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CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION

SCI CASE NO.: CA09068

VEHICLE: 2007 MCI MODEL D4505 MOTORCOACH

LOCATION: MICHIGAN

CRASH DATE: SEPTEMBER 2009

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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.

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CALSPAN ON-SITE MOTORCOACH FIRE INVESTIGATION
SCI CASE NO.: CA09068
VEHICLE: 2007 MCI MODEL D4505 MOTORCOACH
LOCATION: MICHIGAN
CRASH DATE: SEPTEMBER 2009

BACKGROUND

This on-site investigation focused on the origin and severity of the fire that involved a 2007 Motor Coach Industries (MCI) motorcoach (**Figure 1**). The motorcoach was occupied by the 46-year-old male driver and 35 adult passengers while traveling at highway speeds on a divided roadway. Several of the passengers detected a significant jolt in the travel of the motorcoach and subsequently smelled the odor of smoke. They alerted the driver and he checked his outside mirrors and noted smoke emanating from the right rear axle area. The driver brought the vehicle to a controlled stop on the right shoulder of the roadway. The driver ordered the evacuation of the passengers through the right front door. There were no injuries associated with this event. The fire originated in the right tag axle area and spread through the undercarriage and into the passenger compartment. The driver called the emergency response system and requested police and fire assistance. The fire department arrived on-scene and suppressed the fire. The motorcoach was towed from the scene and transferred to a regional company-owned repair facility where it was inspected for this investigation.



Figure 1. Front right view of the 2007 MCI motorcoach.

This fire incident was identified through an Internet news search by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) on September 24, 2009. The notification was forwarded to the Calspan Special Crash Investigations (SCI) team for follow-up. The SCI team established cooperation with the Safety Director of the motorcoach company and coordinated an on-site inspection date of October 9, 2009. The inspection involved the detailed documentation of the exterior, interior, and undercarriage of the motorcoach. The motorcoach was registered to the Canadian affiliation of the company; therefore the repair facility could not access the service history of this motorcoach. A fire expert conducted a review of the images and the SCI documentation for this investigation. His opinion relating to these issues is included as *Attachment A* of this report.

SUMMARY

Incident Site

This fire incident occurred on a four-lane divided highway in a rural area during daylight hours. According to local weather reports, the weather was overcast with a temperature of 17.7 degrees C (64 degrees F) and 94 percent humidity. The winds were southwesterly at 11 km/h (7 mph). The roadway consisted of two lanes in the east and westbound directions of travel that were divided by a depressed grass median. The investigating officer stated that in the vicinity of the incident site the roadway was straight and level with a posted speed limit of 113 km/h (70 mph).

Due to the location of the motorcoach in relation to the incident site, a distance of 603 km (375 miles), the site was not inspected by the SCI investigator.

Vehicle Data

The involved motorcoach was a 2007 MCI Model D4505 with a 55-passenger capacity. The motorcoach was manufactured in October 2006 and was identified by Vehicle Identification Number (VIN): 1M86DMDA37P (production number deleted). The motorcoach was registered to the Canadian division of a large motorcoach carrier. The motorcoach was powered by a Cummins 10.8 liter, 410 HP rear-mounted engine that was linked to an Allison B500 series 6-speed automatic transmission. The service brakes were Meritor all-wheel disc with anti-lock. The total Gross Vehicle Weight Rating was 21,772 kg (48,000 lb) with Gross Axle Weight Ratings of 7,257 kg (16,000 lb) front, 10,206 kg (22,500 lb) intermediate/drive, and 5,443 kg (12,000 lb) rear/tag. The manufacturer recommended tire size was 315/80R22.5 with rims sized 57 x 21 cm (22.5 x 8.25 in). The cold tire pressure recommendations were 827 kPa (120 PSI) for the front steer and drive axle tires and 621 kPa (90 PSI) for the tag axle tires. All of the tires on the motorcoach were size 315/80R22.5. The tire data at the time of the inspection was as follows:

Position	Tire Manufacturer Model/TIN	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	Michelin XZA2 Energy (unknown TIN)	810 kPa (117.5 PSI)	14 mm (18/32 in)	None
Right Front	Michelin XZA2 Energy (unknown TIN)	789 kPa (114.5 PSI)	11 mm (14/32 in)	None
Left Drive – Outer	Firestone FS??? (unknown TIN)	Flat	6 mm (7/32 in)	Tread and sidewall surfaces burned
Left Drive – Inner	Michelin X???? (Unknown TIN)	Flat	10 mm (12/32 in)	Tread and sidewall surfaces burned
Right Drive – Outer	Goodyear G291 MJ74 1CJW 4605	Flat	8 mm (10/32 in)	Tread and sidewall surfaces burned
Right Drive – Inner	Michelin X????	Flat	9 mm (11/32 in)	Tread and sidewall surfaces burned
Left Tag	Goodyear ????? (Unknown TIN)	Flat	6 mm (8/32 in)	Tread and sidewall surfaces burned
Right Tag	Unknown	Flat	Unknown	Completely consumed by fire

