FIRE SUPPRESSION SYSTEM DEVELOPMENT FOR THE FORD CROWN VICTORIA POLICE INTERCEPTOR

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ABSTRACT

This paper summarizes the design, development and testing of the Fire Suppression System (FSS) option for the 2005 Ford Crown Victoria Police Interceptor (CVPI). The FSS is designed to sense impact and activate two pyrotechnic hybrid devices that discharge fire suppressant foam.

Police cars have a higher exposure than non-police cars to high-speed rear-end accidents that can compromise the fuel system on any vehicle. In response to concerns regarding this exposure and the risk of fire following these severe accidents, in July 2002, Ford joined with the Arizona Attorney General to form the Police Officer Safety Action Plan Blue Ribbon Panel and Technical Task Force.

The Technical Task Force investigated fire suppression and fire prevention technologies used in military, auto racing and marine applications. The Task Force then evaluated the basic materials used in these applications. FIA-qualified samples of Halon, FIA qualified Aqueous Film Forming Foam (AFFF), Solid Propellant Gas Generators, foams and emulsifiers and various powder dispensing methods including aerosols, and impact-activated powder panels were tested in various configurations with gasoline ignited under the rear of stationary vehicles on a concrete pad. Ultimately, the Task Force subjected six proposed systems to a test in which a Crown Victoria was decelerated from 30 mph to simulate post collision motion.   Gasoline was artificially dispensed and ignited in this test. The most successful technology in suppressing the resulting fire was a Hybrid Fire Suppression System from Aerojet. This system dispenses a water based foaming suppression agent using a pyrotechnic gas generator.

Ford performed the system integration role in the development of this technology while Aerojet and Takata supplied the fire suppressor and crash sensor module, respectively. The fire suppression system development took place in several phases, starting with static component/materials tests. Ultimately, full vehicle crash tests were conducted using forced ignition and release of fuel. In March 2004, the first complete extinguishment of a forced ignition fire following a 75 mph crash test fire was accomplished.

INTRODUCTION

The CVPI is a large, rear-wheel drive car which has a V-8 engine, full-frame construction and other features required by police departments and law enforcement agencies. Ford estimates that 85% of police cars on the road today are CVPIs. Beginning with the 1992 model year, the CVPI met Ford's internal safety guidelines, which included a series of 50 mph car-to-car crash tests to the rear and filler neck side of the CVPI.

Because of their use – in traffic stops, at accident scenes and in connection with road construction – police cars have a higher exposure than non-police cars to high-speed rear-end accidents that can compromise the fuel system on any vehicle. In response to concerns regarding this exposure and the risk of fire following these severe accidents, in July 2002, Ford joined with the Arizona Attorney General to form the Police Officer Safety Action Plan, Blue Ribbon Panel and Technical Task Force.

In connection with the work of the Technical Task Force, Ford engineers investigated shielding, bladder tanks and fire suppression technology to reduce the risk of fire and fire-related injuries following very rare, high-energy rear-end accidents. After evaluating fire suppression systems offered for other applications, Ford determined that new technology was required for an automotive application in the mass-produced CVPI.

Ford evaluated various technologies before selecting pyrotechnic hybrid suppressors proposed by Aerojet as the most appropriate technology. Ford performed the system integration role in the development of this technology. Aerojet was selected as the supplier of the fire suppressor and Takata was selected as the supplier of the crash sensor module. Development continued with a series of 75 mph car-to-car crash tests that included forced ignition of gasoline. In March 2004, the first complete extinguishment of a forced ignition fire following a 75 mph crash test fire was accomplished.

Production of CVPIs with the Fire Suppression System option at the Ford assembly plant in St. Thomas, Ontario is expected to begin in 2005. The FSS option is not available for prior model year CVPIs because its installation requires modification to the vehicle frame and integration with a new vehicle computer and data bus for the 2005 model year.

