FIRE AND EXPLOSION GROUP
FACTUAL REPORT OF INVESTIGATION

(25 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

November 29, 2005

Fire and Explosion Group

Group Chairman's Factual Report

A. ACCIDENT

Accident Type:	Motorcoach Fire
Date and Time:	September 23, 2005 at 6:07 a.m. Central Daylight Time
Accident Location:	Northbound Interstate 45, .2 miles south of Mars Road, Near Wilmer, Dallas County, Texas
Vehicle#1:	1998 MCI 54-passenger Motorcoach
Motor Carrier:	Global Limo
Fatalities:	23
Injuries:	14

NTSB File # HWY-05-MH-035

B. GROUP

Chairman Joseph Kolly
Office of Research and Engineering
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C. SUMMARY

On September 23, 2005 at about 6:07 a.m. CDT, a 1998 MCI 54-passenger motorcoach was traveling northbound on Interstate Highway 45 (I-45) with 44 passengers and the driver, evacuating in anticipation of Hurricane Rita. The passengers were from an assisted living facility in Bellaire, Texas, and most needed to be carried or assisted onto the motorcoach by firefighters. The trip began about 2:30 p.m. on September 22, 2005. The motorcoach had been traveling over 13 hours in heavy traffic when the right rear (#3 axle) tire went flat and needed to be changed near the FM 1126 overpass in Rice, Texas. The tire left approximately 6,800 ft. of tire marks before the motorcoach came to a stop. A service mechanic was summoned to assist and he changed the tire. The motorcoach continued north on I-45 for about 26 miles.

At approximately 6:00 a.m. a motorist noticed the right rear (#3 axle) hub was glowing red/white hot. He was able to stop the motorcoach in the traffic lane and tried to tell the driver (who did not speak English) of the danger. The motorcoach driver waited for traffic to clear and proceeded to pull the vehicle to the right shoulder. The motorcoach driver exited along with a nursing staff-passenger (the trip coordinator) and two other nurse-passengers and saw flames coming from the right rear wheel well. The passengers, with help from the nursing staff on-board and other motorist, began to disembark. At 6:07 the first call was made to 911. Fourteen intact oxygen cylinders were recovered from the motorcoach along with parts of 4 others for a total of eighteen. One of those cylinders shows evidence of failure. Six nursing staff-passengers on the vehicle, a parent of one of the nursing staff, and 14 patient-passengers were able to exit the burning vehicle. Twenty-three patient-passengers, many of those who needed assistance in walking or needed to be carried off the vehicle were unable to escape.

D. DETAILS OF THE INVESTIGATION

The motorcoach was placed on a lowboy trailer and moved from the accident site to a protected garage area at the District 3 maintenance depot the day of the accident. It was then made available for a detailed examination. The following are the observations from that examination. Additionally, the site of the accident, and a site of a grass fire approximately 3.2 miles south on I-45 were also examined.

Accident Site

The accident site was located on the right shoulder of I-45N, near the Beltline Road overpass (Figure 1). The road surface was stained by fire debris (Figure 2), and a grass fire had spread from the motorcoach east toward the service road. The concrete road surface appeared to have a localized area

of spalling[1] where the rear of the motorcoach was located during the fire (Figure 3). After the fire, the roadway had been cleared of debris using a skid steer type loader.

Figure 1: Site of the accident

Figure 2: Fire debris stained roadway

Figure 3: Concrete spalling, shown with pen for scale

[1] Defined in NFPA 921 as chipping or pitting of concrete or masonry surfaces

Grass Fire Site

On the day of the accident at a location approximately 3.2 miles south of the accident site (at exit 266) a grass fire occurred along the median between the northbound and southbound lanes (Figure 4). The fire was reported to the Ferris Volunteer Fire Department prior to the accident at 6:04am. In the middle of the burnt patch of grass, two small metal objects were found (Figure 5). These metal objects were similar in appearance to metal objects recovered from the tag axle spindle assembly of the accident bus.