(??? Represents unknown, destroyed by the fire)

The interior of the motorcoach was configured for a passenger capacity of 55 with 13 rows of seats consisting of two seats in each row on each side of the center aisle. A three passenger seat was located in the 14th row on the left side adjacent to the onboard restroom. The passenger seats were cloth surfaced and were configured with adjustable head restraints, reclining

seatbacks and outboard armrests. Aircraft-style overhead storage compartments were located above the seating positions with top-hinged plastic doors. Individual reading lights were mounted to the bottom aspect of the overhead compartments.

The driver's position was equipped with a suspension seat and a 3-point lap and shoulder safety belt system. The instrument panel gauges recorded full for the fuel tank and 827 kPa (120 PSI) of air pressure for the steer axle brakes and 0 kPa of pressure for the braking system at the rear axles at the time of the SCI inspection.

The motorcoach was configured with two emergency roof exits. Both of these exits were closed and intact at the time of the SCI inspection. All side windows were labeled as emergency push-out exits. The windows were closed and were not utilized as emergency exits at the time of the fire incident.

The motorcoach was also configured with a kneeling front suspension. This suspension design allowed the driver to lower the front suspension of the motorcoach when stopped, creating a lower step height for passengers, enabling easier access into and out of the motorcoach. There were two switches; one located on the instrument panel at the driver's position and the second located on the exterior of the motorcoach aft of the right side loading door to activate the kneeling feature. The basic function of the system exhausts air pressure out of the front axle bellows, dropping the front suspension onto the rubber stops. When the recover switch is pressed, the air system inflates the suspension back up to normal ride height.

Vehicle Service History

The repair facility manager stated that he could not access the service records for this Canadian registered motorcoach; therefore the recent service history for this vehicle is unknown.

Incident Sequence

Pre-Incident

The driver of the motorcoach was traveling in a westerly direction on the outboard lane of a divided roadway during daylight hours. He was en route to several western cities on a scheduled route. The driver was traveling at a speed of approximately 113 km/h (70 mph) with the 35 passengers onboard the motorcoach.

Incident

While traveling westbound, the passengers felt a jolt from the back of the motorcoach accompanied by a "popping" sound. The passengers relayed to the driver that they detected the odor of smoke. The driver observed smoke emanating from the right rear axle area in the right outside mirror. He slowed the vehicle and brought the motorcoach to a controlled stop on the north shoulder of the roadway and ordered the evacuation of the passengers. The passengers proceeded to the grass roadside; a safe distance from the motorcoach. The investigating officer stated there were no injuries to the driver or the passengers.

Post-Incident

The driver called the emergency response system and notified the dispatcher of the location of the motorcoach and the immediate need for police and fire assistance. The local fire department responded to the call. As the fire department arrived on scene, the fire had spread throughout the back and undercarriage of the motorcoach. Firefighters used a pike pole to penetrate and removed several of the laminated side windows to vent the fire during the firefighting activities. The fire subsequently spread to the interior of the motorcoach over the rear axle area. The fire was quickly extinguished.

The investigating officer stated that due to the heavy smoke and the uncertainty of the fire, the roadway was closed to traffic during the firefighting activities. The motorcoach company dispatched another motorcoach to the incident site to pick up the passengers and continue to their destinations.

Vehicle Damage – Exterior

The fire damage was concentrated in the rear aspect of the motorcoach at the drive and tag axle locations. The fire spread rearward into the engine compartment and upward into the interior. The forward portion of the motorcoach was not damaged. The underbody luggage bays were undamaged. The following describes the fire damage by location.

Front

There was no fire related damage to the front of the motorcoach. The laminated windshields were intact within the gasket mounting system. Smoke and soot staining was present on the interior surface of the windshields with the heaviest concentrations on the bottom aspect of the glazing. The windshield wipers were in the stowed vertical positions. The spare tire was mounted horizontally behind the front bumper system. The bumper fascia was abraded by previous damage with no fire related damage. The rear view mirrors were affixed to A-pillar mounted stalks and were positioned forward of the windshields. The flat and convex mirrors were intact, without damage. Aftermarket deer whistles were mounted on the mirror stalks. The headlight and turn signals assemblies were intact and without fire related damage.

