Wilson (2006:4) revealed that no microscopic results were poor enough to prevent the matching of a bullet to a standard in the two-week samples, but that they posed a serious problem in a few of the four-week samples. Some of the individual land impressions on the four-week samples had suffered sufficient degradation to the point where a match with the standard bullet could not be made.

4.4 EVIDENCE PREPARATION

McGimpsey (2006:2) describes bullets examined for the purpose of calibre determination and the microscopic examination and comparison of the marks imparted on the bullet by a firearm. McGimpsey (2006:2) outlines the examination procedure, which may include the following:

- Record a digital image of the item as received.
- Note the condition of the item.
- Wherever possible mark the item to identify it for future reference. Care should be taken to avoid marking the area that may be used for microscopic examination. Bullets should not be marked on the bearing surface.
- Conduct a detailed examination and record observations, and where applicable carry out the following:
    - Remove trace material

- o Sterilise the item so that it is not biohazardous
- o Record dimensional data
- o Weigh the item
- o Note the construction/profile/condition
- o Record any damage and/or defects.

4.4.1 Cleaning the bullet

McGimpsey (2006:4) outlines the handling of trace evidence. If the examiner suspects that a fired bullet is biohazardous, it must be cleaned. “The purpose of this procedure is to provide the examiners with guidelines for the sterilisation of case items and the removal and subsequent retention or disposal of trace evidence” (McGimpsey, 2006:1). Hatcher (1935:274) agrees that bullets frequently have to be cleaned before microscopic examination due to the fact that they may be covered in clotted blood.

The removal of various trace materials is tabulated in Table 4.1 using various reagents to clean bullets prior to microscopic examination. Booker (1980:153) explains that examining bullets that are mutilated, battered, corroded, contaminated or which have too few identifiable characteristics is a great challenge for firearms examiners.

Table 4.1 Cleaning procedures using reagents for various trace materials (McGimpsey, 2006:3)

TRACE MATERIAL	PROCEDURE
Blood, tissue or other biohazardous materials	If necessary, a soft brush or cotton swab may be used to wash the item with antimicrobial soap and cold water, to remove large amounts of biohazardous material. Dry with a soft cloth.
Plaster	Rinse/soak/swab the item with 15% acetic acid, then rinse thoroughly with water and dry with a soft cloth.
Paint	Swab the item with acetone or 70% ethanol and dry with a soft cloth. Do not use acetone on lead.
Primer sealant	Swab the item with acetone or 70% ethanol.
Tarnished bullets	Dip the item in, or swab with e-Z-est jeweluster, then rinse the item

and/or cartridge cases	thoroughly with water and dry with a soft cloth.
Corrosion	For lead bullets or less extensively corroded jacketed/plated bullets, place in water in an ultrasonic cleaner for approximately 30 seconds. Then soak in 10% perchloric acid for approximately 2 minutes. Place the bullet in water for another 10 seconds in the ultrasonic cleaner. Rinse the item thoroughly with water and dry with a soft cloth.

Laskowski (1997:216) describes how bullets are cleaned with a solution called Celeo (21) to remove adhering blood and tissue. Even after cleaning the bullets, a dull bronze patina was found on the surface, which makes microscopic examination extremely tedious. Booker (1980:154) warns that the removal of any material from bullets requires careful technique in order not to create additional damage. Respondent C (personal interview, June 9, 2007) explains that scientists are well aware of the risk involved when cleaning bullets.

4.4.2 Factors that may influence the condition of a bullet in the laboratory

When it comes to bullet identification, Hatcher (1935:289) explains that serious difficulties are sometimes presented because of the extreme shape deformation of the bullet and consequently the obliteration of striation marks. Usually the condition of bullets received at the laboratory is far from ideal to allow any exclusive microscopic finding, which leaves the examiner with challenges. Respondent H (personal interview, November 3, 2007) highlights the challenges, which was also encountered by Respondent A (personal interview, November 12, 2007):

- Corrosion due to the exposure of any liquid substance (e.g. wet blood, water, etc.).
- Degradation of striation marks due to exposure to chemical reagents.
- Attempts by the examiner to bend or reshape the metal of the bullet to expose striation marks.