TECHNOLOGY SELECTION

The Technical Task Force first investigated fire suppression and fire prevention technologies used in military, auto racing and marine applications. The Task Force then evaluated the basic materials used in these applications. FIA-qualified samples of Halon, FIA qualified Aqueous Film Forming Foam (AFFF), Solid Propellant Gas Generators, foams and emulsifiers and various powder dispensing methods including aerosols, and impact-activated powder panels were tested in various configurations with gasoline ignited under the rear of stationary vehicles on a concrete pad. Certain technologies were eliminated from consideration as the result of this early investigation and testing. Ultimately, the Task Force subjected six proposed systems to a test in which a Crown Victoria was decelerated from 30 mph to simulate post collision motion. Gasoline was artificially dispensed and ignited in this test. The most successful technology in

suppressing the resulting fire was a foam suppression agent dispensed using a pyrotechnic gas generator.

DEVELOPMENT

The fire suppression system development took place in several phases. Because there were no existing recommended tests for fire suppression systems for mass-produced cars, the Task Force had to develop test protocols. The testing started with static component/materials tests. The focus of the initial static fire testing was to evaluate how flames propagated around the vehicle and to better understand the fire threat. Later testing involved moving vehicles to better understand fire propagation in post-collision fuel fed fire events. Ultimately, full vehicle crash tests, with forced fuel release and ignition, were conducted.

These crash tests involved a Taurus striking the rear of a parked CVPI at 75 mph. There was a 50% overlap between the vehicles. At impact, 200 ounces of pressurized (65 psi) gasoline was released from a separate tank onto the front side and top of the fuel tank. The release of the gasoline was completed over 22 seconds. A locally mounted rocket motor was used to ensure ignition of the gasoline.

DEVELOPING THE TEST SYSTEMS

The crash and other testing performed required the development of test equipment, data acquisition equipment, and equipment to dispense and ignite fuel.

Fuel Dispensing System

Vehicle crash testing of the FSS required a fuel dispensing system to reliably and repeatedly dispense known amounts of fuel. In the initial static testing, 40 ounces of gasoline were poured from a plastic container onto the test surface. Efforts were also made to more accurately and consistently dispense the fuel under the vehicle. Initially, a 12.7mm hole was drilled near the bottom of the vehicle's fuel tank and a stopper with a long length of wire was used to initiate fuel flow. Unreliable actuation with this approach led to use of cylindrical tubing as a holding tank and the fuel shut-off solenoid from a compressed natural gas (CNG) fuel system for fuel flow control. Limited capacity and leakage due to fuel compatibility issues necessitated redesigning the dispensing system.

It also became necessary to increase fuel flow rates to improve test fidelity. To achieve greater fuel flow rates, it was necessary to pressurize the dispensing tanks. Initially, the low-pressure tanks were reinforced with a steel girdle to reduce the possibility of deformation and tire valve stems were added to allow pressurization. In the final configuration, cylindrical pressure vessels were used.

In the 75 mph crash tests, the purpose-built fuel dispensing tanks were bolted to the floor pan, initially in the rear seat area and later to the front passenger seat due to rear-seat intrusion in the tests. The dispensing tanks contained the 200 ounces of fuel dispensed in the test. Dual solenoids were used to increase flow area and provide a means for changing fuel flow rates during the test. , A melt plug cap and redundant vent paths were added to prevent pressure build

up in the event the test fire was not extinguished. To accommodate vehicle deformation during the crash test, flexible tubing was used in routing the dispensed fuel to the manifold that directed fuel flow under the vehicle. This tube was armored and sealed where it passed through the vehicle's floor pan.

<u>Fuel Ignition System</u>

The Task Force's testing also presented challenges and necessary changes for igniting the gasoline in the tests.

Although electric matches and spark generators existed, the most common, reliable and available means for ignition available for the initial static fire testing was a simple flaming rag on a stick. Difficulties coordinating fuel dispense and ignition led the team to use off-the-shelf Estes model rocket igniters, "boosted" with paper matches, to ignite the fuel. Even with electrical ignition, it became apparent that correct placement of the igniter within the fuel field was important for consistent ignition.

