William & Mary Law Review

Volume 25 (1983-1984)
Issue 4

Article 7

May 1984

Capabilities of Modern Forensic Laboratories

Irving C. Stone

CAPABILITIES OF MODERN FORENSIC LABORATORIES

IRVING C. STONE*

I. INTRODUCTION

The sophistication of attorneys, jurors, and jurists is placing increased emphasis on scientific evidence and expert testimony. A modern forensic laboratory, therefore, must include a broad range of scientific disciplines. In the physical evidence section of the laboratory, forensic scientists have become acutely aware of the needs of the criminal justice system. Indeed, courts demand, and juries expect, that physical evidence will be properly collected and analyzed, and that the results will be available for examination at trial by objective forensic scientists. Law enforcement agencies also recognize the value of the forensic laboratory in the investigative and prosecutorial phases. Because forensic science procedures can confirm or deny the association of potential defendants with crime scene evidence, the role of the modern forensic scientist has moved from that of a prosecution or defense advocate to an objective reference source for the judicial system.

The methods by which forensic scientists analyze physical evidence have developed rapidly. Less than thirty years ago, the compound microscope and tedious wet chemical methods were the tools of the forensic laboratory. Today, scientists employ a plethora of analytical instruments—such as the gas chromatograph, mass spectrometers, and sophisticated X-ray apparatus—to resolve forensic problems; the variety of microscopes includes infrared, ultraviolet, polarizing, phase contrast, comparison, and scanning electron microscopes. The sophistication of equipment and diversity of applications has compelled forensic scientists to pursue specialized functions. This Article will review five specialized areas of forensic science:[1] questioned document examination; trace evi-

* Assistant Professor and Director of the Graduate Program in Forensic Sciences, University of Texas Health Science Center; Chief, Physical Evidence Section, Southwestern Institute of Forensic Sciences. B.S. 1952, Iowa State University; M.S. 1961, Ph.D. 1967, George Washington University.

1. The applications of forensic science extend far beyond the five specialized areas re-

dence analysis; firearms and gunshot residue analysis; forensic serology; and arson analysis.

II. Questioned Document Examination

Questioned document examination includes handwriting comparisons, detection of indented or obliterated writing and altered documents or checks, typewriting comparisons, and examination of forged prescriptions.[2] The comparison of handwriting and typewriting, the detection of forgeries and alterations, and similar analytical functions have affected such matters of national prominence as the authenticity of the will of Howard Hughes.[3] More recently, the analysis of inks and paper also has become important.

Pseudoexperts are more prevalent in the field of questioned document examination than in any other forensic science specialty. Most reputable questioned document examiners are associated with the American Academy of Forensic Sciences or the American Society of Questioned Document Examiners. These organizations probably recognize fewer than 500 bona fide questioned document examiners in the United States, and several times that number of pseudoexperts. A discernable difference exists between a graphologist, or "handwriting expert," and a questioned document examiner. The difference in formal training is primarily responsible for the difference in expertise. The United States Army, the Postal Service, the Treasury Department, the FBI Laboratory, and many large forensic laboratories have extensive training programs that teach not only the ability to compare handwriting and printing, but also the ancillary skills required of a questioned document examiner. Unlike the relatively untrained amateur, the questioned document examiner receives experience and training in different

---

viewed in this Article. Other areas of forensic expertise include serial number and motor number restoration, magnetically recorded voice analysis, locksmithing, metallurgy, and drug toxicology. Indeed, the field of drug toxicology alone has generated substantial research and commentary. *See, e.g.*, E. Clarke, Isolation and Identification of Drugs (1969); Handbook of Analytical Toxicology (1969); Modern Legal Medicine, Psychiatry, and Forensic Science (1980).

2. On the analysis of questioned documents, see generally Brunelle, *Questioned Document Examination*, in Forensic Science Handbook 672 (R. Saferstein ed. 1982).

3. *See* Cabanne, *The Clifford Irving Hoax of the Howard Hughes Autobiography*, 20 J. Forensic Sci. 5 (1975).

types of writing implements, the examination and analysis of inks and paper, the unique problems posed by modern copy machines, and the use of special instrumentation.

