Journal of the National Academy OF Forensic Engineers®

http://www.nafe.org
ISSN: 2379-3252

Vol. XVI No. 2 December 1999

Forensic Analysis for Headlights ON or OFF?

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My presentation will outline the procedures that may be used to determine whether a vehicle had its lights on or off at the time of the accident. Usually the tow truck operator will be required to remove debris deposited on the road by the accident vehicles. Often some of this debris will be crucial in determining the condition of the lights at impact. Each accident will be different but certain predictable results will often be evident in the debris left by the accident. We will use a combination of predictable results from forces on the lamp and wiring, caused by the accident, to determine whether the lights were on or off.

The accident happened one hour before sunrise on a paved rural highway through an industrial area. The speed limit on the highway was 55 MPH. A pickup truck, heading Westbound, was completing a gentle sweeping turn to the left. A concrete truck was exiting an industrial area, from the right, and also turning Westbound. The impact point occurred before the concrete truck had fully completed its turn Westbound.

No serious or permanent injuries resulted from this accident, but the outcome of the pick-up's headlights on or off would determine which insurance company would be liable for the damage. The concrete truck driver asserted that the pickup truck did not have its lights on. The pickup truck driver asserted his lights were on, but he did not see the concrete truck turning into his path. The fundamental question to be answered by this investigation was; did the pickup truck have its lights on or off at the time of the accident? What physical evidence would support such a conclusion?

Predictable Conditions

Several predictable physical results were key to determining if the pickup truck had its lights on or off at the time of the impact. Filaments that are incandescent (light on) at the time of impact will deflect more easily than filaments that were cold at the time of impact (light off). Small gage wire is used for the less intense light filaments and will deflect with a more pronounced appearance than heavier filaments. Larger gage filaments are used for headlights while the smaller gage filaments are used for running or clearance lights that produce less light intensity. Deflection of the filament ranges from slight distortion to a tangled or

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even tangled and broken filament if the point of impact is severe and/or close to filament. This filament deflection is very consistent and predictable when the filament is subjected to a sudden change in velocity. This deflection is proportional to the severity of the change in velocity and inversely proportional to the distance from the actual impact point. The deflection can also be influenced by the relative stiffness of the vehicle that carries the lamp to be examined. A light vehicle that is easily bent and deflected will show less distortion as the distance from the impact becomes greater. Likewise a very stiff vehicle, such as a heavy truck, will be less sensitive to the distance from the impact point, however the heavier truck will also generally have a smaller change in velocity.

Aged or used lamps will build up a deposit on the inside of the lamp glass that will appear as darker glass when compared to a new lamp. The older the lamp, the darker the glass will appear. In the extreme condition, age and use will produce darkness intense enough to make the filament difficult or impossible to visually examine. In these extreme conditions a small hole in a piece of cardboard placed between an external light source and the lamp to be examined, will allow examination from the opposite side with a microscope. Sometimes the filaments will sag due to old lamps and long usage and this must not be confused with deflection from a vehicle impact. Sagging or old long use of lamp filaments will always be deflected downward due to gravity while deflection from impact will usually be generally horizontal and not necessarily in the direction to the force. Less intense light filaments (smaller) often recoil and deform in a direction different than the direction of force. The more intense (larger) filament will deflect less than a less intense (smaller) filament. Therefore, heavier filaments will be less severely deformed due to the same change in velocity as smaller filaments. A halogen filament is larger and stronger and therefore will be less deflected than a running light filament in the same proximity to the impact point.

Lights that were off during the impact and turned on later can sometimes be detected by the evidence on the area around the light. If the glass enclosure was broken or the vacuum lost while the filament was still intact with the filament energized, a telltale blue/grey smoke will be produced by the failing filament. The filament will quickly fail because of the presence of the oxygen inside the glass enclosure. The blue/grey smoke will coat items immediately above the failing filament. If the glass enclosure is still in tack but the vacuum lost, the smoke will coat the inside of the glass. However, if the glass enclosure was broken without breaking the filament while the filament was energized the smoke will be allowed to escape; the area above the lamp will be coated with the telltale smoke. Sometimes the driver realizes, after the impact, that their lights were not on and will turn the lights on after the impact. This can be very difficult to detect. If the smoke evenly coats the areas above and around the

broken lamp glass, it should be considered suspicious. When the lamp glass is broken during the accident the air around these parts will be swirling and the smoke will not deposit evenly. Another clue to the time of energizing the circuit will be the deflection of the filament, if incandescent during the crash the filament would exhibit hot shock. If the severed filament exhibits cold shock, with the blue/grey smoke, it is an indication that the filament may have been energized after the accident.

