VEHICLE FORENSIC LAMP
EXAMINATIONS

In many collisions there are discrepancies regarding the status of vehicle headlights, taillights, turn indicators, flashers, and brake lights. Drivers and witnesses involved in an accident often disagree as to whether or not the vehicles involved had a specific lamp on or off at the time of the accident. If a lamp is not illuminated at the time of the collision it may reduce conspicuity and not allow another party enough opportunity to notice the warning and take the proper actions to avoid a collision. A lamp examination may successfully answer some of these questions.

Incandescent lamps are based on heat driven light emissions. The lamp consists of filament attached to two posts in which electric current passes through. Some multi-purpose bulbs have two filaments. When a bulb is turned on the electric current travels through the filament and heat is generated to producing light. A glass bulb encases the filament and prevents oxygen from reaching it. An incandescent lamp follows the principle that the thicker the filament the more resistance to the electric current. A brighter light is produced as the resistance through which the current must travel increases. Therefore, generally an automotive bulb with a thicker filament will indicate a high beam or brake light and a thinner filament will indicate a low beam or tail light when concealed within the same envelope. The glass envelope enclosing the filament blocks out oxygen, but over time it may blacken due to evaporated tungsten. The bulb may filled with an inert gas such as Argon to decrease this phenomenon.

In 1983 Tungsten-Halogen light sources were first introduced to the United States. After modifications and improved technology they are still commonly used for low beams, high beams, and fog lamps in vehicles today. Tungsten-Halogen lamps are similar to Incandescent lamps; they are based on heat driven light emissions generated by an electric current flow through the tungsten filament. The filament is sealed in a glass bulb filled with inert gas and a halogen gas, this differentiates the Tungsten-Halogen lamp and Incandescent lamp. The halogen increases the life cycle of the bulb by chemically combining with the evaporated tungsten and depositing it back onto the filament. This consequently decreases the blackening of the bulb. The benefit of the Tungsten-Halogen lamp is that it can operate at a higher temperature without decreasing its life span and it can produce a whiter light.

Recent research in lighting has provided two new types of bulbs for use in the automotive industry; Xenon High Intensity Discharge Lamps and Light-Emitting Diodes or LEDs. The High-intensity discharge lamp produces its light by creating an arc between two tungsten electrodes housed in a glass envelope containing Xenon. This bulb does not contain a filament and thus no filament analysis can be performed to determine the status of the bulb at the time of the collision.

Light-Emitting Diodes are based on semi-conductors. LED lights are markedly clear and appear to have a more intense color than the Incandescent or Tungsten-Halogen Lamp. The benefit of LED lighting is a decrease in energy consumption, a longer lifetime, and a smaller size when compared to an equivalent bulb.

However, they run on a more precise current and require more heat management; therefore, they have a higher system expense and more uncertainty due to the time frame they have been in use. Recent improvements in technology have produced a white LED and there is limited use currently as headlights. This light also lacks a filament for analysis.

