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 FORENSIC METALLURGY DISCIPLINE

Background

Metallurgy is the study of metals; from their extraction from ore and processing into raw materials, to their manufacturing into useful products. Metallurgy encompasses a number of subfields including mechanical metallurgy, corrosion and electrochemistry, physical metallurgy, fracture mechanics, failure analysis, solid state materials theory, extraction and refining, and several others. Since metallurgy is such a broad engineering field, the metallurgist/forensic examiner is typically a generalist who applies knowledge of different specialty areas to examine metallic evidence and, when necessary, presents it in legal proceedings. The methods used for forensic metals examinations are essentially analogous to those routinely used by metallurgists and metallurgical engineers in academia, industry, and other government laboratories.

The use of native metals, such as gold, is known to date to as early as 40,000BC. The development of methods to produce bronze (ca. 3000BC) and iron (ca. 1200BC) are regarded as technological developments of the greatest importance by archeologists and have been used to denote the corresponding historical periods as the Bronze Age and Iron Age, respectively. Technological development slowly progressed over the ensuing centuries resulting in the production of ever more useful alloys, such as steel. A 16th century text by Georg Agricola, called *De Re Metallica*,[1] describes a number of surprisingly sophisticated processes used in the mining of metal ores and metal extraction and summarizes the metallurgical knowledge of that era. Agricola is sometimes considered a founding father of the science of metallurgy.

During the 19th century, electrolytic industrial processes were developed that permitted the large scale production of aluminum and made that metal widely available for the first time. Later in the century, the development of the Bessemer process[2] made possible the production of vast quantities of inexpensive carbon steel. The relatively low quality of these early steel products (by modern standards) resulted in many train wrecks, contributed to the sinking of the HMS Titanic, and led to many other high profile catastrophes in the late 19th and early 20th centuries.

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[1] Agricola, Georgii, *De Re Metallica*, libri Xii-Basileae 1556. An English translation was published by Dover Publications, New York in 1950.

[2] The Bessemer process was the first inexpensive process for the mass production of steel from molten pig iron. The process uses pressure air to oxidize the impurities in the iron and permit their removal from the molten metal.

This situation prompted large scale research efforts to understand the causes of such failures and led to vast improvements in our understanding of the failure mechanisms affecting metal components. Massive research efforts in areas such as alloy development, heat treatment, forming and shaping, mechanical behavior, fracture mechanics, failure analysis, corrosion, and many other areas provided a foundation for our modern, technological society and established metallurgy as a mature engineering discipline.

Advancements in metallurgy have kept pace with advancements in science and technology generally. Metallurgy and the related discipline of materials science remain at the cutting edge of technology. Nano-materials, microelectronics and similar advanced technology owe their existence to on-going research in these fields. The modern metallurgist has access to an arsenal of advanced instrumental techniques; libraries of published academic, government and industrial studies; and well-established professional and accreditation organizations. As with other engineering disciplines, access to such resources permits the forensic metallurgist to arrive at well-founded conclusions that are based upon established scientific and engineering principles.

Comparisons of testing results with standards and specifications established by industrial and standards organizations such as ASTM International[3] commonly permit a metallurgist to draw a variety of conclusions about a specimen of interest.

Principles of Metallurgy Examinations

Because metallurgy/metallurgical engineering is a mature engineering discipline, it has been extensively researched and covers a broad range of subjects. The metallurgical analyses conducted by the Department use techniques that are commonplace within the metals industry. When performing metallurgical examinations, the examiner may come to a wide variety of conclusions about submitted items depending upon the request, the evidence received, and the examinations conducted. A summary of the types of examinations routinely performed and the conclusions reached about these are provided below.

Metallurgy examinations generally fall into one of three categories:

A. Identification: An examination for identification purposes evaluates the physical and chemical nature of the evidence. Conclusions are normally limited to statements of fact describing the items.

B. Failure analysis: A failure analysis examines a damaged component or assembly to determine how it came to be in its present state. The strength of failure analysis conclusions is sometimes limited by the information available from the sample being analyzed and from the circumstances of the event(s) leading to failure.

