CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION

SCI CASE NO.: CA10028

VEHICLE: 1990 MCI MODEL 102-C3 MOTORCOACH

LOCATION: VIRGINIA

INCIDENT DATE: JUNE 2010

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety system.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. CA10028	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Motorcoach Fire Investigation Vehicle: 1990 MCI Model 102-C3Motorcoach Location: State of Virginia		*5. Report Date*: November 2010 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* *11. Contract or Grant No.* DTNH22-07-C-00043	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: June 2010 *14. Sponsoring Agency Code*	
15. Supplementary Note This on-site investigation focused on the origin and severity of a fire that initiated in the engine compartment area of a 1990 MCI Model 102-C3 motorcoach			
16. Abstract This on-site investigation focused on the origin and severity of a fire that initiated in the engine compartment area of a 1990 MCI Model 102-C3 motorcoach. The motorcoach was occupied by the male driver and 20 adult passengers ranging in age from 60-92 years of age. The driver was conducting a tour and was traveling at a slow speed in a cemetery. He stated that he heard a loud noise and the motorcoach lost power; however, the engine continued to run and increased in Revolutions per Minute (RPM) as he applied throttle. The driver stopped the motorcoach, placed the transmission in park, set the parking brake, and proceeded to the rear of the motorcoach to investigate the problem. As he approached the back of the motorcoach, he observed smoke and fire, and immediately ordered the evacuation of the passengers. The driver retrieved the onboard fire extinguisher and proceeded to the back of the motorcoach; however, the fire spread beyond the capability of the small ABC extinguisher. He called the emergency response system to request police and fire assistance. The fire spread to the passenger compartment prior to extinguishment by the responding fire department. The motorcoach was towed to a local tow yard and was deemed a total loss.			
17. Key Words 1990 MCI Model 102-C3 Motorcoach Fire Fire Origin		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 14	*22. Price*

TABLE OF CONTENTS

BACKGROUND **1**

SUMMARY **2**

INCIDENT SITE 2
VEHICLE DATA 2
INCIDENT 4
PRE-INCIDENT 4
INCIDENT 4
POST-INCIDENT 4
VEHICLE DAMAGE 5
EXTERIOR - FRONT 5
LEFT SIDE 5
BACK 6
RIGHT SIDE 7
ROOF 7
GLAZING 8
TIRES AND WHEELS 8
INTERIOR 9
SCI FIRE SOURCE 10
FIGURE 20. INCIDENT SCHEMATIC. 14

ATTACHMENT A: FIRE EXPERT'S REVIEW AND OPINION REPORT **A1**

CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION
SCI CASE NO.: CA10028
VEHICLE: 1990 MCI MODEL 102-C3 MOTORCOACH
LOCATION: VIRGINIA
INCIDENT DATE: JUNE 2010

BACKGROUND

This on-site investigation focused on the origin and severity of a fire that initiated in the engine compartment area of a 1990 MCI Model 102-C3 motorcoach **(Figure 1)**. The motorcoach was occupied by the male driver and 20 adult passengers ranging in age from 60-92 years of age. The driver was conducting a tour and was traveling at a slow speed in a cemetery. He stated that he heard a loud noise and the motorcoach lost power; however, the engine continued to run and increased in Revolutions per Minute (RPM) as he applied throttle. The driver stopped the motorcoach, placed the transmission in park, set the parking brake, and proceeded to the rear of the motorcoach to investigate the problem. As he approached the back of the motorcoach, he observed smoke and fire, and immediately ordered the evacuation of the passengers. The driver retrieved the onboard fire extinguisher and proceeded to the back of the motorcoach; however, the fire spread beyond the capability of the small ABC extinguisher. He called the emergency response system to request police and fire assistance. The fire spread to the passenger compartment prior to extinguishment by the responding fire department. The motorcoach was towed to a local tow yard and was deemed a total loss.

Figure 1. On-scene image of the MCI motorcoach fire. (Internet news image.)

The notification of this incident was provided to the Calspan Special Crash Investigations (SCI) team by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) on June 16, 2010. The SCI team initiated telephone contact with the motorcoach company and established cooperation with the Safety Director to inspect the motorcoach, interview the driver, and obtain the recent vehicle service history. Based on the level of cooperation, the case was assigned for on-site investigation on June 29, 2010. The on-site investigation was conducted on July 1, 2010. The investigation involved the detailed documentation of the damage to the motorcoach, disassembly of the exhaust system from the turbocharger, interviews with the Safety Director and driver of the motorcoach, and the inspection and documentation of the incident site. A fire expert conducted a review of the SCI documentation and the images to determine fire origin and cause. His opinion relating to these issues is included as *Attachment A* of this report.