Wires that are energized at the time of severing will produce a telltale round ball on the ends of the wire when severed. The rounded ends are produced when the conductor gets smaller and smaller until the wire quickly overheats and burns the conductor as it breaks the current flow. Wires that have the telltale ball or rounded ends confirm that the wire was energized at the time of cutting or severing of the energized wire.

Headlights or taillights will be less visible when at an viewed at an angle. When headlights or taillights are viewed from the side they become nearly invisible. Only the edge of the glass lens or other nearby elements will be visible. However, the lights will be most visible when viewed from a direction toward the vehicle along it's axis. Therefore, lights viewed from any side angle will reduce the visibility of the vehicle lights.

Reflective tape is highly visible with low levels of light from a wide variety of angles. It has been shown that side reflection tape or reflectors make vehicles very visible in low light conditions.

Evidence Gathered

The accident impact time was approximately 1 hour before sunrise. The pickup truck had been traveling Westbound for at least 30 minutes prior to the accident. The road traveled by the pick-up, was rural and sparsely lighted. It was therefore reasonable that the pick-up truck had its lights on before the impact. The pick-up truck was just finishing a sweeping turn to the left as the concrete truck entered from the right and also turning Westbound on the highway. The speed limit on this highway was 55 miles per hour. The damage to the pick-up, and very limited information from the accident report prevented a determination of the speed of the pick-up truck. The concrete truck was likely not traveling in excess of 15 miles per hour. The conditions were dry at the time of the accident.

The batching area from where the concrete truck was exiting was separated from the roadway by a 6 foot high concrete block fence parallel to the highway. The concrete truck was entering from the right side of the Westbound pick-up truck. The concrete truck most likely did not have time to complete the turn

onto the Westbound lane before impact. The headlights would be angled away from the approaching pick-up truck. The tail lights would not be in full view at the time the concrete truck was entering the travel lane of the pick-up truck. The concrete truck driver indicated he did not believe the pick-up truck had its lights on just prior to the impact.

The concrete truck did not have reflective tape or other reflectors on the sides of the vehicle. Reflective tape on the sides of trucks is very effective for illuminating the vehicle in very low lighting conditions. An observation confirmed that all the concrete trucks at this batching facility lacked reflective tape on the sides and rear of the trucks.

Further observations confirmed that the headlights and taillights on all the concrete trucks at this facility were very difficult to see in the dark, unless viewed from the front or rear. This condition would be exacerbated when the truck is at an angle turning away from the approaching vehicle. The tail lights would not be fully visible due to the truck configuration and the placement of the tail lights.

The heavy rear frame structure of the concrete truck suffered very little damage and the truck was not taken out of service for repair. The very large and heavy concrete truck was much stronger than the fender of the pick-up truck; therefore, the pick-up suffered virtually all of the damage. The concrete truck was not available for inspection because of its slight damage.

Figure 1
Front view of pickup truck showing damage to the right side fender and headlight area. The right front fender and headlight/running/turn light portion were pushed rearward to the middle of the passenger side door.

The damaged pick-up truck (See Figure 1) was stored at Sadisco (Insurance Co. holding facility); Riverview, FL. The pick-up truck was totaled due to the

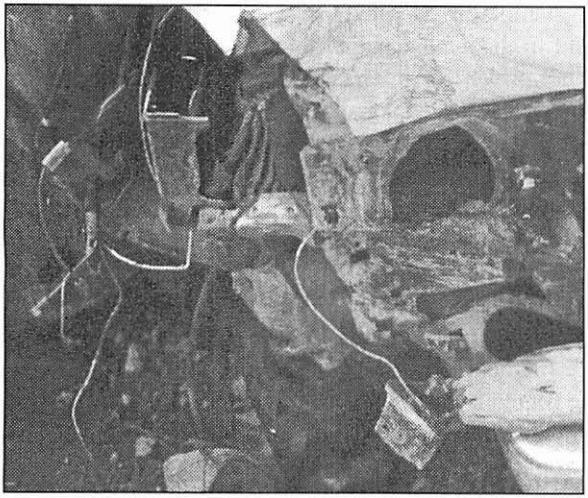

Figure 2
Close up view of right side headlight area. Note the headlamp and running lamp including the housings were missing. The headlight socket with three wires was found in the bed with other debris from the accident.

damage from the impact. The right front fender was pushed back into the passenger side door. The right front wheel was severed during the impact. The pickup truck suffered significant induced damage outside the direct contact area. The concrete truck was not available for inspection because the damage was not sufficient to hold the truck out of service.

