Standard Guide to Forensic Engineering[1]

This standard is issued under the fixed designation E2713; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides an introductory reference to the professional practice of forensic engineering, and discusses the typical roles and qualifications of practitioners.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2493 Guide for the Collection of Non-Volatile Memory Data in Evidentiary Vehicle Electronic Control Units

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *expert, n*—an individual with specialized knowledge, skills, and abilities acquired through appropriate education, training, and experience.

3.1.2 *forensic engineering, n*—the application of the art and science of engineering in matters which are, or may possibly relate to, the jurisprudence system, inclusive of alternative dispute resolution.

National Academy of Forensic Engineers[3]

4. Significance and Use

4.1 This guide is intended as a foundation for other E58 Committee standards that are focused on specific technical disciplines, for example Guide E2493.

4.2 The emphasis of this guide is on the practice of forensic engineering in the United States, though elements of practice in other countries may be similar. Commercial use of the terms "engineer" and "engineering" are regulated by state and federal law; this document uses these terms only to describe a technical discipline, and not to confer title or status. Courts may decide that individuals with qualifications other than those described herein can testify as experts in forensic engineering.

4.3 Certain forensic engineering investigations of incidents and claims may be related to the behavior or condition of one or more physical systems, or the manner in which they were used. These investigations may also be related to compliance inspections, subrogation, litigation, and other activities. It is important to note that some incidents may be considered *alleged*, particularly when objective proof of their occurrence is not apparent.

4.4 Suggested additional readings are listed in Appendix X1.

CHARACTERISTICS OF FORENSIC ENGINEERING PRACTICE

5. Individual Characteristics

5.1 *Typical Qualifications:*

5.1.1 *The equivalent of a Bachelor degree or Bachelor of Science degree, or graduate degree, in engineering, from an appropriately accredited college or university program.* Degrees obtained from accredited engineering programs typically include education in the areas of advanced mathematics, the theoretical and practical study of physical sciences, the design of physical systems, and logical reasoning. Note that forensic engineering itself is not a separate discipline of engineering—it is an application of engineering, as defined above.

5.1.2 *State licensure as a Professional Engineer (PE) in one or more disciplines of engineering.* It is noted, however, that there are many disciplines of engineering (for example, biomedical, ceramic) for which PE licensure is not offered. Licensure is available for the engineering disciplines that most commonly pertain to public works (chemical, civil, electrical, mechanical, etc.), though each state may vary the disciplines offered for licensure. Some states require PE licensure as a precondition for practicing certain aspects of forensic engineering. Current requirements for attaining a PE license typically include the following elements; these requirements also vary by state:

5.1.2.1 An engineering degree as described above, or equivalency recognized by the state licensing board. State licensing boards may also require post-graduate coursework.

5.1.2.2 At least four years of professional experience in engineering. Depending upon the state, experience credit may be given for earning a masters degree or doctorate; conversely,

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[1] This guide is under the jurisdiction of ASTM Committee E58 on Forensic Engineering and is the direct responsibility of Subcommittee E58.01 on General Practice.

Current edition approved Nov. 15, 2011. Published December 2011. DOI: 10.1520/E2713-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from National Academy of Forensic Engineers (NAFE), 174 Brady Avenue, Hawthorne, NY 10532, http://www.nafe.org.

additional experience may be required for those with educational credentials outside those previously discussed.

5.1.2.3 Successfully passing two nationally standardized eight-hour examinations on the fundamentals, principles, and practices of engineering.

5.1.3 *Possible professional certification in one or more fields of technical knowledge.* Such certifications typically follow advanced study or experience in the field, or both. A certification board may require some or all of the following elements:

5.1.3.1 Discipline-specific evidence of professional competence.

5.1.3.2 Professional references.

5.1.3.3 Examination(s).

5.1.3.4 Evidence of periodic continuing education.

5.1.4 *Participation in engineering professional societies in the engineer's area of practice and interest.* Membership grades (such as associate, member, senior member, fellow) may vary depending upon years of practice and other elements.

5.1.5 *Significant experience in one or more technical fields.*

5.2 *Elements of the Practice of Forensic Engineering:*

5.2.1 The preliminary scope of an investigation is agreed upon by the engineer and court or client, and the scope may evolve as the investigation progresses. Legal issues may significantly affect the investigative scope. Regardless, engineers are not advocates for any particular party or outcome in a claim or legal action. The guiding principle is to use the knowledge imparted by their education, training and experience to conduct an investigation that results in considered, reasonable, defensible, and logically based opinions on the specifics of the incident.

5.2.2 Contingency fee-based investigations are unethical, as outcome-based compensation may affect the reliability of the engineer's opinions.

5.2.3 Engineers should stay within their area of expertise. It is important to note, however, that an experienced engineer typically has a broad area of expertise, based on the logical focus of engineering education and based on the commonalities that are inherent in the properties and behaviors of physical systems.

