VEHICLE FIRES

A PRACTICAL APPROACH

by
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Determining the origin and cause of a vehicle fire is indeed a formidable task. Before one attempts to determine the "how s" and "why s" of a vehicle fire you must know and understand the makeup of the materials that the vehicle is constructed from. Knowing the ignition temperatures, flash points, melting points and flammability of the various materials is a *must* in making these determinations. Use reference guides such as *NFPA 921 Guide for Fire & Explosion Investigations.* It is also very important to know how recently the vehicle has been operated. It is much easier for fires to accidentally start in a hot engine area than a cold and a fire will burn and expand quicker in a hot engine compartment. Unlike dwelling fires, vehicle fires burn similar to a fire in a barrel or small incinerator. The major damage occurs in a short period and the fire becomes all encompassing. Normally, within fifteen minutes, major destruction has occurred and in many cases, the evidence that would indicate what caused the fire to start will be destroyed. There are two major groups that vehicle fires come under, Intentional and Accidental.

Intentional Fires

Insurance fraud is one of the major reasons for vehicle fires and in many cases; the vehicle has been reported stolen. To make this a successful endeavor the owner must make this whole scenario appear as though it was performed by a thief; therefore, the owner must think like a thief. He or she has to make sure everything is done to make the vehicle look as though it was stolen when it is found by the police or fire department. The ignition system must be defeated in such a way that someone could start and/or steer the vehicle. If they don't defeat the ignition system they must be able to show that someone could have a copy of their key, use a special key that will operate their vehicle or their lock was picked. This is an area where the investigator must use a lot of caution because of the many lock-picking and by-passing devices that are available on the market today... If the vehicle is equipped with an alarm or anti-theft system, this also must be defeated. Many of these devices like Chapman locks and kill switches can deter the amateurs' thief but knowledgeable thieves can defeat most of these systems in a short period. In most of these systems, the thief goes under the hood and simply pulls the alarm or shorting wire off. With the newer vehicles the transponders are very popular and offer a greater challenge to thieves.

Vehicles are stolen for various reasons some of which are profit, joy rides or to be used in a crime. The owner wanting to follow this assumption, in many cases, will remove something of value to make the theft scenario look good. The problem at this point is that the owner, in most cases, does not know how to do all the above. To cover up for his lack of knowledge, he will burn the vehicle hoping to cover his mistakes. Vehicles that are stolen for joy rides and to commit crimes are burned in many cases to cover up fingerprints or any evidence that may have been left behind. If the engine is in very bad condition or possibly to the point of seizing, the owner will sometimes start the fire in the engine compartment as well as the interior. If the insured performed all of the above procedures properly then your job of proving fraud will be near impossible. Thankfully, in many of these cases, they do not do all that they should properly. In all of these cases a thorough investigation of the vehicle and the facts surrounding the theft must be performed. Determining the origin and cause of these fires is usually straight forward because no one is trying to hide the fact that the vehicle has been purposely set on fire. Note; Do not do these investigations lightly. If a police or fire agency is going to charge the owner with attempting to defraud the insurance company and burning of a motor vehicle, a good fire investigation must be done. If the fire is put out in a reasonable period, you will have a good chance of making the exact determination and finding an accelerant if one was used. In many of these fires the vehicle is taken to a remote location where it is near impossible to get at the vehicle readily thus allowing it to burn near complete. As impossible as it may seem, we have had successful investigation with these so-called

"Crispy Critters". In the debris, we have found keys and other items that indicate the vehicle was not stolen.