The pick-up's left side (driver) front fender, head-light and running light were intact and were inspected and photographed at the site. No blue/grey smoke was visible in either lamp. The running light filament exhibited deflection that confirmed the driver's side running light was on at the time of impact.

The left running light (See Figure 3) below the headlight on this pick-up truck contained a lamp with two filaments. This lamp was a common 1152 running/stop light lamp that lamp contains two filaments. The smaller gage filament is the running light or 'tail-light' while the larger gage filament is the turning light or 'stop light' filament. The smaller gage filament on the driver's side front running light was significantly deflected indicating an incandescent (running light on) filament at the time of impact. A microscope inspection also

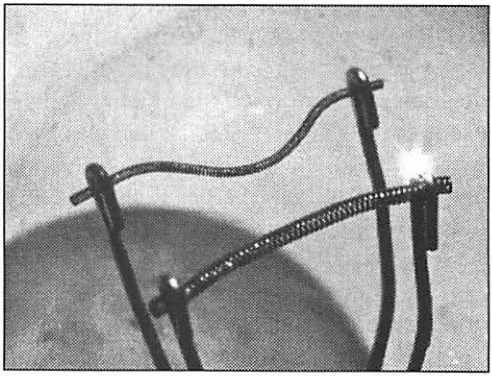

Figure 3
Curved filament running lamp, straight filament turn/hazard lamp filament. A closer view of the smaller filament was darker and more pitted than the heavier filament.

confirmed that the running lamp was used extensively because of the darker color and the pitting present in the smaller gage filament used for the running lamp. However, this does not prove that the headlights were on at the time of the impact. The running lights can be engaged without the headlights. These lights would have been visible by the concrete truck driver, but would not meet the law requiring the headlights must be on before sunrise. No filaments or lamp parts were available from the right side running light; therefore, no analysis could be made from right side the lamp filaments for their on or off condition at the time of impact.

New or seldom used filaments will exhibit a brighter and less pitted appearance on the filament than a filament that has had extensive usage. In this case the driver's side headlight filaments were examined with a microscope. The high beam filament was bright, exhibited very slight pitting of the filament, and was nearly straight. This would indicate that the high beam filament was not often used. The nearly straight filament would indicate that the filament was not incandescent at the time of impact. The high beam headlights were not on at the time of the accident. This does not affect the condition of the low beam filament at the time of impact.

The smaller gage filament for the low beam exhibited a very pitted appearance in addition to being slightly curved. However, it could also be argued that this curvature was the result of cold shock because the filament deflection was slight. This still did not provide definite proof that the low beam lights were on or off at the time of impact. Therefore, a conclusion of on or off could not be positively made by using only this evidence from the driver's side lamp analysis.

A mechanics shop manual wiring diagram was acquired for the 1985 Ford F-250 pick-up truck. The wiring diagram confirmed the circuitry and color coding originally designed for the headlight and running light filaments. The wiring diagram also confirmed the running lights remained on with the headlights. An exemplar 1985 Ford F-250 pickup was used to confirm the running lights are on with the headlights. The running lights may be illuminated without the headlights being on, but the headlights cannot be illuminated without the running lights also being on.

An examination of the passenger side headlamp area showed all remnants of either the high beam or the low beam filaments were missing. However, by carefully searching the bed of the pick-up truck the remnants of a socket and three braided, color coded wires approximately 8 inches in length were found (See Figure 4). A comparison of these wires to the drivers side headlight socket wires confirmed the same configuration and color coding of the wires. The mechanics shop manual provided further confirmation of the color coding and

wiring diagram for these headlights. Only one small part of the back reflector of the sealed beam headlight and its knife blade type plug-in connector to the socket was still available for inspection. A microscope examination of the wire ends revealed convincing physical evidence to prove the lights were on at the time of the impact.

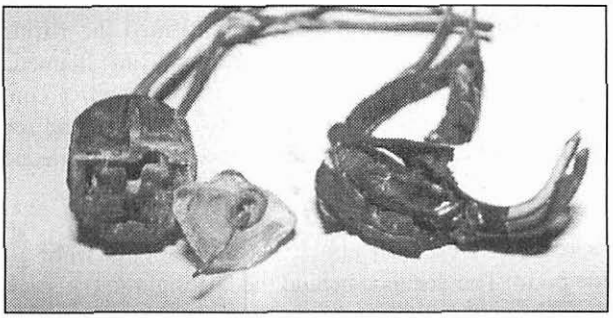

Figure 4
Right front headlight socket and approximately 8" of three wires.