C. Comparative Examinations: When conducting metallurgical examinations to compare evidence to specifications or to other evidence, the examiner assesses whether characteristics are in agreement or disagreement in order to come to a conclusion.

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[3] Formerly known as the American Society for Testing and Materials.

Depending on the identifiable characteristics, an examiner can form any of the following conclusions:

- The items are associated to each other by common characteristics.
- The items are associated to some subclass of similar items on the basis of their specific physical and/or chemical characteristics.
- The items have insufficient identifiable characteristics to evaluate whether they may share a common source. (Inconclusive)
- The items are not from a common source. (Exclusion)
- The items do (or do not) conform to a particular standard specification.

Theory of Forensic Metallurgical Examinations

The basic methods of mechanical, chemical and physical testing of metal objects were established to support industrial and scientific endeavors and adopted for use in the forensic community. Therefore, the standard operating procedures that are used in the Department are based on well established chemical, instrumental and physical testing techniques that are universally accepted in the scientific and engineering communities. While instrumentation continues to improve, the basic methods and theories have been employed for decades. Thousands of standards that govern both the mechanical and chemical properties of metals as well as the means for measuring these properties have been issued by organizations such as the American Iron and Steel Institute, the Society of Automotive Engineers, and ASTM International. [4] For example, there are ASTM standards that cover the required tensile strength and minimum ductility of a particular type of steel alloy, and complementary standards that detail how tensile testing can be carried out in order to verify the steel alloy actually has the properties required for that type of steel.

Nearly all of the testing performed in the Department has been adopted from the industrial counterparts described above. That testing may include physical, chemical and mechanical testing of a wide variety of metal objects. The Metals Handbook[5] is a 33 volume publication, spanning 31,000 pages, which provides an overview of the metallurgy discipline and serves as one of the field's standard references.

Metallurgy Processes

There are different methodologies and processes for conducting a metallurgy 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. Examinations begin with a review of the documentation that is received with the evidence. This helps to establish what examinations are being requested and why. The examiner then chooses and applies the appropriate examinations and methodology that are relevant to the request. The methods used have undergone validation within the Department.

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[4] AISI website: https://www.steel.org; SAE International website: http://www.sae.org; ASTM International website: http://www.astm.org

[5] *Metals Handbook*, ASM International, Metals Park, OH (1986-2014).

The evidence received is initially given a thorough visual examination in which anything of potential interest is noted, for example, evidence of corrosion, mechanical damage, trademarks, or aftermarket alteration.

The evidence is next documented photographically, including recording images of any important features that were previously noted. At this point, the examinations may diverge depending upon the request made.

A. Identification

Identification examinations involve the evaluation of the nature of the evidence, chemically and physically.

Any design features are noted and detailed dimensional measurements are made with micrometers, rulers, and similar tools. The objects are typically checked with a magnet to see if they are ferromagnetic.

When appropriate, the items will also be weighed. Examples include valuable items such as precious metal ingots.

Non-destructive elemental analysis of the items is typically conducted to determine the composition of the item (carbon steel, aluminum, copper alloy, etc.). The most common method used for these examinations is x-ray fluorescence spectrometry (XRF). Compositional examinations have been routinely performed for many decades in the metals and manufacturing industries.[6]

If appropriate, metallography or mechanical property tests can be conducted to provide information on the processing history of the item. Metallography consists of polishing the metal object to a flat, mirror-like finish, etching it with a chemical solution and examining it at high magnification using an appropriate microscope. Mechanical testing could include tensile testing, impact testing, or hardness testing, for example.

For ***alloy identification***, the item will be subjected to compositional testing. X-ray fluorescence (XRF) can be used to assign most alloys to a class (e.g. maraging steels, stainless steel, 2000 series aluminum etc.)[7] or to a specific alloy type (e.g. 14K yellow gold, cartridge

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[6] Slickers, K., *Automatic Atomic-Emission-Spectroscopy, 2nd Ed.*, Bruhlsche Universitatsdruckerei, Germany 1993; Jenkins, R., Gould, R.W. and Gedcke, D., *Quantitative X-ray Spectrometry*, *2nd ed.*, Marcek Dekker, Inc., New York 1995.