SUMMARY

Incident Site

The motorcoach fire occurred on a narrow one-lane, one-way road through a cemetery during daylight hours. At the time of the incident, the weather was cloudy and dry. According to local weather forecasts, the temperature was 31 degrees C (88 degrees F) with relative humidity of 48 percent and easterly winds of 8-13 km/h (5-8 mph). The one-lane road was surfaced with asphalt and was 3.3 m (11.0 ft) in width. On the approach to the incident site, the road was straight and transitioned to a left curve with a two percent positive grade. The left side of the road was bordered by a hand-laid coble stone shoulder/rain gutter. Located outboard of the stone rain gutter was a steep embankment with a positive slope with stone that transitioned to a grass surface. The right roadside consisted of a negative slope that was grass surfaced. A large diameter hardwood tree was located 1.4 m (4.6 ft) outboard of the pavement edge and was scorched by the fire. **Figure 2** is an overall view of the incident site and the pre-incident trajectory of the motorcoach. A schematic of the incident site is included as **Figure 20.**

Figure 2. Overall view of the incident site and the easterly trajectory of the motorcoach.

Vehicle Data

The involved motorcoach was a 1990 MCI Model 102-C3. The motorcoach was manufactured in March 1990 and was identified by the following Vehicle Identification Number (VIN): 1M8GDM7A2LP (production number deleted). The motorcoach was powered by a 2-stroke Detroit Diesel 6V92 V-6 engine with a displacement of 9.0 liters, rated at 300 horsepower. The engine was linked to a 4-speed Allision HT740 automatic transmission. The engine was configured with a Garrett turbocharger that was mounted on top of the V-block engine. The casting number on the air intake side of the alloy casting of the turbocharger was NR-75R M-24 1.

The motorcoach manufacturer's placard was riveted to the aft wall of the stainless steel staircase at the front of the bus. The placard identified the Gross Vehicle Weight Rating (GVWR) and the recommended tire size and pressures. The GVWR was 18,144 kg (40,000 lb) and the Gross Axle Weight Ratings (GAWR) of the individual axles is as follows:

Steer – 6,532 kg (14,400 lb)
Intermediate (Drive) 9.979 kg (22,000 lb)
Rear Tag – 2,722 kg (6,000 lb)

The manufacturer recommended tire size was 12.75-22.5 for all three axles with cold tire pressures of 690 kPa (100 PSI) for the steer axle, 586 kPa (85 PSI) for the drive axle, and 552 kPa (80 PSI) for the tag axle. The motorcoach was equipped with Firestone FS400 tires on the steer axle, size 315/80R22.5. The manufacturer and tire models for the drive and tag axle tires were unknown due to fire related damage. The right tag axle tire was

manufactured by Firestone, model unknown. The tire data at the time of the SCI inspection was as follows:

Position	Measured Pressure	Measured Tread Depth	Damage
LF	Unknown	8 mm (10/32 in)	None
RF	724 kPa (105 PSI)	8 mm (10/32 in)	None
Left Drive – Outer	Unknown	Unknown	Unknown, removed from wheel
Left Drive - Inner	Flat	Unknown	Burned by the fire
Left Tag	Flat	Unknown	Burned by the fire
Right Drive – Outer	Flat	6 mm (8/32 in)	Burned by the fire
Right Drive - Inner	Flat	Unknown	Burned by the fire
Right Tag	Flat	13 mm (17/32 in)	Burned by the fire

The suspension of the motorcoach was an air-ride type with pneumatic bladders at all axle positions. The steering was power hydraulic. The service brakes were air-activated drum brakes at the three axle positions with spring brake chambers on the drive axle. The electrical system was comprised of a 24-volt system with the batteries and master cut-off switch located on the right side of the motorcoach, rearward of the fuel tank. The fuel tank was steel and was located immediately aft of the right steer axle, below the C and D-pillars. The fuel tank placard listed a capacity of 591 liters (156 US gallons) with the following: *Section 383.67 of Motor Carrier Safety Regulations Requires That The Tank Not Contain More Than 148 US Gallons, 561 Liters.*

The fuel tank and the filler cap remained intact and were not damaged. The fuel level at the time of the incident was unknown.

The undercarriage of the motorcoach between the axles was designed for stowage of luggage and cargo. There were three upward opening luggage bay doors on each side of the motorcoach.