The wiring on the left side headlight socket was visually traced and confirmed that the wiring diagram depicted the wire coding for each filament and was the same in the accident vehicle. The left side sealed beam, halogen headlight was removed for laboratory analysis. A glass cutter and heat were used to remove the halogen lamp from the sealed beam headlight. An exemplar sealed beam headlight lamp was also obtained for comparison to the accident vehicle headlight. An extensive microscope, both visual and photographic, inspection was performed on these two headlight lamps. These observed conditions were used for comparison of the accident headlight lamps taken from the drivers side. The vehicle high beam filament was bright and very slightly curved. This condition was compared with the exemplar lamp, thus confirming the high beams were seldom used and were not on at the time of impact. However, the low beam filament exhibited substantial pitting and darker color, confirming this low beam filament was used extensively. The curvature on the low beam filament was more curved than the exemplar filament and supported the conclusion the low beam headlights were on at the time of the impact. However, it was not conclusive proof that the low beam headlights were on at the time of the impact. The slight additional curvature could be argued to have been caused by 'cold shock' rather than the 'hot shock' from an incandescent filament. The heavy filaments used for halogen lamps in addition to the distance from the impact zone, precluded a positive conclusion for either on or off based on this evidence alone.

Electrical wires that are energized at the time of sudden separation will form a small rounded end on the wires due to breaking continuity of the circuit. Electrical wires that are not energized at the time of separation will be necked down or be sheared cleanly, but will not show a rounded end. The debris in the bed of the pick-up truck was collected at the impact site by the tow truck oper-

ator. Among the debris was a headlight socket with three wires approximately 8 inches in length. Each of the conductors consisted of multiple small wires to make the conductor. Each wire had enough insulation still intact to provide a positive color code. A comparison to the shop manual confirmed the wiring color code for the heavy (high beam) filament, the smaller (low beam) filament, and the neutral wire. A microscope inspection of the three braided wires confirmed one was well rounded on the ends, one was slightly rounded, and the other was sheared clean with no indication of rounding of the individual braided wires.

The three braided wires that were still attached to the socket were all sheared very near the same point. The distance behind the headlight to the shear point was 8 inches or less. Using a crushing speed of 50 miles per hour this would suggest approximately 10 milliseconds after initial impact to sever the wires. The battery was located behind the severed wires, allowing the electrical current to be present in the wires when severed. The three severed braided wire ends were closely viewed and photographed with the aid of a microscope.

The light green with black stripe (high beam filament) wire was sheared leaving sharp ends (See Figure 5) on the individual wires within the insulation. This confirms no power was present during the instant the wire was sheared. This filament, the high beam, was not energized at the time of impact. This alone would not be significant if all the wires were without energy when severed.

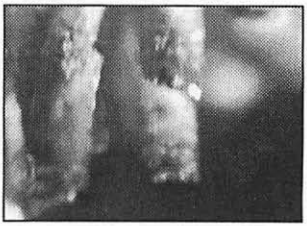

Figure 5
Individual wires within the light green with black stripe insulation. Note the sharp sheared wire ends, this confirms a lack of current when sheared.

The red/black insulation covering the braided wires provided current to the low beam filament. These individual wires were slightly rounded. This would indicate the wires were most likely energized at the time of severing. While this is an indication, it still cannot be sufficient to conclude the current was definitely on when this wire was severed.

The black insulation covered wire, the neutral wire, had all the individual wires well rounded. This confirmed without doubt that the neutral definitely had current at the time this wire was severed. With the neutral wire definitely carrying current, the wire with the slightly rounded wires would be the most likely continuation of this circuit. That circuit passed through the low beam headlight on the right side of the pick-up truck at the time of impact.

Combining the evidence with the other suggested information from the left side deflected headlight filament, the conclusion can definitely be stated that the pick-up truck had its low beam headlights on at the time of impact. The wiring diagram and comparison with exemplar vehicles confirmed that the running lights would be on with the headlights.

Conclusion

The pick-up truck had its low beam headlights and running lights on at the time of this accident.

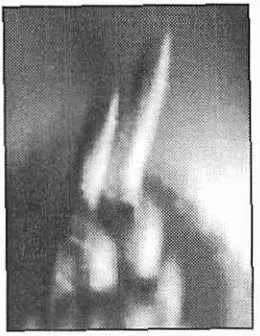

Figure 6
This is the red black wire that was connected to the low beam filament. Note the slightly rounded ends.

Figure 7
Black wire neutral, showing strong rounded ends, a positive proof that this wire was energized at the time of severing.