A device called the electrostatic detection apparatus allows the questioned document examiner to detect and decipher indented writing on pads, notes, or other paper. Infrared and ultraviolet microscopes are used to detect alterations and obliterations. Reflectance spectrophotometry and X-ray diffraction can analyze paper pigments, and the examiner can use special comparison microscopes to view specimens simultaneously. Under certain conditions, various chromatographic analyses of ink are available. Finally, the analysis of charred documents, gambling papers, and fraudulent prescriptions are also within the realm of a questioned document examiner.

III. Trace Evidence Analysis

Trace evidence analysis includes the examination and comparison of paint, fibers, hair, glass, soil, metals, and flammable and explosive residues. Analysts also test building materials, safe insulation, asphalt, plastics, cement, concrete, mortar, and wood for comparison and identification.

In paint identification cases, the forensic scientist follows a logical progression of examinations and analyses.[4] First, the analyst compares the color, layer sequence, and paint type of known and questioned samples. The paint can be analyzed, layer-by-layer in some cases, by infrared spectroscopy and energy-dispersive X-ray. The analysis may include identification of both organic vehicle and pigments. A technique called pyrolysis gas chromatography potentially can distinguish between paints of the same color which might be found, for example, on two automobiles painted in different assembly plants.

Fiber analysis, which uses many of the same techniques as paint analysis, received recent publicity in the Wayne Williams trial.[5] Analysts matched numerous carpet fibers taken from the bodies of several victims with fibers from the rugs and carpets in the home

4. On the analysis of paint, see Thornton, *Forensic Paint Examination*, in Forensic Science Handbook 529 (R. Saferstein ed. 1982).

5. *See* Williams v. State, 251 Ga. 749, 312 S.E.2d 40 (1983).

and automobile of the defendant. Sophisticated analysis of some fibers traced the source to a single carpet supplier. Usually, analysts identify fibers by color, dye, and type. Many new polymer fiber types are developed each year, requiring the forensic scientist to remain abreast of the developments.

The forensic scientist analyzes hair samples through the technique of comparative microscopy.[6] By comparing the surface and internal morphological features of known and questioned hairs under the forensic comparison microscope, the hair examiner often can determine conclusively that a particular person is not the source of a hair. If all microscopic features are the same, however, the examiner can conclude only that the known and questioned hairs might have originated from the same source. Except under the most extraordinary conditions, the examiner cannot determine conclusively that a hair taken from a crime scene belongs to a particular person.

Forensic scientists are developing techniques to determine the sex and ABO blood type of the person from whom a hair came. Because hair is tissue, determination of the Barr bodies can indicate gender.[7] Blood typing is facilitated if tissue is attached to the root end of the hair. Japanese researchers have reported a technique for crushing hair samples to obtain the ABO blood type,[8] but other researchers have had difficulty reproducing the work.[9] The technique, however, is a destructive test, precluding subsequent use of the hair sample for comparison by the defendant's expert.

Canadian, American, and British researchers have investigated neutron activation analysis as a sensitive method for determining the trace metal content of hair.[10] Scientists generally agree, how-

---

6. On the analysis of hair samples, see Stone, *Hair and Its Probative Value as Evidence*, 45 TEX. B.J. 275 (1982). *See also* Bisbing, *The Forensic Identification and Association of Human Hair*, in FORENSIC SCIENCE HANDBOOK 184 (R. Saferstein ed. 1982).

7. In normal females, the sex chromosomes occur as a pair of x-chromosomes; the normal male has only one x-chromosome. These are referred to as Barr bodies.

8. Yada, Okane & Sano, *Blood Grouping of a Single Hair by Means of an Elution Technique*, 32 ACTA CRIM. JAP. 7 (1966).

9. Wynbrandt & Chisum, *Determination of the ABO Blood Group in Hair*, 11 J. FORENSIC SCI. SOC'Y 201 (1971); *see also* METROPOLITAN POLICE FORENSIC SCIENCE LABORATORY, BIOLOGY METHODS MANUAL ch. 9, at 1 (1978).

