Forensics by Any Other Name

By Caoimhin P. Connell, CIH

For many, the word "forensics" conjures images of a coroner performing autopsies, dead-of-night investigators peering through microscopes looking for subtle differences in the striations of a bullet, or a disheveled detective producing the murder weapon, a pistol, which he "carefully" holds by a pencil inserted into the barrel.

The "CSI effect" directly influences our ability to meet expectations. During a recent investigation, a homeowner suggested that I collect a sample of various items for DNA analysis. She wanted to prove that her estranged husband and a second unknown individual had been in several rooms in the house. The problem was that her husband used to live in the house and his DNA would have legitimately been everywhere. We had no identity for the supposed second person and no legal authority to obtain DNA from all unknown persons in the U.S.

The homeowner, a CSI aficionado, believed that a DNA sample is simply inserted into one end of an instrument and the person's identity pops out the other end. In truth, the collection of the desired samples would have been of little probative value in answering her questions. But because her point of reference was based on the TV program "CSI," her expectations exceeded good scientific process and actual technical prowess.

Unreasonable expectations are similarly seen in professional circles. As a law enforcement officer, I was part of a team that investigated the death of an infant who had been living in a clandestine drug lab. I was able to show that a reasonable person could conclude that exposures to a variety of illegal drugs and hazardous chemicals in the drug lab would have contributed to the child's death.

However, science, good industrial hygiene exposure modeling and fundamentals of toxicology notwithstanding, a prosecutor thought the idea was "exotic" and declined to pursue the matter. In the prosecutor's mind, the application of science should necessarily mean there is no doubt left in a conclusion—just like in television. Science, however, is a process, not an end, and a good scientist will characterize the uncertainty and error associated with his/her work.

The Real Side of Forensics

"Forensics" to those of us in the real law enforcement field merely implies that the work is prepared for courtroom presentation and subsequent evaluation by the "trier of fact." Forensic investigations are usually less glamorous than imagined and a far cry from the antics of the CSI investigators who would be sued in civil courts, criminally prosecuted for civil rights violations and probably imprisoned if they conducted their dramatic TV investigations in real life. For the private consultant, forensic investigations are more likely to be associated with civil proceedings than criminal.

In my case, I am fortunate to wear two hats, one as a police officer and one as a forensic industrial hygienist consulting in the private sector. However, in both arenas, my ability to present data depends on 1) asking a pertinent question; 2) defining data quality objectives (DQOs) that will speak to the question; and 3) defending the data. These presentations become "evidence," and evidence falls into a variety of classifications ultimately defined along lines of confidence and error.

Types of Evidence

In most of my criminal proceedings, the evidence I present is known as "inference evidence," a type of "substitutional" evidence, wherein legal precedence and resolved legal questions are presumed or substituted for direct evidence. I also present "direct evidence" and "real evidence" and provide that information during factual "testimony evidence" wherein I answer questions related to material fact. Seldom during criminal proceedings will I be asked to express expert opinion or provide "demonstrative evidence" although I may give lay opinion based on my personal experiences. During these criminal presentations, the process may actually be more important than the content.

However, as a consulting forensic industrial hygienist, I will use available real evidence to prepare expert opinion and demonstrative evidence. The underlying rationale of those opinions and conclusions must be based on sound science and tenable data. Samples and analysis presented under CSI expectations that lab results and technologically advanced tests somehow equal truth will be quickly shot down in the legal battle that follows.

The inherent probative value of data lies not in laboratory reports but within the development of DQOs upon which those samples and analysis should be based. Without DQOs, one does not have data—one has numbers. And those numbers, in the absence of DQOs, may be the rope by which the sampler will be hanged.

Individuals who collect samples and think the value of the sample comes from the laboratory analysis will likely suffer defeat. For example, in one case, my investigators collected the clothing of a person who worked around a variety of mineral compounds and submitted the clothing to a respectable laboratory that specialized in SEM/EDX analysis. The investigators asked the lab to analyze the white powder on the clothing. The lab did a splendid job, and gave the investigators exactly what they asked for—an elemental analysis of the powder(s).

I received the lab report for inclusion in my evaluation. Unfortunately, the investigators asked the wrong question, and the lab report could not support the pertinent question. The elemental composition was not an issue. I had asked, "Is the white powder trona?" The elemental analysis was inconclusive for trona since the resulting elemental composition could have equally applied to various minerals, including trona. The resulting data were useless even though the lab did a great job.