Respondent H (personal interview, November 3, 2007) and Respondent I (personal interview, December 17, 2007) both agreed that bullets exposed to chemical reagents run the risk of loosing striation marks, but this can be avoided by simply exposing the bullet to chemical reagents over short periods of time and monitoring the condition.

The idea is not to over-expose the bullets to the point where the cleaning phase starts having a negative impact on the evidence being examined.

4.5 CRITERIA OF FIREARM IDENTIFICATION

One of the main areas of firearm analysis is the comparison of projectiles found at a crime scene with projectiles obtained from test-firing a suspect firearm. Gorman (1976:265) defines firearm identification as a sub-set of toolmark analysis. “It is possible, in many instances, to compare one projectile with another even after numerous projectiles have been fired through the barrel” (Hamby, 1999:22).

Toolmark analysis fundamentally follows from the Locard exchange principle that every contact leaves a trace. Specifically for toolmarks analysis, harder objects, when they come into contact with softer objects, will leave an impression or mark of their surface features on the softer object. Fig. 4.1 shows rifling marks from the inside of a firearm barrel, which are formed in a spiral nature, lengthwise down the barrel.

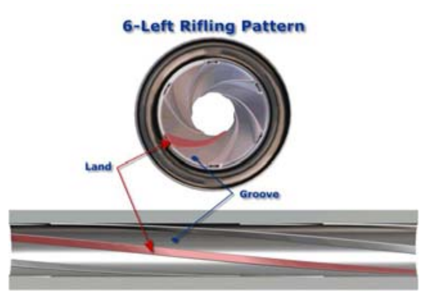


Figure 4.1 *Rifling consists of grooves cut or formed in a spiral nature, lengthwise down the barrel of a firearm (Wilson 2006:3).*

“The barrel of a firearm is manufactured from a solid steel rod that has been hollowed out by drilling” (Saferstein, 2004:432). “The spiral pattern of lands and grooves is machined in the barrel of rifled-barrelled firearms, causing random imperfections which are unique to each individual firearm" (Nichols, 2003:299).

4.5.1 Rifling

During the firing process the marks from the firearm are imparted onto the ammunition components. "As the projectile accelerates down the barrel, the impressions from the lands and grooves, known as rifling, are scraped into the surface of the bullet" (Meyers, 2002:159). Rifling patterns consist of grooves cut or formed in a spiral nature, lengthwise down the barrel of a firearm. "Two types of marks are drawn on the surface of the bullet, class and individual characteristics (Jenkins, 1943:21).

4.5.2 Class characteristics

Jenkins (1943:21) defines these types of characteristics as any intentional or design characteristics that would be common to a particular group or family of items. Pertaining to bullets, the class characteristics are specific to the land width, direction and angle or rate of twist and bullet calibre. "When identifying a fired bullet from a specific firearm both class and individual characteristics are used" (Wilson, 2006:1).

"Class characteristics may be design features chosen by the manufacturer for the firearm and are not specific for a particular firearm, meaning that many models and makes of firearms can have the same class characteristics" (Mathews & Howe, 1999:286). These types of marks are important, but must only be used as a screening tool. If class characteristics are not in agreement between two unknown ammunition components, they can automatically be excluded as having been fired by the same firearm. For example, when one projectile has five lands and grooves and another has six lands and grooves, it can be concluded based on the rifling characteristics that they were fired from two different firearms.

4.5.3 Individual characteristics

According to Saferstein (2004:435), no two rifled barrels, even those manufactured in succession, will have identical striation markings. Thompson (1998:286) notes that the theory of firearm identification permits a qualified firearms examiner to conclude that two features on a surface are of a common origin if there is sufficient agreement between their markings.

Meyers (1993:281) defines the theory of identification as the sufficient agreement of striation marks being determined on the basis of the reproduction of random imperfections from the surface of the firearm into a pattern on the bullet and/or cartridge case. When sufficient agreement is determined, it is concluded that the marks present are of such a quality and quantity that the likelihood of them being produced by different firearms is so remote as to be a practical impossibility.

