Lamp Bulb Examinations

Table of Contents

Lamp Bulb Examinations

1 Introduction

In vehicular accidents, the question of whether the involved parties had their headlights, taillights, or other marker lights illuminated frequently arises. Similarly, the question of whether a vehicle was moving in reverse may arise under certain circumstances and can sometimes be answered by examining the back-up lights in the rear of the vehicle. Examinations of vehicle lamps frequently allow strong inferences to be made regarding the operating condition of the lamps at the time of an accident.

2 Scope

This document applies to caseworking personnel who perform metallurgy analyses on vehicle lamps that have tungsten wire filaments.

3 Principle

Material response to an applied force typically varies with temperature, strain rate, and conditions of static and dynamic loading. Examination of a lamp that has been subjected to impact loading can often support an inference as to its operating condition (on/off) during the event. When in service, lamp bulbs operate at such extremes of temperature that impacts during accidents can permanently alter the physical characteristics of its components. Exposure of the lamp's internal components to the atmosphere can also produce characteristic changes.

Vehicle lamp filaments are made of tungsten and are normally brittle at room temperature but are quite ductile at operating temperatures. By examining the physical characteristics of a lamp filament, it is often possible to determine the operating condition when it was subjected to an impact of the type encountered in a collision. For example, a cleavage (brittle), intergranular or fibrous fracture indicates the lamp was off when the filament broke. Severe deformation of a filament generally indicates that it was hot when impacted since tungsten is usually not ductile at room temperature.

Moreover, tungsten is not oxidation resistant. Consequently, if the glass surrounding a tungsten filament breaks while the lamp is on, severe oxidation of the filament will occur. Furthermore, small fragments of the glass envelope will commonly melt, then become fused to the filament when it cools. By careful inspection of these characteristics, it is frequently possible to determine the operating condition of a lamp when it was subjected to an impact.

4 Specimens

Specimens for this examination generally consist of vehicular lamp bulbs (e.g., automotive, motorcycle, aviation, marine).

5 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 (optional)
- Electric charcoal starter (optional)
- 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.

6 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.

7 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.

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 resistance element (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. X-radiographic examinations should be considered for any automotive sealed beam headlamps (or any other lamp type for which it is deemed appropriate) with an unbroken glass envelope or intervening material obstructing direct visual and microscopic observation of any electrical elements present or of the location(s) such elements are expected to occupy.

E. 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 information deemed to be of value.

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 effected parallel to the long axis of the filament.

G. Microscopic examinations should be conducted of the lamp filament(s) at higher magnification in the ARC for the presence of deformation, fused glass, fracture(s), bulbous ends, wire recrystallization (to evaluate service life), characteristics of arcing, welds, and any other information of foreseeable value.

H. If the glass envelope is apparently intact, or if microscopic examination of the fracture surfaces is desired, careful removal of the glass envelope to expose the electrical elements for microscopic examination may be required. 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 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 bayonet 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 torch, heat the stress concentration region as quickly as feasible. If an oxyacetylene 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, SEM imaging will be considered to characterize any filament failure as to the ductile-brittle behavior, 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 the results of all of the examinations.

8 Instrumental Conditions

8.1 Imaging Systems

A. The instrumental conditions of imaging systems are generally adjusted by the operator to achieve sufficient resolution for analysis. The SEM is most often operated at 25 kV in the secondary electron imaging mode, however, accelerating voltage may be reduced to resolve fracture surface features. Backscattered electron imaging can be useful for locating transfers of material having a different average atomic number than the substrate.

B. 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. 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 first verified against a calibrated scale.

8.2 SEM/EDS

Compositional analysis by SEM/EDS will be conducted as follows:

A. Run the instrument performance verification routine. File one copy with the instrument performance records.

B. Prepare and insert the specimen(s) ensuring electrical continuity with the sample stage.

C. Adjust the instrument conditions to image the region of interest for analysis. Backscattered electron imaging can be helpful to locate features that differ in mean atomic number from their surroundings.

D. Acquire the spectrum. Acquisition duration will depend on the conditions chosen and the sample area exposed to the incident beam. The acquisition time can be extended to optimize spectrum clarity or shortened to enhance collection efficiency based on the case requirements.

E. Label the elemental peaks on the acquired spectrum, considering peak shapes and energy positions, the relative heights of adjacent peaks and system-generated peaks. Many SEM/EDS systems have software that can accurately identify the escape and sum peaks in a spectrum. The peak identification system resident in the instrument software can be augmented by analyzing CRMs of similar composition to the specimen of interest.

F. Ensure the instrument identification and the operating parameters are recorded on the printed spectra or elsewhere in the case notes.

9 Acceptance Criteria

9.1 Instrument Performance

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

9.2 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.

10 Limitations

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

11 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 pertinent material Safety Data Sheets (SDS) prior to conducting examinations. If additional guidance is required, contact the Laboratory Health and Safety Group.

C. Observe fire safety precautions when oxyacetylene 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 automotive lamp bulbs are usually pressurized or evacuated. Appropriate eye protection and gloves must be worn when breaching the envelope.

12 REFERENCES

- 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, 1985

- Noon, R. K., *Engineering Analysis of Traffic Accidents*, CRC Press, pp. 83-91, 1994

13 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.