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HIGHWAY VEHICLE FIRES

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According to the United States Fire Administration, one of every six fires is a vehicle highway fire. In the United States between 2004 and 2006 there was an annual average of 258,500 vehicle highway fires resulting in approximately 490 deaths, 1,275 injuries and one billion dollars lost. Approximately 68% of all highway vehicle fires involved normal passenger vehicles such as personal cars and trucks. Another 15% of highway vehicle fires involved some other type of passenger vehicle, and 6.3% involved freight transport vehicles¹.

Although the losses attributed to highway vehicle fires is annually declining² as a result of newer safer automobiles, it is clear more work needs to be done in this area. The first step in making automobiles safer is determining why they catch fire in the first place such that those responsible can be held

accountable. This is accomplished through proper vehicle fire investigation.

A complete vehicle fire investigation includes examination of the site of the fire as well as examination of the vehicle itself.

A thorough examination of the site where the fire occurred, such as the side of the highway, will yield useful information to the investigator. The grade of the roadway and the position of the vehicle on the roadway are important factors as they influence the direction of fire spread. Sometimes debris, such as vehicle components or electrical conductors, is left at the fire scene. Examination of such debris can be vital in order to eliminate possible fire causes. The weather and wind direction at the time of the fire are also important considerations, and some research or background information is required to obtain accurate data.



Figure 1: Engine compartment fire in progress.
Monroe Fire Department (www.monroefd.com)

Environment Canada has a free online database containing historic weather data that lists hourly temperature, wind direction, wind speed, and a description of conditions for locations throughout

¹ U.S.F.A. *Highway Vehicle Fires*. Topical Fire Report Series. Vol. 9, Issue 1., September 2008.

² U.S. Fistration. URL:

<http://www.usfa.dhs.gov/statistics/national/vehicles.shtm>.

Canada. Where vehicle fires are involved, the surrounding environment at the time of the fire must be considered in order to perform a complete investigation, and arrive at a scientifically sound hypothesis.



Figure 2: Examination of windshield. Glass is intact at top of windshield and melted at bottom, indicating fire spread from engine compartment.

The investigation of a vehicle fire begins with establishing the origin of the fire. The National Fire Protection Association 921, "Guide to Fire and Explosion Investigations" contains a "Vehicle Fire" section that should be referenced by fire investigators. Other reference materials include the Ignition Handbook, and peer reviewed technical papers that deal with various issues, such as the hot surface ignition temperatures of various fluids. The basic methodology for investigating

a fire endorsed by NFPA 921 is the scientific method. This is a systematic approach that is used to uncover factual data and test hypotheses. The origin of the fire can either be established by a thorough and comprehensive scientific evaluation or by a single irrefutable account of the area of origin by a dependable eyewitness.

The investigator can determine the area of origin by performing fire pattern and arc mapping analyses.

Some common fire patterns include radial oxide burn patterns on body panels, melting to the windshield, and damages to tires. During a fire, radial oxide burn patterns will remain on the exterior body panels and can be useful in determining the area of origin and direction of fire spread. A radial oxide burn pattern suggests the fire spread from a point in line with the centre of the pattern. The condition of the windshield can also be evaluated to determine the direction of fire spread. A windshield that is consumed/melted at its base is usually an indicator of fire spread from the engine compartment, whereas a windshield that is consumed/melted at its top is usually an indicator of fire spread from the passenger compartment.



Figure 3: Radial oxide burn patterns on hood.

The condition of the front tires can also provide indication as to the area of origin and direction of fire spread. During engine compartment fires, fire spreads to the tires quickly and results in heavy consumption damages to them. During passenger compartment or cargo compartment fires, the tires often sustain minimal damages. The investigator must be especially careful when evaluating vehicle fire patterns as an imbalance of fuel loads with high heat release rates can create misleading patterns. Proper origin determination requires that all fire patterns and witness information be considered in order to scientifically determine an area of origin.

Arc mapping analysis can also aid in determining the direction of fire spread. Beads produced by electrical arcing activity remain on conductors after a fire and indicate which circuits were energized at the time of the fire. Correctly identifying arc beads and accurately mapping them may allow the investigator to define a precise area of origin. Arc mapping analysis should be performed as part of a complete evaluation of the vehicle electrical system, which includes examination of affected conductors, examination of all fuse/relay panels, and consideration to all energized electrical systems and devices.

Once the area of fire origin has been determined, the fire investigator must consider all of the possible causes for the fire. Common ignition scenarios for passenger vehicle fires involve the following:

1. A fugitive leak of fluid such as brake fluid, engine lubricating oil, or

fuel occurring within the engine compartment and becoming ignited by arcing, sparking, or hot engine components;

2. An electrical ignition source, such as a high-resistance connection, overloaded wiring, or short-circuit;
3. A mechanical ignition source, such as mechanical friction; and
4. The careless misuse of smoker's materials; and,
5. A deliberate act.



Figure 4: Engine compartment after fire.

The fire investigator must consider the physical properties of all the flammable and combustible liquids within a vehicle as well as the flammability of the materials and upholstery that are used in the construction of the vehicle. Although the interior materials of vehicles are required to meet flammability standards within the passenger compartment of vehicles, special expertise is required to interpret the real-life implications of these standards. In addition, when considering ignitable hot fluids on a hot surface, consideration must be given to shielding and the location of the hot

surfaces with respect to the location of the fugitive hot fluids.

Electrical sources are an important consideration in the ignition of vehicle fires. Batteries within vehicles provide a competent source of ignition even after the ignition switch has been turned off. Furthermore, some circuits remain energized when the ignition is off such that evaluation of the vehicle electrical system is crucial even when the vehicle was not in use at the time of the fire. Special expertise is required to examine the electrical system of a vehicle after a fire and determine whether the electrical system was responsible for the initiation of the fire.



Figure 5: Example of arc bead on a supply conductor to a starter motor.

Newer vehicles present new challenges for investigation of post collision vehicle fires. Hybrid vehicles that utilize electromotive force from stored battery power can increase the risk of electrically initiated fires. Manufacturers are also using electrical systems with higher voltages between 24, 36, and 48 volts DC and 120 volts AC/DC. More sophisticated vehicles utilize engine management systems which incorporate triac(s) (bi-directional electronic switches) that can react more quickly than conventional fuses and breakers.

Proper vehicle fire investigation is essential to determining cause and assigning responsibility, especially when litigation is a possibility. It is necessary for the investigator to examine both the scene of the fire and the vehicle in order to perform a complete investigation. When examining the vehicle, the investigator must determine an area of origin, and then evaluate all vehicle systems and potential fire causes within that area in accordance with the guidelines of NFPA 921. This process requires special knowledge and expertise in the areas of fire dynamics, fire chemistry, mechanical systems, and electrical systems. It also requires continual education in vehicle technology as the vehicle industry continually changes at a rapid pace. Ultimately, the goal of proper vehicle fire investigation is to accurately determine fire cause and responsibility such that future fires can be avoided through safer vehicle designs.

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Ryan Cockle is an engineering graduate with Rochon Engineering Corporation, a multidisciplinary forensic engineering firm. Ryan is a NAFI certified fire and explosion investigator, vehicle fire investigator, and fire investigator instructor. Ryan and the Professional Engineers at Rochon Engineering Incorporated have depth of expertise in vehicle fire investigation. Visit us at www.rochons.ca