The interior of the motorocoach was configured with the driver's compartment and eleven rows of seating with two seats on each side of the center aisle. The seating capacity was 44 passengers. The passenger seats were configured with adjustable head restraints and outboard armrests. There were no center armrests. The seats were covered with padding and fabric. A restroom was incorporated into the back right corner of the motorcoach.

A single access door was located at the right front of the motorcoach. The door was forward hinged and was electrically operated. The staircase was stainless steel and consisted of four rubber covered steps.

Incident

Pre-Incident

The driver was assigned to a two-day tour with the 1990 MCI motorcoach for the group comprised of 20 adult passengers. This fire incident occurred in a cemetery, which was the last scheduled stop on the second day of the tour. The motorcoach had been in continuous operation for approximately 8-hours with the engine running the entire duration to maintain the air conditioned temperature of the motorcoach. The driver was traveling at a slow speed, ascending the positive grade in the cemetery when he heard a loud noise from the rear of the motorcoach. He immediately noticed a loss of power as he attempted to accelerate. The driver stated that the engine continued to run with a noticeable increase in engine RPMs as he applied more throttle. The driver stopped the coach, set the parking brake, and left the engine running as he exited the motorcoach to investigate the problem.

Incident

As the driver approached the back of the motorcoach, he observed smoke and fire in the engine compartment. He proceeded to the front of the motorcoach and ordered the immediate evacuation of the passengers. Following the safe evacuation without incident or injury, the driver retrieved the onboard ABC fire extinguisher and returned to the back of the motorcoach with the intention of suppressing or containing the fire. Flames were visible from under the motorcoach and the fire became too intense for the driver to get close enough to use the extinguisher. The driver walked away from the motorcoach and called the emergency response system to report the fire and request police and fire department assistance.

Post-Incident

The local professional fire department arrived on-scene within minutes of the call. The first arriving fire truck had difficultly maneuvering in the cemetery. This truck reportedly contained a small amount of water to suppress the fire. There were no fire hydrants in the cemetery; therefore a call for assistance was made for the closest tanker truck. This truck was empty and a second truck was called to assist. While the firefighters were waiting for the arrival of additional equipment, the Safety Director of the motorcoach company arrived on-scene. He stated that the firefighters used a pike pole to break the windows out of the motorcoach in an effort to vent the fire. At this point, the Safety Director stated that the fire immediately spread to the interior of the motorcoach. Approximately 20 minutes after the initial call for assistance, the foam truck and the water tanker arrived on-scene. The firefighters used the available foam and water to suppress the fire.

A backup motorcoach was driven to the scene to transport the passengers to their final destination. Most of the luggage was recovered from the luggage bays of the vehicle. The motorcoach was towed from the back by a conventional heavy-duty tow truck. The steer axle tires were undamaged by the fire. A secondary vehicle from the tow company followed the tow truck and the motorcoach to recover any components that may have fallen from the towed unit. The motorcoach was towed to the tow yard where it was inspected for this investigation. There was no alteration or removal of components from the motorcoach prior to the SCI inspection.

Vehicle Damage

Exterior - Front

The front of the motorcoach **(Figure 3)** sustained minor severity damage that was associated with the fire. There was no damage below the base of the split windshields. Both laminated windshields were pierced by the firefighters with a pike pole and removed from the vehicle to vent the interior of the motorcoach. The windshield wiper blades appeared to have been recently replaced and remained undamaged, in the up and stowed positions. The perimeter gaskets for the windshields were intact with slight heat damage to the upper aspect of both gaskets. The Plexiglas panel above the windshields was in place, distorted by heat and stained by smoke and soot.

Figure 3. Frontal view of the MCI motorcoach.

Left Side

The fire related damage to the left side of the motorcoach began at the midpoint and extended rearward. The painted side surface was intact with slight smoke staining extending from the A to the D-pillars. The rubber splash shield over the left front tire was intact. There was significant smoke/soot staining to the first of three luggage compartment doors. The aluminum outer surface of this door was fully intact and the top-hinged door remained fully operational.

The painted body panels began to display evidence of heat and fire exposure immediately forward of the left E-pillar. The body panel aft of the left E-pillar displayed evidence of heat-induced buckling with blistering of the paint. The paint was burned from the body panel surfaces aft of the left F-pillar. The aluminum trim below the beltline was melted at the rear third of the F- to G-pillar location and continued to the midpoint of the G- to H-pillars. An aluminum trim strip above the luggage bay doors was melted at the midpoint of the left F- to G-pillars and extended aft of the H-pillar, to a point over the tag axle location. High heat was present in the sheet metal body panels at the F- to G-pillar locations over the rear axle positions. These panels were buckled with rust present on the steel. **Figure 4** is an oblique view of the damage to the left side of the motorcoach.