[7] Maraging steels are a group of iron based materials that are alloyed with high levels of nickel (typically 15-25%). They are characterized by superior strength and toughness resulting from the precipitation of intermetallic compounds. Stainless steels are a group of iron based alloys containing at least 10.5% chromium characterized by much greater resistance to rust and corrosion in many freshwater and oxidizing environments when compared to carbon steels. 2000 series aluminum alloys are a group of precipitation hardenable materials produced by alloying aluminum with defined levels of copper as well as other elements that depend on the specific alloy (e.g. 2017, 2024). Many are characterized by high strength to weight ratios and have been widely used in the aerospace industry.

brass, etc.). Most materials received in metallurgy are analyzed by XRF due to its nondestructive nature.

Department examiners also have the ability to perform compositional analysis using Spark Discharge in Argon-Optical Emission (SDAR-OES) spectrometry. The instrument uses an electric arc to vaporize part of the metal sample. This results in the formation of a plasma which emits radiation in the visible and UV range of the electromagnetic spectrum that is characteristic of the elements present in the sample. Analysis of these emissions using an optical spectrometer yields a detailed, quantitative analysis of the elemental composition of the sample. This method is destructive but is often more sensitive than XRF.[8]

Identification of an alloy involves direct comparison of the alloy with a reference standard of the same alloy, when one is available. Alternatively, direct comparison of quantitative test values to published compositional standards can be used to identify the alloy.

In instances where the concentrations of light elements (e.g. carbon, boron) are needed to identify the alloy, SDAR-OES is used to supplement the information obtained from XRF analysis. Because these methods work on different physical principals, one method can also serve as a confirmation of the other.

In rare cases, metallography may also be performed on the items to examine their microstructure. Atlases of standard micrographs that show the typical appearance of a given alloy subjected to a particular heat treatment exist for most common materials.[9]

Trademark, Barcode and Underwriters Laboratory (UL) numbers searches can be conducted when the evidentiary item contains a UL number; potentially identifying the registered owner of a barcode, trademark or UL number by searching publically available databases. For example, the US Patent and Trademark Office[10] maintains a searchable trademark database on its website. If the request were only to identify the manufacturer, examinations could be limited to photography to document a trademark or other marking of interest. Searches of an appropriate database and contact with the manufacturer (if needed) are generally sufficient to confidently identify the owner of the observed marking.

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[8] Volker B.E. Thompsen, *Modern Spectrochemical Analysis of Metals-An Introduction for Users of Arc/Spark Instrumentation*, ASM International 1996; ASTM International (2014), *ASTM Method E415 Standard Test Method for the Analysis of Carbon and Low Alloy Steel by Spark Atomic Emission Spectrometry;* ASTM International (2009), *ASTM Method E1085 Standard Test Method for Analysis of Low-Alloy Steels by X-Ray Fluorescence Spectrometry*.

[9] *Metals Handbook*, Vol 9, *Metallography and Microstructures*, ASM International, Metals Park, OH, 2004; Schrade, A. and Rose, A. (editors), *De Ferri Metallographia, Structure of Steels,*Vol 2, Verlag Stahleisen mbH, Germany (1966); Beiss, P., Dalaim, K. and Peters, R., *International Atlas of Powder Metallurgical Microstructures,* Metal Powder Industry (2002).

[10] Trademark Electronic Search System (TESS): http://tmsearch.ustpo.gov/bin/gate.exe?f=tess&state4804:w5hj7.1.1

B. Failure Analysis

Failure analysis is a well-established metallurgy discipline and has been the subject of a large volume of research and development since at least the 1940's.[11] If a service history[12] for the items is available, it is reviewed in detail for information that may be relevant to the examinations. The following series of examinations typically follows the initial photo-documentation of the item.