Figure 4: Grass fire site

Figure 5: One of the metal object found at grass fire site

Motorcoach

Fuel System

The accident motorcoach had a diesel engine. The fuel tank was located aft of the baggage compartment and forward of the wheel well area. From the fuel tank, two flexible fuel lines[2] served as the supply and return paths of the fuel system. The supply line was under negative pressure and the return line was pressurized. The flexible fuel lines from the fuel tank transitioned to braided steel lines at a manifold located in the engine compartment. After the manifold the fuel supply was routed through a fuel filter, the fuel pump and then a secondary fuel filter before reaching the engine. The return line from the engine went to the manifold and then back to the fuel tank.

The fuel system was examined from the fuel tank to the engine and back. The flexible supply line from the fuel tank was consumed by fire starting less than a foot from the tank all the way to the connector on the manifold located in the engine compartment (Figure 6). From the manifold, the braided steel line to the primary fuel filter appeared intact. The shut off valve was attached to the end of this line, but was separated from the primary fuel filter. Only a portion of the primary fuel filter remained on the engine. This portion was the part that bolted on to the engine block and was the location where the fuel lines were connected and the filter canister would attach (Figure 7). This component shows signs of severe heat exposure.

[2] Synflex® Composite Fuel Tubing is a flexible, thermoplastic elastomer product with a Nylon liner. It is a non-reinforced, seamless tube, designed and tested for use with non-crimp barbed fittings, and rated for use with diesel fuel in a temperature range of -50°F (-45°C) to +250°F (122°C).

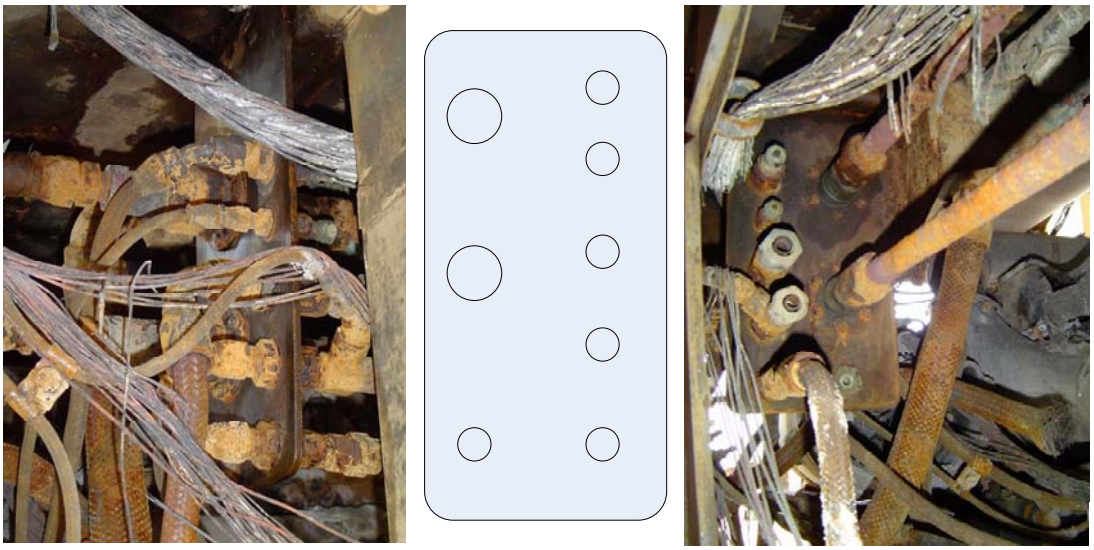

Figure 6: Manifold in engine compartment

Figure 7: Primary fuel filter mount

The braided steel hose line from the primary fuel filter to the fuel pump was missing (Figure 8). The braided steel line from the fuel pump to the secondary fuel filter was intact. The line from the secondary fuel filter to the engine appears intact. The braided steel return line from the engine to the manifold was intact. The braided steel fuel line from the primary fuel filter to the heater unit was disconnected from the fuel filter's mounting bracket (Figure 7) but otherwise intact up to the heater unit. From the heater unit the return fuel line is intact up to its connection on the manifold. From the manifold the flexible return line to the fuel tank was consumed to less than a foot from the tank.