10. *See* Perkons & Jervis, *Trace Elements in Human Head Hair*, 11 J. FORENSIC SCI. 50 (1966); V.P. Guinn, *New Developments in the Application of Activation Analysis to*

ever, that the variation from hair to hair on one head and the variation due to diet and environment require additional research before neutron activation can be judged valid for positive, unique association of hairs.[11] Other negative considerations include cost, the need for a nuclear reactor, and the destructive nature of the test.

In burglary and automobile hit-and-run cases, investigators frequently seek glass particles. Samples of glass from the broken window at a point of entry, the windshield, or headlamp fragments are collected. The forensic scientist compares the clothing of the suspect or decedent and the glass at the accident scene with the window, windshield, or headlamp lens.[12] By determining a set of three refractive indices for each glass sample,[13] the forensic scientist can detect minute differences in composition. The analyst also determines the density of the glass specimens. Researchers are developing techniques to perform a nondestructive elemental analysis of glass particles found on the suspect and at the crime scene. In one limited research project, laboratory analysts were able to differentiate seventy-five windowpanes removed from four adjacent houses which were slated for destruction.[14]

IV. Firearms and Gunshot Residue Analysis

The firearms examiner today must do far more than just match bullets to guns. Although bullet and cartridge case comparisons with suspect weapons comprise a significant part of the examiner's duties, firearms examiners also must be skilled interpreters of gunshot residues. Residues may be found on tissue, clothing, or other objects. The firearms examiner also must analyze explosive residue and perform toolmark comparisons.

Frequently, bullets removed during autopsies are submitted to

---

Problems of Crime Investigation (7th Japan Conference on Radioisotopes, Tokyo, May 1966).

11. R. Saferstein, Criminalistics: An Introduction to Forensic Science 141 (1977).

12. On the analysis of glass, see Miller, *Forensic Glass Comparisons*, in Forensic Science Handbook 139 (R. Saferstein ed. 1982).

13. The refractive index of a piece of glass is an easily measured physical property which determines the degree to which the glass will refract or alter the direction of the light rays passing through it. *See id.* at 154.

14. Unpublished research of Dr. I.C. Stone (Southwestern Institute of Forensic Sciences).

the firearms unit for identification. From the class characteristics of the bullet—caliber, number of land and groove impressions, and direction of twist imparted to the bullet by the gun barrel—the examiner can suggest weapon types. A computer access system called the Crime Laboratory Information System was designed several years ago to use the computer capabilities and data of the FBI Laboratory. Many large forensic laboratories have on-line access to the system. By entering the class characteristics and the carefully measured land and groove data, the analyst can obtain the list of firearms most likely to have discharged the bullet. Thus, the analyst can report to the law enforcement officer the type of weapon he should be seeking.

The firearms examiner also must understand the mechanical operation of firearms. The examiner spends more time testifying about trigger pull and safety mechanisms than about the match between a bullet and a weapon. Knowledge of firearms operation requires special schooling and training beyond the usual firearms laboratory casework. Companies such as Smith & Wesson, Remington Arms, Ruger, and Colt offer specialized courses in mechanical operation. A well-trained examiner, therefore, can dismantle a firearm and determine if the firearm has been altered or if safety features have been compromised. As the firearms examiner moves into the technical area of mechanical operation, a reference collection of handguns and long guns becomes important. In addition, the firearms examiner's ammunition file must contain a variety of calibers, manufacturers, and ages. Thus, the firearms examiner's education, training, reference collections, and facilities determine his ability to examine firearms properly.

Gunshot residue examinations involve an analysis of a variety of evidence.[15] For example, the firearms examiner performs three steps to detect gunshot residue on clothing: visual examination for evidence of gunpowder and powder soot; chemical tests for presence and distribution of lead, copper, nitrates, and nitrites; and instrumental analysis of clothing by energy-dispersive X-ray for presence and distribution of lead, copper, barium, and antimony.

