Hot Surface Ignition – Unraveling the Myths

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INTRODUCTION

Every year in the United States, property losses associated with motor vehicle fires exceed 1 billion dollars and account for an estimated 20 percent of all reported fires [1]. Over two-thirds of these vehicle fires originate within the engine compartment [1] where numerous fuels and ignition sources exist in close proximity. While ignition of an automotive fluid by a hot surface within the engine compartment is often claimed in litigation involving motor vehicle fires, little data exists in the literature on this subject and expert opinions with respect to this ignition mechanism are often incorrect.

One of the most common errors associated with expert opinions involving hot surface ignition is the inappropriate use of "ignition temperature" data in reference books and guides. A classic error is for the fire expert to make a direct comparison between this "ignition temperature" and the temperature of the surface. If the surface temperature was higher than the "ignition temperature", the expert incorrectly concludes that ignition occurred when this fluid came into contact with the hot surface.

In this presentation, the source of the "ignition temperature" data is examined and new data involving a single drop of liquid contacting a horizontal heated plate is presented. Then, tips and suggestions for questioning the opposing expert claiming a hot surface ignition are presented.

IGNITION BY A HOT SURFACE

The ignition data for automotive fluids presented in most standard reference books and fire investigation guides was derived using ASTM E-659, Minimum Auto Ignition Temperature of Chemical Liquids. In this test, approximately 100 μl of fluid is inserted into a uniformly heated 500 ml glass flask containing air at a predetermined temperature as shown in Figure 1. As the liquid enters the flask, it evaporates and mixes with the surrounding air. The fuel and air mixture is then observed for 10 minutes or until auto ignition occurs. The temperature of the air and the volume of the liquid sample are both adjusted until the minimum auto ignition temperature is determined.

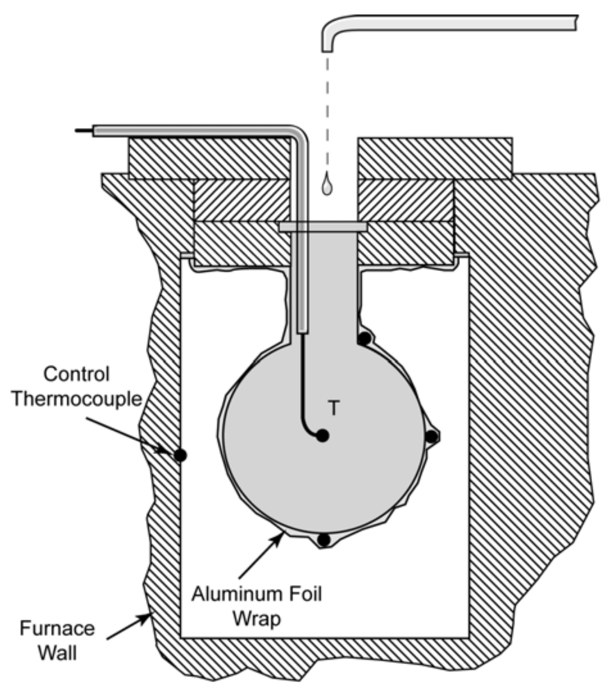

Figure 1 Apparatus used to measure the minimum auto ignition temperature of liquid chemicals as defined by ASTM E 659.

One of the most important, and often overlooked, features of ignition is that it is strongly coupled to the experimental conditions. This is illustrated in Figure 2, which shows the lowest ignition temperature for a single fluid under eight different test conditions. The lowest temperature to achieve ignition occurred when using the ASTM E-659 test apparatus and is shown as condition 1. Ignition in each of the other test conditions required temperatures much greater than the temperature required in the ASTM apparatus. Therefore, an expert opinion based on a comparison of the ASTM auto ignition temperature to the surface temperature is generally inappropriate. The surface temperature required for hot surface ignition is usually much greater than the ASTM auto ignition temperature. Failure to recognize this could lead to erroneous opinions concerning the cause and origin of the fire in question.