The surfaces of the item are carefully inspected for the presence of corrosion, cracks, abrasions, sharp radii and other indications of imperfections or stress concentrations in the object. Distortions of the object often provide insight into the loading conditions it was subject to and are carefully examined and noted. The fracture surfaces are analyzed in detail visually and photographed. Further analysis using visual microscopy and/or scanning electron microscopy would then typically be used to characterize and photo-document the fracture features that indicate the particular mechanism that led to failure (e.g. fatigue, creep rupture, cleavage, microvoid coalescence, etc.). This basic practice is known as fractography.[13]

Next, the item's chemical composition would typically be characterized non-destructively using XRF or a related method known as Energy Dispersive Spectrometry (EDS). XRF employs an X-ray source to ionize the atoms in a sample of interest and stimulate fluorescent X-ray emission by that sample. The emitted X-rays are then recorded using an appropriate spectrometer. The wavelengths of the fluorescent X-rays are characteristic of the elements present and can be used to determine what elements comprise a sample. The relative intensities of the characteristic X-rays can also be used to determine the relative abundances of the elements present. EDS is similar but instead uses an electron beam to stimulate X-ray emission by the sample. When necessary, destructive testing using optical emission spectrometry (SDAR-OES) can also be completed.

If appropriate, metallography is performed to analyze the microstructure of a metal object and to look for other features of interest. Metallographic analysis can provide extensive information on the processing history of the metal, and can be used to examine for secondary cracks, slag inclusions, plating thicknesses, porositym and other important characteristics of the alloy that can provide clues to its failure mechanism. For example, it is well-established that branching cracks commonly accompany stress corrosion cracking.

In some instances, standard mechanical tests are performed to verify the material has the minimum properties required for its use in a given application.

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[11] *Metals Handbook*, Vol 11, *Failure Analysis and Prevention*, ASM International, Metals Park, OH, 2002; ASM, International Failure Analysis Committee, *Handbook of Case Histories in Failure Analysis,* ASM International 1992; Hertzberg, Richard W. et. al., *Deformation and Fracture of Engineering Materials*, 5th edition, John Wiley & Sons, Inc. 2012.

[12] A service history is a list of major events that occurred to an item while it was in service. A simple example is a list of all of the preventative maintenance and repairs performed on an automobile since it was purchased. Any accidents, floods, etc. could also be considered part of the service history (e.g. CARFAX).

[13] *Metals Handbook*, Vol 12, *Fractography,* ASM International, Metals Park, OH, 1987.

Failure analysis is a highly complex procedure. In specific instances, other types of examinations might also be required.[14] Any such examinations are validated according to the requirements of the Department laboratory's quality assurance system before being introduced into casework.

In general, an examiner then uses the totality of the physical, mechanical, metallographic, fractographic and chemical observations to formulate a conclusion that explains the cause of the observed characteristics. This is not always straightforward, and considerable engineering knowledge is required.

In the simple case of *<u>on/off determinations</u>* in an automotive lamp,[15] microscopic examinations of the lamp filament follow photography of the initial condition of the lamp. It has long been known that the tungsten used to produce lamp filaments is brittle at room temperature. At elevated temperatures, the filament becomes ductile making it possible to stretch it. The changes that occur in a lamp when it is struck while hot (or cold) are well-documented and easy to observe when present.

Electrical continuity measurements are made with an ohmmeter to confirm the filaments remain intact if they appear to be so visually.

Scanning electron microscope with energy dispersive spectrometry (SEM/EDS) can be used to examine the filament if the glass envelope surrounding the lamp is broken. The reasons for doing so are three-fold: (1) A hot tungsten filament oxidizes rapidly when exposed to air whereas a cold one will not, (2) broken glass will fuse to an incandescent lamp filament but not to a cold one, and (3) the fracture surface of a filament is instructive when trying to determine the lamp's operating condition when separation of the filament occurred. Ductile fractures or beaded ends indicate the filament was hot when it separated. Brittle fractures indicate that it was cold.[16]

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[14] ASTM International (2004), *ASTM Method E2332 Standard Practice for the Analysis of Physical Component Failures;* ASTM International (2013), *ASTM Method G161 Standard Guide for Corrosion-Related Failure Analysis*.