Respondent B (2007), a scientist at the Centre of Forensic Sciences identifies other factors that contribute to the individuality of firearms markings:

- Erosion by harsh solvents during cleaning.
- Marks generated by tools, such as screwdrivers when disassembling the firearm.
- Wear from usage.
- Corrosion from atmospheric causes, such as rusting.

4.6 MICROSCOPIC EXAMINATION

Meyers (1993:283), describing the comparison of marks and surface contours, states that these are made up of peaks, ridges and furrows with comparable heights, depths, widths and spatial relations. “The firearms examiner uses microscopic comparisons of markings to associate an item of evidence with a particular source” (Meyers, 2002:159).

4.6.1 The comparison microscope

"The most significant contribution to the science of firearms identification was the introduction of the comparison microscope" (Hatcher, Jury & Weller, 2006:15). A side-by-side comparison is done with a comparison microscope to compare the striations on two different bullets. The comparison microscope consists of two microscopes linked by an optical bridge with one binocular eyepiece, which allows the examiner to look at two bullets or cartridges simultaneously. The Leica comparison microscope shown in Fig. 4.2 is connected to a laptop computer for a live view of the images being examined (www.firearmsid.com, accessed 11/27/07).

Figure 4.2 The Leica comparison microscope with a laptop for a live view of the images being examined (www.firearmsid.com assessed 11/27/07)

4.6.2 Microscopic results

Rowe (2000:947) explains that firearm examiners can render one of three opinions following the microscopic comparison of fired bullets and/or cartridges. "When the examination is completed the examiner must form a subjective opinion of identification or elimination based solely on the qualitative features of contours, depth and spacing of striae" (Booker, 1980:162).

- Positive identification

  The questioned firearm fired the questioned bullet. "The class and individual characteristics of the questioned bullet match those of test-fired bullets from the questioned firearm" (Rowe, 2000:947). Fig. 4.3 illustrates a photomicrograph.

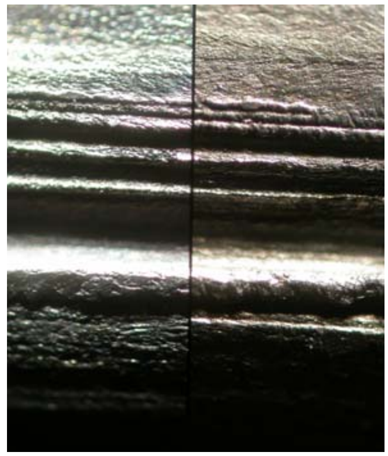


Figure 4.3 Microscopic comparison view (40 x magnification) of striation markings of two bullets fired from the same semi-automatic pistol. The markings correspond to each other (Photo taken by the researcher for this study)

- Elimination/negative identification

  The questioned firearm did not fire the questioned bullet. The class characteristics of the questioned firearm did not match the class characteristics of the questioned bullet. Fig. 4.4 demonstrates a microscopic comparison of land impressions of two bullets fired from different firearm barrels.

Figure 4.4 Microscopic comparison of land impressions of two fired bullets fired from different firearm barrels (Photo taken by the researcher).

- Inconclusive

  Siegal et al. (2000:946) defines inconclusive as follows the questioned bullet can neither be confirmed nor eliminated as having been fired by the questioned firearm. The class characteristics of the questioned bullet and the firearm are both the same but the individual characteristics are insufficient or limited, due to damage.

4.7 ADMISSIBILITY OF EVIDENCE IN A COURT OF LAW

Hatcher et al. (2006:1) explain that science has come to the aid of justice to an astonishing degree. The conviction of criminals in criminal cases by firearms evidence is more frequent and the courts have consistently expressed confidence in the evidentiary value of firearms evidence. In South Africa, "Evidence is essentially seen as oral, written or real material before being received by the court in an appropriate formal way" (De Vos, 2006:10).

4.7.1 General acceptance

It is up to the various forensic witnesses to persuade the court of the significance of the evidence they have examined. Any evidence that is to be presented in a court of law has to be reliable. There are examples of case law in North America that are applied by forensic scientists globally.