---

15. On the analysis of gunshot residue, see Stone, *Evidence of Firearms Discharge Residues*, 1981 BAYLOR L. REV. 285. *See also* Krishnan, *Detection of Gunshot Residue: Present Status*, in FORENSIC SCIENCE HANDBOOK 572 (R. Saferstein ed. 1982).

Following this scheme, the examiner can detect residues from the discharge of a firearm and identify whether the firearm was discharged at close, intermediate, or distant range. The examiner uses the weapon and ammunition involved in the shooting incident to obtain test patterns for comparison with the clothing. If an examiner does his work properly, he can determine the range of discharge into the clothing with an error of only a few inches. If a firearm was discharged at a distant range, the examiner can determine the minimum distance of the weapon at the time of discharge. Certainly, the care taken in handling a garment affects whether gunshot residue will be available for examination.

The detection of gunshot residue on hands has evolved dramatically since the paraffin test of the 1930's.[16] By 1963, incorrect positive results had discredited the paraffin test. Researchers attempted various chemical tests and schemes[17] before developing neutron activation analysis to measure antimony and barium in handwipings from persons suspected of discharging a firearm. Because of the limited availability of neutron activation analysis, however, laboratories have turned to flameless atomic absorption spectrophotometry to detect lead, antimony, and barium in handwipings. These three metals are present in the primers of most modern handgun ammunition; one manufacturer of .22 caliber ammunition uses only a lead compound in the primer. Unlike neutron activation analysis, flameless atomic absorption spectrophotometry is affordable for most forensic laboratories.

Some experts have questioned the value of spectrophotometric analysis to detect gunshot residue.[18] The presence of lead, antimony, and barium on the back of the hand is not conclusive proof

16. In the paraffin test, the analyst poured molten paraffin onto the hands of a suspect and allowed the paraffin to solidify into a cast. The analyst removed the cast and tested for the presence of nitrates typically found in gunshot residue. *See* Krishnan, *supra* note 15, at 573.

17. *See, e.g.*, Harrison & Gilroy, *Firearms Discharge Residues*, 4 J. FORENSIC SCI. 184 (1959); Walker, *Bullet Holes and Chemical Residues in Shooting Cases*, 31 J. CRIM. & CRIMINOLOGY 497 (1940).

18. Some forensic laboratories, primarily those associated with law enforcement agencies, do not analyze handwipings for metals characteristic of gunshot residue because explaining to a jury how a weapon can be discharged without leaving detectable residues on the hands is difficult. Further, the presence of lead, antimony, and barium in handwipings does not prove conclusively that a person fired a weapon.

that the person fired a gun; the residues may be due to the hand's proximity to a discharging firearm. Similarly, metallic residues on the palms may be due to a defensive gesture. The presence of gunshot residue on the hands is only temporary; one can remove it readily by washing or vigorous rubbing. Even with normal activity, gunshot residue remains on the hands for less than two hours. Over the last ten years in Dallas, the forensic laboratory has reported positive evidence of gunshot residue metals in about forty percent of all suicides with handguns.[19] In analyzing handwipings from live suspects, fewer than ten percent revealed positive evidence of residue.[20]

The absence of significant levels of gunshot residue metals, therefore, does not mean that the suspect did not fire a weapon; it means only that no residues were found. The presence of elevated levels of metal, however, indicates the presence of gunshot residue and the possibility that the suspect recently discharged a firearm. The presence of residue becomes most important when the firearm is available for test firing to determine whether the firearm leaves residues on the firing hand. Finally, one must realize that gunshot residue analysis is useful only with handguns. Long guns, such as shotguns and rifles, do not leave detectable residues on the firing hand except under unusual circumstances.

Some laboratories analyze gunshot residue with a scanning electron microscope fitted with an energy-dispersive X-ray capability. Investigators use special techniques to lift residues from the backs of hands, and then analysts examine the particles with the scanning electron microscope, and analyze them with the energy-dispersive X-ray. With this equipment, the analyst searches for particles characteristic of primer residues in appearance and composition.

