Application of the Daubert Standard to Forensic Paint Examinations

Scientific Working Group for Materials Analysis (SWGMAT)
Paint Subgroup

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Daubert vs Merrell Dow Pharmaceuticals -1993

(Daubert v. Merrell Dow Pharmaceuticals, Inc. *(1993) 509 U.S. 579, 589.*)

This document and its attachments are intended to act as a guide and aid in addressing Daubert admissibility challenges. In fact, the Daubert factors listed below are a culmination of a series of cases, not just the primary one cited above. These legal standards are mandated in United States Federal courts as dictated in Rule 702 of the Federal Rules of Evidence. They can and do differ with different states rules of evidence.

Requires five factors be considered in determining admissibility:

1. Testability of the scientific theory or technique using the scientific method
2. Peer review and publication
3. Known or potential error rate
4. The existence and maintenance of standards controlling the technique's operation
5. General acceptance in the relevant scientific community

Scientific Basis of Forensic Paint Examinations

Modern paint is a manufactured product typically consisting of a mixture of numerous materials (components). Its most apparent feature is the variety of colors available. Different paint manufacturers will usually use different components in their products. Any given manufacturer also offers a variety of grades or types of paint depending on its projected end use or its cost. These different grades or types also differ in the components or the relative amounts of components put into them. As such, even for a single layer of paint, there is a tremendous amount of variation from product to product and there are literally thousands of different kinds of paint in our environment.

Paint is usually encountered as evidence of association in a cured form often consisting of multiple intact layers, called a paint chip. As noted above, each layer of paint in these chips carries the features distinct to that paint. Obviously, the more layers of paint present in a chip, the less likely it is for one to randomly encounter another source of paint with the same characteristics (layer sequence and individual layer components). The basic thrust of a forensic paint examination is to try to differentiate between paint samples and eliminate the possibility that they have the same source. Paint is usually mass-produced using a recipe and sometimes in rather large batches. Accordingly, one has to consider the possibility that a given paint could be applied to a number of different objects. Therefore, it is often impossible to definitively associate a given paint sample's origin with one source to the exclusion of all other sources. There are exceptions to this, as in the case of paint chips with fractured edges or surface configurations that physically correspond to the paint at the source.

Using established forensic techniques, however, can lead to scientifically based conclusions as to the possibility that given paint samples had the same source. If one applies a thorough analytical scheme which differentiates between the various physical and chemical features in most paints, then one can deduce whether or not the paints are like one another. If significant differences are found, the results lead the examiner to the conclusion that the paints are dissimilar and did not have the same source. If no significant differences are found, the results lead the examiner to the conclusion that the paints are alike in all the observed and measured significant characteristics, and that it is possible that the paints originated from the same source. The evidentiary significance of the correspondence is reflected by the ability of the analytical scheme to differentiate between most paints. This ability can be demonstrated by published discrimination studies.

Automotive paints from different sources usually differ in their layer structures and compositions. Evaluating these characteristics and then searching an international database of original paint layer structures and compositions as well as other resources may permit the identification of the years, makes, and models on which that paint was used. This can provide investigative leads when a source for comparison has not been identified.

1. Testability of the scientific principle using the scientific method

With respect to the Daubert decision, the US Supreme Court stated in its ruling: *"Ordinarily, a key question to be answered in determining whether a theory or technique is scientific knowledge that will assist the trier of fact will be whether it can be (and has been) tested. Scientific methodology today is based on generating hypotheses and testing them to see if they can be falsified; indeed, this methodology is what distinguishes science from other fields of human inquiry."*

Hypothesis testing is the process of deriving some proposition (or hypothesis) about an observable group of events from accepted scientific principles, and then investigating whether, upon observation of data regarding that group of events, the hypothesis seems true. Because it is hypothesis testing that distinguishes the scientific method of inquiry from non-scientific methods, and because the scientific method of inquiry is required for the resulting inferences to be the basis of admissible expert testimony, hypothesis testing would apparently be deserving of careful consideration even if it were not one of the Court's five enumerated factors. The basic technique of hypothesis testing has been well established for decades.