"In North America two different but very similar standards governs what scientific evidence is admissible in court. Some use the standard from a 1923 case of Frye v. the United States (1923), which held that the court could accept expert testimony" (Hunter, 2006:31). The following criteria have been adopted globally:

- Sufficiently established
- Generally accepted in the scientific community
- Well-recognised scientific principles.

Since the court ruling in 1923 in the case of Frye v the United States, which involved the acceptance of toolmark evidence, that scientific evidence should be allowed, it gained general acceptance in that particular field. Eckert (1997:9) notes that forensic science can be of little value unless it is properly presented in a court of law.

In 1993 the US Supreme Court, in the case of Daubert & Merrel Dow Pharmaceuticals, (htpp://supct.law.cornelledu/supct/html accessed 10/4/2007) dismissed these general acceptability standards and insisted that Federal rules of evidence should control the admissibility of evidence. The rule states that an expert can give evidence if the scientific community of that discipline regards it as a proper subject for testimony and the witness is shown to be suitably qualified.

Clifford (1998:500) explains that the evidence must be shown to be relevant so that the trial judge can decide on its admissibility. The effect of the Daubert findings was to ultimately set down four criteria for the acceptability of expert evidence, which according to Respondent E (personal interview, November 16, 2007) lists the viewpoint of those Laboratories in South Africa:

- Testability of the scientific principle.
- Known potential error rate.
- Peer review and publications.
- General acceptance in a particular scientific community.

4.7.2 Evaluation of evidence

In South Africa, De Vos (2006:16) explains that an important factor for the admissibility of evidence is the amount of weight that that’s assigned to the evidence being presented. De Vos (2006:16) lists the factors to be taken into account as a whole to weigh evidence:

- Probabilities.
- Reliability of witnesses and the opportunity for observation.
- Absence of interest or bias.
- Merits or demerits of the testimony itself.
- Inconsistency, contradictions.
- Corroboration.
- Other relevant factors.

In the case of S v Maqhina 2001 (1) SACR 241, the court ruled that if the prosecution case relies on the result of the scientific analysis, the examination processes, including the control measures that were applied, must be conducted in such a way that at any time later it could be verified by another scientist.

4.8 SUMMARY

This study revealed that the discipline of forensic science is well grounded in the forensic community. There is much merit, as shown by the number of successful comparisons of evidence, which have been made and verified by other examiners.

When the examiner has reached his conclusion based on the microscopic examination of the bullets, he must form a subjective opinion of the positive identification or elimination based on the qualitative surfaces. Any bullet has the potential to retain individual marks. It is important that the examiner should clean the firearm thoroughly and complete a comprehensive examination to obtain the best chance of producing conclusive results.

CHAPTER 5

FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

The following findings and recommendations were made to address the research questions of this study. The findings that were selected were based on the answers to the initial questions posed in Chapter 1. Based on the available research, interviews, case studies and the researcher's research, it is clear that various factors influence the condition of a bullet. However, timelines could not be established.

5.2 CHAPTER 2

This chapter studied the origin of fired bullets, methods of how crime scenes should be searched, the collection and packaging of evidence, and challenges regarding trace evidence. The purpose of this chapter was to determine the factors that have to be considered in bullet damage.

5.2.1 Findings

The primary findings of Chapter 2 are listed as follows:

- Terminal ballistics causes bullet deformation and damage, which have a direct impact on microscopic comparison. The condition of bullets may vary depending on the type of bullet and the material of the target surface.
- Improper collection of fired bullets from various target materials causes damage to the circumference of the bullet, which will affect the microscopic findings of the examiners.
- Improper packaging of bullets in various containers may cause damage. Differences in degradation occur depending on the type of packaging. The most damage was seen in samples in the regular specimen cup and the plastic zip lock bag. Very little change was observed in bullets

wrapped in paper towel and those placed in envelopes which still had dried blood on them.

- Trace evidence adhering to the bullet obscures striation marks needed for microscopic examinations. Therefore the preservation of trace evidence on fired bullets does not mean that the bullet is being preserved – on the contrary, trace evidence can cause damage to the striation marks needed for microscopic comparison.