Figure 4. Left side view of the motorcoach.

The second luggage bay door sustained burning and blistering of the painted surface, most prevalent at the rear half of the door. The rubber rub strip on the lower third of the door was melted. This door was opened by the firefighters and was operational at the time of the SCI inspection. The third (most rearward) luggage compartment door

sustained melting of the aft aspect of the aluminum body panel. The paint was burned from the door with evidence of high heat exposure to the door from the burning drive axle tires. This was most prevalent on the aft half of the door. This luggage compartment door remained operational post-event.

The painted body panel aft of the left tag axle (H- to I- pillars) was intact with smoke and soot staining present on the lower and forward aspect.

The left side engine access door was opened by the responding firefighters. The sheet metal-surfaced door displayed evidence of high heat oxidation to the upper two-thirds with warping of the steel panel. The paint at the upper forward aspect of the corner panel aft of the side access door at the base of the I-pillar was burned with an area of high heat oxidation. The lower painted surface of the panel was intact.

Back

The back of the motorcoach **(Figure 5)** consisted of solid panels and three doors. Two center closing sheet metal doors provided access to the engine compartment. The firefighters opened these doors during the early phases of the fire suppression process. The paint was burned from the left engine compartment door, most notably at the upper third aspect. The door panel was warped by exposure to heat. This door also contained the aluminum license plate. The plate remained intact with the paint burned from the aluminum. The door was jammed in the open position by upward deflection of the bumper during the towing process. The right engine compartment door was opened by the firefighters. The painted surface was completely burned with warping of the steel skin. High heat oxidation was present to the upper inboard aspect of this door.

Figure 5. Back view of the motorcoach.

The taillight assemblies were located outboard of the engine compartment doors on the corner body panels. Both plastic lenses were melted and a single incandescent bulb remained in the each assembly.

The bumper system consisted of a rubber bumper fascia that concealed the steel bumper beam. The fascia was intact with minimal heat-related damage to the upper surface. The right corner of the fascia was burned by the fire.

The corner body panels on the back plane that extended from the floor to the beltline of the motorcoach remained intact. The left panel exhibited smoke and soot staining at the upper inboard aspect of the panel. The right corner panel yielded high heat evidence in a vertically oriented pattern along the inboard edge of the panel. The paint in this area was burned with the surrounding paint smoke and soot stained.

The access door to the cooling system located above the engine compartment doors was warped by the heat of the fire. The paint was burned off the bottom edge of the top-hinged door with the remainder of the white paint blackened by smoke and soot.

The formed fiberglass panel on the upper back of the motorcoach was intact with smoke and soot staining above the outboard edges of the access door for the cooling system.

Right Side

The right side of the motorcoach **(Figure 6)** was burned in a pattern similar to the left side. The right entry door was smoke stained with no fire or heat related damage noted to the door. The painted body panels were smoke and soot stained from the right B- to the E-pillar areas. The fuel filler cap access door was located at the aft edge of the C-pillar. This door was intact and free of fire or heat related damage. The battery compartment was located immediately aft of the filler cap/fuel tank location, between the C- and D-pillars. The door was closed and the batteries, associated wiring and cut-off switches were intact without damage.

Figure 6. Right oblique view of the motorcoach.

Three luggage compartment bay doors were located aft of the battery box. The forward and middle compartment doors were smoke and soot stained. The aft aspect of the third door was burned by the fire that developed from the drive axle tires. The paint was burned from the door and the forward aspect of the luggage bay door was smoke and soot stained.

The body panels from the F- to the J-pillars were burned as a result of the tire involvement. At the location of the F-pillar, the painted surface was blistered with smoke and soot staining. Extending rearward, the panels over the rear axle areas were warped by the heat with the paint completely burned from the sheet metal panels with evidence of high heat oxidation. The trim at the beltline was melted over the axle locations.

The right side access door to the engine compartment was intact with high heat oxidation to the sheet metal skin. The paint was completely burned from the door. The door was opened by the firefighters and due to heat-related distortion, this door would not re-latch.