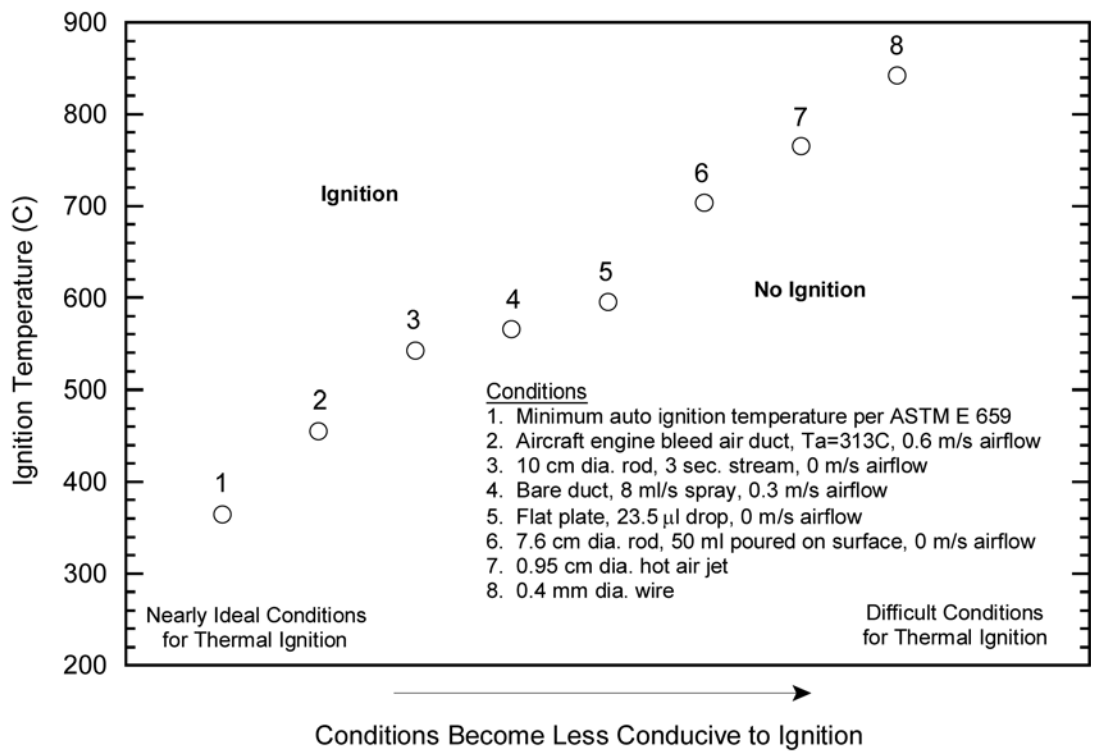

Figure 2 Effect of conditions on the temperature required to ignite MIL-L-7808, a turbine engine lubricant [2].

Although hot surface ignition of automotive fluids is often claimed in litigation, there is little data in the literature concerning the hot surface ignition properties of these fluids. To address this issue, Colwell and Reza [2] recently conducted a series of more than 2,500 ignition tests involving 14 automotive fluids. The experimental set-up for these tests was a horizontal flat plate onto which a single drop of the fluid was injected as shown in Figure 3.

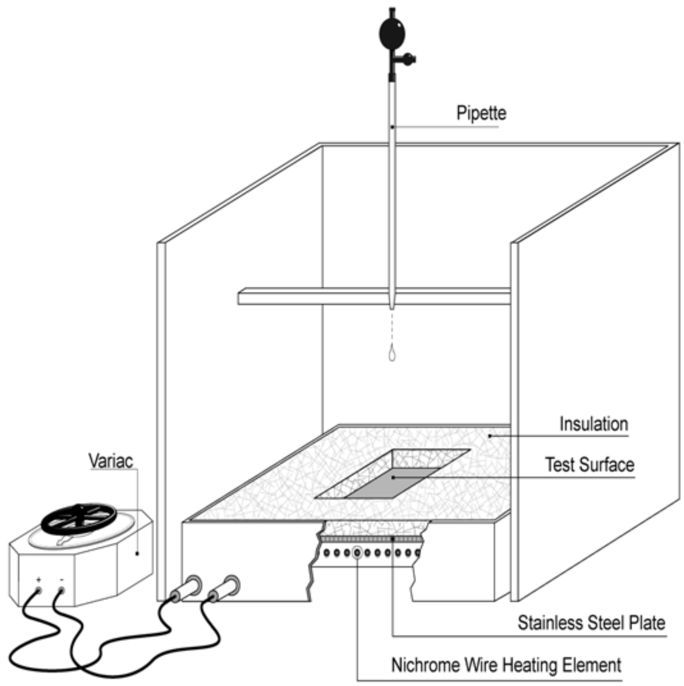

Figure 3 Hot surface ignition experimental set-up.