Wind during the moving tests and subsequent vehicle impact tests required additional changes in the fuel ignition system to ensure reliable ignition. Model rocket engine igniters, "canon fuse," nichrome wire and grinders generating metallic sparks all proved to be inadequate to reliably ignite gasoline in a 20 mph wind. As a result, model rocket motors, with their nozzles removed, were used as an ignition source. They burned for approximately 2.5 seconds to simulate a persistent ignition source and projected a flame of sufficient robustness to insure ignition of the dispensed fuel.

The rocket motor nozzles were removed to reduce exhaust velocity — when the nozzles were in place, the exhaust evaporated the dispensed fuel rather than igniting it. Additionally, a mounting block was developed to retain the modified rocket motors to the vehicle's frame in the required location when subjected to the acceleration loads developed during impact testing. Redundant rocket motors were used to overcome a 20% rocket motor ignition failure rate observed during early testing.

STATIC VEHICLE FIRE TESTS

The initial focus of the static fire testing was to evaluate how flames propagated around the vehicle and to better understand the fire threat. The static tests also offered a quick means for testing new FSS concepts and verifying production configurations.

Over time, the test systems changed from manual controls and data acquisition to a highly automated system.

For most of the testing, static tests were controlled by an automatic data acquisition and control system to ensure test consistency. Upon sequence start, the system would initiate data capture, activate the fuel solenoid valves, ignite the fire and function the FSS. The timing used for these tests (Table 1) was similar to the timing documented during crash tests. During several tests, additional trails of fuel were spilled behind the test vehicle to simulate a moving vehicle.

Additionally, exploratory tests were conducted where the fuel dump and/or burn times were increased.

Table 1. Timing used for static fire tests.

Item	Start Time (sec)	Stop Time (sec)
Fuel Solenoid A	0	20
Fuel Solenoid B	0	2.7
Fire Ignition	1.7	--
FSS Function	4.5	--

Fire Description

With all of the testing performed outdoors, environmental factors played a role in shaping the fire character. The wind had a significant effect on the shape and intensity of the fire. Although tests were postponed during extreme high wind conditions for safety reasons, small wind gusts were tolerated. The temperature at which the tests were performed appeared to have much less of an effect on the intensity of the fire. Ambient temperatures varied from approximately 30 F (and snowing) to 90 F (and sunny) with no dramatic visible difference in fire behavior.

The test vehicle was parked on a concrete surface with minimal slope. As a result, water puddles formed under the vehicle from rainfall. Although tests were conducted in the presence of water puddles, the concrete surface under and around the vehicle was typically squeegee'd to remove any standing water prior to a test. Additionally, the vehicle was placed in the exact same location on the test pad during each test. Test consistency was a critical factor in determining the relative merits of varying FSS configurations.

During a typical test sequence, fuel would spray out of the two nozzles and splash against the front of the fuel tank, up above the #4 (rear suspension) cross-member and around all of the drive train and suspension components. As fuel continued to flow out of the nozzles, it would drip down onto the concrete and develop into a large puddle under the rear third of the vehicle. Upon rocket motor ignition the fire would build to a steady level within approximately one second. The specific nature of the fire would depend on the prevailing wind velocity and direction during the test.

Development Testing

In excess of 80 static fire tests were conducted over a period of 12 months during the development of the FSS. The final design architecture included two suppressors activated simultaneously.

Refurbishable test versions of the FSS were manufactured to reduce cycle time between tests. These systems incorporated suppressors with varying Solid Propellant Gas Generator (SPGG) configurations and were configured such that different distribution systems could be attached

and tested. The test vehicle frame and body were modified to have quick release access panels in the trunk area to provide easy access to the FSS mounting location, fire ignition source and fuel delivery system.

Distribution System Development

Several nozzle types were tested to optimize the suppressant plume, foaming and application. These included aspirating nozzles, directed spray nozzles and splash plates. Although all of these nozzles were very effective at directing and foaming the agent, they tended to decrease the overall effectiveness of the system by slowing the suppressant plume momentum.

Additional down tubes and non-deploying spray bars were added to inundate the area surrounding the fuel tank, drive train, suspension system and above the #4 crossmember with suppressant. These spray bars proved effective and alleviated the need for the suppressant plume from the four pop-down nozzles to reach up into this highly complex underbody area. The down tubes and spray bars allowed the pop-down nozzles to be optimized for fighting the near-ground fire.