Roof

The fire extended vertically from the high fuel load created by the involvement of the drive and tag axle tires into the roof area of the motorcoach. The aluminum roof panels were burned through

Figure 7. Burn-through of the right aluminum roof panels.

forward and aft of the right G-pillar, above the roof side rail **(Figure 7)**. The roof panels were buckled and distorted by heat in the areas of the F- to H-pillars. A similar burn pattern was present on the left roof area over the G-pillar area with complete burning of the paint from the F- to the H-pillars.

The emergency roof exits were completely consumed by the fire as the fire spread into the passenger compartment. The forward roof exit was located between the roof bows at the B- to C- pillar locations with the rear exit located between the G- to H-pillars.

Glazing

All of the glazing panels of the motorcoach were laminated glass. The firefighters used a pike pole to penetrate and remove all the glazing panels from the motorcoach during the firefighting efforts, with the exception of the right door and the side windows to the driver's compartment. These intact panels were smoke and soot stained. The rubber gaskets and the aluminum trim were burned in the areas of the F- to H-pillars on both sides of the motorcoach. This was attributed to the high heat generated by the combustion of the drive and tag axle tires.

Tires and Wheels

The motorcoach was equipped with Alcoa aluminum wheels and radial tires. The left and right front tires and wheels were not damaged by the fire. As the engine compartment fire spread forward, the tag and drive axle tire became involved and produced a large fuel load to the fire.

The left outboard drive axle tire was removed from the alloy wheel prior to the SCI inspection. There were no tire remnants (i.e., bead wire) present on the wheel. The wheel was intact, but was discolored due to heat. The outer sidewall of the left inboard drive axle tire was burned through at the 3-6 o'clock positions with the steel belts exposed. The tire was de-beaded from the wheel and the majority of the tread was burned. The tire retained its shape, but lost air pressure and remained on the wheel. The alloy wheel was intact, but displayed heat-related discoloration. **Figure 8** is a view of the left rear axle tires and wheels.

Figure 8. Fire damage to the left drive and tag axle tires and wheels.

Figure 9. Right side drive and tag axle tires.

The outer sidewall of the left tag axle tire was burned circumferentially and the thickness of the tread was burned. The tire de-beaded from the alloy wheel, but remained on the wheel. The alloy wheel was discolored by heat and the hub cover was melted by the fire.

The outer sidewall of the right outer drive axle tire was burned full-thickness circumferentially with the steel belts exposed **(Figure 9)**. The tread was burned with the exception of the tire patch that was in contact with the pavement at the time of the fire. The tire had rotated on the alloy wheel approximately 90 degrees during the tow process. The intact tire patch was located at the 9 o'clock position at the time of the SCI inspection which yielded 6 mm (8/32 in) of remaining tread depth. The alloy wheel was intact with heat-related discoloration and slight charring of the bottom aspect. The outer sidewall to the inner drive axle tire was burned full-thickness and the tread was burned smooth. The tire de-beaded from the wheel. The alloy wheel was not visible, but remained intact.

The right tag axle tire displayed similar damage to the drive axle tires with burn-through of the sidewalls and burning of the tread. The alloy wheel was blackened by smoke and soot and was otherwise undamaged. The tire patch that remained in contact with the pavement yielded 13 mm (17/32 in) of tread depth.

Interior

The interior of the motorcoach sustained extensive damage as the fire spread into the passenger compartment **(Figure 10)**. The inside surface of the right front door was smoke and soot stained. The laminated lower door window was intact, but cracked due to heat. The upper glazing panel was intact with heat cracking and blistering of the plastic laminate in the upper third area of the window. The status of the door following the egress of the passengers is unknown (open or closed).

Figure 10. Rear interior view of the fire damage to the interior of the motorcoach.

The stainless steel staircase was soot and smoke stained with debris that had fallen or was displaced by firefighters onto the steps. The rubber surfaced steps were intact without heat or fire damage.

The driver's compartment remained intact with melting of the plastic instrument panel and the gauge shields. The steering wheel rim was superficially charred. The driver's seat fabric remained intact with subtle heat and fire damage to the inboard and back surfaces of the seatback. The T-shift handle for the automatic transmission was located to the right of the driver's seat. The T-handle was slightly charred/melted by the fire.

The fabric and foam cushions on all of the passenger seats were partially consumed by the fire, involving the upper aspect of the fabric and the head restraint covers. The fire

and heat related damage was more prevalent of the back surfaces of the seats as the fire spread forward within the motorcoach.

The aircraft-style overhead luggage compartments with the top hinged doors were heavily damaged by the fire. All of the doors were melted with the most severe damage occurring at the rear of the motorcoach. The rear compartments in the area of seat rows 6-11 on the right side were nearly completely burned while the left side units from row 4-11 were heavily burned with sag on the remaining units into the seating areas.