5.2.4 The engineer's education, training, and experience are notably applied in the determination of appropriate tasks and research to be performed in an incident investigation. Distinct from hypothetical "events" that may warrant new scientific inquiry, these incidents have typically already occurred, and engineers rely on known engineering principles when determining necessary and expected levels of investigative breadth and rigor. Standardized methods and procedures should be used when appropriate for the investigation.

5.2.4.1 *Breadth*—Knowledge of engineering principles forms the basis for effectively determining key issues to be analyzed and methods for analysis—in the context of the investigative scope of the case. Physical systems may have different elements that could be analyzed in a particular investigation; experience would show that analysis of many of these elements would provide information not relevant to the investigation. This is revealed in the prescriptive standardized analysis procedures of certain scientific and technical disciplines, which attempt to focus on relevant elements of predictably-behaving systems, and to analyze them in a consistent manner. When appropriate standardized procedures do not exist, engineers rely on their education, training, and experience to craft an investigative plan, sometimes under unique, transitory, or potentially adverse incident site conditions that may preclude testing and peer review

5.2.4.2 *Rigor*—Engineering requires a certain level of rigor for any analysis method in use. For complex physical systems, advanced and meticulous analysis methods may be appropriate—but likely only for analyzing certain portions of the system; other portions may be comparatively simple to analyze. Selection of appropriate levels of rigor should take into account the standards to which the system was held preceding the incident, the standards of care that may exist for conducting such investigations, and the robustness of support (for opinions) that such rigor will provide.

5.2.4.3 *Comment*—Each forensic engineering investigation is unique and may evolve in direction and complexity. In this scenario, the engineer may decide to pursue a course of analysis that is tangential to his or her existing experience—generally, this is how experience is gained. Engineering training (in critical thinking, logic, reason, and physics) provides the foundation for conducting both the straightforward and the tangential analyses with a reliance on established engineering principles; the same training informs the decision to initiate further research or to seek the advice of peers.

5.2.5 Forensic engineering investigations may involve items of evidence. Inspections of this evidence should be done in a manner that minimizes the alteration or destruction, or both, of such evidence and the information it contains, and that also takes into consideration the interests of other involved parties in conducting their own inspections. Various penalties may be incurred for evidence spoliation. Standardized procedures for conducting inspections should be used, when appropriate.

6. Forensic Engineering Practice in the Community

6.1 *Engineers in General:*

6.1.1 Engineers have a unique role within society, as they are largely responsible for most tangible, functional human-made or processed components within the society. For example, creators of roadways, bridges, and buildings rely on engineers, as do product manufacturers, public utilities, food producers, and the healthcare industry. Certain engineering professional societies have Codes of Ethics, which outline the general expectations of the profession.

6.2 *State-Licensed Professional Engineers:*

6.2.1 Professional Engineers are statutorily required to prioritize public health, safety, and welfare above all other professional considerations. As such, supervision by a PE (for relevant disciplines) is typically required for the engineering design, construction, and modification of public works projects; the primary exemptions are for engineers employed by a manufacturer or by the government. Specific exemptions vary state-to-state.

6.2.2 Each state has specific and detailed laws and rules regarding responsible supervision and approvals of project work, conflicts of interest, and other elements of PE conduct.

The PE may be subject to penalties for misconduct, gross negligence, incompetence, and related infractions of these laws and rules.

6.3 *Forensic Engineering Practitioners:*

6.3.1 These engineers are relied upon to provide objective technical information and opinions to courts, individuals, estates, businesses, attorneys, and other entities. These entities in turn may make financial, legal, and business decisions based largely on the opinions of the engineer.

7. Forensic Engineering in the Legal System

7.1 *Background and Legal Precedents:*

7.1.1 Forensic engineering may play a role in the disposition of court cases, alternative dispute resolution, and other litigation. The activities and conditions under which an engineer becomes an accepted expert by the court are dependent upon evolving legal issues, a discussion of which is beyond the scope of this introductory document. However, the following documents and court decisions are among those discussed in certain cases involving forensic engineering. Different jurisdictions recognize different rules and court decisions.

Documents and Court Decisions

Frye v. United States, 293 F. 1013 (1923)
Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993)
General Electric Company v. Joiner, 118 S. Ct. 512 (1997)
Kumho Tire Company, Ltd., v. Carmichael, 119 S. Ct. 1167 (1999)

7.2 *Communication of Engineering Insight:*

7.2.1 Assisting the engineer's client:

7.2.1.1 The engineer's first objective is to clearly explain the technical factors of the incident to the client. As the investigation progresses, the engineer should keep the client informed of findings.

7.2.2 Assisting the court, jury, or other triers of fact:

7.2.2.1 Physical systems and their behaviors are complex. Engineering analysis may facilitate simplified representations of the properties and behaviors of physical systems, so that they may be better understood. The testifying engineer's goal is to explain the broader concepts and the details of a particular system or behavior, in a way that may allow the triers of fact to adequately understand the essentials of the physical system. Further, the engineer's goal is to clearly describe the investigative and analytical methods that were used, the reasons those methods were selected, and the basis for his or her opinions, within the investigative scope of the case.

