D5 Vehicle Fuel Systems: Low Performance at a High Cost to Motorists

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The goals of this presentation are to explain how and why a variety of automotive safety defects exist, along with effective countermeasures and safer alternative designs. The effects of low cost vs. high performance in automotive designs will be demonstrated by analyzing and discussing fuel leakage and ignition designs attending otherwise preventable human injuries.

This presentation will impact the forensic science community by illustrating how to recognize and prevent unsafe fuel system designs as well as by introducing forensic evidence associated with fuel system failure, including puncture and separation of fuel system components, ignition sources, fire burn patterns, and effects on vehicle occupant survivability. Attendees will learn how and why fire occurs in readily survivable collisions in passenger cars, light trucks, and heavy trucks.

Vehicle fuel systems have presented extreme hazards to motorist safety since the creation of motor vehicles. One gallon of gasoline has sufficient energy to propel a vehicle many miles; therefore, it can have instantaneous life-threatening consequences on occupant survivability if ignited due to fuel leakage occurring during an otherwise survivable collision.

Many early vehicle designs employed gravity-feed fuel tanks located between the engine and windshield. This design often caused non-collision-related fires due to fuel leakage onto hot engine and exhaust components. Fuel tanks were then relocated underneath seats and elsewhere inside occupant compartments and, with rare exceptions, along the exterior vehicle perimeter. This general practice continued well into the 1960s and, in some designs, even later.

The earliest efforts involving automobile fuel system evaluation involved ground vehicle safety testing conducted by the United States Air Force in the 1950s, eventually leading to the 1966 creation of Federal Motor Vehicle Safety Standard (FMVSS) 301. By the late 1960s and early 1970s, sufficient research had been performed at the University of California Los Angeles in the Department of Transportation (DOT) Experimental Safety Vehicle program and at independent laboratories, such as Dynamic Science Inc., to develop properly mounted, crashworthy vehicle fuel systems that were sufficiently cost-effective to enable wide-scale adoption in mass-produced vehicles sold to the public.

The theme of low price vs. high performance clearly reared its head as, unfortunately, automakers have, to the present time, resisted efforts to implement improved high-performance fuel systems in favor of those with low cost, despite the continuing evolution of design improvements in racing vehicles and military aircraft fuel system integrity. These high-performance design improvements are significantly more advanced than those found in current mass-produced automobiles. Such design improvements are not only far more crashworthy, they often contain fire-preventive materials or protection systems that were validated via analysis and testing by researchers. This knowledge was disseminated in the Department of Defense *Crash Survival Design Guide* and other technical safety engineering literature published decades ago.

Unfortunately, the quest for low price is manifested in numerous examples in which automakers built vehicles that ignored well-established fuel system safety design guidelines. Specifically, fuel tanks have been located in vulnerable areas aft of the rear axle, inside cabs on pickups and utility vehicles, and outside frame rails (i.e., “sidesaddle”) on millions of light-duty pickup trucks manufactured through 1987. The lessons that should have been learned from these low-cost, dangerous designs were ignored by automakers who continued to produce unsafe vehicles well into the new millennia. These designs persist with fuel tank locations aft of the rear axle, fuel tanks with no check valves or tethers on filler necks, and fuel tanks lacking effective impact shields or interior bladders to resist fuel leakage if the tank is compromised. This has resulted in a significant number of fire deaths and recalls involving late-model production vehicles. With rare exception, there are no automaker efforts to test production fuel systems in real-world collision conditions, such as vehicle-to-vehicle crash testing at foreseeable highway speeds. Government efforts to improve FMVSS 301 still do not include designs to mitigate fuel tank leakage caused by “underride effects” commonly seen in many vehicle-to-vehicle collisions. Fuel system failures have also been caused by contact with guardrails, signs, and other common roadside fixed objects. None of these events are considered or evaluated by the DOT or any automaker.

Fuel system design flaws persist in heavy trucks as well, as plainly evidenced by designs clearly showing fuel tanks mounted outside the frame rails of large commercial trucks. Little evolution has occurred in this design since the 1950s. Diesel tanks constructed of thin-walled aluminum are extremely vulnerable to mechanical compromise, content leakage, and disastrous fire. While comparatively safe in bulk liquid form, diesel fuel readily ignites when atomized into a fuel/air mist as commonly occurs during a collision. Fuel tanks on these trucks have exposed filler valves that are vulnerable to impact by vehicles and relatively benign collisions against fixed objects. Collision-induced malfunctions in vehicle electrical systems can provide ignition sources for some time following the impact(s) of the initial collision.

Fuel System, Fire, Safety