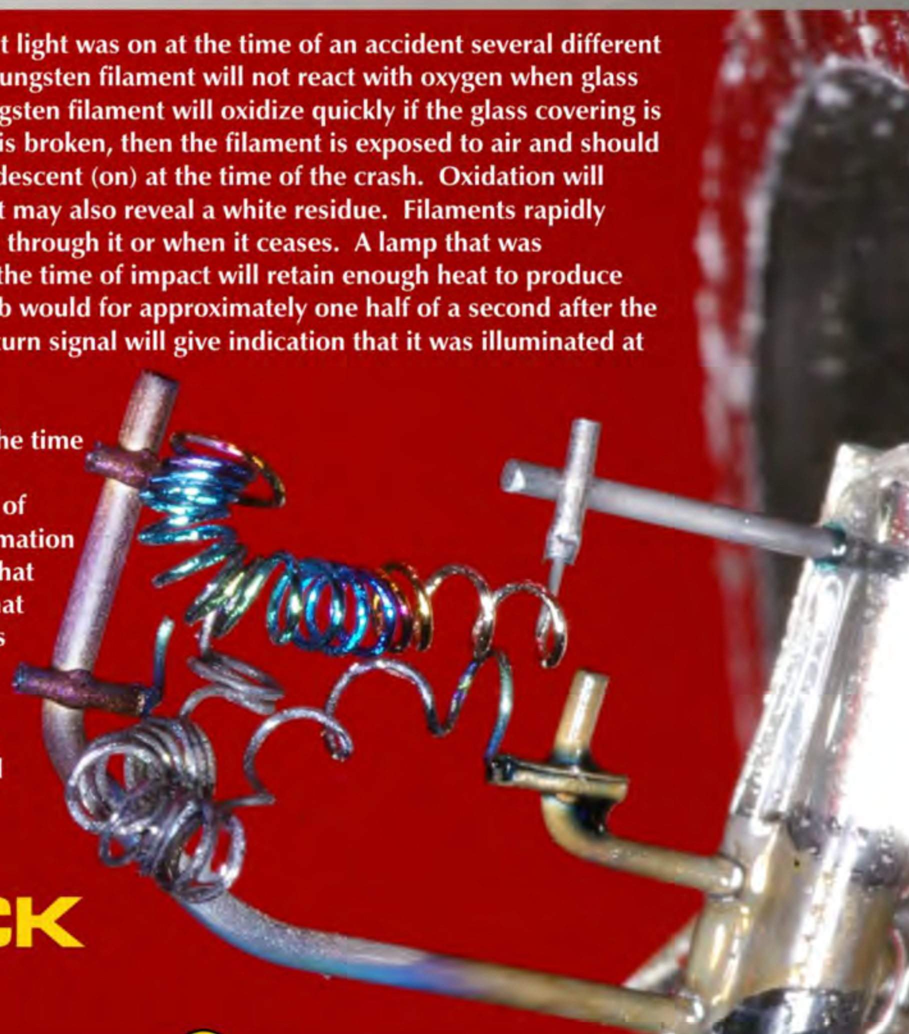
If the status of the lamps on a vehicle are in question, such as were the headlight, brake lights or turn signals on at the time of the collision, it is necessary to perform a forensic lamp examination on the vehicle.

The first and most important step in a vehicle lamp examination is to verify that the vehicle is in the same condition as it was immediately following the accident. It is important to not switch the lights on or off following the accident as this act alone may destroy the evidence you are seeking.

There are essentially four factors that determine the reaction of an Incandescent Lamps and Tungsten Halogen Lamps filament to impact. These factors include: severity of the impact, filament age, size of filament, and the temperature of the filament. When performing a lamp examination there are three different conclusions that an examiner can distinguish. The lights can be found to be on at the time of impact, off at the time of impact, or the evidence may be indeterminate. Another factor that needs to be considered before determining a conclusion is proximity heating. This is an act of one illuminated filament produces enough heat energy to heat another filament adjacent to it. However, in lamps with only one filament, this cannot occur.

In order to determine that an Incandescent light was on at the time of an accident several different scenarios may be present. A typical cold tungsten filament will not react with oxygen when glass envelope is intact or broken, but a hot tungsten filament will oxidize quickly if the glass covering is broken. If the glass envelope of the lamp is broken, then the filament is exposed to air and should show evidence of oxidation if it was incandescent (on) at the time of the crash. Oxidation will cause a discoloration of the filament and it may also reveal a white residue. Filaments rapidly heat and cool when current begins to pass through it or when it ceases. A lamp that was illuminated before a collision but is off at the time of impact will retain enough heat to produce the same evidence that an illuminated bulb would for approximately one half of a second after the current is withdrawn. Therefore a cycling turn signal will give indication that it was illuminated at the time of the collision.