8. Keywords

8.1 expert; forensic engineering; professional engineer; testimony

APPENDIX

(Nonmandatory Information)

X1. SUGGESTED ADDITIONAL READINGS

X1.1 United States Government Documents

X1.1.1 *Federal Rules of Civil Procedure:*

X1.1.1.1 Rule 26—Duty to Disclose: General Provisions Governing Discovery.

X1.1.2 *Federal Rules of Evidence:*

X1.1.2.1 Rule 702—Testimony by Experts.

X1.1.2.2 Rule 703—Basis of Opinion Testimony by Experts.

X1.1.2.3 Rule 705—Disclosure of Facts or Data Underlying Expert Opinions.

X1.1.3 *Reference Manual on Scientific Evidence, Federal Judicial Center.*

X1.2 Publications

X1.2.1 *National Academy of Forensic Engineers:*[3]

X1.2.1.1 "NAFE and Kumho: Amicus Curiae brief of NAFE, Decision of the US Supreme Court, Update following decision," NAFE, January 2001.

X1.2.1.2 "Guidelines for the P.E. as a Forensic Engineer: The Engineer as an Expert Witness," NAFE, January 2001.

X1.2.1.3 Dixon, E.J., "The NSPE Code of Ethics Applied to Forensic Engineering," *Journal of the National Academy of Forensic Engineers*, Vol 9, No. 1, June 1992.

X1.2.1.4 "Contingent Fee Practice of Forensic Engineering is Unethical," NAFE, January 2005.

X1.2.1.5 "NAFE Policy on Accident Reconstruction," NAFE, July 2000.

X1.2.1.6 Liptai, L.L, and Cecil, J.S., "Forensic Engineering and the Scientific Method," *Journal of the National Academy of Forensic Engineers*, Vol 26, No. 1, June 2009, pp. 147–156.

X1.2.1.7 "NSPE-NAFE Joint Position on Forensic Engineering," NAFE, 2006.

X1.2.2 *American Academy of Forensic Sciences:*[4]

X1.2.2.1 *Journal of Forensic Sciences*—various articles.

X1.2.3 *ASTM International:*[5]

X1.2.3.1 Bassett, A., "Forensic engineering: making the case for a new main committee," *Standardization News*, January–February 2009.

X1.2.3.2 Lentini, J., "Standards impact the forensic sciences," *Standardization News*, February 2001.

X1.2.4 *Miscellaneous:*

[4] Available from American Academy of Forensic Sciences (AAFS), Journal of Forensic Sciences, 6700 Woodlands Parkway, Suite 230-308, The Woodlands, TX 77381, http://www.aafs.org.

[5] Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428, http://www.astm.org.

X1.2.4.1 "Recommended Practices for Design Professionals Engaged as Experts in the Resolution of Construction Industry Disputes," ASFE Inc.[6]

X1.2.4.2 Donohue, J.J, and Ballod, C.E., "Using an expert witness as a landmine: analysis of Pineda v. Ford Motor Company," *Litigation News*, American Bar Association.[7]

X1.2.4.3 "Code of Ethics," American Society of Mechanical Engineers.[8]

X1.2.4.4 "Code of Ethics," National Society of Professional Engineers.[9]

X1.2.4.5 "Criteria for Accrediting Engineering Programs," ABET Inc.[10]

X1.2.4.6 "About NCEES," National Council of Examiners for Engineering and Surveying.[11]

X1.2.4.7 Lewis, G.L., ed., *Guidelines for Forensic Engineering Practice*, American Society of Civil Engineers, Reston, VA, 2003.

X1.3 Standards

X1.3.1 *ASTM Standards:*[2]

X1.3.1.1 E620 Standard Practice for Reporting Opinions of Scientific or Technical Experts

X1.3.1.2 E678 Standard Practice for Evaluation of Scientific or Technical Data

X1.3.1.3 E860 Standard Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation

X1.3.1.4 E1020 Standard Practice for Reporting Incidents that May Involve Criminal or Civil Litigation

X1.3.1.5 E1188 Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator

X1.3.1.6 E2332 Standard Practice for Investigation and Analysis of Physical Component Failures

X1.3.2 *NFPA Standards:*[12]

X1.3.2.1 NFPA 921 Guide for Fire and Explosion Investigations

X1.3.2.2 NFPA 1033 Standard for Professional Qualifications for Fire Investigator

[6] Available from The Geoprofessional Business Association (ASFE), 8811 Colesville Rd., Suite G106, Silver Spring, MD 20910, http://www.asfe.org.

[7] Available from American Bar Association (ABA), Chicago Headquarters, 321 North Clark Street, Chicago, IL 60654, http://www.americanbar.org/aba.html.

[8] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[9] Available from National Society of Professional Engineers (NSPE), NSPE Headquarters, 1420 King St., Alexandria, VA 22314, http://www.nspe.org.

[10] Available from ABET, 111 Market Pl., Suite 1050, Baltimore, MD 21202, http://www.abet.org.

[11] Available from National Council of Examiners for Engineering and Surveying (NCEES), 280 Seneca Creek Road, Seneca, SC 29678, http://www.ncees.org/About_NCEES.php.

[12] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.