In applying the scientific method to forensic paint examinations, a hypothesis is developed – the Q (questioned source) and K (known source) paints did not originate from the same source. In order to scientifically test that hypothesis, the null hypothesis is adopted and the analyst attempts to disprove it. Accordingly, the null hypothesis would be that the Q and K paints originated from the same source. The analyst then subjects the samples to a series of scientifically valid tests that provide a high degree of discrimination between paint samples (discrimination power) in order to prove that the samples are different. If that is accomplished, the analyst can then state that they have disproved the null hypothesis that the samples originated from the same source. They must then conclude that the original hypothesis was correct, i.e. the two samples did not originate from the same source. If the analyst fails to disprove the null hypothesis, they have not proven that the two samples did originate from the same source; only that this possibility can not be eliminated.

2. Peer review and publication

See bibliography in Appendix A.

ASTM International (ASTM) and the Scientific Working Group for Materials Analysis (SWGMAT) guidelines are consensus documents, written and voted on by a large cross section of the forensic trace evidence community. Two such documents have been published generally addressing forensic paint examinations:

- ASTM E1610-02, "Standard Guide for Forensic Paint Analysis and Comparison," ASTM International, West Conshohocken, PA, 2005.
- Forensic Paint Examination and Comparison Guidelines, Scientific Working Group for Materials Analysis (SWGMAT), Forensic Science Communications, Vol.1, No. 2, July 1999. Accessible on line at: http://www.swgmat.org/Forensic%20Paint%20Analysis%20and%20Comparison%20Guidelines.pdf

3. Known or potential error rate

The assessment of the accuracy of the conclusions from forensic analyses and the estimation of relevant error rates are key components of the mission of forensic science. Past research in this area has focused on studies of potential systematic errors, such as observation bias or measurement validity, process improvements to reduce error, and discrimination studies. While all are important areas to study in order to understand and improve analytical processes, none of these areas strike at the core of the issue, answering the question: "What is the error rate for the examination of evidence in the various forensic disciplines employed in crime laboratories?" This is a question that forensic scientists and courts have struggled with since the Supreme Court ruled that error rate is one of the key factors in the assessment of admissibility. In forensic paint examinations, when attempting to determine a known or potential rate of error, one must first examine the variability of various paint formulations as well as the scientist's ability to distinguish different formulations.

There have been numerous discrimination studies in forensic paint examination that demonstrate the variability of paints and the power of the analytical methods used for the discrimination of paint samples. Some examples follow with a summary of each found in Appendix B:

1. Tippett, C.F., et. al., "The evidential value of the comparison of paint flakes from sources other than vehicles," Journal of the Forensic Science Society, 8 (2,3), 1968, pp. 61-65.
2. Gothard, J.A., "Evaluation of automobile paint flakes as evidence," Journal of Forensic Sciences, 21 (3), 1976, pp. 636-641.
3. Gothard, J. and Maynard, P., "Evidential value of automotive paint," proceedings of the 13th International Symposium of the ANZFSS (Australian and New Zealand Forensic Science Society), September 8-13, 1996, Sydney, Australia.
4. Ryland, S.G. and Kopec, R.J., "The evidential value of automobile paint chips," Journal of Forensic Sciences, 24 (1), 1979, pp. 140-147.
5. Ryland, S., Kopec, R., and Summerville, P., "The evidential value of automobile paint. Part II: Frequency of occurrence of topcoat colors," Journal of Forensic Sciences, 26 (1), 1981, pp.64-74.

6. Buckle, J., Fung, T., Ohashi, K., “Automotive topcoat colour occurrence frequencies in Canada,” Canadian Society of Forensic Science Journal, 20, No. 2, 1987, pp. 45-56.
7. Edmondstone, G., Hellman, J., Legate, K., Vardy, G.L., and Lindsay, E., "An assessment of the evidential value of automotive paint comparisons," Canadian Society of Forensic Science Journal, 37, No.3, 2004, pp. 147-153.
8. Wright, D.M., Bradley, M.J., and Mehltretter, A.H., “Analysis and discrimination of architectural paint samples via a population study,” Forensic Science International, 209, 2011, pp. 86-95.

