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Forensic Science Standards: Where They Come From and How They Are Used

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Abstract *This article provides a brief history of standardization in the forensic sciences, describes the current sources of these standards, and addresses how the standards promulgated by various organizations fit into the quality-assurance program of the forensic-science laboratory. The value of using voluntary consensus standards is described, and a table listing all of the voluntary consensus standards promulgated by ASTM Committee E 30 on Forensic Sciences is provided.*

Keywords Accreditation, certification, quality issues, methods, practices, standards

Introduction

The forensic sciences are comprised of a multitude of organizations; one of the ways these organizations serve the profession is by developing standards. These standards range from aspirational documents like ethical codes to procedural descriptions of how to administer a quality-assurance program, to analytical methods describing how to conduct a particular analysis. All of these are important and most modern forensic practitioners and agencies recognize this fact.

The current paradigm for quality assurance in the forensic sciences is represented in the "Forensic Quality Triangle" shown in Figure 1. While the bottom leg of the triangle is entitled "standardization" in this context, it refers only to the standard methods and practices for handling and analyzing evidence. In reality, both the certification and the accreditation legs require the adoption of standards as well.

Certifying bodies require a standard body of knowledge from which to develop examinations (Forensic Specialties Accreditation Board, 2007). In developing study guides for their examinations, the certifying bodies implicitly standardize the requisite knowledge required for competent practice, and this in turn guides the type of training and education considered a prerequisite for a forensic scientist to become certified. Most certifying bodies have their own codes of ethical practice and, because certification is primarily a gateway to professional development, certifying bodies also promulgate standards for continuing professional education. The American Board of Criminalistics (ABC), for example, now offers double recertification points for workshops that meet their "Course Content Criteria" (ABC, 2004).

Likewise, accreditation is meaningless without standards provided to applicant organizations to communicate what is expected.

Standard methods and practices are an integral part of any quality-assurance system (ISO 17025-2005, 13). Using voluntary consensus standards as the basis for in-house analytical procedures is the best way to satisfy the requirements for validity set forth in ISO 17025. Being capable of referring to peer-reviewed voluntary consensus standards is also a tremendous aid in designing and maintaining an organization's quality assurance manual, as well as in avoiding reliability challenges. Under either the *Frye* or the *Daubert* standard, the court considers general acceptance and peer review. Voluntary consensus standards are heavily peer-reviewed before they even come into existence. In thinking about how to apply standards to an organization's practice, it is useful to classify the standards into one of the four levels of quality assurance documentation (Goult, 1997). A typical QA documentation scheme is shown in Figure 2. In a typical QA manual, Level 1 contains an organization's mission statement, organizational chart, and an outline of the organization's goals and responsibilities to each group of stakeholders. It also describes how distribution of the quality-assurance manual is controlled and how changes are to be made

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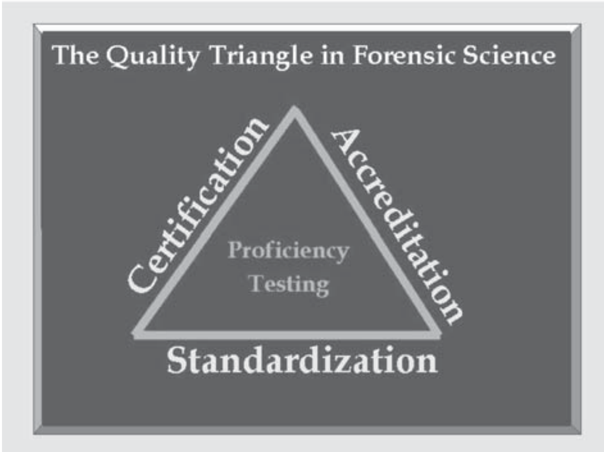

Figure 1. The quality triangle in forensic science.