Primary Suppression Mechanisms

The fire resulting from the baseline test scenario is very difficult to extinguish, as it is essentially comprised of two different types of fires. First, there is a spray fire in the partially enclosed underbody volume that contains the rear suspension, exhaust system, and fuel tank. Fuel sprays and splashes many complex surface areas in the post-collision crumpled vehicle structure, out of direct line of sight of a FSS nozzle. Second, there is a large uncontained puddle fire that extends out behind the vehicle. This puddle fire is pushed by the prevailing airflow.

As a result of historical test experience and observations made during the static testing, key features were integrated into the FSS design. Many of these features are unique to a hybrid fire extinguisher and were necessary to successfully suppress the baseline fire. The FSS discharges a mixture of vaporized water-based suppressant and inert gas (laden with chemically active aerosol) rapidly into the highly complex volume below the #4 crossmember and around the fuel tank. The gaseous nature of the suppressant allows it to reach flames hidden behind mechanical components. A large plume of the same suppressant mixture is discharged via the pop-down nozzles onto puddle fire below and behind the vehicle. Here the quick discharge provided by the suppressor and the density of the suppressant droplets give the plume the momentum necessary to overcome the elements and successfully penetrate the flame front. Once the suppressant enters the flame front, the water-based suppressant pulls heat out of the fire and chemically inhibits the combustion reaction resulting in a very quick suppression event. The momentum of the suppression pulse also aids in pushing any remaining fire away from the vehicle. Finally, the surfactant contained within the remaining suppressant becomes quite foamy during the vigorous discharge event and has been found to be quite effective at coating the remaining fuel on the ground with a foamy surfactant layer inhibiting any remaining fire from re-igniting the fuel under the vehicle. Figures 1-3 show a typical fire and suppression event.

Figure 1. Fire just prior to suppression event.

Figure 2. Vehicle during suppression event.

Figure 3. Vehicle just after the fire is suppressed.

FULL VEHICLE CRASH TESTS

Full Vehicle crash tests involved a Taurus striking the rear of a parked CVPI at 75 mph with a 50% overlap between the vehicles biased to the driver's side. At impact, 200 ounces of pressurized (65 psi) gasoline was released from a separate tank onto the front side and top of the fuel tank. The release of the gasoline was completed over 22 seconds. A locally mounted rocket motor was used to ensure ignition of the gasoline.

Since there were no existing tests or tests standards for forced ignition testing, much of the test instrumentation and protocol had to be developed specifically for this test series. Onboard instrumentation had to be protected against acceleration loads, fire, and fire extinguishing. Additionally, the on-vehicle data acquisition system was modified to control the timing of both fuel release and fuel ignition. No "off the shelf" impact qualified CAN Bus reader existed so it had to be developed. Data acquisition and controllers were relocated from the vehicle interior to the hood away from deformation zone, padded to protect against shock loads (verified with sled tests), and sealed against water intrusion from external fire extinguishing.

In addition to the typical external camera overhead and side views of the intrusion zone, additional panning views (high speed video and film) were added. On-board cameras were also added to the underbody and interior of the target vehicle to observe flame propagation in and around the underbody. The underbody cameras had to be protected from impact and fire (wire leads were insulated with aluminum tape, for example).

Fuel flow was initiated by switch strips that were actuated by the bullet vehicle. The switches were placed rearward of the target vehicle at a distance that corresponded to the time necessary for fuel to reach the dispense location. Full flow through both solenoids occurred for 1.7 seconds, at which time one solenoid was closed and fuel continued to flow until the remainder of the 200 ounces was dispensed (approximately 22 seconds total). Two different ignition scenarios were tested: ignition at impact and delayed ignition (about half the distance from impact to where the struck vehicle came to rest.). In either case, the ignition sequence was triggered by switch strips located on the rear bumper of the target vehicle.