Unquestionably, the most abused data I encounter occurs when I am asked to be a rebuttal witness in cases involving indoor molds and fungi. I am usually able to impugn an opponent's report within minutes based exclusively on his/her sampling data. Almost all indoor sampling performed by home inspectors and so-called "certified mold inspectors" for mold are useless and meaningless. The samples have almost always been collected by poorly trained (or untrained) indi-

viduals whose microbial expertise was gained in a 2-day class taught by a former roofing contractor.

Samples collected by these de novo experts have been collected in the absence of DQOs. Without DQOs, there is no foundation for the data; there is no information about confidence accuracy or precision; and the data are almost always untenable and cannot withstand the rigors of scientific challenge. To date, I have never encountered air sampling or bulk sampling of molds performed by "certified" mold inspectors or home inspectors during building assessments for molds that were meaningful. However, in every case, the inspector grossly misinterpreted such sampling and analysis.

Frequently, mold inspectors attempt to argue that sampling for molds is new and that there are no standards or guidelines or acceptable protocols. This is simply not true, and none of the sampling parameters surrounding molds are new. The tenants of good sampling and sampling theory are generally independent of the analyte and apply to sampling for everything from bone dust to benzene and include sampling for molds. The tenants of good sampling practices and sampling theory have existed for decades. I recently addressed the ASTM International D22 Standards Committee and used publications from 1955, 1974 and 1977 to remind my colleagues that there is nothing new about sampling theory as it applies to molds.

In *Frye v. U.S.* (1923), the courts pondered the reliability of evidential force and science and recognized that while the courts will exercise great latitude in admitting expert testimony deduced from a well-reasoned scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs. Deviations from established acceptability are not well tolerated.

Focusing on evidentiary relevance and reliability requires an assessment of whether the reasoning and/or methodology underlying the testimony is scientifically valid and whether that reasoning and/or methodology can reasonably be applied to the question asked. The courts emphasize that the focus is on the principles and methodology and not on the conclusions of scientific evidence. In making this determination, among other things, the trier of fact (usually the judge) will consider:

1) whether the scientific theory or technique can be and has been tested;

2) whether it has been subject to publication and/or peer review;

3) the known or potential rate of error;

4) the existence and maintenance of standards controlling the technique's operation;

5) general acceptance in the scientific community.

When industrial hygienists perform standard sampling for chemical exposures, they typically use validated methodologies, and the sampling and analysis errors have been characterized. The DQOs have already been inherently employed by the occupational standard they are attempting to meet and the method they are using.

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When IHs report their data, they typically report those data along with statements of uncertainties, errors and confidence. Those data, presented in that manner, are tenable, however uncertain or imprecise, since the uncertainties are stated up front. Such a report will be easily defended since there is not much to attack. However, if an IH fails to present the uncertainties and does not recognize those uncertainties when making decisions, s/he is open to valid criticism.

Reference material relied upon to establish scientific acceptability or protocol can be its own pitfall. All too frequently, I see forensic investigators wantonly cite articles from seemingly respectable journals and, without foundation, presume that the information in the "study" is somehow unassailable.

In many cases, the investigator has not actually read the study to determine firsthand how the cited information is limited (since it is always limited) and/or flawed. Often, the article is fatally flawed in that the premise upon which the study or article is based is false or a foundational confounder was overlooked. If the investigator has not read the study or lacks the technical expertise to analyze the study and answer critical questions concerning the confidence of the article and study, reliance on the reference will undermine his/her entire credibility in court.

Positive Aspects of the CSI Effect

The CSI effect does not necessarily always work against us. If I am conducting a forensic interview or forensic interrogation, the misinformation a subject may have about my scientific ability to detect his/her deception will work in my favor. For example, if I walk into an interrogation and drop a heavy folder with a thud on the table and the thick folder is marked "Forensic Laboratory Reports," the innocent person will express a sigh of relief; s/he is confident that the folder contains proof of his/her exculpatory state. The deceptive person, on the other hand, knows that the folder contains the proof of his/her guilt, and the person must become even more deceptive to circumvent detection.

In reality, the folder may or may not contain the proof perceived. It may contain a complete inventory of stationery held by the police department for the last 10 years and other irrelevant information hastily assembled before entering the room. However, the more convinced the subject becomes of our ability to "scientifically" find the truth, the harder it is for a deceptive person to escape detection, and the easier it is for an innocent person to pass through the process unscathed.