Another indication of a lamp being on at the time of impact is the presence of hot-shock. Hot-shock is the uncoiling or deformation of the filament - the more uncoiling or deformation of the filament the stronger the evidence that the lamp was on. An analogy would be that of a flexible Slinky toy when the filament is illuminated and exposed to a shock. When the acceleration from the crash acts upon the filament it will stretch, then retain the uncoiled and sometimes twisted state.

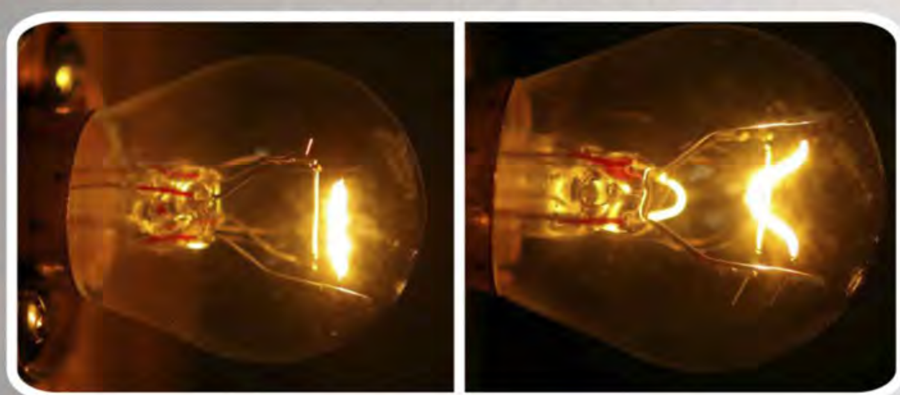


HOT SHOCK

Evidence that would support the conclusion that the lamp was off at the time of impact could also be present. A lamp that was "cold" or off at the time of impact will not be affected by exposure to oxygen if the glass bulb is broken during the collision. Therefore, if the glass bulb is broken and there is no oxidation present this would indicated that the lamp was off at the time the glass bulb was broken. A cold lamp will typically fracture the brittle filament if the impact force is strong enough. A filament that is fractured also indicates that it was off at the time of impact. A filament that is off will typically show no signs of stretching or uncoiling. One exception to this would be proximity heating.

It should be noted that the absence of hot-shock does not mean that the light was off. It could simply mean that the force at that lamp may not have been strong enough to produce hot-shock. The further the lamp is away from the area of contact damage the lower the acceleration that is experience by the filament. A headlamp that was in the area of the contact damage may show hot shock while the headlamp on the other side of the vehicle may be indeterminate. This is one example of how an indeterminate conclusion could be reached. A filament that appears in its original condition and therefore does not indicate that is was lit or unlit at the time of the impact would also be considered indeterminate. As an incandescent lamp or Tungsten-Halogen lamp ages a filament may also experience "age sag", which is stretching due to everyday forces and high temperature effects. Repeated road shocks from potholes, etc, can also cause the filament to stretch over time.

Another situation that may appear is the elongation and stretching of both filaments in a single bulb. While it could be true that both filaments were on at the time on the impact, it could also be possible that one filament was on and produced enough heat to cause warp of the second filament; this is called proximity heating. As a result, the deformation of the adjacent filament appears as though it was on, but it is really an effect from the neighboring filament. In the photo above the bulb's thin filament was illuminated when exposed to anacceleration. The acceleration was insufficient to cause cold break to the thicker filament, but did cause elongation of the thin filament. Then, while the thin filament remained illuminated another force was applied. As a result, slight stretching is present in the thicker filament that was not on at the time of the impact. It was heated by the adjacent thin filament which produced enough heat to produce stretching after experiencing a significant force.



The concepts discussed are some of the common aspects involved in vehicle lamp examinations. There are many additional factors and details that could become of concern depending on the parameters involved in each individual collision. A thorough forensic examination can be performed in conjunction with a crash reconstruction to determine the status of the lamp at the time of the collision. Although new technologies are creating lamps that do not have filaments the majority of vehicles on the road contain lamps with filaments and will remain on the roadways for many years to come.