Multiple test iterations were required to successfully develop the fire suppression system and testing hardware. Initial tests focused on understanding the post impact environment and system interactions. In the first forced ignition test, the fire was nearly extinguished; however, a kernel of fire trapped in a deformed section of the wheel well relit the dispensed fuel pool.

The second phase of crash testing incorporated the fire suppression system mounted under the rear suspension cross member. In this test series the need for nonconductive armored initiator leads and redundant wiring became apparent. Suppressant volumes and gas generator output were inadequate to suppress the forced fire. These tests confirmed that wheel speed data was still available post impact and the back-up power supply could still provide power to the control module.

During the third phase of testing, deployment timing was conducted off the control module internal timer and was successful in suppressing the forced fire.

The final series of tests were conducted with production intent armored cable, control module, and fire suppression system. The control system operated correctly and functioned the system just prior to vehicle coming to rest based on wheel speed input, resulting in suppression of the forced fire.

FIRE SUPPRESSION SYSTEM DESIGN

The CVPI Fire Suppression System is mounted beneath the vehicle and attached to the frame above and forward of the fuel tank and rear axle. The electronic control module is mounted inside the passenger compartment centered underneath the rear seat cushion. In the event of a high-speed, high-energy rear impact, a system of crash sensors and high-speed electronic processors deploy pyrotechnic gas generators (similar to air bag technology), which deploy suppressant and surfactant materials through a system of manifolds and nozzles. Accordingly the FSS can be considered as having four main systems: (1) Sensing and Activation; (2) Wiring; (3) Bottles and (4) Distribution.

Sensing and Activation

One of the first issues in the development of the Fire Suppression System was to determine when and how to activate the system. The CVPI has passed 75 mph car-to-car crash tests without continuing fuel leaks. In one test, a CVPI was struck at 100 mph without puncturing the fuel tank or causing significant leakage of fuel. This unprecedented crash testing could not guarantee that no leakage or fire would occur in a real world accident, but this testing and other work of the Task Force provided information regarding the type of severe accident in which deployment of a fire suppression system could reduce the risk of fire. Ford evaluated various sensing methods including fire sensors, crash sensors and manual activation methods. The technology had to be reliable in high-energy crashes of 75 mph. (The US Federal Standard rear crash is conducted at 30 mph. A 75 mph crash has energy levels approximately 6 times greater than an equivalent 30 mph crash.) The most appropriate system included crash sensors that detected high-energy rear crashes.

When to deploy?

 If the suppressant is dispensed too early, the suppressant may not provide protection from persistent ignition sources at the post-collision rest location, which can be hundreds of feet from the point of impact. On the other hand, if the suppressant is dispensed too late, the fire could overwhelm the ability of an on-board suppression system. Testing was performed to determine robustness of the system in various burn durations. The team determined that the fire suppression system should deploy as the vehicle is about to come to rest post-collision.

During testing, the Task Force demonstrated that some of the ABS wheel speed sensors could survive the crash and were providing data on the CAN until the vehicle came to rest. As long as the data is available, the FSS uses it to improve the accuracy of the deployment time. Otherwise, a post collision event timer is used to estimate the appropriate dispense time.

Although the system is primarily designed as an automatic suppression system, police agencies requested a manual activation switch for scenarios outside of the automatic suppression

envelope. This switch is located in the interior of the car near the rear view mirror and can be used by vehicle occupants to manually deploy the system any time the vehicle is in a Key On or Engine On mode. The manual activation switch is protected against inadvertent activation by a cover and can be accessed by pushing on the cover to release it, pulling the cover open, or the system can be deployed by firmly striking the cover.

<u>Electronics that survive the crash</u>

Deployment as the vehicle is about to come to rest depends on the suppression system surviving the crash. Most previous crash detection systems are designed to accomplish their task as the crash is proceeding (airbag and seat belt pretensioners). The FSS provides capability to function the system up to 9 seconds after the crash. This is accomplished by providing backup power and redundant activation circuits in a fire suppression system module that is placed under the rear seat.

