Functionality Examinations

1 Introduction

Many manufactured devices function on the basis of well-established engineering and design criteria. Consequently, when a device fails to function as intended, it is usually possible to discern the cause of the failure by careful inspection of the device's components. A common example of such activity is the diagnosis and repair of a faulty system in a motorized vehicle by an automobile mechanic. Similarly, an electronics technician might replace a faulty power supply or hard drive in order to restore a computer to proper working order.

In general, these sorts of repairs require a working knowledge of the device's operating principles. The possible causes of a particular malfunction can be diagnosed by examining the subsystems of the device and determining which of them may be responsible for the observed problem. Correction of the problem indicates it has been appropriately diagnosed.

2 Scope

This document applies to caseworking personnel who perform metallurgy analyses. There are a wide variety of mechanisms, components, metals, treatments, conditions, types of damage, applications, environments, and combinations of these, as well as an unpredictable range of determinations that can be requested with regard to the failure or damage sustained and exhibited, in any particular evidence submission. The following procedure outlines the basic analyses most commonly performed in functionality testing an item or assembly.

3 Principle

Generally, it is possible to establish whether a mechanism is operating correctly by supplying the appropriate energy source to it. These can include dry cell batteries, electrical power, wind, gasoline, sunlight, pressurized gas, or another source, depending upon the device's requirements.

When the device is a sensor, it is also necessary to supply its stimulating species in order to verify its proper function. For example, a smoke detector can be tested by exposing it to a smoke source. Similarly, a radiation detector can be tested using an appropriate radioactive source material.

When a device is not functioning, it is often possible to determine why by examining it closely. For example, a broken wire in an electrical device could prevent it from working as intended. If replacement of a failed component restores its function, it may be deduced that it was the cause of the malfunction, provided that it can also be demonstrated that another defective component did not contribute to the failure of an otherwise sound component.

4 Specimens

Nearly any mechanical device and many non-mechanical devices can be examined using this procedure.

5 Equipment/Materials/Reagents

A list of items commonly used in this examination follows. Not every item is used for every investigation. The instrumentation and equipment used will depend on the configuration of the item or mechanism to be examined for functionality. When an instrument marked with an asterisk is used, see the appropriate Chemistry Unit (CU) Metallurgy standard operating procedure (SOP) (15 References) for additional equipment/materials/reagents.

a. Nikon D200 digital camera and/or Nikon DXM1200 digital camera (or equivalent)

b. Stereomicroscope with a fiber optic light source and a magnification of at least four (4) diameters

c. Faxitron CS-100 or NSI 5000 radiography unit (or equivalent)*

e. Miscellaneous hand tools

f. Digital multimeter

g. Manually operated gas pump

h. Graduated cylinder (500 ml)

i. Leak detecting solution (Snoop® or equivalent)

j. Miscellaneous components for substitution of missing or damaged components

k. Compressed non-reactive gases

6 Standards and Controls

The standards and control samples to be employed in this procedure will depend on the specific analytic methods employed and the nature of the items under analysis. Exemplars for evidentiary items will be obtained as needed. Any instrument used in this procedure will employ such standards as are required under its specific SOP (see section 15 References).

7 Sampling

Not applicable.

8 Procedure

a. Perform a preliminary examination and note any apparent shipping damage as well as any material transfer from shipping and/or handling. Record any dial/gauge readings and make an evaluation as to type of device including the nature of the input and output (e.g., gas, electrical power, fluid). Record any valuable manufacturer's markings, visible or restorable.

b. Photograph the “as received condition” (ARC) of the specimen, noting the overall condition of the appliance or item, any damage exhibited, and the spatial relationship of the controls and components.

c. If appropriate, perform radiographic examination of the internal components of the device.

d. If feasible and appropriate, obtain a comparable, undamaged device (exemplar) for examination and comparison.

e. Conduct both visual and low power magnification examinations to assess the totality of the item and/or system, its integrity and the specific relative position(s) of controls, control components, and other functional components. Examine any exhibited damage, exogenous debris, material, or item not present by design and any post-production modifications. In addition, note any missing components and any other characteristic of interest or value.

f. Check electrical, flow, or other appropriate continuity with a multimeter, pump or other appropriate detection device(s). Make note of any relevant circuit, system, and/or fluid behavior.

g. If the device is electrically activated, gradually apply input voltage until device activation or full-rated power is reached. Observe voltmeter, ammeter, and/or ohmmeter at various locations in circuits as necessary. Note the threshold voltage of activation if testing an audible alarm device.

h. If the device is flow-activated, pass gas through the device to detect any sources of leakage. Leakage in the pressurized device may be detected by submersion, audibly, or by spraying the pressurized portions of the item with soapy water[1] or other leak detection solution (e.g., Snoop®). Note: If leakage is detected, measure the volume of escaping gas and note duration of collection (elapsed time). One method of doing this involves using a graduated cylinder which has been submerged then inverted over the leak. If no leak is detected, pressurize the system to its rated pressure and observe for leak(s) and/or proper functioning.

i. Summarize findings based on all collected data of value.