Level 1 *Philosophies and Policies* Quality Assurance Manual Mission Statement Organizational Chart
Level 2 *Principles and Strategies* Quality Assurance Practices Document Control
Level 3 *Current Practices* Instructions for carrying out specific tasks Description of project file contents
Level 4 *Evidence of Compliance* Forms and records

Figure 2. Typical quality assurance documentation scheme.

and documented in the manual. The quality-assurance manual is itself a Level 1 document. Level 2 documents describe the operation of the quality-assurance program including procedures for soliciting feedback from clients, procedures for responding to complaints, procedures for issuing corrective or preventive actions, and states the frequency with which internal and external audits of a company's or agency's work product will take place. Level 3 documents are the procedures followed in conducting any major activity. The most important requirement for Level 3 documents is that they accurately describe the work of the organization. Level 4 documents are the forms that an agency or company uses to facilitate the collection and preservation of information. These forms are described in the procedures written down in Levels 2 and 3.

Sources of Standards

Professional Associations

One of the first standards that a forensic practitioner is likely to encounter is the *codes of ethics* of professional associations, which scientists and their supervisors join early in their careers. Ethical codes can range from broad statements of purpose to a specific list of desirable and undesirable behaviors. Typically, these standards are incorporated either directly or by reference in an agency's Level 1 quality-assurance documentation. Ethical codes can also be a source of inspiration for Level 2 quality-assurance documentation. Any viable code of ethics not only describes which behaviors constitute ethical conduct and which do not, but it also includes an enforcement mechanism. This mechanism describes procedures for filing ethical complaints and for investigating and resolving them. Each agency needs to adopt a similar mechanism for investigating both ethical and quality issues, and for resolving these issues by the issuance of corrective or preventive actions.

Every professional association is likely to have its own code of ethical practice. Those appropriate to forensic science include national and regional forensic science associations. These ethical codes are typically embedded in the association's bylaws.

The requirements for membership in professional associations may also provide guidance in terms of the education, training, and experience required to competently perform the tasks of a typical association member.

Accreditation and Certification Bodies

The American Society of Crime Laboratory Directors (ASCLD) states that participation in an accreditation program is "important to demonstrate to the public and to users of laboratory services a laboratory's concern for and commitment to quality" (ASCLD, 1994). Further, ASCLD states, "Laboratory managers should support peer certification programs which promote professionalism and provide objective standards that help judge the quality of an employee's work" (ASCLD, 1994). Clearly, the forensic science community and the larger legal community expect forensic science organizations to look to certification and accreditation bodies for guidance.

Certification bodies, at least those that follow the standards set by the Forensic Specialties Accreditation Board (FSAB), will, like many professional associations, specify a minimum level of knowledge, training, and experience required to become certified. These standards are implicit in the application process and in the examination study guides. Further, an FSAB-accredited certifying body is required to have a mechanism for withdrawal of certification from individuals who engage in unethical conduct. Therefore, most certification bodies will also have their own code of ethics.

The standards that can be derived from the bylaws or the policy and procedure manuals of certification bodies may include Level 1, Level 2, and Level 3 documents. In order to pass an examination, it is generally required that candidates be conversant with the generally accepted analytical standards of a discipline. Accreditation bodies, and particularly ASCLD/LAB, are the ultimate source of Level 1 and Level 2 standards for forensic science laboratories. The ASCLD/LAB international program is based on ISO Guide 17025-2005, *General Requirements For The Competence Of Testing And Calibration Laboratories,* and contains additional requirements specific to forensic science laboratories.

Scientific Working Groups

Since the early 1990s, the FBI laboratory and the National Institute of Justice have sponsored technical and scientific working groups. The goal of these groups is to improve discipline practices and to build consensus in the forensic science community (Adams & Lothridge, 2000). Currently active SWGs sponsored by the FBI laboratory include:

SWGDAM—DNA Analysis
SWGDE—Digital Evidence
SWGDOC—Questioned Documents
SWGFAST—Latent Fingerprints
SWGGUN—Firearms and Toolmarks
SWGIBRAC—Illicit Business Records
SWGIT—Imaging Technologies
SWGMAT—Trace Evidence and Materials
SWGSTAIN—Blood Pattern Analysis

Additionally, TWGFEX, a group that includes both a technical working group for site investigations of fires and explosions and a scientific working group dealing specifically with laboratory practices (SWGFEX) exists at the National Center for Forensic Sciences (NCFS) at the University of Central Florida. It is sponsored by the National Institute of Justice, with some supervision by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATFE).