The ceiling of the passenger compartment was covered with fabric and was burned. The fire damage was heaviest in the pillar areas F-H as the fire spread upward from the high fuel load off the rear tires.

The forward partition of the restroom was intact, but charred. The interior of the restroom was smoke/soot and heat damaged.

The floor of the motorcoach was plywood with a finished flooring material on the interior of the vehicle. The floor was burned through between seating rows 8-9 (G-pillar area), the area over and forward of the drive axle. The floor forward and aft of this location was charred, but intact.

SCI Fire Source

The fire appeared to have originated in the engine compartment area of the motorcoach based on driver statements and fire-related evidence. An assessment of the fire origin was conducted by an inspector for the FMCSA prior to the SCI investigation. This inspector's assessment was relayed back to the motorcoach company and he suspected the turbocharger as the likely origin of the fire. An overall view of the engine compartment is provided in **Figure 11**.

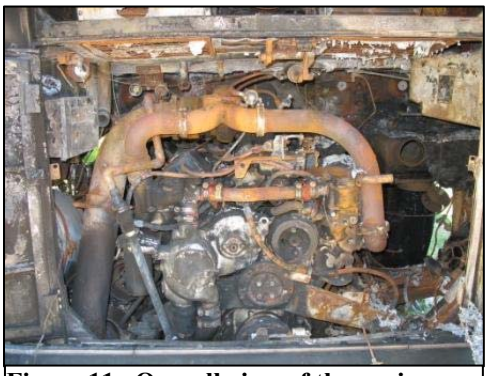

Figure 11. Overall view of the engine compartment.

The SCI inspection of the motorcoach identified two potential sources of the fire, both electrical in nature. The potential sources involved an arced 24-volt power cable and/or the alternator. The SCI investigator ruled out the turbocharger as a potential origin based on the following observations.

The turbocharger and the associated manifolds were thoroughly inspected. The exhaust Y-pipe that extended from the exhaust manifolds to the hot side intake of the turbocharger exhibited high heat. The formed 7.6 cm (3.0 in) diameter steel pipes and the cast iron Y-manifold were intact with all clamps and connectors in place with tight fitments of all connections.

The aluminum duct from the air box to the cold air intake side of the turbocharger was consumed by the fire, thus exposing the intake impeller of the turbocharger. The high temperature silicone connector that joined the duct to the turbo was partially consumed by the fire. The steel band clamp remained in place on the outboard side of the turbocharger. The impeller and the cast aluminum housing were intact **(Figure 12)**. The impeller was slightly blackened by soot and spun freely by hand. Without a complete disassembly, there was no notable binding or damage to the impeller shaft or bearings. The fins of the impeller were intact and free of damage. The surrounding casting was intact with minimal discoloration due to the fire.

Figure 12. Intake impeller and cast alloy housing of the turbocharger.

Figure 13. Exhaust pipe removed from turbocharger.

The steel oil line to the midpoint of the turbocharger that provided lubrication to the unit was intact with no indication of external or internal oil leakage.

The exhaust side of the turbocharger was inspected. The 12 cm (4.75 in) diameter exhaust pipe that extended from the discharge side of the turbocharger to the muffler was loose, but intact at the turbocharger connection. The SCI investigator loosened the band clamp at the turbocharger and removed the exhaust pipe from the vehicle. The initial inspection of the exhaust pipe revealed carbon deposits on the upper aspect of the pipe with no trace of oil deposits **(Figure 13)**. The lower aspect of this exhaust pipe and the adjoining pipe to the muffler were clean of carbon deposits.

The hot (discharge) side of the turbocharger was inspected for signs of damage and oil deposits. The cast iron body of the turbocharger was intact with no visible cracks. The casting was clean and yielded a rusted surface. The exhaust side impeller was covered with a film of carbon and spun freely when turned by hand. Again, similar to the intake side, there was no damage to the fins or apparent internal damage with no deposits of oil present **(Figure 14)**.

The exhaust tailpipe was inspected for evidence of oil with no traces of engine oil present in the tailpipe or the muffler. The tailpipe contained a thick layer of carbon on the full circumference of the tailpipe.

Figure 14. Exhaust impeller and cast iron housing of the turbocharger.

Figure 15. Carbon deposits in the tailpipe of the motorcoach.