Some agencies and laboratories have used the trace metal detection test to detect gunshot residue. In this test, an investigator sprays the suspect's palms with a chemical that reacts with metallic ions, such as lead, zinc, copper, or iron. An ultraviolet light

19. Unpublished data (Southwestern Institute of Forensic Sciences, Dallas, Tex.). *See generally* Stone, *Myths and Statistics Regarding Gunshot Residues*, FORENSIC SCI. GAZETTE, May 1984, at 3.

20. *See supra* note 19.

causes the metallic species to fluoresce, and the fluorescent color indicates the type of metal. This technique determines whether a person touched, handled, or held a metallic object; it does not determine whether he discharged a firearm. Patterns on the hands are photographed and compared with the suspected object to obtain a signature pattern. The test is not used widely because of the number of variables that affect the results. These variables include the amount of oil on the weapon, the degree of oxidation of the metal, perspiration, and the duration of contact. The most significant disadvantage is that these metal traces remain on the hands for as long as forty-eight hours, thereby increasing the number of potential sources of the metal traces.

V. Forensic Serology

Of all the specialized areas of forensic science, none has evolved more rapidly than the analysis of blood and body fluids.[21] Significant advances have been made in the past few years by applying immunohaematologic techniques from the bloodbank and hospital laboratory to blood and body fluid analysis. By adapting these techniques for the analysis of antigen, enzyme, and protein systems, forensic scientists can analyze wet blood, dried bloodstains, seminal stains, bone, tissue, hair, and various red blood cell antigens.

Each system has a unique frequency of occurrence within the population. In the ABO antigen system, for example, the primary blood types are A, B, O, and AB.[22] Each type occurs within a hereditarily determined frequency distribution; distributions also vary according to race.[23] Using statistical methods, forensic scientists can calculate the relative uniqueness of the blood samples being compared. For example, several years ago in Dallas, police arrested a murder suspect whose clothing contained what appeared

21. On forensic serology, see generally Forensic Science Handbook 267-415 (R. Saferstein ed. 1982); R. Saferstein, *supra* note 11, at 247-78.

22. In addition to the ABO system, the forensic scientist can analyze the Rh and MN systems in wet blood and dried stains. The Rh and MN systems, however, are less stable over time than the ABO system.

23. These frequencies are well known in the United States. *See* American Association of Blood Banks, Probability of Inclusion in Paternity Testing: A Technical Workshop 29-33 (H. Silver ed. 1982).

to be blood stains. Blood obtained from the decedent during an autopsy was analyzed for genetic antigen, enzyme, and protein markers. The decedent possessed several unusual and relatively rare types which analysts also found on the suspect's clothing. Analysts also determined that the blood on the clothing was different from the suspect's group and type, and a forensic serologist testified that the blood on the clothing definitely was not the suspect's.

Because heat, time, and microbial activity can cause deterioration of the serologic species, investigators must collect and deliver specimens to the laboratory quickly and correctly. If investigators do not deliver the evidence for three months, or if the forensic laboratory delays testing for an identical period of time, analysts would be able to identify only eleven of the sixteen antigen, enzyme, and protein systems. After six months, only three of the sixteen would be identifiable.

The same blood analysis techniques are employed in paternity exclusion studies.[24] Analysts draw blood from the mother, child, and alleged father under strict identification procedures. Analysis of more than twenty different red blood cell antigen, enzyme, and protein tests enables the serologist to identify ninety-five percent of the falsely accused fathers. A new technique, isoelectric focusing electrophoresis, increases the exclusion to more than ninety-five percent. Human leukocyte antigen typing conducted in conjunction with red blood cell antigen typing excludes more than ninety-six percent of the falsely accused fathers. Until reliable commercial human leucocyte antigen plates become available, however, only laboratories associated with tissue and organ transplant facilities can perform the typing. Even in the small fraction of cases where exclusion is not possible, a serologist can calculate the probabililty or likelihood of paternity.