Figure 8: Fuel pump and secondary fuel filter

Along the centerline between the left and right rear wheel wells, the fuel lines run beneath the passenger cabin floor along a service tunnel together with power steering and coolant lines (Figure 9). There are two fiberglass cover panels located underneath the motorcoach in the wheel well area. The cover panels facilitate access to this service tunnel from the outside. The rearmost cover was consumed by fire (Figure 10), creating an opening to the passenger cabin floor, and exposing the fuel lines (which were consumed by fire) and other lines. The other lines were metallic and remained intact. The forward access cover was charred but remained in place.

Figure 9: Tunnel under floor

Figure 10: Access opening under motorcoach

Tag Axle Power Steering

The accident motorcoach was equipped with an active steering TAG axle assembly. The hydraulic lines connected to the TAG axle power steering cylinder were examined (Figure 11). There are three hydraulic lines that link the rear axel steering (RAS) cylinder to the rest of the power steering system. These three lines are intact from their connection on the steering cylinder up to the fittings that end these lines. The fittings at the ends of these lines would attach to an aluminum manifold which was missing (Figure 12). A solidified mass of melted aluminum was found on top of the transmission just below the location where the manifold was originally installed. In the engine compartment the power steering hydraulic lines were examined. The metallic return line coming from the front of the motorcoach along the tunnel was connected to the back of the manifold and appeared intact (Figure 6). The braided steel return line from the manifold to the power steering fluid reservoir was also intact. The braided steel line from the reservoir to the power steering pump showed signs of chaffing at the clamp location (Figure 13). Visual evidence of leaks in this area, in the form of stains, was evident on neighboring engine compartment components. From the power steering pump, the braided steel supply line was intact up to its connection at the manifold. At the manifold, the supply line transitions to metallic pipe and is directed back to the service tunnel along the motorcoach centerline.

Figure 11: RAS cylinder

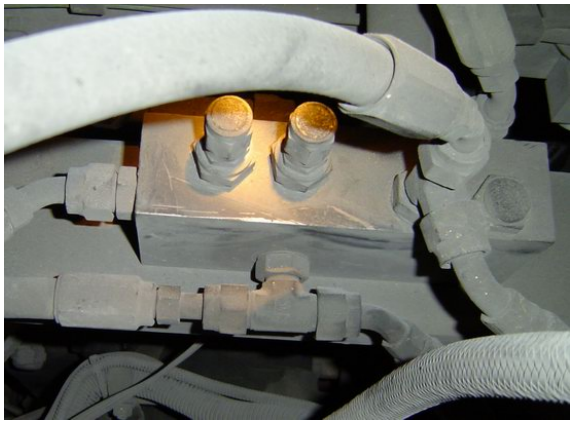

Figure 12: RAS hydraulic connector block, from exemplar bus

Figure 13: Chaffed line from hydraulic fluid reservoir

Heating Ventilation and Air Conditioning System (HVAC)

The HVAC system of the motorcoach was mostly destroyed by fire. The motorcoach was equipped with an HVAC system for the passenger compartment and a separate smaller system for the driver's area. The HVAC system for the passenger compartment was symmetrical along the centerline of the motorcoach with a separate controller for each side. In the passenger area, the supply air was introduced into the cabin via overhead diffuser nozzles located on the underside of the luggage rack (Figure 30). The return air was drawn into the return ducts through vent grills (Figure 14). The return ducts were located at floor level, spanning the length of the motorcoach and were built into the side walls. These return ducts were aluminum extrusions. Sections of these return ducts were missing and their adjoining parts showed signs of severe heat exposure. These sections were located above the wheel well areas on both sides of the motorcoach (Figure 15, 28, 29).

Figure 14: Return vent grill in exemplar bus

Figure 15: Return duct, right side missing section

Areas along the inside surface of the ducting fore and aft of the missing sections were relatively free of soot, followed by increasing signs of heavier sooting. The recirculation duct in the right rear wheel area was missing, and the steel portion feeding the return duct was damaged and bowed in an upward direction (Figure 35).