Left Side

The fire spread through the undercarriage and involved the left rear tires. The tires became a source of fuel for the fire as the fire burned upward onto the left side of the motorcoach. The fiberglass splash shield over the axle positions was consumed by the fire with only the center portion of the shield and the mounting brackets remaining. Smoke staining began on the side body panels forward of the drive axle and extended to the back corner. The paint began to blister 13 cm (5 in) aft of the centerline of the drive axle with complete burning of the painted surfaces extending 79-175 cm (31-69 in) aft of the drive axle and over the tag axle location. The high heat area was directly over the tag axle and resulted in buckling



Figure 2. Fire damage to the left rear side of the motorcoach.

of the body panels (**Figure 2**). The aluminum trim at the midline of the body panels was melted over a 33 cm (13 in) area above the tag axle. The high heat burn pattern extended vertically to a point that was 11 cm (4.5 in) below the beltline. The blistering of the paint ended 206 cm (81 in) aft of the drive axle.

The sheet metal surfaced body panel located rearward of the tag axle and the side access door to the engine compartment exhibited distinct burn patterns to the painted surfaces. Electrical wiring located within this area was consumed by the fire as it spread left and rearward into the engine compartment.

Back

The fire damage to the back plane of the motorcoach extended from the mid-body line, upward to the top of the vehicle (**Figure 3**). The rear bumper was a painted aluminum channel with a wide rub strip. There was no damage to the bumper system or to the taillight/backup light lenses located above the bumper corners. The engine compartment was concealed by two center closing sheet metal surfaced doors. The paint was burned from the mid area of the right door with burning of the paint to the upper center aspects of both doors. The formed corner panels located outboard of the engine compartment doors were burned through at the level of the upper doors. These areas housed the taillight and turn signal assemblies.



Figure 3. Fire damage to the back of the MCI motorcoach.

The louvered fiberglass panel above the engine compartment provided ventilation for the air conditioning condenser and the radiator. This panel was charred with the gel coat burned off the fiberglass. The right corner area of the back plane exhibited higher heat with more extensive damage than the left side. The solid fiberglass panel above the louvered panel was burned through on the right side with near complete charring of the gel coat over the entire panel.

Engine Compartment

The fire spread rearward into the engine compartment (**Figure 4**) and burned most of the combustible components. The fire evidence was predominately high within the engine compartment, as the paint remained intact on the engine block. There was no evidence of high heat oxidation in the engine compartment.



Figure 4. Engine compartment of the MCI motorcoach.

Right Side

The damage to the right side of the motorcoach began at the forward edge of the drive axle opening and extended to the back right corner (**Figure 5**). The paint was burned from the sheet metal surfaced body panels with distortion of the panels over the drive and tag axle locations. There was melting of the trim over the axle positions and to the trim at the beltline forward of the I-pillar, over the tag axle. The window trim was also melted at his location.



Figure 5. Right side fire damage over the rear axle areas.

The fiberglass splash shield was burned over the axle positions with the forward aspect of the skirt remaining intact. The presence of high heat was most notable over the tag axle location with discoloration and severe buckling of the sheet metal panel.

Glazing

The front of the motorcoach was fitted with two laminated windshields that were gasket-mounted. The windshields were intact with smoke and soot staining on the interior surfaces, with the most prevalent staining occurring at the lower surfaces. The mounting gaskets were intact.

The driver's side windows were located between the left A and B-pillars and consisted of three separate windows. The forward window located immediately aft of the left A-pillar was fixed. The top glazing panel was also fixed. Both of these glazings remained intact with minimal smoke staining to the inside surfaces. The window forward of the left B-pillar was operational and was opened in the forward direction at the time of the SCI inspection. The window was intact with smoke staining present.

The left side of the motorcoach contained eight glazing panels that spanned the passenger compartment area. These glazing panels consisted of a deep tint, tempered exterior panel that was bonded to the push-out window frame. The inner panel was laminated glass. The forward five glazing panels were intact with smoke and soot staining to the inside surfaces. The rear three glazing panels, over and aft of the rear axle positions, were broken out by the firefighters in an effort to vent the fire. Some perimeter glazing of the tempered outer panels remained in place. The rubber window frame gaskets were partially burned, but still intact within the window frames.

The right loading door contained two fixed laminated glazing panels. Both panels remained intact with minimal smoke staining to the interior surfaces.

The right side glazing consisted of eight windows in the passenger compartment area. The windows were the same as the left side with two separated glazing panels forming the window units. The four forward windows were intact with smoke staining to the inside surfaces. The firefighters used a pike pole to impact and disintegrate the four rear outer glazing panels (**Figure**

6). The fifth and sixth laminated glazing panels were penetrated and holed with the majority of the glazing remaining in the window frame. The last two right side laminated glazing panels were completely removed from the motorcoach. The perimeter gaskets were burned from the seventh window frame with majority of the gasket remaining in the last right side window frame.