The identification and analysis of human seminal fluid has developed along with dried blood stain procedures. Seminal fluid originates primarily in the prostate gland of the human male. One of the primary constituents of seminal fluid is an enzyme called acid phosphatase. Analysts measure the amount of acid phosphatase found in vaginal, anal, and oral specimens obtained from vic-

24. On paternity exclusion analysis, see generally *id.*

tims of sexual assaults. Because the concentration of acid phosphatase in seminal fluid is several hundred times greater than the concentration in other body fluids, such as blood and vaginal fluid, quantitative analysis can eliminate alternative sources of the enzyme. The serologist also may be able to determine an assailant's ABO blood type from the seminal fluid. Eighty percent of the population carry a gene that enables analysts to determine the ABO blood type from body fluids other than blood. Thus, serologists frequently use saliva and seminal fluid as evidence for blood typing. Unlike the sixteen identifiable systems found in a blood sample, however, only four systems are analytically identifiable from saliva and seminal fluid samples.[25]

The presence of spermatozoa, the male reproductive cells, in a female sexual assault victim is evidence of sexual contact. Forensic scientists have studied the persistence of the seminal constituents in vaginal samples.[26] Most forensic scientists believe that the acid phosphatase enzyme level in the vaginal vault returns to normal levels within eighteen hours after intercourse. Spermatozoa, on the other hand, are present in vaginal samples for at least two or three days after intercourse. Consequently, the search for live or motile spermatozoa is an important procedure that must be performed during the examination of a sexual assault victim. By comparing the blood types and other systems of the suspect with specimens taken from the victim, the serologist can determine only that the suspect might have had recent sexual contact with the victim. Although the serologist cannot make a conclusive determination, the evidence of potential contact—or the lack of such evidence—may be probative of the suspect's guilt.

The ability to determine the ABO blood type of fingernails and toenails is a recent development in the capabilities of forensic lab-

---

25. Two of the four systems identifiable in saliva and seminal fluid samples, peptidase-A and glyoxylase I, must be obtained within four hours of the assault. The remaining two systems, ABO and phosphoglucomutase, persist for longer periods.

26. *See, e.g.*, Rutter, Kind & Smalldon, *Estimation of Time Since Intercourse from Acid Phosphatase/UV270 Absorbance Ratios*, 20 J. FORENSIC SCI. SOC'Y 271 (1980); Sensabaugh, *The Quantitative Acid Phosphatase Test. A Statistical Analysis of Endogenous and Postcoital Acid Phosphatase Levels in the Vagina*, 24 J. FORENSIC SCI. 346 (1979); Willott & Allard, *Spermatozoa: Their Persistence After Sexual Intercourse*, 19 FORENSIC SCI. INT'L 135 (1982).

oratories. Using case studies from Michigan, Texas, and Wisconsin, commentators have described how to establish the scientific foundation for uniqueness of each fingernail on the basis of growth striations.[27] In the Michigan case, the Michigan Supreme Court ruled that testimony about the uniqueness of fingernails as a means of identification did not satisfy the requirements of the *Frye* rule.[28] In the Wisconsin case, the trial judge permitted testimony linking a fingernail from a murder scene to the right thumb of the defendant after expert witnesses had laid a foundation for the evidence.[29] The trial judge made the ruling after the prosecution tendered papers from scientific journals and current research results to support the evidence. The expert witnesses indicated that the matching of fingernail growth striations from a crime scene nail to a sample from the defendant was just as accurate as the matching of bullet and cartridge case marks, toolmarks, and fingerprints.

VI. Arson Analysis

The forensic laboratory plays a supporting role in fire investigations, analyzing fire debris for the presence of accelerants, such as gasoline and organic solvents.[30] Many fires are started without chemicals, however, leaving only suspicious burn patterns to support a conclusion of arson. In these cases, the forensic laboratory can do little other than to identify the suspicious patterns.

Because investigators usually take samples at fire scenes only if they suspect arson, not all fires are sampled. The high percentage of positive findings in arson cases, therefore, is not surprising.[31]

---

27. *See* Stone & Wilimovsky, *Evidentiary Basis for Fingernail Striation Association*, 12 J. Police Sci. & Ad. ____ (1984).