9 Instrumental Conditions

a. The instrumental conditions of imaging systems are generally adjusted by the operator to achieve sufficient resolution for analysis. See section 15 References for SOPs containing additional recommendations of instrumental conditions for digital radiography.

b. Macro- and micro-photographs will contain a reference scale whenever feasible, however these are included for general reference, and measurements will not be taken from the images. Micron markers that are automatically generated by camera or microscope software are to be considered approximate and also will not be used to measure features within the image unless the marker is verified against a calibrated scale.

10 Decision Criteria

The conclusions derived from this procedure are based on careful interpretation of all of the factual information gathered from testing and investigation. A valid conclusion is one which reasonably explains the observations made during the various stages of examination. In some cases, the proper functioning of a device is self-evident. In other instances, it is possible to infer the functioning (or malfunctioning) of a device based on an analysis of its physical remains. The uncertainty associated with such an analysis will depend strongly on the nature of the evidence submitted and the available factual information. Conclusions will be expressed in reports and testimony according to current FBI Laboratory requirements (see section 15 References).

11 Calculations

The range of possible calculations that may be encountered in functionality evaluations is case-specific and potentially spans all engineering disciplines. No particular calculation is routinely

[1] The use of soap solutions may tend to remove any residues which may be present on the surfaces of the device.

used for this examination. Examples of some of the types of calculations which may be encountered are available in the listed references.

12 Measurement Uncertainty

When quantitative data are gathered to define the limits of functionality of an item or assembly, measurement uncertainty will be calculated in accordance with the *Procedures for Estimating Measurement Uncertainty* in the *Chemistry Unit Quality Assurance and Operations Manual*.

13 Limitations

The limitations of a particular functionality test are determined by the device condition and type, the available background information and numerous other factors specific to the situation under consideration. Although specific limitations cannot be predicted within this procedure, any limitations encountered during functionality examinations will be recorded in the case notes, and, if appropriate, included in the *Laboratory Report*.

14 Safety

a. Wear an x-ray film badge or dosimeter when operating instruments that generate x-rays. The instruments have protective enclosures and internal safety interlocks to prevent inadvertent x-ray radiation exposure. Never bypass or disable safety interlocks on instruments.

b. Wear personal protective gear and use engineering controls that are appropriate for the task being performed (e.g., safety glasses when cutting and chemical fume hood when etching). Electrical or mechanical hazards may require special precautions (e.g., grounding to prevent electric shock or wearing a face guard to prevent impact from flying debris.) Review instrument SOPs and pertinent material Safety Data Sheets (SDS) prior to conducting examinations. If additional guidance is required, contact the Laboratory Health and Safety Group.

15 References

Wolf, S., *Guide to Electronic Measurements and Laboratory Practice*, 2nd edition, Prentice-Hall, Inc. 1983

Scatler, N., *Mechanisms and Mechanical Devices Sourcebook*, McGraw-Hill 2011

Parmley, R. O., *Machine Devices and Components Illustrated Sourcebook*, McGraw-Hill 2004

Oberg, E., Jones, F. D., Horton, H. L., and Ryffell, H. H., *Machinery's Handbook*, 25th Edition, Industrial Press Inc., 1996

Chemistry Unit Quality Assurance and Operations Manual, Federal Bureau of Investigation, Laboratory Division, latest revision

FBI Laboratory Operations Manual, Federal Bureau of Investigation, Laboratory Division, latest revision

FBI Laboratory Quality Assurance Manual, Federal Bureau of Investigation, Laboratory Division, latest revision

Methodology for Report Writing in the Metallurgy Discipline, Metallurgy Manual Metal 900, Chemistry Unit, latest revision

Chemistry Unit (CU) FBI-Approved Standards for Scientific Testimony and Report Language for the Metallurgy Discipline, Metallurgy Manual Metal 901, Chemistry Unit, latest revision

Digital Radiography, Metallurgy Manual Metal 303, Chemistry Unit, latest revision

Department of Justice Uniform Language for Testimony and Reports for the Forensic Metallurgy Discipline, latest revision

Rev. #	Issue Date	History
4	03/02/2018	Renumbered Metallurgy SOP Manual documents. This document was formerly Metal 3 and is now designated Metal 201. Added personnel to section 2. Made minor editorial corrections throughout document. Deleted obsolete equipment in section 5. Augmented section 6. Deleted section 7 and renumbered subsequent sections. Removed example from section 10. Added measurement uncertainty statement to section 12. Updated safety requirements in section 14. Added references to section 15.
5	12/21/2018	Added paragraph regarding equipment use to section 5 heading. Added reference to instrument SOPs in sections 5, 6 and 9. Removed micrometers and added digital radiography to section 5. Removed reference to NIST standards for dimensional measurement from section 6. Added 8c to include radiography. Renumbered following steps in section 8. Augmented section 9 to include specific instrument procedures. Added statement regarding conclusions to section 10. Added SOP references to section 15.

Redacted - Signatures on File

Approval

Metallurgy Technical Leader Date: 12/20/2018

Chemistry Unit Chief Date: 12/20/2018

QA Approval

Quality Manager Date: 12/20/2018