Tires/Wheels

The motorcoach was configured with mixed manufacturer tires that were previously identified by manufacturer, model, and condition. There was no fire related damage to the front steer axle tires or alloy wheels. The front Michelin tires remained inflated with deep tread depth.



Figure 6. Firefighter induced damage to the right side glazing panels.

The left outer drive axle tire exhibited minor severity fire damage that involved the tread and the inner and outer sidewalls. The burn pattern was not full thickness to the tire; however, the tire was aired out and de-beaded from the alloy wheel (**Figure 7**). During the tow and transfer process of the motorcoach, the tire rotated on the alloy wheel. The burn pattern, which was at the top of the tire at the time of the fire, was at the 5 o'clock position at the time of the SCI inspection. There was no fire damage, heat transfer, or smoke staining to the alloy wheel.

The upper inner sidewall and tread of the left inboard drive axle tire was burned in a similar pattern to the outer tire. The burn pattern was not full-thickness; however, the tire was flat and de-beaded from the alloy wheel.



Figure 7. Left outer drive axle tire and wheel.



Figure 8. Fire damage to the left tag axle tire.

The upper half of the inner sidewall of the left tag axle tire was burned full-thickness with the top area of the tread burned with residual tread depths of 0-3 mm (0-4/32 in). The tire was flat and de-beaded from the alloy wheel. **Figure 8** is the tire damage to the left tag axle tire.

The right outer drive axle tire de-beaded and rotated on the alloy wheel during the towing process. The burned area of the tire was initially at the top position and was rotated to the bottom position at the time of the SCI inspection. Approximately 180 degrees of the outer sidewall was burned, with a segment burned full-thickness, exposing the steel belts. The tread was also burned in this area with the majority of the 9 mm (11/32 in) tread depth burned smooth. The alloy wheel was slightly discolored by heat, but remained intact. A hubometer was installed on the right outer drive axle. The plastic face of the hubometer was melted; however, the odometer reading of 603,351 km (374,915.1 miles) remained visible.

The right inner drive axle tire was burned in a similar pattern to the outer tire. The inboard sidewall was burned full-thickness resulting in air loss. The tire de-beaded from the alloy wheel. The tread block was burned and the tire had rotated on the wheel approximately 180 degrees during the towing process. The alloy wheel was intact with minimal evidence of heat discoloration (**Figure 9**).

The right tag axle tire was completely consumed by the fire (**Figure 10**). The only remaining tire evidence was the bead wires that were draped around the brake and axle assemblies. The upper inboard aspect of the tag axle alloy wheel was burned and melted by the fire. The outer half of the wheel was intact with high heat discoloration at the 6 o'clock position of the wheel. The steel lug nuts that secured the wheel to the axle were in place and rusted. The decorative lug nut caps were completely burned.



Figure 9. Right outer drive axle tire damage.



Figure 10. Overall view of the right side tire and tag axle wheel damage.

The sheet metal splash shields that were mounted vertically between the drive and the tag axles limited the spread of the fire from the tag axle tire to the drive axle tires. These splash shields remained intact on both side of the motorcoach.

Undercarriage

At the time of the SCI inspection, the motorcoach was inside the repair facility and was positioned over an inspection/repair pit. The right tag axle alloy wheel was damaged by the fire and remained in place on the axle. The lug nuts were in place and rusted from exposure to heat and water. There was no evidence that the lug nuts were removed prior to the inspection. The wheel bearing dust cover that was bolted to the hub, was melted by the fire. The wheel bearing adjustment nut was missing from the axle. The forward aspect of the axle threads were damaged

with the appearance of an impact by a hammer-like tool. The outer wheel bearing race was intact within the hub assembly; however, the tapered roller bearings, the oil seal, and the inner race were missing from the assembly. Oil was still present in the hub assembly. The inner wheel bearing also appeared to have separated. The repair facility manager stated to the SCI investigator that this wheel bearing and wheel assembly was not altered or disassembled by the motorcoach company prior to the SCI investigation. **Figures 11 and 12** are views of the right tag axle shaft and the wheel bearing races.



Figure 11. Right tag axle shaft and the wheel bearing races.



Figure 12. Close-up view of the wheel bearing races with the seals, tapered roller bearings and inner races missing.

