This document sets forth background materials on the scientific research supporting examinations as conducted by the forensic laboratories at the Department of Justice. It also includes a discussion of significant policy matters. This document is provided to assist a public review and comment process of the related Proposed Uniform Language for Testimony and Reports (posted separately). It is not intended to, does not, and may not be relied upon to create any rights, substantive or procedural, enforceable by law by any party in any matter, civil or criminal, nor does it place any limitation on otherwise lawful investigative and litigative prerogatives of the Department.

SUPPORTING DOCUMENTATION FOR DEPARTMENT OF JUSTICE PROPOSED UNIFORM LANGUAGE FOR TESTIMONY AND REPORTS FOR THE EXPLOSIVES CHEMISTRY DISCIPLINE

Background

Chemistry is the study of matter and its changes. Forensic chemistry is the application of chemistry for legal proceedings; it involves determining the chemical identity and characteristics of substances and performing chemical comparisons of substances.

Chemists conduct analyses of unknown powders, liquids, and other materials to chemically identify any explosives or explosives-related compounds. Debris and fragmentation from post-blast crime scenes are also examined for traces of unconsumed explosives and reaction products. In addition, chemical reaction ("bottle" or "pressure") bombs are forensically analyzed for chemical composition.

Principles of Explosives Chemistry Examinations

Explosives chemistry analysis permits a broad array of analyses based upon well-established chemical and instrumental techniques that are universally accepted in the scientific community. These techniques are not limited to forensic science and are routinely used in a variety of industries as well as in academia. While instrumentation has advanced to become more sensitive with shorter analysis times, the same basic methods and theories have been employed for decades. These chemical and instrumental techniques provide reliable data that are dependent upon the chemical properties of the substance being analyzed. As such, an examiner is typically able to interpret the data to deduce the chemical identity of the substance. On occasion, the data does not support a chemical identification; however, the data may allow the examiner to group the substance within a class of chemicals or products.

Explosives Chemistry Processes

There are different methodologies and processes for conducting an explosives chemistry examination. The Department shares information regarding some appropriate processes below. The Department does not suggest that the processes outlined here are the only valid or appropriate processes.

Common forensic chemistry examinations include:

- Bulk/intact explosive analysis: analyses of powders and liquids for the presence of explosives, explosive components and explosive precursors.

- Explosive residue analysis: analyses of post-blast items, clothing, or swabs for the presence of trace amounts of unconsumed explosives or reaction products.

- General unknown analysis: analyses of substances which are of indeterminate origin or which cannot be readily classified among the types of substances routinely examined within Explosives Chemistry Groups. This also includes chemicals used in chemical reaction bombs. The analytical approaches used when examining an unknown substance will vary depending on the physical state and the quantity of the substance available.

Examinations performed to determine the presence or absence of specific analytes within or on an item are referred to as targeted examinations. Examinations performed on general unknown substances are referred to as non-targeted examinations. In accredited laboratories, each examination is conducted in accordance with the laboratory's quality assurance system (including, among other things, validated procedures for the conduct of examinations) along with the Technical and Scientific Working Groups on Fire and Explosions (T/SWGFEX) guidelines for the chemical identification of intact explosives and post-blast explosive residues.[1] When possible, orthogonal techniques (*i.e.*, two or more techniques predicated on different chemical principles) are employed in order to reach a determination. In practice, it may not be achievable to use two absolutely orthogonal techniques, so significantly different techniques are often used instead. For example, the combination of gas or liquid chromatography with mass spectrometry is considered sufficient analytical data to allow for the identification of many explosive chemical components.[2] The more orthogonal the techniques, the higher the level of confidence in the assignment of identity.[3] Applying professional judgment, examiners form their conclusions based on established criteria and report and testify to such conclusions.

Upon receipt of a case, the examiner evaluates the evidence to determine the standard operating procedure(s) (SOP(s)) to apply. All accredited laboratories will have SOPs. Typically, the SOP(s) employed will involve performing multiple techniques of increasing sensitivity and selectivity. These are classified as screening or confirmation techniques for targeted examinations. For non-targeted examinations, the training and experience of the analyst helps dictate the initial techniques to be employed. When the weight of a substance needs to be reported, a quantitative technique will be used.