The goal of the SWGs is to issue guidelines for Level 2 quality-assurance practices and Level 3 analytical and evidence-handling procedures. For example, SWGDOC has issued guidelines for the minimum training requirements for forensic document examiners as well as numerous analytical methodologies dealing with specific questions in document examination. Many of the SWGs have subcommittees dealing with terminology, quality assurance, ethics, education, and training.

While there is no question that the work product of the SWGs is a valuable addition to the forensic science literature, there have been some issues raised as to the breadth of practitioners represented in the various groups. Because of the way they operate, there can only be a limited number of members; with federal agencies funding these groups, it could be argued that the membership of the SWGs does not reflect an accurate cross-section of the forensic science community.

To counter these arguments, some of the SWGs have elected to subject their work product to the broader peer review provided by ASTM Committee E30 on Forensic Sciences. There were some obstacles that had to be overcome in order to effect this relationship, the most serious being that the SWGs developed documents at taxpayer expense, then turned them over to an organization that would hold the copyright on these documents and sell them. An award to West Virginia University's Forensic Science Initiative from the National Institute of Justice providing access to all ASTM forensic science standards at no cost to all public forensic science agencies effectively resolved this issue.

To date, SWGMAT, SWGFEX, SWGDOC, and SWGDRUG have all decided that the best way to promulgate widespread adoption of their guidelines is to bring them through the ASTM standards development process. This process ensures a wider acceptance of a new standard because it has been through a peer-based consensus process. The process also ensures consistency of formatting and terminology, and it further ensures that, regardless of the future status of a particular scientific working group, the work product will be captured and maintained as long as it remains relevant to forensic science practice.

ASTM Committee E30 on Forensic Sciences

Among the organizations in the United States formulating standards for forensic sciences, ASTM Committee E30 on Forensic Sciences is alone in meeting the five requirements set forth in OMB Circular 119 (which regulates federal participation in the development and use of voluntary consensus standards) for an organization to be capable of promulgating "voluntary consensus standards."

Table 1. ASTM Committee E30 on Forensic Sciences, Published Standards, by Subcommittee