Four of the studies (#2, #3, #4, and #7) cover the comparison of random samples of automotive paints using full analytical protocols. In these studies, the average rate of false inclusions is 0.002 percent. Conversely, that means that 99.998% of the time the samples were correctly excluded when it was known that they came from different sources. All of the false inclusions involved pairs of original paints originating from vehicles of the same make, model and year of manufacture. Two of the studies (#1 and #8) deal with a random sampling of architectural paints. The results indicate a false inclusion rate of 0.0001 percent. Conversely, that means that 99.9999% of the time the samples were correctly excluded when it was known that they came from different sources. Calculations for each study can be found in Appendix D. Although these studies were conducted in widely divergent time frames, and in some cases with different methods, the results of each are approximately the same. Two of the studies (#5 and #6) deal with the discrimination power of automotive paints based on the color of the finish coat. When using general color classifications, over 90% of the vehicles on the road can be eliminated as potential sources of a questioned paint sample based on this characteristic alone. Considering more specific color classes, the elimination rate is on the order of 95% or greater for all but a few.

It is not always easy to acquire sufficient sample populations to thoroughly test the discrimination power of our analytical techniques. Thus, the field has also turned to “worst case scenario” discrimination studies, in which the sample population is not completely random but is selected from samples that would be difficult to discriminate. Some examples follow with a summary of each found in Appendix C:

1. May, R.W. and Porter, J., "An evaluation of common methods of paint analysis," Journal of Forensic Sciences, 15 (2), 1975, pp.137-146.
2. Reeve, V.C. and Keener, T., "Programmed energy dispersive x-ray analysis of top coats of automotive paint," Journal of Forensic Sciences, 21 (4), 1976, pp. 883-907.
3. Howden, C.R., Dudley, R.J. and Smalldon, K.W., "The non-destructive analysis of single layered household paints using energy dispersive x-ray fluorescence spectrometry," Journal of the Forensic Science Society, 17, 1977. pp. 161-167.
4. Laing, D.K., et. al., "The discrimination of small fragments of household gloss paint by microspectrophotometry," Forensic Science International, 20, 1982, pp. 191- 200.
5. Fukuda, K., "The pyrolysis gas chromatographic examination of Japanese car paint flakes," Forensic Science International, 29 (3,4), 1985, pp. 227-236.
6. Ryland, S.G., "Infrared microspectroscopy of forensic paint evidence," In <u>Practical Guide to Infrared Microspectroscopy</u>, Humecki, H.J., ed., Marcel Dekker, Inc.,1995, pp. 222-232.

7. Ryland, S.G., et. al., “Discrimination of 1990s original automotive paint systems: A collaborative study of black nonmetallic base coat/clear coat finishes using infrared spectroscopy,” Journal of Forensic Sciences, 46 (1), 2001, pp. 31-45.
8. Govaert, F. and Bernard, M., “Discriminating red spray paints by optical microscopy, Fourier transform infrared spectroscopy, and X-ray fluorescence” Forensic Science International, 140 (1), 2004, pp. 61-70.
9. Buzzini, P. and Massonnet, G., "A market study of green spray paints by Fourier transform infrared (FTIR) and Raman spectroscopy,” Science and Justice, 44 (3), 2004, pp. 123-131.
10. Bell, S., Fido, L.A., Speers, S.J., and Armstrong, W.J., “Rapid forensic analysis and identification of “Lilac” architectural finishes using Raman spectroscopy,” Applied Spectroscopy, 59(1), 2005, pp. 100-108.
11. Bell, S., Fido, L.A., Speers, S.J., and Armstrong, W.J, Spratt, S., “Forensic analysis of architectural finishes using Fourier transform infrared and Raman spectroscopy, Part II: White paint,” Applied Spectroscopy, 59(11), 2005, pp.1340-1346.
12. Eyring, M., Lovelace, M., and Sy, D., “A study of the discrimination of some automotive paint films having identical color codes,” proceedings of the NIJ/FBI Trace Evidence Symposium, August 13-16, 2007, Clearwater Beach, FL.
13. Roux, C., Inkster, J., Maynard, P, Ferguson, B., “Intra-sample vs. inter-sample variability in architectural paint,” proceedings of the NIJ/FBI Trace Evidence Symposium, August 13-16, 2007, Clearwater Beach, FL.
14. Plage, B., Berg, A.-D., Luhn, S., “The discrimination of automotive clear coats by pyrolysis-gas chromatography/mass spectrometry and comparison of samples by a chromatogram library software,” Forensic Science International 177, 2008, pp.146-152.
15. Ryland, S., “Discrimination of retail black spray paints,” Journal of the American Society of Trace Evidence Examiners, 1(2), 2010, pp. 109-126.