[1] http://www.swgfex.org/#!publications/c6ki.

[2] T/SWGFEX Recommended Guidelines for Forensic Identification of Intact Explosives, Appendix A, (2004), http://www.swgfex.org/#!publications/c6ki.

[3] Jimmie C. Oxley, Maurice Marshall, and Sarah L. Lancaster, "Principles and Issues in Forensic Analysis of Explosives", in *Forensic Chemistry Handbook*, ed. L. Kobilinsky (New Jersey:Wiley, 2012), 34.

Screening Techniques

Targeted examinations typically begin with a screening technique. The purpose of screening techniques is to test for the presence or absence of a target analyte (*i.e.*, the substance of interest) or to indicate when further testing may be warranted. The screening technique(s) is selected based on the target analyte and the nature of the specimen. Screening techniques include, but are not limited to:

- Gas Chromatography (GC)
- Liquid Chromatography (LC)
- Ion Chromatography (IC)
- Fourier Transform Infrared Spectroscopy (FTIR)
- Chemical Color Tests
- Microscopic examination (stereo light or polarizing light)
- Thermal susceptibility testing

Confirmation Techniques

A positive screening result is confirmed by an analyst by performing orthogonal analyses. The confirmatory test(s) for a target chemical are typically more specific than the screening technique. These techniques provide structural or elemental information about the sample. Confirmatory techniques include, but are not limited to:

- Mass Spectrometry (MS)
- Fourier Transform Infrared Spectroscopy (FTIR)
- X-Ray Diffraction (XRD)
- Raman Spectroscopy
- Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM/EDS)

The T/SWGFEX guidelines for the chemical identification of intact explosives and post-blast explosive residues offer detailed guidance on the selection of analytical techniques required for the identification of various explosives and associated chemical components.[4]

Non-Targeted Examinations

For non-targeted examinations (*i.e.*, examinations of general unknowns), an appropriate analytical scheme, as determined by the analyst, is employed to chemically identify or classify the questioned sample. A common example of a general unknown examination is an analysis of an unknown powder or liquid which may be an explosive precursor. Examinations of unknown substances are dynamic in nature. The applied techniques and the sequence of examinations follow from the results of the most recently performed technique. The techniques used in non-targeted examinations are the same as those employed in targeted examinations. Examination of a general unknown substance becomes a targeted examination when a specific analyte is suspected to be present.

[4] http://www.swgfex.org/#!publications/c6ki.

Quantitative Techniques

The only quantitative value currently reported is the weight of a substance. The weight of a substance is determined using a calibrated analytical balance and is reported along with an estimation of measurement uncertainty at a specified confidence level. Measurement uncertainties are estimated according to a documented SOP, derived from the Guide to the Expression of Uncertainty in Measurement (JCGM 100:2008) (GUM)[5], a widely accepted method for determining measurement uncertainty, as well as ASCLD/LAB policy[6] and guidance[7] documents.

Estimated quantities of a substance (e.g., weight, volume, purity, or concentration) may be reported and/or stated as an opinion when a validated quantitative method was not used, as long as the method used is reliable for such estimation and it is clearly stated that the estimate is not the result of a validated quantitative measurement.

Conclusions

Once an examiner reaches a conclusion(s), criteria specified in the SOP are used to report and testify to the conclusion(s). Typical conclusions include:

(a) Identification
(b) Consistent with
(c) Not identified (Negative)
(d) Cannot be differentiated
(e) Can be excluded

[5] Joint Committee for Guides in Metrology, *Evaluation of Measurement Data - Guide to the Expression of Uncertainty in Measurement* (JCGM 100:2008 GUM 1995 with minor corrections) (1st ed. 2008).

[6] ASCLD/LAB-*International*, ASCLD/LAB Policy on Measurement Uncertainty, AL-PD-3060 Ver 1.0, May 1, 2013; ASCLD/LAB-*International*, ASCLD/LAB Policy on Measurement Traceability, AL-PD-3057 Ver 1.0, May 1, 2013.