5.2.2 Recommendations

A great deal can be done to eliminate or minimise bullet damage by ensuring that bullets are preserved correctly for microscopic examination. It is recommended that:

- Laboratories should educate and advise investigating officers of the risk involved if blood is not removed from the bullet or air-dried.
- Opportunities should be sought to deliver presentations on the proper collection and packaging of fired bullets.
- Bullets found at crime scenes covered in blood should be swabbed, rinsed with water and air-dried. The swab can be used for DNA analysis.
- A standard crime kit should be developed to collect and package bullet evidence.

5.3 CHAPTER 3

This chapter discusses processing timelines when items are submitted to/received by the laboratory, types of examinations performed by the Firearms section and other forensic disciplines. This chapter focused on time and attempted to establish a timeline for bullets exposed to blood, and at what point the blood started to cause damage.

5.3.1 Findings:

The primary findings for Chapter 3 are as follows

- Blood causes damage, and the degree of damage differs depending on whether it is dried blood or liquid blood.
- No benchmark timeline could be established. The study found that timelines vary significantly depending on the type of bullet, the environment and the medium it is exposed to.
- Bullets exposed to blood over the same periods of time produced different microscopic results.
- Laboratory experiments have revealed that minimal damage to striation marks occurs when bullets exposed to blood are air-dried prior to being packaged.

5.3.2 Recommendations

It is recommended that:

- It should be communicated to investigators that blood causes damage to bullets, and they should be educated accordingly.
- Further experimental research should be conducted with various bullet profiles in various conditions exposed to different trace evidence materials to establish timelines for bullet damage.
- The opportunity should be sought to incorporate guidelines for the collection and packaging of firearm evidence (e.g. bullets) into the detective course curriculum of police agencies.

5.4 CHAPTER 4

This chapter focuses on the examination process, the scientific method, firearm identification and its acceptability in a court of law.

5.4.1 Findings

The primary findings are as follows:

- Bullets are cleaned with various chemical solutions depending on the type of bullet, and this may have a degradation effect on bullets.

- Firearms are unique and firearm identification methods are well established globally in the scientific community.
- Firearm identification is subjective in nature, hence the potential for examiners to look at the same evidence and obtain different microscopic results.
- Firearm identification is admissible in a court of law if it meets the following criteria:
  - Testability of the scientific principle.
  - Known potential error rate.
  - Peer review and publications.
  - General acceptance in a particular scientific community.
- Factors that may influence bullet damage in the laboratory:
  - Corrosion – due to backlog (timeline for the examiners to get to the case).
  - Degradation of striation marks due to the exposure to chemical reagents.
  - Attempts by the examiner to bend or reshape the metal of the bullet to expose striation marks.

5.4.2 Recommendations

It is recommended that:

- The examiner should photograph the bullet in its original condition before exposing it to any chemical reagent.
- Further research should be conducted by the forensic science discipline to objectify firearm identification. Objective and quantitative methods should be developed by the firearms community to obtain microscopic findings.
- Strategies should be explored to reduce backlogs at forensic laboratories to ensure that the preservation of evidence is not at risk.
- Examiners should not make premature decisions based on the condition of the fired bullet, as it can be very misleading. Any bullet has the potential to retain individual marks.

5.5 CONCLUSION

In the cause of this dissertation the researcher have explored various factors that influence bullet damage. After a close examination, the study has shown a linkage between the exposure of projectiles to blood and the degradation of the fine detail over time, necessary for microscopic comparisons.

During the investigation of a gun related crime a wide range of factors must be considered, from the time the bullet is fired at a crime scene until the evidence is examined at the laboratory. Despite the many variables that might influence microscopic results this study found based that more than 50% of the microscopic findings resulted in a positive identification.

The Forensic Firearms and Toolmarks discipline relies on scientific methods to perform examinations that are acceptable in the scientific community and admissible in the courts of law. Through continuous research, existing methods can be revised and new methods discovered. This can assist in improving investigation processes to ensure that evidence are preserved correctly and examinations are conducted in a fair and timely fashion.

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