CRASH DATA RESEARCH CENTER
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CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION

SCI CASE NO.: CA09049

VEHICLE: 2003 MCI MODEL G4500 MOTORCOACH

LOCATION: OHIO

INCIDENT DATE: JULY 2009

Contract No. DTNH22-07-C-00043

Prepared for:

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

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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. CA09049	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Motorcoach Fire Investigation Vehicle: 2003 MCI Model G4500 Motorcoach Location: State of Ohio		*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: July 2009 *14. Sponsoring Agency Code*	
15. Supplementary Note This on-site investigation focused on the origin of a fire of an in-transit motorcoach. The involved motorcoach was a 2003 Motor Coach Industries (MCI) Model No. G4500.			
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17. Key Words 2003 MCI Model G4500 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* 10	*22. Price*

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CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION
SCI CASE NO.: CA09049
VEHICLE: 2003 MCI MODEL G4500 MOTORCOACH
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BACKGROUND

This on-site investigation focused on the origin of a fire of an in-transit motorcoach. The involved motorcoach was a 2003 Motor Coach Industries (MCI) Model No. G4500 **(Figure 1)**. The motorcoach had a 55-passenger capacity. The motorcoach was occupied by a 70-year-old male driver and approximately 40 passengers. The motorcoach was traveling in a southerly direction on an interstate roadway at highway speeds when the driver observed smoke emanating from the right rear axle area. He brought the vehicle to a controlled stop on the right shoulder of the interstate. The driver used the onboard fire extinguisher to contain the fire. He ordered the immediate evacuation of the passengers and called the emergency response system to request police and fire assistance. The local fire department responded to the scene and suppressed the fire. There were no injuries associated with this incident.

Figure 1. Right side view of the 2003 MCI motorcoach.

This incident was identified by the Calspan Special Crash Investigations (SCI) team through an Internet news search on July 17, 2009. The notification was forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) and assigned for on-site follow-up. The Calspan SCI team initiated telephone contact with the investigating police agency and obtained a copy of the Police Crash Report. Additional follow-up was conducted with the motorcoach company and cooperation was obtained from the Safety Director to inspect the motorcoach. The motorcoach was transferred to a company-operated repair facility in Louisville, KY where it was evaluated by the motorcoach company for repair. The SCI inspection of the bus was conducted on August 25, 2009. This on-site investigation involved a thorough inspection of the motorcoach to determine the origin of the fire, an interview with the manager of the repair facility, and the documentation of the incident site. A fire expert conducted a review of the images and the SCI documentation of the incident. His opinion relating to the fire origin and cause is included as *Attachment A* of this report.

SUMMARY

Incident Site

Figure 2. Overall view of the incident site.

The incident occurred on a four-lane divided interstate roadway during daylight hours. At the time of the fire incident, the weather conditions were clear and dry with a temperature of 26 degrees C (79 degrees F) with west-northwesterly winds of 9.3 km/h (5.8 mph). The weather data was obtained from an Internet-based weather data service. The travel lanes were 3.7 m (12 ft) in width with paved shoulders on both sides of the southbound lanes. Rumble strips were cut into the asphalt surface of the shoulders adjacent to the edge lines. In the vicinity of the incident site, the interstate was straight and level. The posted speed limit was 105 km/h (65 mph). **Figure 2** is an overall view of the incident site. The incident schematic is included as **Figure 14.**

Vehicle Data

Figure 3. View of the engine compartment in the 2003 MCI motorcoach.