[15] Baker, J.S., Aycock T.L., and Lindquist, T., *Lamp Examination for ON or OFF in Traffic Accidents*, Topic 823 of Traffic Investigation Manual, Northwestern University Traffic Institute, 2003; Noon, R.K., *Engineering Analysis of Traffic Accidents*, CRC Press, pp. 83-91, 1994; Johnson, L.D, et al. *"Accelerations and Shock Load Characteristics of Tail Lamps from Full-Scale Automotive Rear Impact Collisions"*, Society of Automotive Engineers, Paper # 2002-01-0548, 2002; Dydo, J.R., et al., "*Response of Brake Light Filaments to Impact*" Society of Automotive Engineers, Paper # 880234, 2002; Fries, T.R. and R.O. Lapp, *"Accident Reconstruction - Response of Halogen Light Filaments during Vehicle Collisions"* Society of Automotive Engineers, Paper # 890856, 1989; Kawakami, A., H. Sekimori, and A. Shinohara, *"Accident Information for Traffic Accident Reconstruction - The Role of the Automobile Lamp Filament"* Society of Automotive Engineers, Paper # 930661, 1993; Keskin, A.T., W.S. Reed and R.L. Friedrich. "Brake Light Filament Deformation Analysis for Vehicular Collisions" *Society of Automotive Engineers*, Paper # 880233, 2002; Severy, D.M. *"Headlight-Taillight Analysis from Collision Research"* Society of Automotive Engineers, Paper # 660786, 1966; Stone, I.C. *"Forensic Laboratory Support to Accident Reconstruction"* Society of Automotive Engineers, Paper # 870427, 1987; Dolan, D.N. *"Vehicle Lights and Their Use as Evidence."* Journal of the Forensic Science Society 2(2), (1971); Haas, M.A., M.J. Camp and R.F. Dragen. "A Comparative Study of the Applicability of the Scanning Electron Microscope and the Light Microscope in the Examination of Vehicle Light Filaments." *Journal of Forensic Sciences,* 20, (1975); Thorsen, K.A., "Examination of Bulb Filaments by the Scanning Electron Microscope", Canadian Society of Forensic Sciences Journal, 14(2), (1981).

[16] *Id.*

In general, an examiner then uses the totality of the physical and chemical observations to formulate a conclusion that explains the cause of the observed characteristics.

C. Comparative Examinations

Comparative examinations between two items typically follow the sequence listed below. At each step of the testing, the examiner will look for evidence to disassociate the two items. If such evidence is observed, the remaining examinations are typically not completed.

Background research will be conducted when necessary to undertake an examination. For example, the ASTM specifications covering the design of a particular kind of steel cable would be consulted if it were relevant to the issue under study.

Microscopic visual examinations are made of the object and any features of interest are recorded photographically. The objects are then typically checked with a magnet to see if they are ferromagnetic. The design features of the item, if any, are noted and detailed dimensional measurements will be made with micrometers, rulers, and similar tools. When appropriate, the item will also be weighed (e.g. for valuable items such as precious metal ingots).

Non-destructive elemental analysis of the items is typically conducted by XRF. Signature analysis (by spectral overlay) is used to look for differences in the elemental profiles of the known and questioned sources.

Destructive elemental analysis of the objects may be conducted using optical emission spectrometry. Comparisons of the quantitative elemental compositions of the objects are conducted using standard statistical methods.[17]

Metallography or mechanical testing may also be employed. For quantitative mechanical property tests, like Rockwell hardness[18] measurements, the results are compared using standard statistical methods (e.g. two sample t-tests).

In a *specifications fraud* case, a validated test method is used to examine whatever characteristic may be in dispute. For example, if the material is required to achieve a specified hardness, a Rockwell or other appropriate hardness test would be performed on the material. Similarly, chemical testing (XRF, EDS, SDAR-OES) can be used to verify the alloy used is (or is not) one of those permitted by the contract specifications (many thousands of distinct alloys are commercially available, including at least 3500 grades of steel[19]). Other metallurgical testing techniques could also be employed depending upon the nature of the request.

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[17] e.g. Bonferroni corrected t-tests, Two Sample Hotelling's T-Squared test.

[18] Rockwell tests are a collection of standardized tests that measure the indentation hardness of materials. In many metals, Rockwell hardness is directly correlated with the tensile strength of the material.