The least likely of the fire's electrical sources involved the possible arcing of a battery cable (**Figure 16)**. This 6-gauge cable extended along the right side of the motorcoach aft of the tag axle tire and yielded evidence of severe arcing in two places with welding of the copper wire at the arced locations. Immediately rearward of the arced locations, the cable was burned through with complete separation of the braided cable **(Figure 17)**. The area surrounding this cable damage did not exhibit the high heat oxidation commonly associated with fire origin.

Figure 16. Arced and separated battery cable.

Figure 17. Close-up view of the arced cable.

The most likely origin of this motorcoach fire involved the alternator that was mounted to the lower right side of the diesel engine. The alternator was belt driven off the engine's power-takeoff. The alternator was missing from the vehicle at the time of the SCI inspection. The alloy housing of the alternator was presumed to have been consumed by fire. Its contents probably fell to the pavement and were swept-up post-event by firefighters or maintenance personnel of the cemetery. The cemetery workers could not recall specifics regarding the clean-up of the debris at the fire site when interviewed by the SCI investigator.

The lower right corner of the engine compartment displayed high heat oxidation with a distinct burn pattern that extended vertically upward into the cooling fan housing for the

radiator **(Figure 18)**. This pattern originated on the transverse engine mount at the lower right corner of the engine. Two mounting plates were positioned in this area; one welded to the transverse mount and the second located forward of this mount. The mounting points did not contain bolts at the time of the inspection. Melted aluminum pooled immediately to the right of these mounts **(Figure 19)**.

The high heat burn pattern extended upward from this mounting point across the right side of the engine and into the squirrel cage cooling fan. The aluminum housing for this fan was melted by the fire. Evidence of high heat was present above the cooling fan on the right lower corner of the radiator reservoir, right of the vehicle's centerline. This high heat pattern was not present on the symmetrical- mounted left cooling fan. The right to left disparity in the heat pattern was indicative of the right biased fire origin.

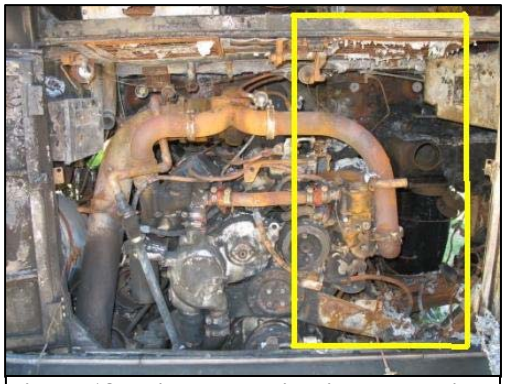

Figure 18. High heat oxidation to the right side of the engine area.

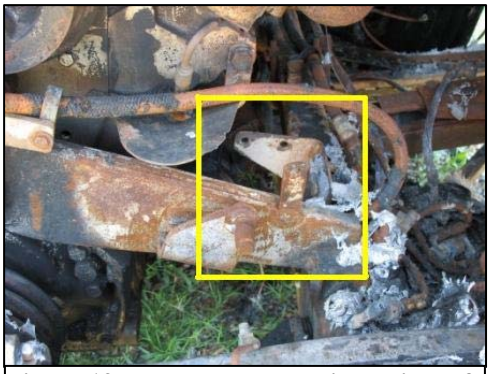

Figure 19. Presumed mounting points of the alternator.

The fire subsequently spread forward and involved the tag and drive axle tires that became a large fuel source for the fire.