The involved motorcoach was a 2003 MCI, Model G4500 with a 55-passenger rating. The motorcoach was manufactured in November 2002 and was identified by the following Vehicle Identification Number (VIN): 3BMXSMWA73S (production number deleted). The motorcoach company reported odometer reading was 1,612,943 km (1,002,264 miles). Although specified as equipped with a Detroit Diesel Series 60 12.7 liter rear-mounted engine, this motorcoach was configured with a Caterpillar engine **(Figure 3)** linked to an Allison B500 automatic transmission. The service brakes were air-operated drum with automatic slack adjusters and anti-lock. The electrical power was a 24-volt system with the batteries mounted immediately forward of the right drive axle. The suspension was an air-ride system with manual leveling. The Gross Vehicle Weight Rating was 21,769 kg (48,000 lb) with axle distributions of 7,256 kg (16,000 lb) for the steer axle, 10,431 kg (23,000 lb) for the drive axle and 5,442 kg (12,000 lb) for the tag axle. The manufacturer recommended tire size was 315/80R22.5 with rim sizes of 57x21 cm (22.5x8.25 in) for all three axles. The recommended cold tire pressures were 827 kPa (120 PSI) for the steer axle and 586 kPa (85 PSI) for the drive and tag axles. The motorcoach was equipped with Michelin XZA2 Energy radial tires, size 315/80R22.5 at all eight positions. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Pressure	Measured Tread Depth	Damage
Left Front	476 kPa (69.0 PSI)	10 mm (12/32 in)	None
Right Front	514 kPa (74.5 PSI)	11 mm (13/32 in)	None
Left Drive - Outer	Unknown	9 mm (11/32 in)	None
Left Drive – Inner	Unknown	9 mm (11/32 in)	None
Left Tag	721 kPa (104.5 PSI)	3 mm (3/32 in)	None
Right Drive - Outer	Unknown	11 mm (13/32 in)	None
Right Drive - Inner	Flat	12 mm (15/32 in)	Fire damage to sidewall with a partial tread separation
Right Tag	721 kPa (104.5 PSI)	10 mm (12/32 in)	None

The interior of the motorcoach was configured with a left side-mounted driver's seat and forward controls. The driver's seat was partitioned from the passenger compartment by a Plexiglas shield at the back side of the seat. The driver's seat was a high-back seat that was mounted on a box frame with a pneumatic suspension system. A manual 3-point lap and should belt system was mounted to the left B-pillar. The steering wheel was equipped with a tilt mechanism.

The loading door was conventionally located at the right front area of the motorcoach. The staircase was composite and consisted of five steps that terminated at the level of the center aisle. The passenger seating consisted of two rows of seats with two high-back seats in each row. There were 13 seats in each row with a 3-passenger seat at the back of the motorcoach, left of the onboard restroom. The seats were fabric covered with fixed outboard armrests and a folding center armrest. The seatbacks reclined and all seats had integrated head restraints. **Figure 4** is a rear view of the interior configuration of the motorcoach.

Figure 4. Rear view of the interior of the motorcoach.

An open overhead storage system was mounted to the ceiling and side walls to provide for storage of carry-on items. There were two rows of elastic shock cord that were routed through the vertical supports to retain the stowed items within the open compartments.

The center isle was covered with a vinyl flooring material. Rigid plastic panels covered the ceiling of the motorcoach.

The motorcoach was equipped with multiple emergency exits. There were two roof-mounted exits positioned at seating rows 1-2 and 9-10. An emergency side door was located on the right side of the motorcoach at seating row 9 and was a full-height, floor to ceiling door. Push-out emergency egress windows were located at rows 1-2, 3-4, 11-12 and 13-14 on both sides of the motorcoach. The side glazing panels at rows 5-10 were fixed.

There was no fire-related damage to the interior of the motorcoach.

Service History

The available service history of this motorcoach is identified in the following table:

Service Issue	Service Date	Odometer Reading
Replace tag axle brake shoes	12/13/2007	Unknown
Left steer axle tire replacement	1/14/2009	Unknown
Right steer axle tire replacement	1/14/2009	Unknown
Left drive axle outer tire replacement	5/11/2009	Unknown
Right drive axle inner tire replacement	5/14/2009	Unknown
Right drive axle outer tire replacement	5/14/2009	Unknown
DOT inspection	5/19/2009	1,569,484 km (975,259 miles)
Oil change, 43 liters (38 qts)	6/7/2009	1,605,819 km (997,837 miles)
Replace steer axle brake shoes	6/9/2009	Unknown
Left tag axle tire replacement	6/16/2009	Unknown
Replace drive axle brake shoes	6/29/2009	Unknown
Left drive axle inner tire replacement	7/5/2009	Unknown

Incident

Pre-Incident

The driver of the motorcoach was a 70-year-old male. He conducted a pre-trip inspection of the motorcoach and filed a pre-trip inspection report noting poor performance of the air conditioning system for the driver's position, excessive wear on several of the passenger seats, and the lack of adjustment of the driver's seat. None of these conditions were related to the fire or the performance of the motorcoach.

