Lamp Bulb Examinations

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1 INTRODUCTION

In vehicular accidents, the question of whether the involved parties had their headlights, taillights, or other marker lights illuminated frequently arises. Examinations of vehicle lamps frequently allow strong inferences to be made regarding the operating condition of the lamps at the time of an accident. Specimens for this examination generally consist of vehicular lamp bulbs (e.g., automotive, motorcycle, aviation, marine).

2 SCOPE

This document applies to caseworking personnel who perform metallurgy analyses on vehicle lamps that have tungsten wire filaments. It supplements METAL-210 and METAL-220 by detailing inspection techniques that can be advantageously applied to vehicle lamps.

3 EQUIPMENT

A list of items commonly used in this examination follows. Not every item is used for every lamp investigation. The instrumentation and equipment used will depend on the configuration of the items to be examined.

- Macro camera
- Stereomicroscope having a fiber optic light source and a magnification of at least four (4) diameters with camera
- Ethyl or methyl alcohol (laboratory grade)
- Digital X-ray radiography system*
- Glass-scoring instrument
- Oxyacetylene mini-torch
- Tissue, napkins or suitable water-retaining and shapeable medium
- Needle-nose pliers
- Welder's glasses
- Fire retardant apron
- Puncture resistant gloves
- Rotating dish or 'Lazy Susan'-type platform
- Electric charcoal starter
- Fluke digital multimeter (or equivalent)
- Scanning electron microscope (SEM)*
- SEM with energy dispersive X-ray spectroscopy (SEM/EDS)*

* When an instrument marked with an asterisk is used, see the appropriate Chemistry Unit (CU) Metallurgy technical procedure for additional equipment.

4 STANDARDS AND CONTROLS

The standards and control samples to be employed in this procedure will depend on the specific analytic methods used and the nature of the item under analysis. Exemplars for comparison to evidentiary items will be obtained as needed and available.

5 PROCEDURE

A. Conduct a preliminary evaluation of the specimens noting the type of lamp represented, the condition of lamp components or remnants, and the nature of any damage exhibited, per METAL-210 and METAL-220.

B. Review any supplied photographs of the accident and/or damaged vehicle(s) to evaluate the spatial relationship between the lamp damage and the damaged regions of vehicle(s) in order to infer possible impact energy transmission and attenuation.

C. Photodocument the specimens to record the "as-received condition" (ARC) of the submitted lamps or remnants to characterize the presence and condition of both the glass envelope and the filament. Also record the 3-dimensional spatial relationship of any electrical components present and the presence of any exogenous debris that may be detected by macroscopic and/or microscopic examination.

D. Perform visual and low power magnification examinations of the lamps to observe and record the condition of envelope, the type of bulb and any manufacturer's markings on the bulb or base. Record any observations of the symmetry and deformation exhibited by filament(s), any filament discoloration, as well as any other apparent defects or damage.

E. X-radiographic examinations per METAL-330 should be considered for lamps when the inner components are obscured, such as:

    1. automotive sealed beam headlamp
    2. lamp with an unbroken glass envelope
    3. lamp with intervening material obstructing direct visual and microscopic observation of any electrical elements present or of the location(s) such elements are expected to occupy.

F. After the state of the filament(s) has been definitively determined, check the electrical resistivity (or conductivity) of the electrical element(s) with a multimeter for static and dynamic electrical continuity. The lamp should be moved along each of its three principal axes during the dynamic continuity test to account for the possible presence of mechanically contacting fracture surfaces on the filament. The three principal axes are typically oriented parallel to the length of the lamp, parallel to the length of the filament, and in the direction which is mutually perpendicular to these two axes. Exact orientation is not critical. However, filament fracture may not be detected if motion is only applied parallel to the long axis of the filament.

G. Perform microscopic examinations of the lamp filament(s) in the ARC to inspect for the presence of deformation, fused glass, fracture(s), bulbous ends, wire recrystallization (to evaluate service life), characteristics of arcing, welds, and any other defect or failure information.

H. If the glass envelope of a non-functioning bulb remains intact, carefully remove the glass envelope to expose the electrical elements for microscopic inspection. This will be done in a manner least likely to damage or alter any electrical elements or residues present within the bulb. The following technique has proven to be effective for historically common large, sealed-beam headlights and introduces no detectable damage or alteration to critical components if performed properly. However, it is only one of several techniques available for effective envelope separation.