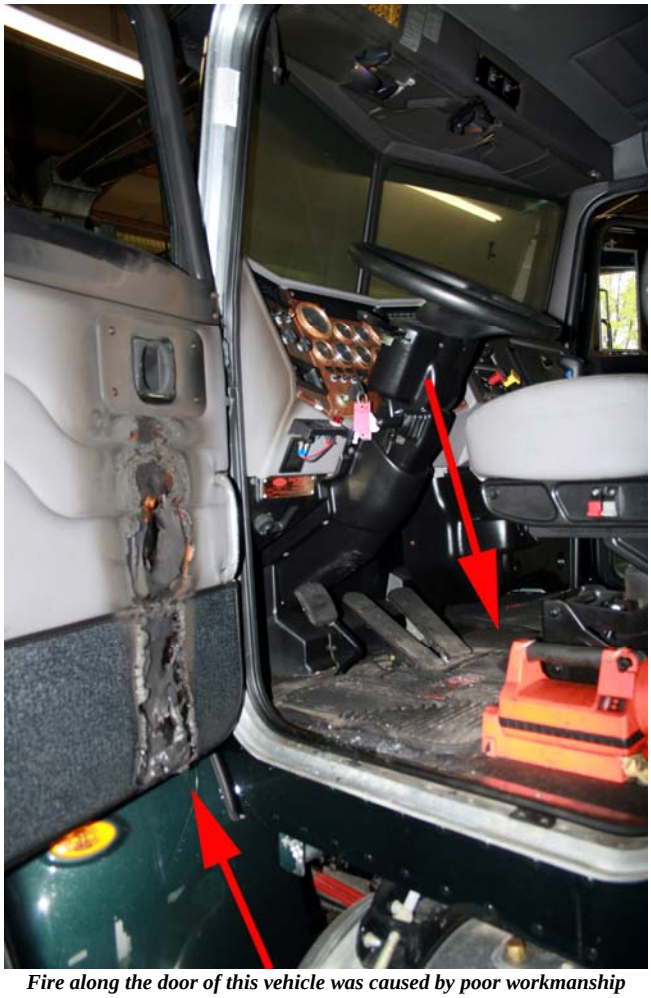
Other types of intentional fires are; revenge, to cover up a crime and destroy evidence.
Investigating a revenge fire is difficult because no one seems to know the reason why or motive the vehicle was burned unless a message of some type was conveyed to the victim. In many cases, these fires are left undetermined if they are burned out, credited to vandalism or are very obvious due to the hurried manner the fire was set. These fires occur in the vicinity of where the victim works or lives. Rarely will you see a vehicle stolen for the purpose of revenge. This would expose the perpetrator to his greatest fear, which is of being caught.

Fires to cover up a crime or destroy evidence are not always obvious because you are dealing with professional thieves that know how to steal vehicles. In many cases, these vehicles are fairly new and fast. These vehicles will be found with various levels of ignition damage and nothing will be stolen from them. If the insurance company or police agency investigator does not know that the vehicle was stolen for use in a crime, they may suspect that the owner is involved because nothing was stolen from the vehicle. This is where proper investigative techniques must be used to avoid accusing an innocent person of a crime or denying their insurance claim.

Improperly factory installed battery cable on the solenoid caused five new vehicles to burn.

Accidental Fires

This is where your knowledge of the particular vehicle is very important. Before attempting to examine the vehicle, check on line to the various consumer and government agencies to see if there are recalls or historical data to assist you. The majority of accidental fires occur in the engine compartment. This is true for automobiles, trucks and heavy equipment. Prior knowledge of how the components are laid out and how dense their arrangement is will help you to understand how rapid the fire spreads. The engine compartments of modern vehicles have many plastic components that once ignited will quickly spread the fire. In some inexpensive or older vehicles, the population of components in the engine is sparse and there is less plastic used. In these vehicles fire does not spread as rapidly therefore burns for a longer period or it has a better chance of burning itself out. The origin of the fire in the engine is sometime quite difficult because of the amount of flammable items and how easy the fire transmits between them. For example, assume that an electrical wire in a harness shorted in such a way that it became very hot. This would cause the vinyl coating on the wire, and those surrounding it, to melt and then ignite. The harness will now act like a wick carrying the fire to a location where other flammable items are, thus causing them to ignite. Now assume the secondary fire burns very intense before the fire is put out. For example: If the fire burns in the area of the master cylinder or hydraulic lines in heavy equipment, the fluid will ignite resulting in an intense area of burning. The appearance of this second burn will make it look like the origin. This will also mislead investigators to thinking that the short was caused by second fire. Like in most fires, the greatest area of burning is not necessarily the area of origin. What came first, the chicken or the egg? This is a common dilemma in vehicle fire determination.



Fire along the door of this vehicle was caused by poor workmanship while installing a 12volt line to a lantern charger

Vehicle fires are caused by defective or worn components, poor workmanship, age or normal deterioration and lack

of proper maintenance. Before attempting to examine a burned vehicle, find out its history. When was the last time the vehicle was driven? How well did it run? When is the last time the vehicle was serviced? Have there been any product recalls on this vehicle?