The trip originated at a bus terminal in Michigan with a southerly route planned with scheduled stops in Ohio, Kentucky and Texas. According to company records, the motorcoach was last fueled at the onset of this trip. The driver loaded several pieces of luggage in the undercarriage luggage bays and approximately 40 passengers boarded the motorcoach. He departed the station and proceeded south on the interstate roadway and traveled approximately 137 km (85 miles) at interstate speeds.

Incident

The driver was traveling on the outboard travel lane during the clear and dry daylight conditions. He checked his right outside mirror and observed smoke emanating from the right rear axle area of the motorcoach. The driver slowed the motorcoach and brought the vehicle to a controlled stop on the right shoulder. The driver turned-off the engine and applied the emergency brake. He retrieved the onboard ABC fire extinguisher, exited the motorcoach, and proceeded to the right rear axle location **(Figure 5)**. The driver contained the fire with the dry-chemical extinguisher and called the emergency response system to report the fire and request police and firefighting assistance. The driver returned to the motorcoach and ordered the evacuation of all passengers. The passengers exited the motorcoach and proceeded to the grass roadside, a safe distance from the motorcoach. There were no injuries associated with this fire.

Figure 5. Fire area the involved the right driver axle undercarriage.

Post-Incident

The fire department responded to the call for assistance and used water to extinguish and cool the remnants of the undercarriage/tire fire. The driver called his dispatcher to report the fire and the location of the incident. The motorcoach company dispatched another motorcoach to the scene of the incident. The passengers boarded the replacement motorcoach and the underbody luggage was transferred. The replacement motorcoach continued to the planned destinations. The involved motorcoach was towed to a local tow yard.

The motorcoach company performed an initial assessment of the damage. It was determined that the vehicle was repairable. A tow service was hired to transport the motorcoach to a regional company repair facility in Louisville, KY. The Safety Director noted that the right rear brakes required a level of disassembly prior to towing the motorcoach. The motorcoach was inspected at the repair facility for this investigation.

Motorcoach Damage

Exterior

The exterior body panels of the motorcoach were fiberglass composite and were not damaged by the undercarriage-related fire. Smoke and soot deposits were present on the axle skirting over the right drive axle and the side body panel above the drive axle position. In addition to the smoke deposits, the painted surface at the bottom edge of the shirt was blistered by heat with an orange-peel like

Figure 6. Heat damage and smoke staining to the right drive axle skirt and body panels.

appearance **(Figure 6)**. The smoke deposits continued in a forward direction from the axle position and were present to the area of the fuel filler door and above, immediately forward of the drive axle. This pattern indicated a forward direction of the smoke. The smoke/soot deposits to the painted body panels were not a permanent discoloration as the blackened deposits could easily be removed.

Interior

There was no fire or smoke related damage to the interior of the motorcoach.

Undercarriage

The undercarriage of the motorcoach sustained minor severity damage that involved the inner tire of the right drive axle, the right drive axle brakes, with minor fire damage to the adjacent air suspension bladder and air lines to the air brake chamber. The specific components and the related damage are described in detail below. **Figure 7** is an undercarriage view of the right drive axle area.

Figure 7. Overall view of the undercarriage components at the right drive axle area.

Prior to the SCI investigation, a local motorcoach repair facility removed the drive axles to facilitate the towing of the motorcoach to the regional repair facility. In addition, the right drive axle brake shoes were removed. The brake drum was repositioned on the axle. The inner tire was removed from the steel wheel and placed in the undercarriage luggage bay of the motorcoach along with the axles and the brake shoes. The outer tire was not damaged and remained in position on the motorcoach at the time of the SCI inspection.

Drive Axles

The SCI inspection of the drive axles revealed no evidence of damage, or damage incurred by a potential wheel bearing failure. The axle was wet with oil and was not damaged. **Figures 8 and 9** are views of the right drive axle that was removed from the motorcoach prior to towing transfer to the repair facility.

Figure 8. Removed right drive axle.

Figure 9. Close-up view of the outboard end of the axle and the axle flange.

Right Inner Drive Axle Tire

The inner drive axle tire was removed from the steel wheel and placed in the luggage bay of the motorcoach prior to transfer to the repair facility. The SCI investigator removed the tire and documented the following:

The tire was a Michelin XZA2 Energy radial, size 315/80R22.5. The tire was identified by the TIN B1D7 B3JX 1109 with a maximum inflation pressure of 896 kPa (130 PSI) with load ranges of 4,125 kg (9,090 lb) on a single axle, and 3,750 kg (8,270 lb) when used on a dual axle. The tire was tubeless and regroovable. The motorcoach service records indicated this tire was installed on the vehicle on 5/19/2009 and was new at the time of installation.