	Subcommittee E30.01 on Criminalistics
E1386-01	Standard Practice for Separation and Concentration Of Ignitable Liquid Residues by Solvent Extraction
E1387-01	Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography
E1388-05	Standard Practice for Sampling of Headspace Vapors from Fire Debris Samples
E1412-07	Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration With Activated Charcoal
E1413-07	Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration
E1588-08	Standard Guide for Gunshot Residue Analysis by Scanning Electron Microscopy/ Energy Dispersive X-ray Spectrometry
E1610-02(2008)	Standard Guide for Forensic Paint Analysis and Comparison
E1618-06e1	Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry
E1843-96(2003)	Standard Guide for Sexual Assault Investigation, Examination, and Evidence Collection
E1967-98(2003)	Standard Test Method for the Automated Determinaton of Refractive Index of Glass Samples Using the Oil Immersion Method and a Phase Contrast Microscope
E1968-98(2003)	Standard Guide for Microcrystal Testing in the Forensic Analysis of Cocaine
E1969-06	Standard Guide for Microcrystal Testing in the Forensic Analysis of Methamphetamine and Amphetamine
E2057-00	Standard Specifications for Preparation of Laboratory Analysis Requests in Sexual Assault Investigations
E2123-01	Standard Practice for the Transmittal of Evidence in Sexual Assault Investigation
E2124-01	Standard Practice for the Specification for Equipment and Supplies in Sexual Assault Investigations
E2125-07	Standard Guide for Microcrystal Testing in the Forensic Analysis of Phencyclidine and Its Analogues
E2154-01(2008)	Standard Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration with Solid Phase Microextraction (SPME)
E2224-02	Standard Guide for Forensic Analysis of Fibers by Infrared Spectroscopy
E2225-02	Standard Guide for Forensic Examination of Fabrics and Cordage
E2227-02(2008)	Standard Guide for Forensic Examination of Non-Reactive Dyes in Textile Fibers by Thin-Layer Chromatography
E2228-02	Standard Guide for Microscopic Examination of Textile Fibers
E2326-04	Standard Practice for Education and Training of Seized-Drug Analysts
E2327-04	Standard Practice for Quality Assurance of Laboratories Performing Seized-Drug Analysis
E2329-04	Standard Practice for Identification of Seized Drugs
E2330-04	Standard Test Method for Determination of Trace Elements in Glass Samples Using Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
E2451-08	Standard Practice for Preserving Ignitable Liquids and Ignitable Liquid Residue Extracts from Fire Debris Samples
E2548-07	Standard Guide for Sampling Seized Drugs for Qualitative and Quantitative Analysis
	Subcommittee E30.02 on Questioned Documents
E444-07	Standard Guide for Scope of Work of Forensic Document Examiners
E1422-05	Standard Guide for Test Methods for Forensic Writing Ink Comparison
E1658-04	Standard Terminology for Expressing Conclusions of Forensic Document Examiners
E1789-04	Standard Guide for Writing Ink Identification
E2195-02e1	Standard Terminology Relating to the Examination of Questioned Documents
E2285-08	Standard Guide for Examination of Mechanical Checkwriter Impressions
E2286-08	Standard Guide for Examination of Dry Seal Impressions
E2287-03	Standard Guide for Examination of Fracture Patterns and Paper Fiber Impressions on Single-Strike Film Ribbons and Typed Text
E2288-03	Standard Guide for Physical Match of Paper Cuts, Tears, and Perforations in Forensic Document Examinations
E2289-08	Standard Guide for Examination of Rubber Stamp Impressions
E2290-07a	Standard Guide for Examination of Handwritten Items
E2291-03	Standard Guide for Indentation Examinations
E2325-05	Standard Guide for Non-destructive Examination of Paper
E2331-04	Standard Guide for Examination of Altered Documents
E2388-05	Standard Guide for Minimum Training Requirements for Forensic Document Examiners
E2389-05	Standard Guide for Examination of Documents Produced with Liquid Ink Jet Technology

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Table 1. ASTM Committee E30 on Forensic Sciences, Published Standards, by Subcommittee *(Continued)*

E2390-06	Standard Guide for Examination of Documents Produced with Toner Technology
E2494-08	Standard Guide for Examination of Typewritten Items
	Subcommittee E3-0.05 on Engineering
E2292-04	Standard Practice for Investigating Carbon Monoxide Poisoning Incidents
E2332-04	Standard Practice for Investigation and Analysis of Physical Component Failures
E2345-04	Standard Practice for Investigating Electrical Incidents
E2493-07	Standard Guide for the Collection of Non-Volatile Memory Data in Evidentiary Vehicle Electronic Control Units
	Subcommittee E 30.11 on Interdisciplinary Forensic Science Standards
E620-04	Standard Practice for Reporting Opinions of Technical Experts
E678-07	Standard Practice for Evaluation of Scientific or Technical Data
E860-07	Standard Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation
E1020-96(2006)	Standard Practice for Reporting Incidents that May Involve Criminal or Civil Litigation
E1188-05	Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator
E1459-92(2005)	Standard Guide for Physical Evidence Labeling and Related Documentation
E1492-05	Standard Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory
	Subcommittee E 30.92 on Terminology
E1732-96a(2005)	Standard Terminology Relating to Forensic Science

These five requirements are:

1. Openness
2. Balance of interest
3. Due process
4. An appeals process
5. Consensus (OMB, 1998)

Committee E30 was founded in 1970 by members of the American Academy of Forensic Sciences who were concerned that the consumers of their work product were ill equipped to determine whether the information presented was accurate, reliable, or meaningful. They saw standard methodologies as a way to address that problem. In fairly short order, these scientists learned that the forensic science community was not particularly interested in, and even occasionally hostile to, the development of standards.