Wire were installed under metal trim and hold-down screw penetrated wire insulation causing short to ground

It has been estimated that modern vehicles contain hundreds of pounds of plastic materials (approximately 250 - 350 lbs, depending on size). The majority of these are thermoplastics and contains flame retardants. Thermoplastics melting temperatures are approximately 340^{o} F and above. It is not until these plastics begin to melt are the fire retardants driven out and at this point, the material becomes virgin plastic and will burn rapidly.

With the new hybrid or all electric vehicles the majority of these are constructed with plastic or fiberglass and will burn very complete leaving little to no evidence as to cause or origin. Finding many wires that short as a result of the fire is very common. In these fires it is very important to get as much information as possible before investigating.

Polyurethane Foam

This is standard material throughout the interior of the modern vehicle. It is contained within the seat cushions, dashboard, headliner, door panels, consoles and armrest. This material will burn with the intensity of gasoline once ignited. I have demonstrated the intensity of a fire fueled only by the plastic and polyurethane foam at many car-burning demonstrations by simply starting a small fire behind the dash using a hand full of newspaper. This will have the interior engulfed in flames within five minutes and it does not make much difference if I left the windows open or closed. Even with windows closed in today's vehicle there is ample air coming through the vents that will feed a slow growing fire. The temperature difference between the inside and outside, in most cases, will quickly cause windows to fracture and break allowing in more air or oxygen. Polyurethane foam burns like any liquid accelerant where the hydrocarbons must be driven into a gaseous state (vapor) before they will burn.

This personal bus stated burning at rear left side while driving

Poor maintenance failed to properly tighten engine pipe exhaust clamp was the cause

Antifreeze Fires

These are probably the most common among older automobile engine fires. Many car and trucks today are involved in fires that are caused by antifreeze leaking on to hot engine surfaces. Many of these fires are going completely unsolved because many investigators do not realize how flammable antifreeze is.

Many times you will hear the scenario that someone was driving along and noticed the engine was overheating or saw steam coming from the engine compartment and when they stopped the engine burst on fire. What happened here? Antifreeze is a mixture of ethylene glycol and water at a normal dilution of 50/50. Ethylene glycol has a flash point of 231.8^{o} F and the auto-ignition temperature is 770^{o} F and the LEL 3.2% UEL 15.3% We also know that the manifold in a running gasoline engine or turbo charger in trucks can reach temperatures that well exceed the Autoignition temperature of ethylene glycol. These temperatures can auto-ignite even the heaviest hydrocarbons found in the engine compartment

When hot antifreeze mix leaks onto the hot surfaces of an engine, the water/glycol will begin to boil, keeping the solvent mix at a temperature of approximately 225^{o} F until most of the water has boiled away. (Mixing antifreeze to water raises its boiling point) At this point, what remains is pure ethylene glycol that will now heat and vaporize to its flash point of 240.8^{o}F. If a stray spark from a high voltage

wire or an electrical component occurs in the area of the vapors from the glycol, ignition will occur. If no spark is available, then the glycol will continue to heat and vaporize. If a portion of the glycol comes in contact with a hot manifold or turbo charger surface, then auto-ignition will occur. Once ignition occurs in either of the above cases, the fire will burn in a normal manner and ignite other petroleum products or plastics in the engine. This phenomenon has been reproduced and documented many times at K-Chem Labs. These experimental results have been used in courtrooms to prove beyond a doubt the manner in which antifreeze fires occur. Being a petroleum product, ethylene glycol or propylene glycol burn very intense and will reach temperatures in excess of 1300^{o} F. These temperatures are sufficient to cause the melting of aluminum and zinc engine components such as radiators, alternator housings, air conditioning pumps, valve covers and carburetors.

These accidental fires will sometimes have the appearance of being intentional because of the heat that is generated or the appearance of accelerant burn patterns. It is normal for aluminum radiators to burn or melt from the top down in a "V" pattern. This happens as the antifreeze boils out and burns causing the radiator to melt. In cold engines, contrary to the above, rarely will you ever see an accidental fire as a direct result of antifreeze. This is why it is very important for a fire investigator to have complete knowledge of all the events related to the vehicle before the fire started.