A significant feature of the results from this study is the overlap of ignition and non-ignition cases. The gasoline ignition data, shown in Figure 4, illustrate this overlap and is typical of the other fluids tested. In this figure, tests which resulted in ignition are assigned a *y*-value of 1, while tests which did not produce ignition are assigned a *y*-value of zero. Instead of a sharp demarcation point indicative of a well defined hot surface ignition temperature, there is a broad temperature range over which ignition becomes more likely. The probability of ignition increases as the surface temperature increases.

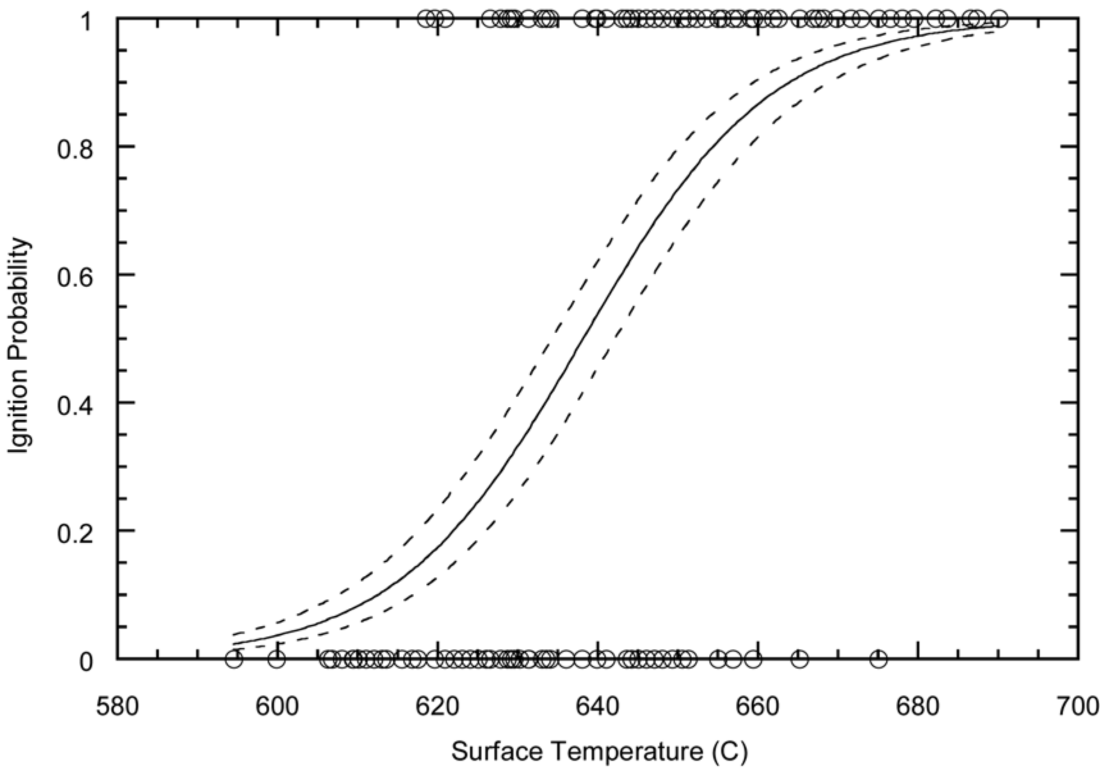

Figure 4 Ignition data points with logistic regression and 95% confidence level curves for gasoline [2].

Results for each automotive fluid tested are shown in Figure 5. It is interesting to note that, although gasoline is frequently alleged to have been the fluid involved in hot surface ignition, it is one of the most difficult fluids to ignite under the conditions tested. It should also be noted that the temperatures required for ignition under the conditions tested using a single drop of fluid on a flat, horizontal plate are higher than typical engine and exhaust surfaces, which generally range from 200 – 400 C [3].