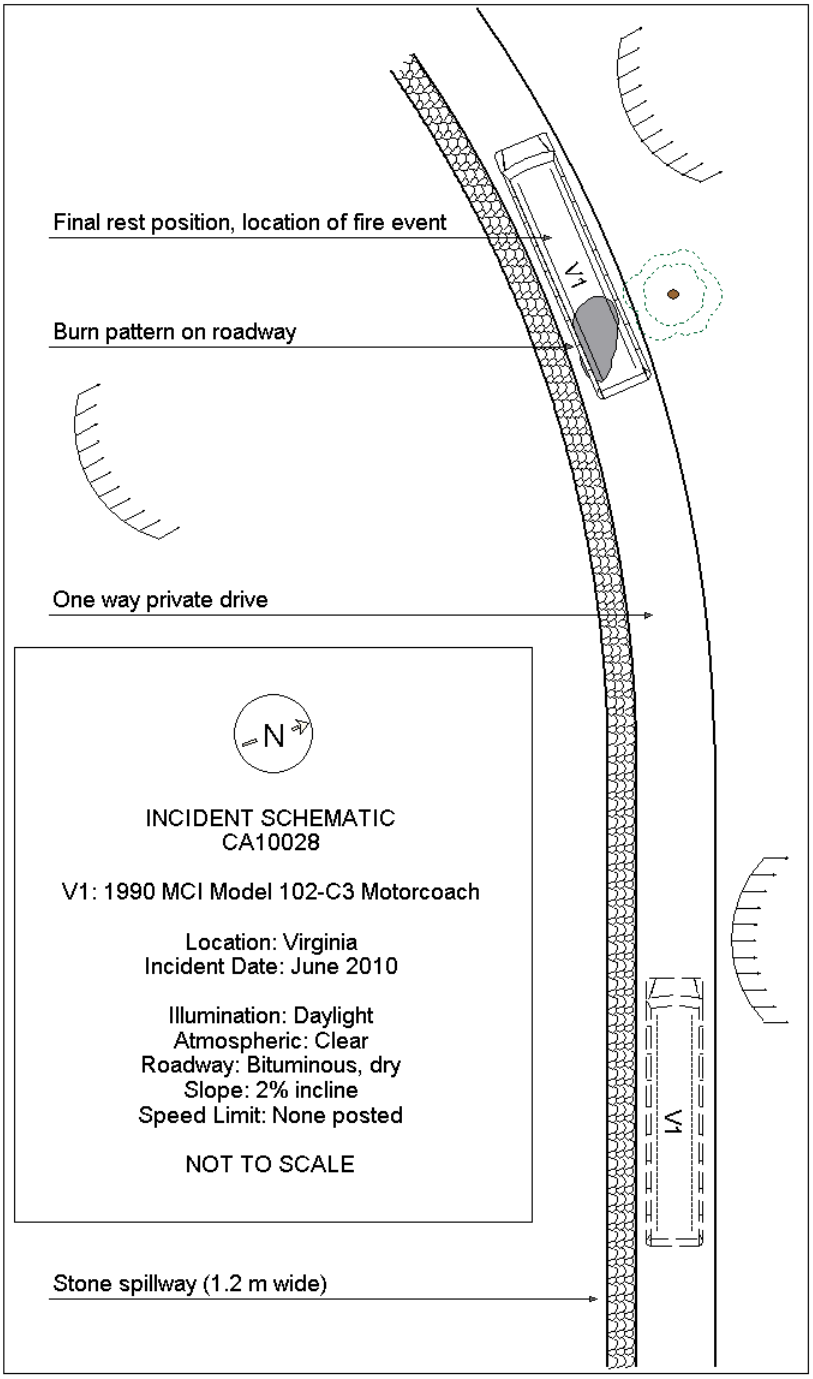

Figure 20. Incident Schematic.

ATTACHMENT A:

FIRE EXPERTS REVIEW AND OPINION REPORT

Independent review and subsequent opinion by a fire origin and cause investigator:
It should be noted that this investigator was not directly involved with the vehicle fire or scene inspections, but rather depended on the photographs and documentations collected by the Calspan SCI team. Whereas this is not the optimal process when conducting an origin and cause investigation, the option of reviewing previous documentation is acceptable methodology according to NFPA 921, "Guide for Fire and Explosion Investigations" (2008 edition), and is adequate for the subject investigations given the scope and purpose of these evaluations.

For each case, photographs and documents were reviewed initially to determine an area or point of origin for the fire. Then this area was analyzed to determine a most probable cause. The area of origin was determined by an interpretation of the fire patterns left by the fire and supporting witness information. Interpreting fire patterns involves assessing the different amounts of damage to the various components involved taking into consideration the progression of the fire which is determined by the various fuel loads involved, the physical properties of the various materials, environmental effects, and the dynamics of the fire itself.

SCI Case Number CA10028

Determination of Origin: Examination of the exterior of the motorcoach shows the front half of the coach was unaffected. The damage on both right and left sides started immediately forward of the rear axles and extended all the way to the back. Examination of the engine compartment shows heavy damage to the right side of the compartment and a series of unidentified burned hoses along the right rear of the engine compartment. This is also the lowest point of the fire. This fire damage is consistent with the driver's report of inspecting the rear of the vehicle and finding smoke and fire emanating from the engine compartment. This analysis shows the area of origin to be in the right rear lower corner of the engine compartment.

Determination of Cause: The area of origin contained an arced power cable but no visible arc partner. The function of this cable is also undetermined. This area also contained multiple unidentified hoses and fittings that had been consumed. Without additional investigation or information pertaining to the function of the engine systems and components in the area of origin, the cause is categorized as undetermined.