Rear Tires

An empty exemplar motorcoach shows approximately a 9 inch long footprint[3] of tire contact with the ground. When a vehicle is stopped the footprint area is shielded from the surrounding environment.

Right Side Tires

The right side tag axel tire was missing and the rim had a flat spot on its outer perimeter (Figure 16). The rims on the tag axle were steel. The drive axel inner tire (Figure 17) was mounted on a steel rim which appeared intact. Approximately a 24" footprint of tire, including the corresponding section of sidewall, was unaffected by the fire. The remaining portion of the tire was heavily damaged by fire. The tread separated from approximately the 8 o'clock thru 2 o'clock position (viewed from outboard side). The belts were frayed on some areas at the 1-2 o'clock position on the inside face. The tread was missing from 8-12 o'clock position.

[3] Footprint is the area concealed between the rubber tire above and the pavement underneath.

Figure 16: Tag axle passenger side

Figure 17: Right drive axle inner

Figure 18: Right drive axle outer

The drive axel outer tire (Figure 18) was mounted on an aluminum rim which appeared intact. Approximately a 24" footprint of tire was unaffected by fire. The corresponding section of sidewall was also unaffected. The remaining portion of tire was heavily damaged by fire. The tread separated from approximately the 7 o'clock thru 2 o'clock position (viewed from outboard side). The tread was missing from 7-12 o'clock position.

Left Side Tires

The drive axel wheels on the left side were not removed from the vehicle at the time of the inspection, so only a limited examination was possible. The left side tag axel rim appeared intact. This was a steel rim. Approximately a 12" footprint of tire was unaffected by fire. The drive axel inner tire (Figure 19) was mounted on a steel rim which appeared intact. Approximately a 14" footprint of tire was unaffected by fire. The remaining portion of tire was heavily damaged by fire. The tread separated from approximately the 3 o'clock thru 12 o'clock position (viewed from outboard side). Complete tread was visible around the tire. The drive axel outer tire (Figure 20) was mounted on an aluminum rim. The rim appeared intact. Approximately a 9" footprint of tire was unaffected by fire. The remaining portion of tire was heavily damaged by fire. The tread separated from approximately the 3 o'clock thru 9 o'clock position (viewed from outboard side). Complete tread was visible around the tire.

Figure 19: Left side drive axle inner

Figure 20: Left side drive axle outer

Combustible Materials in Wheel Well Area

The wheel well area was examined for combustible material. This was done by close inspection of the exemplar motorcoach. The bulk of the materials identified were rubber and/or elastomeric components. The bulk of these materials are the six tires and six airbags used for load leveling. Less substantial components are the six bump stops and the bushings found on the stabilizer bar and drag link. Additionally there are mud flaps located between the tires of the tag and drive axles. All of these materials were consumed by fire. Combustible liquids in the wheel well area include the automatic transmission fluid used in the power steering system, the oil in the six shock absorbers and the differential fluid found in the drive axle.

Side Windows and Overhead Hatches

The side windows were made of single-glazed, heat absorbing, laminated safety glass, mounted in black anodized extruded aluminum frames. Interlocking extrusions at the top frame provide hinge action for the window sash assembly. The front pentangular sash assemblies do not open for emergency escape. The remaining six sash assemblies per side are emergency egress types.

Left Side

All window frames were missing from the left side of the motorcoach. The steel window release pins (Figure 21) were in place and intact with no obvious signs of deformation. One exception was the forward release pin at the #2 window (counting from the front). This release pin was not the same type as all others, and appeared to be a Torx[4] screw. All latch mechanisms were missing from the window release pins except for the forward mechanism at the #7 window, and both mechanisms from the #3 window were in place. One of the latch mechanisms from the #3 window is shown in Figure 22.

[4] Torx is a type of screw head characterized by a 6 point star shaped pattern standardized in ISO 10664.