This is much like the story of the test of guilt that the biblical King Solomon supposedly used. The accused was informed of a magical donkey that could detect guilt and would bray when a guilty person pulled its tail. The accused was instructed to enter a dimly lit room alone with the magic donkey and pull the donkey's tail.

The donkey's tail was actually coated with a pigment. The innocent person would emerge from the room with pigment on his hands, confident they would be exonerated when pulling the donkey's tail. The guilty would quickly figure out that the best way to avoid detection was to not pull the donkey's tail—the absence of pigment on his/her hands was the indication of deception. The "magic" of the donkey rested with the belief and expectations of the accused.

Like Solomon, good forensic interviewers and forensic interrogators will permit a subject to believe fantasy when that fantasy leads to the detection of

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OSHA Revises Respiratory Protection Standards

OSHA announced the final rule on assigned protection factors (APFs) on Aug. 24, 2006. All SH&E professionals should review the new APFs and update their programs accordingly. It may require a re-evaluation of current respiratory protection equipment in use to ensure adequate protection.

The APF final rule completes the revision of the reserve sections of OSHA's Respiratory Protection Standard as published in 1998. The standard will now contain provisions necessary for a comprehensive respiratory protection program, including selection and use of respirators, training, medical evaluation and fit testing.

"This standard helps employers and employees select the right respirator for the job," said Assistant Secretary of Labor for OSHA, Edwin G. Foulke, Jr. "And with the right respirator employees will have adequate protection to be safe and healthy at work."

APFs are numbers that indicate the level of workplace respiratory protection that a respirator or class of respirators is expected to provide to employees when used as part of an effective respiratory protection program. An APF table will be included in the final standard to guide employers in the selection of air-purifying, powered air-purifying, supplied-air (or airline respirator) and self-contained breathing apparatus (SCBA) respirators.

Employers must follow these new requirements and use APFs to select the appropriate type of respirator based on the exposure limit of a contaminant and the level of the contaminant in the workplace. Employers select respirators by comparing the exposure level found in the workplace and the maximum concentration of the contaminant in which a particular type of respirator can be used (the maximum use concentration or MUC). Employers generally determine the MUC by multiplying the respirator's APF by the contaminant's exposure limit. If the workplace level of the contaminant is expected to exceed the respirator's MUC, the employer must select a respirator with a higher APF. ■

Table 1 New Assigned Protection Factors for Respiratory Protection Programs

Type of Respirator[1,2]	Assigned Protection Factors[1] Quarter Mask	Half Mask	Full Facepiece	Helmet/Hood	Loose-Fitting Facepiece
1) Air-Purifying Respirator	5	10[3]	50	—	—
2) Powered Air-Purifying Respirator (PAPR)	—	50	1,000	25/1,000[4]	25
3) Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1,000	25/1,000[4]	25
• Pressure-demand or other positive-pressure mode	—	50	1,000	—	—
4) Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Notes. *[1]Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance or when required respirator use is independent of concentration. [2]The assigned protection factors are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit testing, maintenance and use requirements. [3]This APF category includes filtering facepieces and half-masks with elastomeric facepieces. [4]The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. This level of performance can best be demonstrated by performing a WPF or SWPF study or equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting facepiece respirators and receive an APF of 25. [5]These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 Subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134 (d)(2)(ii).*

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deceptive behavior. Forensic investigators, by their very nature, must be curious, resourceful and have a tenacious attention to detail. The ability to connect the dots, even where there is no apparent connection, is essential.

However, for those dots to result in an accurate picture, the investigator must be able to consider confounders, false positives, false negatives, scope of errors (random and systematic) and how closely the observation is to the facts, regardless of the investigator's desired outcome. Forensic investigators should certainly be imaginative and resourceful but also be able to articulate how that resourcefulness still lies within the context of good science and acceptable practice. You, too, can be a good forensic investigator in two easy lessons, each lasting 10 years. I am almost there (with apologies to Arnold Lehman, 1955). ■

Caoimhin P. Connell, CIH, has been a practicing industrial hygienist for 19 years with an additional 10 years' experience as an analytical chemist in the U.S. and abroad. He developed the data quality objectives and was the primary author of the meth lab assessment protocols for Colorado's new Regulations Pertaining to the Cleanup of Methamphetamine Laboratories. Connell serves on three ASTM committees, and he is a law enforcement officer with a rural county sheriff's office in Bailey, CO. He has been involved in numerous tactical drug lab raids and follow-up assessments of illegal drug labs in criminal and civil cases since 2001.