Improperly installed fuel injector destroyed this vehicle

Gasoline Fires

These happen because of various faults in the fuel line connections, carburetor or fuel injection systems. It is becoming more common today to see the electric fuel pump located in or at the gas tank. The great safety feature built into most of these pumps is that they must receive a return pressure pulse from the return fuel line in order to produce another pulse of fuel. If the feed or return fuel line develops a large fuel leak such that no return pulse gets to the pump, then the system immediately shuts down. The benefit of this is if the fuel line breaks open, only a little fuel will escape. If a fire is generated by this break, no additional fuel will feed the fire. These systems are not a total cure though because the fuel lines can leak a little and still return a pulse to the pump. This little fuel leak can cause a fire to start if a spark or very hot surface comes in contact with fuel or vapors. The listed auto-ignition temperature of gasoline is 810^{o} F. This temperature result is done at the lab in a closed cup Pensky-Martens apparatus and using an ASTM standard procedure. This test does not simulate the conditions in a vehicle. It has been estimated that, it takes temperatures in access of 1700^{o} F to auto-ignite gasoline vapors in the vehicle atmosphere. Do not be mislead by these values, where the flash point of gasoline is anywhere between -45^{o} to -25 ^{o} F, a simple electrical spark, which has a temperature greater than 3500^{o} F, will ignite the gasoline vapors instantly.

Fires that start in the area of the carburetor and burn for an extended period will sometimes cause melting of the carburetor as long as a continual supply of fuel is available. The area under the carburetor in general does not have a lot of flammable products, so there has to be a supply of fuel to cause the heating of the carburetor to its melting point. (900^{o} -1220^{o} F) This also causes the burning of the paint on the hood directly above it. The hood is a great indicator of the location and intensity of the fire in the engine. Breaks or bad connections in metal fuel line are, in many cases, easy to find. With so many vehicle now using plastic lines, finding a fuel leak cause becomes near impossible because all the lines burn away.

The above vehicle was totally destroyed as a result of a the defective auto shutoff filler valve causing diesel to over fill the tank and the vehicle left running while being fueled

Diesel Engine Fires

Much of what I said earlier applies here even though they tend to run cooler than gasoline engines. Turbo chargers failure or leaks can cause fires. A turbo surface can reach temperatures in excess of 900^{o} F while the engine is under load.

Oil Fires

These happen as a result of carelessness, oil leaking from valve covers or leaking lines that migrates to the hot manifold surface. Oil will auto-ignite at 850^{o} F. These are not uncommon fires. There have been factory recalls that addressed this problem by placing diverters to keep leaking oil from flowing onto the manifold. In many cases, these fires will be misread thinking they are caused by a fuel leak. This is because the fire burns up the side of the engine causing damage to the carburetor or area about it.

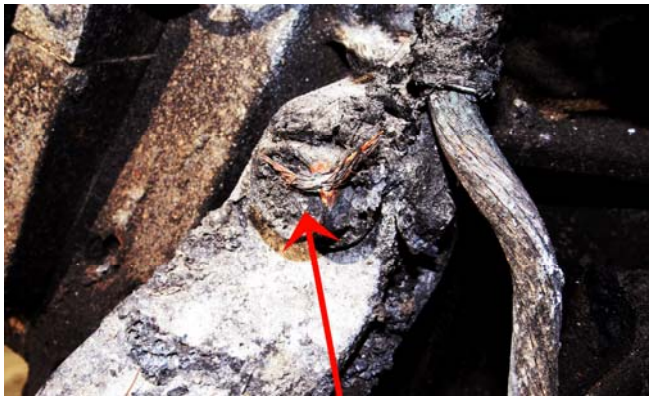
Power steering and **Brake fluid** rarely cause fires to occur but once heated in a fire will burn with great intensity. During a fire, leaking brake fluid from the master cylinder burns intense as it runs down in the firewall area and will sometimes mislead the investigator into thinking an accelerant was poured there or it's the origin of the fire.

This truck burned while idling

A cracked oil feed line to turbo was the cause

Electrical Fires

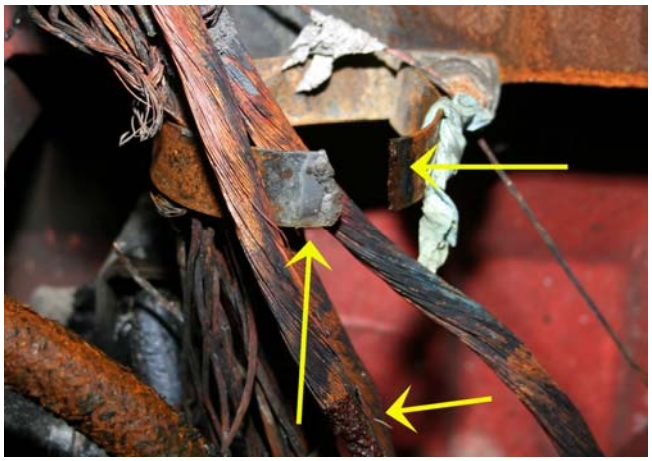
Fire started in front of the vehicle after it was turned off