The inner sidewall of the inboard drive axle tire was shredded with separation from the tread and bead areas **(Figure 10)**. The steel belts of the sidewall were exposed with a 69 cm (27 in) section of the sidewall completely separated from the tire. This damage was typical of a tire that was run flat.

A portion of the sidewall of the inner drive axle tire was charred by fire. This fire damage extended onto the tread area of the tire. The burn pattern appeared to be vertically oriented, indicative of the burn pattern at the top position of the tire when the motorcoach was stopped.

A section of the tire tread separated. A narrow band of tread separated on a diagonal pattern across the full-width of the tread pattern of the tire **(Figure 11)**. The length of the separation was 94 cm (37 in). The burn pattern extended over this area. The underlying belts of the tire were not subjected to fire damage, suggesting this tread section was removed from the tire post-incident.

The inside surface of the inner tire was inspected for evidence of punctures or previous repairs. There was no damage or evidence of punctures, or evidence of previous repairs found within the tire.

The inner sidewall of the right outboard drive axle tire was scuffed from contact by the outer sidewall of the inner tire. No damage occurred to the outboard tire. Rubber fragments were fused to the inboard bead of the inner steel wheel.

Figure 10. Inboard sidewall damage to the right inner drive axle tire.

Figure 11. Partial post-incident tread separation with fire damage across the tire tread.

Right Drive Axle Brakes

The brake shoes were removed from the right drive axle prior to transfer to the repair facility. The shoes were removed from the luggage bay by the SCI investigator. The SCI inspection of the brake shoes revealed the following:

The brake linings were subjected to extreme heat. The linings were 35.6 cm (14.0 in) in length and 21.6 cm (8.5 in) in width on each shoe. Each shoe lining was comprised of two separate linings that were riveted to the shoe with a horizontal gap between the midpoints of the linings. The semi-circular shoes were mounted in a top and bottom (horizontal configuration). The SCI investigator was unable to determine which shoe was mounted in the top position.

Both brake linings exhibited evidence of high heat, presumed to have resulted from prolonged engagement with the brake drum. Material from the linings had eroded from the lining surfaces and was deposited and fused in the center grove of the shoes. The lining material also filled the majority of the rivet holes in the lining.

One of the brake shoes was whitish in color, indicating higher heat, or exposure to fire. A narrow band of the white discoloration was present on the outer surface of the other shoe. **Figures 12 and 13** depict the damage and discoloration to the brake shoe linings.

The brake drum remained in place on the right drive axle. The drum did exhibit some bluish discoloration due to high heat; however, the machined surface of the drum was rusted from exposure to the elements post-incident.

Figure 12. Heat damage/erosion of the right drive axle brake shoe linings.

Figure 13. Close-up view of the damage to the brake shoe lining.

SCI Fire Source

Based on the high-heat evidence to the right drive axle brake shoes and the eroding of lining material, it is believed that this brake partially applied while the motorcoach was traveling at highway speeds. The heat generated by the brake extended inboard in relation to the motorcoach and involved the inner drive axle tire. The tire subsequently aired out as the motorcoach continued en route to its destination. The tire debeaded, self-destructed and self-combusted. The resulting fire, although minor in severity, spread to the undercarriage components and involved the air suspension bladder and the air lines adjacent to the brake chamber.