1. If the specimen is an automotive lamp, equalize the internal protective environment pressure by breaking the gas inlet site (generally prominent between the lugs) with needle-nose pliers or other suitable tool. If the specimen is a different type of lamp, a pinhole may be drilled into the metal base to allow pressure equalization. For safety reasons, equalizing the internal pressure is a very important step.
2. Score the circumferential periphery of the glass envelope completely to establish a localized triaxial state of stress.
3. Wrap a cool, moist tissue paper around the lamp base or other site where low melting temperature material (for example, solder) is present from fabrication. This will assist in establishing a steep thermal gradient in the vicinity of the stress concentration while simultaneously protecting low melting temperature material.
4. Using the charcoal starter or oxyacetylene mini-torch, heat the stress concentration region as quickly as feasible. If an oxyacetylene mini-torch is used, the lamp must be rotated on a rotating table to evenly distribute the heat.
5. Carefully remove the glass envelope when it cracks.
6. Conduct a second stereomicroscopic evaluation.

I. If the fracture mode of the filament cannot be determined with a stereomicroscopic examination, use SEM imaging to characterize any filament failure as to its ductile-brittle character, the fractographic features, and any other characteristic which may indicate or otherwise assist in determination of conditions existing at failure. In addition, SEM/EDS may be used to analyze the composition of the various components and any deposits.

J. Make a determination based on evaluation of all gathered data and observations.

6 INSTRUMENTAL CONDITIONS

6.1 Imaging Systems

A. Radiography is performed at conditions that penetrate obscuring matter and reveal internal lamp components. Image acquisition conditions will be recorded in the case notes

B. Scanning electron microscopy (SEM) is most often performed at an accelerating voltage of 25 kV in the secondary electron imaging mode. However, accelerating voltage may be reduced to better resolve fracture surface features. Backscattered electron imaging can be useful for locating and imaging transfers of material having a different average atomic number than the substrate. Operating conditions will be recorded in the case notes.

C. Macro- and micro-photographs will contain a reference scale whenever feasible, however these are included for general reference, and measurements will not be made from the images.

6.2 SEM/EDS

Compositional analysis by SEM/EDS will be conducted per METAL-210 to identify the nature of deposits on or near the filament. Backscattered electron imaging can be helpful to locate features that differ in mean atomic number from their surroundings (e.g., fused glass).

7 Acceptance Criteria

7.1 Instrument Performance

Adequate function of any test or inspection equipment used will be demonstrated and recorded in the case notes.

7.2 Evaluation of On/Off Condition

The conclusions derived from this procedure are based on careful interpretation of all factual information gathered from testing and investigation. A valid conclusion is one that reasonably explains the observations made during the various stages of examination. The uncertainty associated with such an analysis will depend strongly on the condition of the evidence. Occasionally, more than one possible scenario may explain a given set of observations. If a unique scenario does not explain the observations, all reasonable possibilities should be appropriately reported in the conclusion. Although it may be possible to determine that a lamp was lit at the time of an impact due to its deformation/damage, it is often not possible to determine if the observed damage was due to the impact in question or a previous incident.

8 Limitations

This protocol is not suitable for the examination of lamps not having filaments (e.g., LED or fluorescent light bulbs).

9 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 technical procedures and pertinent material Safety Data Sheets (SDS) prior to conducting examinations.

C. Observe fire safety precautions when oxyacetylene mini-torch equipment is used for envelope separation: use a spotter, ensure the availability of fire extinguishers in close proximity, and wear a flame-retardant apron and gloves.

D. The glass envelopes of sealed-beam automotive lamp bulbs are usually pressurized or evacuated. Appropriate eye protection and gloves must be worn when breaching the envelope.

10 References

- METAL-210, Examinations for Association and Origin, Chemistry Unit, latest revision
- METAL-220, Analysis for Failure, Damage, and Fracture, Chemistry Unit, latest revision
- METAL-330, Digital Radiography, Chemistry Unit, latest revision

11 Revision History

Revision	Issued	Changes
06	09/15/2022	Revised to comply with new formatting requirements. Expanded introduction to include lamps from vehicles other than autos. Relocated descriptive information from Scope to Principle. Expanded description of acceptance criteria.
07	12/02/2024	Relocated descriptive information from Specimen section to Introduction. Removed Principle section and instructional references to retain as training materials. Added reliance on METAL-210 and METAL-220. Added reference to METAL-330. Reordered procedural steps. Removed redundant material that is already contained in METAL-210. Made minor grammatical changes throughout to clarify intent.