It is important to note that the aforementioned studies were not performed to explicitly study error rates in forensic casework but rather to study the variability of paint and the ability to discriminate based on a full analytical scheme. Discrimination studies are typically performed in a single laboratory by experienced examiners using ideal paint chips and may underestimate the actual rate of false inclusions in forensic laboratory casework. Furthermore, they do not address false exclusions. The studies do however provide evidence that paint in our environment is highly variable, and the probability of finding randomly matching paints in our environment is quite low, and the analytical techniques utilized are effective in discriminating different paint formulations.

While these discrimination studies demonstrate a low potential error rate in the analytical process of paint examination; the human error rate in interpreting data generated by the analytical methods has not been fully studied. Because the rate of such error would vary from analyst to analyst and laboratory to laboratory it would be inappropriate to ascribe a general human error rate to a specific analyst. It should be noted that quality control measures in accredited laboratories are designed to minimize the potential of such errors. Such measures include formal training programs, competency testing, proficiency testing, peer review of data and conclusions, validation of and adherence to analytical procedures, audits to assure compliance, as well as continuing education.

Some have suggested using summary results of known external proficiency tests in paint analysis as a measure of error rate. However, test providers have warned against the use of their results for this purpose[1]. Summary test results include results from all laboratories, both accredited and unaccredited. Some participating laboratories may not have the analytical equipment to perform all recommended analytical procedures and may report erroneous results on that basis. Many laboratories utilize proficiency testing in their training processes or to validate a new technique and these results would not reflect those of a trained analyst using validated techniques. Artifacts from test preparation have also been found to influence test results; therefore, errors reported in a summary report have been found to be acceptable results upon further review by external accreditation review boards. The known nature of the testing also may influence the test results as analysts may take more or less care in the analysis of the proficiency test than in casework. Perhaps a better measure of human error rate would be the use of large scale blind proficiency testing in order to avoid some of these problems; but to date, no large scale testing by this method has been performed.

4. The existence and maintenance of standards controlling the technique's operation

There are several peer reviewed published guidelines specifying acceptable protocols and standards used to minimize procedural and instrumental analytical errors and to maximize discrimination potential.

<u>ASTM International and SWGMAT guidelines:</u>

ASTM E1610-02, "Standard Guide for Forensic Paint Analysis and Comparison," ASTM International, West Conshohocken, PA, 2005.

ASTM E2808-11, "Standard Guide for Microspectrophotometry and Color Measurement in Forensic Paint Analysis," ASTM International, West Conshohocken, PA, 2005.