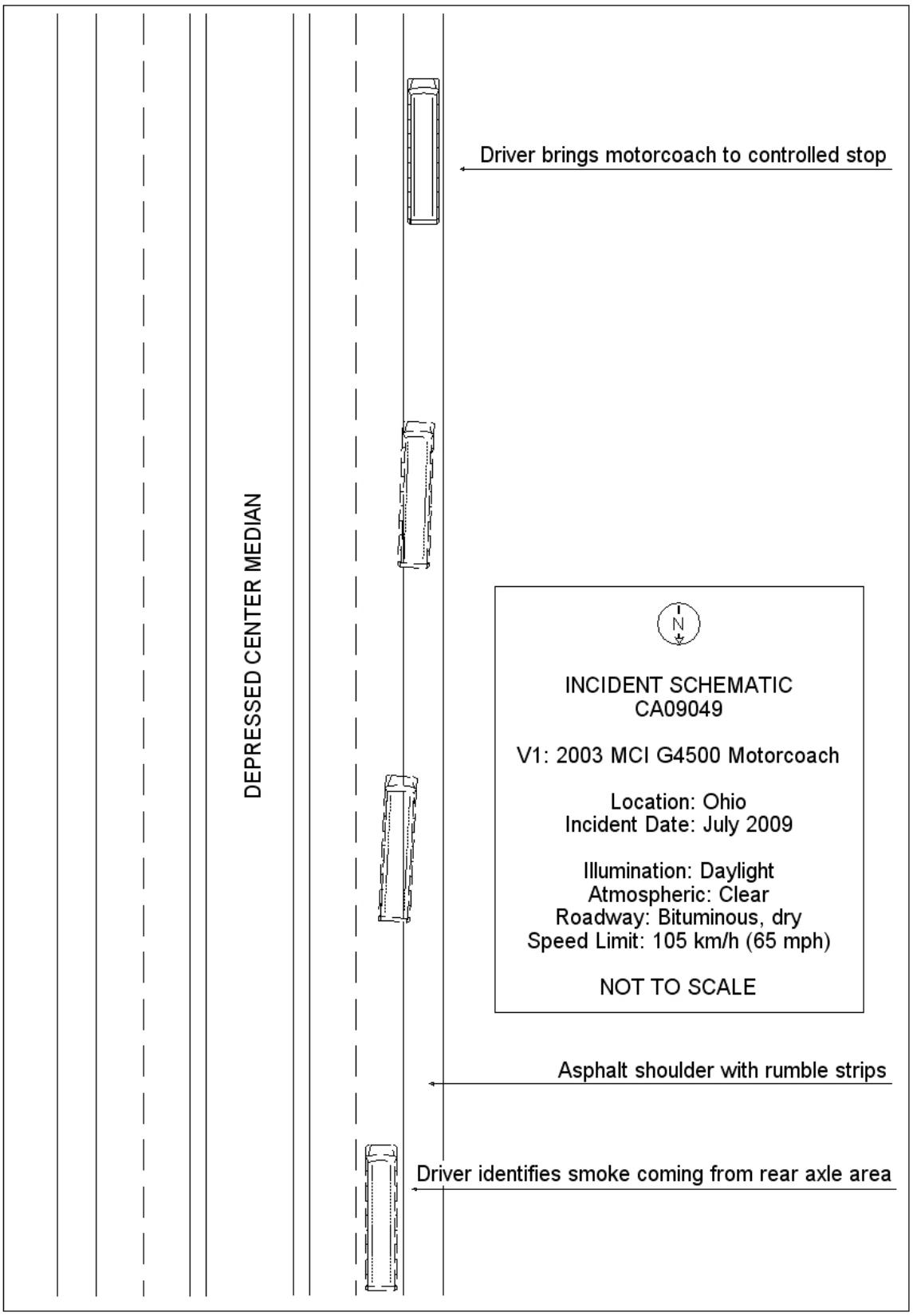

Figure 14. Incident Schematic

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 documentation 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.

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Determination of Origin: Exterior inspection of the motorcoach shows no major damage to the exterior of the vehicle, and smoke and soot deposits only prevalent above the right rear drive axle tires. There was no interior damage, nor damage to the luggage compartment and its contents. Damage to the undercarriage was limited to the vicinity of the right drive axle tires, with the inner tire exhibiting the most amount of fire damage. The first witness was the driver who reported smoke coming from the right rear axle area of the coach which is consistent with the damage observed. This analysis places the area of origin at the right drive axle wheel end and brake assembly.

Determination of Cause: Within the area of origin, the photographs show the tire damage is localized to the tire that is directly above the brake drum. The drum show signs of blueing which indicates extended high temperature exposure, and the brake shoes also show signs of severe overheating. The bearings in the wheel hub were not inspected, and no signs of a leaking wheel seal were observed. The drive axles were undamaged. This evidence is consistent with a dragging right drive axle brake being the most probable cause of this fire. The root cause for the brake drag cannot be determined as a mechanical inspection of the brake chamber, slack adjuster, the S-cam mechanisms, and other associated hardware was not conducted.