[19] World Steel Association website: http://www.worldsteel.org; *Handbook of Comparative World Steel Standards, 2nd edition*, John E. Bringas ed., ASTM International, West Conshohocken, PA, 2002; *Metals and Alloys in the Unified Numbering System, 12 edition*, ASTM International, West Conshohocken, PA, 2012; *Metals Handbook*, Vol

The examinations described above are conducted in accordance with the Department's quality assurance system. Each of the above referenced instrumental methods has been validated for use by the Department.

Quantitative Techniques

Department examiners have the ability to measure and report quantitative values of elemental composition, physical dimensions and mechanical properties. This requires that the reported characteristics were measured with calibrated and verified equipment for which traceability to a national metrological institute has been established. In addition, any values that are reported must include an estimate of measurement uncertainty at a specified confidence level (typically 99.7% confidence). Measurement uncertainties are estimated according to a standard operating procedure (SOP), derived from the Guide to the Expression of Uncertainty in Measurement (GUM),[20] a widely accepted method for determining measurement uncertainty, as well as ASCLD/LAB policy[21] and guidance[22] documents.

Standards in the Field of Forensic Metallurgy

Quality assurance and quality controls are important parts of forensic metallurgy practice. The Department's standards regarding quality assurance and quality control are adopted from standards developed over the past few decades. Because of its industrial origins, metallurgical testing has been the subject of far more research and publication than more traditional forensic disciplines. For example, the American Iron and Steel Institute (AISI), ASTM International, the Society of Automotive Engineers and others have established tens of thousands of standards governing mechanical and chemical testing of metals,[23] the chemical composition limits of tens

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2, *Properties and Selection: Nonferrous Alloys and Special Purpose Materials*, ASM International, Metals Park, OH, 1990.

[20] 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).

[21] 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.

[22] 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.

[23] ASTM International (2009), *ASTM Method E1085 Standard Test Method for Analysis of Low-Alloy Steels by X-Ray Fluorescence Spectrometry;* ASTM International (2009), ASTM International (2011), *ASTM Method E3 Standard Guide for Preparation of Metallographic Specimens;*ASTM International (2011), *ASTM Method E84 Standard Test Method for Knoop and Vickers Hardness of Materials;* ASTM International (2012), *ASTM Method E18 Standard Test Methods for Rockwell Hardness of Metallic Materials.;*ASTM International (2013), *ASTM Method E1621 Guide for X-Ray Emission Spectrometric Analysis;* ASTM International (2013).

of thousands of commercial alloys, the required mechanical properties of alloys, etc. Much of this information provides the basis by which the properties of a metal object are to be judged. As a simple example, an AISI 1020 steel must have a chemistry which falls in narrowly specified ranges in order to be commercially marketed as the alloy in question. Similar standards also apply to the surface finish and mechanical properties of such products. These standards also extend to objects fabricated from metals. For example, the ASTM standard for a 4d roofing nail would require very precise control of the nail length, shank diameter, head shape, point type and so on.

Policy Considerations

In 2006, Congress authorized the National Academy of Sciences (NAS) to conduct a study on forensic science and provide recommendations if warranted. The NAS convened the Committee on Identifying the Needs of the Forensic Science Community, which published a 2009 report.[24] Although the report did not assess metallurgy specifically, it did assess some factors that impact metallurgy.

Two such factors that impact metallurgy are the reporting of analysis results and sampling. In an attempt to create greater uniformity among laboratories regarding the content of reports, the NAS recommended all forensic reports, regardless of discipline, include the following: identification of the tests conducted, certain results of testing, and potential sources of error and statistical error.

The NAS report also noted that "[s]ampling can be a major issue in the analysis of controlled substances"[25] The report further noted that "SWGDRUG and others have proposed statistical and nonstatistical methods for sampling, and a wide variety of methods are used."[26] Appropriate sampling also impacts the metallurgy discipline, and sampling is explicitly addressed in the standard operating procedures of Department examiners.

In conformance with the intent of the NAS recommendations, metallurgy reports also include discussion of the tests performed, the relative strength of the findings, and the limitations associated with a given series of examinations.

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[24] 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).

[25] *Id*. at 134.

[26] *Id*.