"Forensic Paint Examination and Comparison Guidelines," Scientific Working Group for Materials Analysis (SWGMAT), Forensic Science Communications, Vol.1, No. 2, July 1999. Accessible on line at http://www.swgmat.org/Forensic%20Paint%20Analysis%20and%20Comparison%20Guidelines.pdf

"Standard Guide for Using Infrared Spectroscopy in Forensic Paint Examinations," Scientific Working Group for Materials Analysis (SWGMAT). Accessible on line at http://www.swgmat.org/SWGMAT%20infrared%20spectroscopy.pdf

"Standard Guide for Using Scanning Electron Microscopy/X-ray Spectrometry in Forensic Paint Examination," Scientific Working Group for Materials Analysis (SWGMAT), Forensic Science Communications, Vol.4, No. 4, October 2002. Accessible on line at

[1] http://www.ctsforensics.com/assets/news/CTSErrorRateStatement.pdf

http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/oct2002/bottrell.htm/

"Standard Guide for Microspectrophotometry and Color Measurement in Forensic Paint Analysis," Scientific Working Group for Materials Analysis (SWGMAT), Forensic Science Communications, Vol 9., No. 4, October 2007. Accessible on line at http://www.swgmat.org/Standard%20Guide%20for%20Microspectrophotometry%20and%20Color%20Measurement%20in%20Forensic%20Paint%20Analysis.pdf

"SWGMAT Trace Evidence Recovery Guidelines," Forensic Science Communications, October 1999 Volume 1 Number 3. Accessible on line at http://www.swgmat.org/Trace%20Evidence%20Recovery%20Guidelines.pdf

ASTM E 1492-92 "Standard Practice for Receiving, Documenting, Storing and Retrieving Evidence in a Forensic Science Laboratory," ASTM International, West Conshohocken, PA, 2007.

ASTM E 1459-92 "Standard Guide for Physical Evidence Labeling and Related Documentation," ASTM International, West Conshohocken, PA, 2007.

Accreditation standards:

ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories.

ASCLD/LAB-International 2006 Supplemental requirements for the accreditation of forensic science testing laboratories.

5. General acceptance in the relevant scientific community

Forensic specialists have been examining and analyzing trace evidence in criminal cases, including paint, for many years. The acceptance of paint as associative evidence is well established in the scientific literature. Paul Kirk devoted a chapter to it in his classic text "Crime Investigation," published in 1953. In it, there is also reference to an analytical technique still used in forensic paint examinations today, published in the Journal of Criminal Law and Criminology in 1949. Thus, published scientific literature dealing with the forensic comparison of paints dates back at least sixty years. Its foundations go far beyond that, being one of the types of contact trace evidence referred to by Edmund Locard in postulating his exchange principle in 1930.[Locard, E., Am. J. Police Sci., 1, 3, 276-298; 1, 4, 401-418; 1,5, 496-514, (1930).]

The techniques used in forensic paint comparisons are classical microscopical and instrumental analytical chemistry techniques taught in universities and established in the scientific community worldwide. Similar methods are used in the paint industry. None of the techniques or methods are novel approaches. A dated but detailed discussion of the topic can be found in Crown's text "The Forensic Examination of Paints and Pigments," published in 1968. A more general description can be found in Thornton, J., "Forensic Paint Examinations," Chapter 8, *Forensic*

Science Handbook, Vol. I, 2nd ed., Saferstein, R., ed., pp. 430-478, 2002, and in *Forensic Examination of Glass and Paint: Analysis and Interpretation*, B. Caddy, ed., Taylor and Francis, NY, NY, 2001. The protocol put forth in SWGMAT's "Forensic Paint Examination and Comparison Guidelines," Forensic Science Communications, Vol.1, No. 2, July 1999, and in ASTM E1610-02, "Standard Guide for Forensic Paint Analysis and Comparison," ASTM International, West Conshohocken, PA, 2005, was drafted through professional consensus, written and voted on by a large cross section of the forensic trace evidence community. It represents a precisely specified, and scientifically justified, series of steps that lead to results with well-characterized confidence limits.

A demonstration of the historical and continued scientific investigations into forensic paint examinations can be found in the bibliography generated by the Paint Subgroup of the Scientific Working Group for Materials Analysis (SWGMAT). The bibliography is attached to this document for the court's reference (Appendix A).