Defective cooling fan caused the above fire

These take a lot of diligent searching in vehicle fires. So many of the wires are buried within harness that end up burned. Separating these harnesses takes a lot of time and requires a lot of patience. If the fuse panel is still intact, it can be a good source of direction for interior fires.

A lot of the wiring in engines do not have fuses therefore when they short out there is normally melting or fusing together of wires. These wires when found are often brittle if they became very hot. If the short is to ground and the hot wire runs through a harness, you will find the entire wire has the vinyl insulation melted from the point of the short back to the source.



A loose battery cable clamp wore through the insulation causing short. Note; cable never severed!

When smaller wires are fed by larger wires and the smaller wire shorts, the melting will only go back to the larger wire. The above are general facts and like everything, there are variations to these rules. When investigating fires that appear to have started within switches or small motors, use a lot of care removing these parts. They normally have plastic housings and structure, once burned, crumbles easily. Put a container under these parts when you try to remove them in order to catch the small electrical contact as they fall out.

Use Arc Mapping to show the area where electrical activity occurred during the early stages of the fire.

Poorly secured battery cable and fuel lines eventually wore through causing short circuit and fire

Normal Progression of Fire

The progression of fire in vehicles, that have an accidental origin, are obvious but worth reviewing. When looking at the overall progress of a vehicle fire, try to find out what the wind conditions where at the time of the fire. The wind can make a major difference in the progression of a vehicle fire causing misconceptions on how the fire started and burned.

The following progressions are for none wind conditions.

Dash board fires. Fires that start in the dashboard will consume those flammable materials then progress up to consume the headliner quite readily. The windows, if closed, will start breaking out allowing the fire to intensify taking out the rest of the windows. At this point, the vehicle will burn like a large container burning the top of the seats and working down toward the floor.

There is no oxygen at the floor level so the only thing that can occur is radiation damage from above causing melting of synthetic materials and production of more flammable gases to burn above. If an accelerant were on the floor, at this point, it would burn either because of the lack in oxygen. This is why, even after an extensive burn, we can still find accelerant residue in the debris of vehicles. Depending on the type vehicle, at ten to fifteen minutes into the fire, the fire will pass into the engine compartment and into the trunk area. The fire will continue in near "V" pattern from the interior out and consume the entire vehicle in approximately 45 minutes to an hour.

Engine Fires. Hot engines burn faster than cold engines. Assuming the fire starts at the center of the engine compartment and the fire reaches the point where the paint is starting to burn off the major portion of the hood. Breakdown of the plastic firewall components starts. Fire normally passes through the firewall in the area where the heater fan and air conditioner are. The casing of these items is usually plastic or sometimes thin aluminum. Either will be consumed readily allowing the fire to pass into the interior. Once the fire reaches the interior, it will burn in the same manner as the dashboard fire above. As the fire passes through the dash, it will also start to consume the antifreeze coming from the burned

hoses and cause the coolant to boil out of the radiator and burn. The plastic front and rear ends of modern vehicles bring fire to either extreme in a short period. The more plastic or fiberglass these vehicles have as part of the body structures the quicker and more complete the vehicle will burn. Most cars will completely burn in 45 minutes to an hour without any accelerants being added to assist.

This article is by no means a complete guide to doing vehicle fire investigation. I have burned more than 200 cars, boats and trucks at various seminars and vehicle fires have investigated several thousand vehicle fires. The intent of this article is to share my observations and experience. I hope it will serve as an aid to helping others in developing ideas as to the cause of the particular fire that they have to investigate.

Mike Higgins has a background in electronics and chemical analysis. Been involved in advanced training programs and is a Certified Fire & Explosive Investigator. Has burned over 200 cars, trucks & boats at training seminars. Performed hundreds of laboratory experiments on determining how materials burn and investigated over 2000 vehicle fires. Also, has testified over 200 times as an expert in court.

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