28. People v. Wesley, 103 Mich. App. 240, 303 N.W.2d 194 (1981). The court ruled that the expert who testified about the uniqueness of fingernails did not have sufficient experience to verify that fingernail identification was widely accepted or that it provided any degree of certainty of identification. *Id.* at 246-47, 303 N.W.2d at 196. Although the court ruled that the testimony should not have been admitted at trial, it found the error harmless because other evidence of the defendant-appellant's guilt was overwhelming. *Id.* For a discussion of the *Frye* rule, see Moenssens, *Admissibility of Scientific Evidence—An Alternative to the* Frye *Rule*, 25 Wm. & Mary L. Rev. 545 (1984).

29. State v. Shaw, No. 82-Cr-266 (Wis. Cir. Ct. 1982).

30. On the analysis of arson, see Midkiff, *Arson and Explosive Investigation*, in Forensic Science Handbook 222 (R. Saferstein ed. 1982).

31. From 1979 to 1981, the Southwestern Institute of Forensic Sciences received 310 cases of suspicious fires. Investigations in 35% of the cases revealed the presence of possible hy-

Time and sampling methods are important factors in arson cases. In one study, wood, carpet, and soil were treated with gasoline, burned, and analyzed.[32] When the materials were burned for twenty minutes, extinguished, and analyzed, analysts detected no gasoline in samples taken three hours later. When the materials were burned for only five minutes, analysts detected gasoline up to nine hours later in the wood, twenty-four hours later in the carpet, and seven days later in the soil.

The method of sampling the scene is also important. Many household items and construction materials contain man-made materials, such as plastics. To distinguish between a hydrocarbon accelerant and the hydrocarbons normally present in a building, analysts must take control samples.[33] Analysts also must confirm the identification of accelerants by more than one technique whenever possible. By combining multiple techniques with the use of control samples, analysts minimize the occurrence of incorrect positive results.

The techniques most often used in arson analysis are steam distillation, gas chromatography, infrared spectroscopy, energy-dispersive X-ray, and a combined gas chromatography/mass spectrometry technique. A recent case illustrates the combination of techniques, and the advantage of using multiple techniques. A fire began in a closet and burned down a house. An insurance investigator took a debris sample from the point of origin and delivered it to a forensic laboratory for analysis. Ordinarily, an arson analyst also will take a control sample of the same material from a location several feet away from the point of origin.

At the forensic laboratory, the analyst added water to the debris, and heated the mixture for seventy-two hours in a steam distilla-

---

drocarbon accelerants. *See* Stone & Lomonte, *False Positives in Analysis of Fire and Debris*, 34 FIRE & ARSON INVESTIGATOR ____ (1984). A change in analytical procedures apparently will reveal a greater use of accelerants during 1982 to 1983. *Id.*

32. Unpublished research of the Southwestern Institute of Forensic Sciences (Dallas, Tex.).

33. Analysts frequently detect compounds similar to turpentine in wood samples. The compounds are usually indigenous to the wood or are the products of pyrolysis, a chemical decomposition process caused by prolonged or intense heating. By comparing the debris sample to a control sample of the same material taken several feet away from the point of the fire's origin, scientists can detect hydrocarbon compounds that may have served as accelerants, and can exclude naturally occurring hydrocarbons and pyrolysis products.

tion apparatus.[34] The distillation apparatus boiled the sample and trapped the volatile compounds by cooling the vapors rapidly in a special condensation unit. If the investigator had taken a control sample as well, the analyst would repeat the process with the control sample.[35] After obtaining the distillate of volatile compounds, the analyst analyzed the distillate in a gas chromatograph.[36] A gas chromatograph is an analytical tool that separates the volatile organic components, and produces a chart with a number of peaks. Each peak represents a distinct compound. Although the gas chromatograph does not identify the compounds in a mixture, identification is possible if the analyst also tests a series of known liquids or gases. By comparing the peaks and patterns of the known liquids or gases and those of the unknown mixture, the analyst may be able to identify the compounds in the mixture.