The fully redundant squib circuits provide additional reliability in high-energy crashes. Although the wiring runs are in areas that were shown to be relatively intact in high-energy crash tests, redundancy has been provided. Each bottle has 2 separate squib circuits that are energized simultaneously by redundant ASICs in the Fire Suppression System Module.

The automatic deployment strategy required the manual activation switch to be designed to survive the crash accelerations without inadvertently commanding deployment.

<u>Wiring</u>

The wiring between the FSS module and the bottles is armored, redundant and fire resistant. The squib wiring is armored with DuPont KEVLAR   brand fiber in a new process invented for this application.   If crash damage creates short or open circuits on one side of the vehicle, the redundant wiring routed on the opposite side of the vehicle can function both fire suppression bottles. The polymeric outer shell, also used in mining applications, has burn resistance.

<u>Bottles</u>

The suppressor bottles are a type of Hybrid Fire Extinguisher (HFE).   HFEs use a solid propellant gas generator (SPGG) to pressurize, vaporize and expel an agent. A liquid suppressant is expelled out of the bottle by means of high-pressure SPGG discharge instead of supercharged nitrogen gas.   The heat transfer between SPGG gases and liquid suppressant promotes the existence of vapor-phase agent at discharge, even at cold temperatures. This improves the homogeneous distribution of agent in the protected space. Testing has shown that the improved suppressant vaporization and distribution associated with hybrid extinguishers results in reduced agent concentration requirements for equivalent fire suppression performance. Additionally, storage volumes of liquid and solid agents are considerably smaller than gaseous agents. Since the pressurizing gas is stored in solid form until activation, the HFE requires no nitrogen charging.   Thermodynamically, this implies the agent loading density can be significantly increased without incurring the danger of over-pressure at higher storage temperatures. As a result, the extinguisher can be packaged in a smaller volume. Since the liquid agent is stored at

ambient pressure (0 psig for water based suppressants), the storage cylinder is not subjected to the considerable pressure cycles that a conventional nitrogen pressurized bottle would experience. The result is decreased fatigue stresses, reduced leakage potential and a more robust design. The combination of an improved dispersion of a liquid agent via a solid propellant system, reduced agent concentration requirements, the elimination of a nitrogen pressurant and the reduced volume of a liquid agent make the hybrid system the ideal fire suppression solution for the CVPI application. The principal advantages of an HFE include increased agent flow rate control, improved agent distribution, high momentum suppressant plume, rapid fire out times, higher fill density, decreased size, temperature independent performance, reduction in two-phase effects and insensitivity to orientation.

The CVPI FSS suppressor bottles are located in front of the axle and below the #4 (rear suspension) crossmember. (Note that the CVPI is equipped with a solid rear axle, coil spring, and Watts linkage suspension as well as dual exhaust.) This space is relatively undisturbed during 75 mph rear impact crash tests, but the shape of the available space prevents the use of conventional pressure vessel designs. The bottles are formed from Nitronics 30 stainless steel to give the required formability, strength and chemical resistance. Each bottle contains about 6L of suppressant.

The unconventional shapes of the suppressor bottles (see figure 4) proved to be a considerable design challenge during the development of the FSS. The unique shape of each suppressor bottle was a result of rigorous design efforts to integrate the system into a very constrained and dynamic envelop within an existing vehicle structure, while maximizing the volume inside the bottle. Since it was found that a quick discharge that produces a plume with considerable momentum is necessary for effective fire suppression, the suppressor bottles experience a very short pressure pulse during the discharge event. This short pressure pulse combined with a design that maximizes volume necessitated a system design that accommodates yielding of the bottle during a normal discharge event.

Figure 4. Diagram of the left-hand bottle showing gas generator integrated inside (distribution system not shown).

Suppressant

The suppressant is an AFFF foam, modified with potassium salts to lower the freezing point to below –40. The combined properties of surfactants and foam can provide protection from fires that originate well beyond the perimeter of the car that may tend to follow trails of combustible fluids.