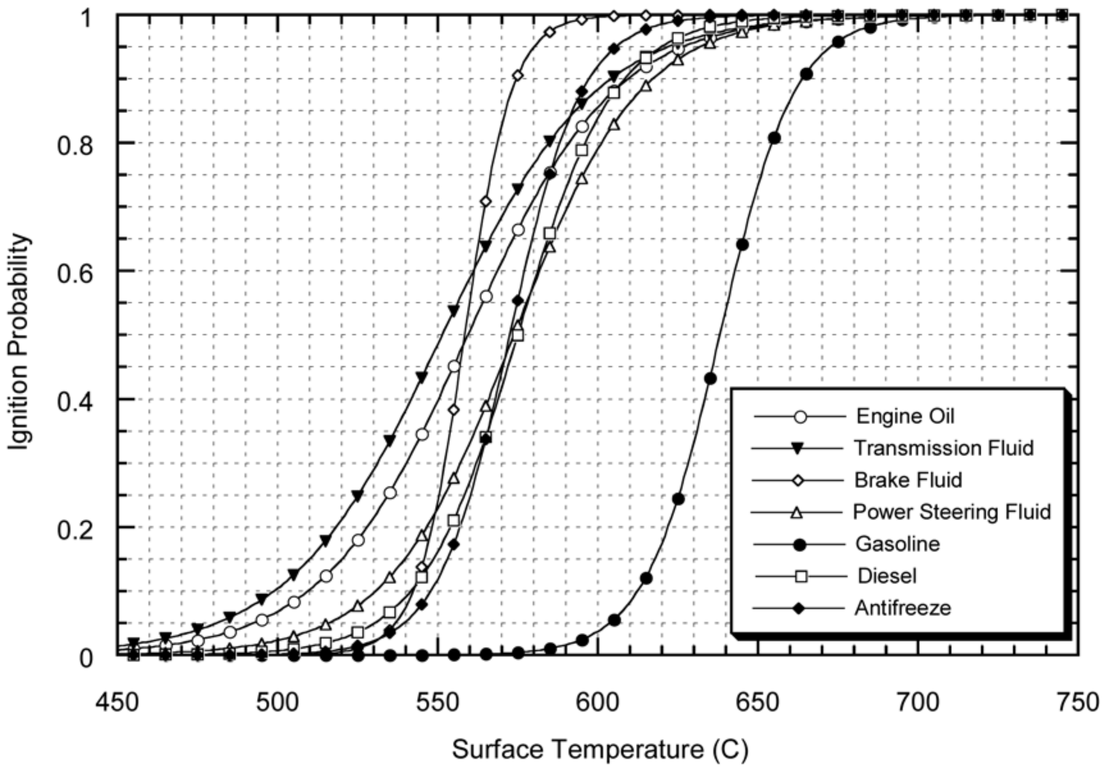

Figure 5 Ignition probability as a function of surface temperature for automotive fluids [2].

QUESTIONS TO CONSIDER WHEN EXAMINING THE OPPOSING EXPERT

If the opposing expert is claiming that hot surface ignition occurred when a particular automotive fluid contacted an engine surface, some areas to explore are outlined below. Failure to address these issues could lead to a successful Daubert motion to exclude the expert testimony.

- Did this expert simply compare the ASTM E-659 auto "ignition temperature" to the surface temperature? If so, this is an inappropriate use of the ASTM E-659 ignition data.
- Were any ignition tests conducted? Little data is available in the literature and since ignition is very sensitive to the test conditions, testing is generally required to develop a defendable opinion.

- Were the tests representative of the actual conditions? Because the temperature for ignition is strongly dependent on the conditions associated with the test or accident, conditions need to be substantially similar.
- Was the statistical nature of the ignition process taken into account? Even under well-controlled laboratory conditions, there can be significant overlap between ignition and non-ignition results and it may be important to characterize this overlap.

CONCLUSIONS

While ignition of an automotive fluid by a hot surface is often claimed in litigation involving motor vehicles, little data exists in the literature on this subject and expert opinions with respect to this ignition mechanism are often incorrect. One of the most common errors associated with hot surface ignition is comparing the ignition temperature from the ASTM E-659 test to the surface temperature. Data in the literature clearly shows that the actual temperature required for ignition is generally much higher than the ASTM E-659 ignition temperature.

Because hot surface ignition is complicated and strongly coupled to the accident or test conditions, testing is usually required to develop a reliable ignition opinion. Failure to conduct careful and appropriate ignition tests, or to not conduct any tests at all, could lead to a successful Daubert motion to exclude the associated expert opinions.

REFERENCES:

[1] Strawhorn, L., "Motor Vehicles" in *Fire Protection Handbook*, Quincy, MA: National Fire Protection Association, 2003, Section 14, Chapter 1.

[2] Colwell, J.D., and Reza, A., "Hot Surface Ignition of Automotive and Aviation Fluids," *Fire Technology*, Vol. 41, No. 2, 2005, pp. 99-117.

[3] Babrauskas, V., *Ignition Handbook*, Issaquah, WA: Fire Science Publishers, 2003.