The forensic laboratory issued a report to the insurer, stating that the analysis revealed a hydrocarbon similar to diesel fuel or naphtha. On the basis of the report, the insurer denied the claim. The insured's attorney obtained the distillate from the insurance company's analyst and submitted it to another forensic laboratory. The second laboratory's gas chromatography analysis confirmed the presence of at least six hydrocarbon compounds—two in the light naphtha range and four in the less volatile diesel fuel range.

The second laboratory conducted additional analyses, using infrared spectroscopy and energy-dispersive X-ray techniques. Infra-

---

34. Although some forensic laboratories heat samples in the distillation apparatus for 24 to 72 hours, research at the Southwestern Institute of Forensic Sciences indicates that a maximum time of one to two hours is preferable. *See* Stone & Lomonte, *supra* note 31. Any volatile compound used as an accelerant will distill within one or two hours. Heating for longer periods, however, may produce pyrolysis products that will interfere with the analysis and give incorrect positive results. *Id.*

35. The arson analyst treats the control sample and the sample taken from the point of origin identically, and compares the test results for each. By isolating and analyzing compounds not found in the control sample, the analyst can identify the potential accelerant. *See supra* note 33.

36. The analyst could have used alternative techniques to obtain a sample for gas chromatography analysis. After heating the debris to 100° for 45 minutes in a sealed container, the analyst could remove a sample of the vapors in the container and inject the sample into the gas chromatograph. The analyst also could heat the sample while passing helium gas through the container. The helium gas would carry the vapors through an activated charcoal trap which would absorb the vapors. After eluting the activated charcoal with an organic solvent, carbon disulfide, the analyst could inject a portion of the solution into the gas chromatograph.

red spectroscopy helps the analyst identify the structural components of the compounds in the mixture. Gasoline and diesel fuel contain a number of additives, and the infrared spectrometer can provide supporting evidence of their presence. The energy-dispersive X-ray can detect lead, bromine, and other matter commonly found in hydrocarbon fuels. Usually, the combination of gas chromatography, infrared spectroscopy, and energy-dispersive X-ray techniques gives the analyst sufficient data to identify the presence of gasoline or some other volatile organic compound. In this case, however, the infrared and energy-dispersive X-ray analysis revealed an absence of diesel fuel, and suggested that the mixture contained pyrolysis products of the fire and the prolonged heating during the steam distillation process.[37]

To resolve the difference in results, the second laboratory used a combined gas chromatography/mass spectrometry technique. In this technique, the volatile components of the distillate are separated by the gas chromatograph and captured in the mass spectrometer where the molecular weight of each compound is determined. Computer analysis of the data positively identifies the compounds in the distillate.

Analysis of the distillate from the insurance company sample identified two types of hydrocarbons. The more volatile substances contained terpenes characteristically found in wood. The second group of four compounds consisted of long-chain fatty alcohols and fatty acids. These are not accelerants, but are pyrolysis products of naturally occurring wood components, composition shingles, and plastics. Thus, the second laboratory's analysis demonstrated conclusively that no evidence of diesel fuel or naphtha was present. Rather, chemicals in the building materials were partially altered by the first laboratory's test and were mistakenly reported as an accelerant.

VII. Conclusion

Forensic laboratories must modify and improve their capabilities as new techniques are developed. The process of training forensic scientists and adapting physical, chemical, and other analytical

37. *See supra* note 33.

methods to the unique needs of the forensic laboratory is a continuous one. If forensic scientists fail to remain abreast of new developments, they will be distrusted by law enforcement agencies, litigants, judges, and jurors.

The forensic scientist does not serve as an advocate for the plaintiff, prosecution, or defendant; he serves as an advocate for an opinion or conclusion based on objective physical evidence. The occasional failure to base conclusions on the best data available, whether due to a lack of technical expertise or inadequate analytical instrumentation, is distressing. This Article has demonstrated the ability of forensic science laboratories to provide useful, accurate information in a variety of areas. By continuing to develop the capabilities of forensic laboratories, forensic scientists can continue to have a vital role in the judicial process.