[7] ASCLD/LAB-*International*, ASCLD/LAB Policy on Guidance on the Estimation of Measurement Uncertainty – Overview, AL-PD-3061 Ver 1.0, May 22, 2013; ASCLD/LAB-*International*, ASCLD/LAB Guidance on the Estimation of Measurement Uncertainty – ANNEX A, Details on the NIST 8-Step Process, AL-PD-3062 Ver 1.0, May 22, 2013; ASCLD/LAB-*International*, ASCLD/LAB Guidance on the Estimation of Measurement Uncertainty – ANNEX B, Drug Chemistry Discipline Three Examples – Weight, Volume and Purity Determination, AL-PD-3063 Ver 1.0, May 22, 2013; ASCLD/LAB-*International*, ASCLD/LAB Guidance on Measurement Traceability, AL-PD-3054 Ver 1.0, May 22, 2013; ASCLD/LAB-*International*, ASCLD/LAB Guidance on Measurement Traceability – Measurement Assurance, AL-PD-3059 Ver 1.0, May 22, 2013.

Identification

An examiner may report and testify to the identity of an analyte in a questioned sample when:

- Positive results have been obtained for an analyte within the questioned substance using orthogonal (or significantly different) techniques, at least one of which was a structural elucidation technique; and

- The pre-defined decision criteria set forth in the relevant SOP were satisfied for each chemical analysis that gave a positive result; and

- The analysis included the use of positive and negative controls if available (or comparison to a reliable library result if no positive control was available).

An example of an identification is: "Residues of Trinitrotoluene (TNT) were identified on Item 1."

Consistent With

An examiner may conclude that a questioned substance is consistent with a particular substance when:

- The analytical data does not support an identification of a specific chemical or product, but does provide reliable information to include a substance within a class of materials.

An example of a conclusion that a questioned substance is "consistent with" a particular substance is: "Residues consistent with the deflagration products of a potassium nitrate-based low explosive were detected on Item 1."

Not Identified / Negative Determination

An examiner may conclude that a particular substance is not identified on or in a questioned substance when:

- The results of the analytical examinations are negative for the substance.

An example of a conclusion that a questioned substance is negative for a particular substance is: "No explosive residues were identified within Item 1."

Cannot Be Differentiated

In cases involving a comparison of samples, an examiner may reach a conclusion that the samples "cannot be differentiated" from one another when:

- The results do not show any meaningful differences in chemical composition between or among the samples.

An example of a conclusion that a questioned substance "cannot be differentiated" from a particular substance is: "The chemical composition of the Item 1 plastic explosive could not be differentiated from the chemical composition of the Item 3 plastic explosive. Thus, Items 1 and 3 could have come from the same source or separate sources with the same chemical composition."

Can Be Differentiated or Can Be Excluded

In cases involving a comparison of samples, an examiner may reach a conclusion that the samples can be differentiated from one another or one sample "can be excluded" as being the source of another sample when:

- The results show relevant differences in analytical responses between or among the samples.

An example of a conclusion that a questioned substance "can be excluded" as being a particular substance is: "Potassium nitrate and sulfur were identified within Item 10. This combination of chemicals was not identified within Item 11. Therefore, Item 11 can be excluded as the source of Item 10."

Weight

For weight determination of a substance requested as needed for statutory reasons, the reported weight will include the following:

- Estimation of Measurement Uncertainty; and
- Confidence Interval.

An example of a weight result is: "The Item 3 material weighed 699.3 milligrams ± 0.4 milligrams (99.7% confidence level) and was identified as low explosive black powder."

Policy Considerations

In 2006, Congress authorized the National Academy of Sciences (NAS) to conduct a study on forensic science, which culminated in a 2009 report.[8] In the report's evaluation of the forensic science discipline of explosives, there was minimal concern relating to explosives examinations and evidence. In summary, the report concluded:

> The scientific foundations exist to support the analysis of explosions, because such analysis is based primarily on well-established chemistry.[9]

The report recognized that T/SWGFEX had established a set of recommendations for the analysis of explosives and that the methods are based on well-accepted standard schemes and protocols.

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[8] National Research Council, Committee on Identifying the Needs of the Forensic Science Community, *Strengthening Forensic Science in the United States: A Path Forward* (2009). National Academy Press: Washington, D.C. (http://www.nap.edu/catalog/12589.html).

[9] *Id*. at 172.