Pyrotechnic Gas Generator

While the FSS is quiescent awaiting the firing signal, there is no pressure within either the generator or the suppressor bottles. Since there is no pressure to leak down, diagnostics for bottle readiness comprise a resistance check on the initiators, exactly as done for conventional airbag systems. Once the squib circuits are energized, the pyrotechnic gas generators pressurize the suppressant liquid, foaming the suppressant and propelling it within the bottles. The suppressant pressure builds in the bottle until a fragmenting burst disk is ruptured allowing the suppressant to flow through a sidewall into the distribution system and out through the nozzles and spray-bars. The generator also greatly contributes to fire suppression by producing a chemically active fire-inhibiting aerosol. The generators expel all of their gas within a quarter second while the tanks complete their discharge within one second.

Each suppressor bottle contains one pyrotechnic gas generator and the assembled bottle with nested generator is classified as DOT Class 9, Life Saving Devices.

Transportation Safety

DOT bonfire testing, with prolonged duration temperatures in excess of 2000 degrees F, has been performed to ensure that the system does not discharge propulsively or otherwise present energetic material hazards in the unlikely event of an external fire. The gas generators contain Auto Ignition Material that causes the discharge of the suppressant before the bottle structure is excessively weakened by high temperature.

Police Use Robustness

The bottles have been tested to discharge without crack propagation after sustaining damage from small arms rifle fire.

Distribution System

The distribution system discharges the suppressant from the bottles to the locations where it can suppress the fire. Testing showed that the nozzles would be most effective if they extend low under the vehicle. Pop-down nozzles (see figure 6) accomplish this goal while reducing durability concerns. When the Fire Suppression System is activated, the pressure bursts the nozzle seals and extends the nozzles downward.

Additional down tubes and non-deploying spray bars inundate the area surrounding the fuel tank and above the #4 (rear suspension) crossmember with suppressant.
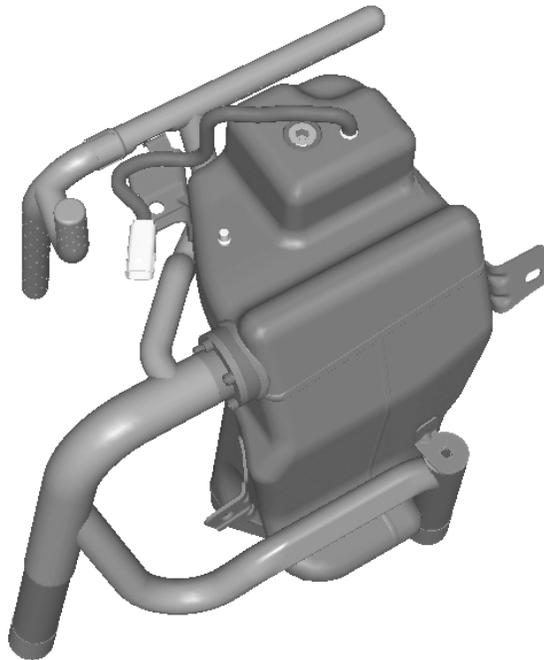
Figure 5: Right Hand Suppressor and Distribution System.

The distribution system is uniquely shaped to provide efficient flow while maintaining clearance to the moving suspension, driveline, and exhaust systems. The system was designed to reduce the risk that it would itself compromise the fuel system.

Durable weather seals prevent the accumulation of debris inside the distribution system. The seals are designed to rupture when the system discharges.
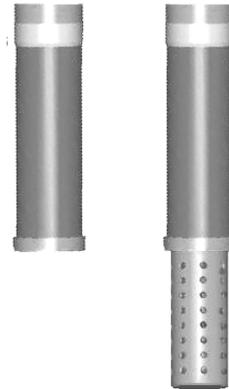
Figure 6 – Deployable Nozzle.

CONCLUSION

Ford Motor Company and its suppliers have developed an automatic fire suppression system as an option for the 2005 Crown Victoria Police Interceptor that reduces the risk of injury due to fire in high-energy rear end accidents.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

AFFF: Aqueous Film Forming Foam

ASIC: Application Specific Integrated Circuit

CAN: Controller Area Network

FIA: Federation Internationale de L'Automobile

HFE: Hybrid Fire Extinguisher

SPGG: Solid Propellant Gas Generator