The truss frame of the motorcoach exhibited areas of high heat oxidation above the right tag axle area. The lateral U-channel cross member displayed high heat as the fire spread from right to left across the undercarriage of the vehicle. Most of the combustible components within the axle area were burned or charred by the fire. The right rear air ride suspension bladders were burned with near complete burn of the tag and mid bladders. The forward bladder was partially burned. The painted surface of the right tag axle shock absorber was burned along with the rubber bushings at the mounting points. The upper bushing to the right drive axle shock absorber was completely consumed by the fire. The lower bushing was in place, but charred.

The left side suspension air bags were burned and melted, but remained in place. The paint of the left tag axle shock absorber was burned and the lower bushing was completely burned from the mount. The upper bushing was charred but intact.

The right tag axle disc brake caliper and rotor were in place at the axle position. Remnants of wheel end grease or wheel end oil were present on the brake caliper and the axle and king pin assembly. The air brake line was completely burned. The bushings to the right trailing arm were charred but intact (**Figure 13**).



Figure 13. Undercarriage view of the right tag axle brake assembly and the melted alloy wheel.

The left tag axle disc brake was intact; however, the air line was completely burned. The air line to the

brake chamber for the left drive axle disc brake was burned through approximately 8 cm (3 in) above the brake chamber.

An air brake valve and the associated air lines were located above the rear axles and centered on the chassis of the motorcoach. All of the rubber air lines were burned by the fire as it spread from right to left across the axle area. A large bundle of wires were routed through this area. All of the insulation was burned from these wires.

The inner wheel wells of the motorcoach were lined with sheet metal. The right wheel well area was burned with remnants of paint and grease/oil remaining in a scattered pattern. It appeared that the sheet metal dissipated the heat more effectively than the heavy gauge cross member.

Interior

The interior of the motorcoach sustained moderate severity damage. The fire spread to the interior through the side windows over the rear axle locations (**Figure 14**). There was no burn-through of the plywood floor or of the side body panels.

The fire involved the fabric covered seats with heat and smoke damage extending forward to the windshields. The left (14th row) three passenger seat had slight heat damage with smoke staining to the upper seat backs and head restraints. The fabric of the posterior aspects of the upper seat backs and the head restraints was burned and melted on left rows 7-13. There was similar, but more severe damage to the right seat backs and head restraints at rows 8-13 (**Figure 15**). The upper aspect of the head restraint foam padding was melted at the rear rows.

All of the overhead luggage compartment doors were melted by heat. The top-hinged doors were melted over rows 9-13. The fabric headliner was charred at the rear rows of the motorcoach with smoke staining extending forward to row 5.



Figure 14. Rearward view of the fire damage to the interior of the motorcoach.



Figure 15. Fire/heat damage to the right row seatbacks.

SCI Fire Analysis

The SCI inspection revealed that the right tag axle wheel bearing adjustment nut and the wheel bearings ran out of position (**Figure 16**) resulting in a misalignment of the rotating wheel end system consisting of the wheel, hub, and brake rotor relative to the axle spindle. As a result, the disc brake rotor, tire and wheel of the motorcoach were misaligned as the vehicle was traveling at highway speeds. The tag axle tire subsequently overheated and self-combusted (**Figure 17**). The fire spread throughout the rear undercarriage of the motorcoach and into the interior causing significant damage to the vehicle. Axle oil was still present in the bearing and hub area of the tag axle. The presence of this oil indicated that the fire originated outboard of the bearing area.



Figure 16. Damaged wheel bearing of the right tag axle.



Figure 17. Fire damage to the right tag axle alloy wheel and the remnants of the tire.

ATTACHMENT A:
FIRE EXPERT'S 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.

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Determination of Origin: Exterior inspection of the motorcoach shows the majority of damage is located directly above the right side rear axles. From there, the fire propagated to the left side rear axle area and into the interior through the windows directly over the two rear axles. The fire did not progress forward as the luggage compartment was undamaged, but did progress rearwards into the engine compartment. The two drive axle tires exhibited similar amounts of damage and the tag axle tire was completely consumed. Passengers reported hearing a "popping" sound, smelling smoke, and reported this to the driver who also reported seeing smoke from the right rear axle area. This analysis places the area of origin at the right side tag axle wheel end.

Determination of Cause: In evaluating the right tag axle wheel end, the wheel hubcap and outboard wheel bearing was found missing along with the associated bearing retention hardware. On a disc brake wheel end, when the outer bearing is missing, vehicle loads are transferred to the brake caliper, brake pads, and rotor causing the brake to overheat and cause a tire fire. This fire is consistent with the loss of the outer wheel bearing being the most probable cause for the tire fire. Since no disassembly was conducted, the root cause for the loss of the wheel bearing and the condition of the inner bearing could not be determined.