One group, however, the forensic engineers, was more accustomed to standardization. Frustrated with the Academy members, they formed their own committee, E40 on the Technical Aspects of Product Liability Litigation. This was an active group for about 20 years and a number of standards were developed, primarily related to procedures to follow while conducting an investigation, as well as documenting and reporting investigative findings.

In 1989, responding to a suggestion that E30 be terminated, an organizational meeting was held in conjunction with the American Academy of Forensic Sciences meeting in Las Vegas. It seemed that some of the sentiment against standardization, at least in some fields, had changed. Fire-debris analysis, which, like forensic engineering, served a significant private sector market, became the first forensic science discipline standardized at the bench level.

The first standards were adapted from guidelines promulgated by the International Association of Arson Investigators (IAAI) Forensic Science Committee. Using the fire-debris analysis standards as a template, additional standards provided by the Technical Working Group on Materials Analysis (TWGMAT now SWGMAT) and SWGDOC soon followed. E30 benefited greatly from the issuance of the *Daubert* decision in 1993, and the resulting (largely unfounded) fear that courts would begin excluding scientific evidence in criminal cases (Moenssens & Strip, 1999; Risinger, 2000). From a membership of less than 40 in 1989, ASTM E30 has grown to a membership of over 600 forensic scientists today. Originally founded with a committee structure to reflect the ten sections of the American Academy of forensic sciences, E30 now has active subcommittees in criminalistics (E30.01), questioned documents (E30.02), digital evidence (E30.12), and standards dealing with interdisciplinary forensic science issues (E30.11). The scope of E30.11 covers such issues as documenting the chain of custody, evidence labeling, preventing spoliation, and the components necessary in an incident report and opinion report.

E30 follows the ASTM methodology for standards development. A standard begins its life when someone recognizes the need for a standard and forms a "task group." A task group can be a group of individuals appointed by a subcommittee chairman, or as happens more often, a

SWG performs the function of a task group. A member of the task group prepares a first draft, and the entire group gets the draft ready for a subcommittee ballot. On the ballot, subcommittee members may vote affirmative, negative, or abstain. Negative votes must be accompanied by a reason for the negative and a description of what changes need to be made to satisfy the concerns of the negative voter.

At the next meeting, or in an online meeting, the subcommittee considers the negative votes and either finds them persuasive, in which case the document goes back to the task group for revision, or finds the negative non-persuasive by a two-thirds majority, at which point the standard progresses to a main committee ballot, sent to all voting members of E30. The same rules obtain at the main committee level. A single negative vote can stop the progress of the standard in its tracks. Until that negative vote is either withdrawn or found non-persuasive by a two-thirds majority, the standard cannot move forward.

This is not simple democracy. When finding a vote not persuasive, it is incumbent upon the subcommittee to articulate a valid reason for doing so. This rationale must be acceptable to the governing body of ASTM, the Committee on Standards (COS). The ASTM standards development system ensures that the output of the system is truly a consensus document. Consensus is defined as,

> General agreement, but not necessarily unanimity, and includes a process for attempting to resolve objections by interested parties, as long as all comments have been fairly considered, each objector is advised of the disposition of his or her objections and the reasons why, and the consensus body members are given an opportunity to change their votes after reviewing the comments (OMB, 1998)

It is the rigorous application of the standards development system that allows ASTM standards to be recognized as truly international standards. One important attribute of ASTM standards is that they meet the criteria set forth in ISO 17025 that allow their adoption by reference in a forensic science laboratory's procedure manual. That standard states:

> International, regional or national standards or other recognized specifications that contain sufficient and concise information on how to perform the tests and/or calibrations do not need to be supplemented or rewritten as internal procedures if these standards are written in a way that they can be used as published by the operating staff in a laboratory. It may be necessary to provide additional documentation for optional steps in the method or additional details. (ISO 17025-2005)

ASTM standards are required to be re-approved or revised on a five-year schedule. Standards that fail to be re-approved become "historical standards" and cease to have any force.

ASTM standards only have "force" to the extent that an organization chooses to adopt them. Following the provisions of a standard, test method is only required when the test method is cited as the basis for an analysis. As is stated in ISO 17025, deviation from a standard test method is permissible, as long as it is technically justified and documented (ISO 17025-2005).

Despite some growing pains, and the continued resistance of some in the forensic science community to the idea of standard protocols, the success and utility of ASTM E30 standards was recognized in 1999 by the Justice Department in its publication *Forensic Sciences: Review of Status and Needs.* Addressing the discipline of fire debris analysis, the document states,

> Fire Debris analysis is a subdiscipline of trace analysis that is in good standing because there is sufficient published work on the analysis and interpretation of the material involved. Standard guides for the examination and interpretation of chemical residues in fire debris have been published through the consensus process of ASTM Committee E–30 on Forensic Science. Research in recent years has been directed toward the improved capture and detection of compounds that can be used as fire accelerants. Significant work also has been devoted to the differentiation of pyrolysis products from ignitable liquid residues. These standardization documents are often quoted in the scientific literature, helping to meet the requirements of the legal community (NIJ, 1999).

As of today, E30 maintains more than fifty published forensic science standards in Volume 14.02, and ten or more are currently in the development process. A list of the current standards is provided in Table 1.

Standards may be purchased individually and made available for immediate viewing if purchased online. It is much more cost effective, however, to obtain the entire volume in which Committee E30′s standards are published, Volume 14.02. A "free" volume of standards is available to anyone who joins ASTM and pays the administrative fee of $75 (US) per year; the cost of Volume 14.02 is otherwise more than three times that amount. It makes sense for each laboratory to have a member, not only for the purpose of obtaining standards at a substantial discount but also to ensure that the agency has the ability to influence the future course of standards development, or at least to be aware of new standards in the process of development. Most public forensic science laboratories in the United States have at least one member participating in the ASTM process. Meetings of Committee E30 are held annually in conjunction with the AAFS meeting.

Why Standards Are Important

Historically, forensic scientists resisted the idea of standardization of methods and practices because "every case is different," or "samples are too small and not homogeneous." While these two statements are true, there are certain underlying principles that apply to all cases and all forms of physical evidence.

Forensic science stakeholders need to be assured that the profession is following standard methodology, so that the stakeholders have a way of judging whether the forensic science results are accurate, reliable, or meaningful in the context of the case they are dealing with. The profession's stakeholders, in fact, have demanded that forensic science analyses be conducted in accredited facilities by certified individuals following standard methodologies (ABA, 2004).

An expert witness may testify that laboratory analysis of a white powder determined it to be methamphetamine. The witness may provide a list of scientific analyses that were done to make that determination. Yet the lawyers, judges, and jurors are still not able to determine for themselves whether those tests are adequate to prove the identity of the substance. Even another scientist, reviewing the amount of information provided in a typical laboratory report, may not be able to evaluate the conclusion because the procedures followed are not listed in the report. On the other hand, if the analyst followed a standardized procedure, the work could be evaluated by another scientist familiar with the procedure followed.

Standard practices, specifications, and test methods make it possible for business to be conducted in a workmanlike manner with all participants having confidence in the validity and reliability of the measurements and analyses involved. In this regard, forensic science should follow the example set by the rest of the business and scientific world. This is a duty that we owe to ourselves and to our stakeholders.

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