Figure 21: Window release pin

Figure 22: Window latch mechanism

Overhead Hatch

The ceiling of the motorcoach had two ventilation hatches one towards the front and one towards the rear. When this type of hatch is in the open position it is either held open by a prop rod or it can be rotated by 180 degrees to rest on the motorcoach's roof. Both of these hatches were consumed by the fire. The forward hatch frame had some partial remains in place (Figure 23), and the latching mechanism was found in the latched position. The rear hatch was completely missing, except for the latch mechanism (Figure 24), which was found in the latched position.

Figure 23: Forward overhead hatch

Figure 24: Latch from rear overhead hatch

Right Side

The right side of the motorcoach had all the aluminum window frames in place. All window frames were closed and in the latched position, except for the #6 location. Here, the frame was broken on the bottom, and the bottom edges were twisted outward, as well as downward (Figure 25). The latches on this window frame were found in the open position. The latch pins were bent up and inward (Figure 26). Witness[5] marks are on both sets of pins and latch mechanisms in this window location.

[5] Witness marks are evidence of contact

Figure 25: #6 right side window frame

Figure 26: #6 right side window, bent latch pins

Exterior

The accident motorcoach had a composite body construction. The body panels below the side windows and above the floor line consisted of a glass fiber-reinforced plastic cored sandwich construction[6]. The panels below the floor line were made of fiberglass reinforced plastic with the exception of the baggage door panels which were 0.064 inch primed and painted aluminum.

The exterior of the motorcoach was heavily damaged by fire (Figures 27, 28, 29). The right side was damaged to a lesser degree than the left side. From the windows upward only the tubular steel framework and some window frames remained. The tubular steel frame showed signs of bending and buckling which were especially pronounced in the roof area. Most of the window glass was missing. Small traces of glass could be seen in some of the window frames that remained in place. The roof was consumed by fire and so were the body panels at the rear of the motorcoach. A visible outward bend of the window side steel frame above the right rear wheel well area was evident. The outward bend was several inches but less than a foot.

[6] MCI 102E Series Maintenance Manual page 3A-1.

Figure 27: Front and rear exterior views

Figure 28: Passenger side exterior views

Figure 29: Driver's side exterior view

Interior

The accident motorcoach contained 54 passenger seats distributed among two aisles (Figure 30). The passenger side aisle had 13 rows of seating plus a lavatory, and the driver's side aisle had 14 rows of seating. The seats consisted of upholstery covered foam padded backs and cushions over steel seat frames. The floor throughout the motorcoach was ½ inch thick plywood with a 0.1 inch thick vinyl covering. There were overhead luggage racks on both sides of the coach. An extruded aluminum frame spanned the length of the luggage rack with cast aluminum support ribs at points in between. The exposed surfaces of the luggage rack were extruded polyvinyl chloride (PVC). The ceiling at the extreme front and at the rear window area were fiberglass reinforced plastic. The main ceiling area was Xorel®[7] FR over acrylonitrile butadiene styrene (ABS).

The interior of the motorcoach was heavily damaged by fire (Figure 31). All the seating materials were consumed leaving the bare metal frames behind. The interior panels were also consumed. Most of the aluminum components were consumed or melted throughout the motorcoach, although the right side of motorcoach appeared to have slightly more aluminum materials remaining than the left side. The ceiling structure was completely consumed by fire as was nearly the entire overhead baggage compartment. Only portions of the overhead aluminum extrusion remained along the right side of the motorcoach. The wooden floor was consumed in the rear of the cabin, along the service tunnel in the middle of the aisle way. The left side of the motorcoach had 14 rows of seating. Rows 8, 9, 10 were extricated for recovery of bodies. The right side had 13 rows of seating. The aisle seats in rows 7 and 8 were extricated for the recovery of bodies. The lavatory in the rear was totally consumed in the fire.

Figure 30: Interior of exemplar bus

[7] Xorel® FR is a fabric woven from polyethylene and treated with a fire retardant.

Figure 31 (Interior views)

Area Above Right Rear Dual Wheels

A steel sheet metal floor panel originally located above the right tandem wheels of the drive axel was separated from the frame creating a large opening into the passenger cabin (Figure 32). The floor panel was found lying loose on the trailer during the examination. At the scene of the accident, this piece of sheet metal was found separated from the frame and resting aft and inward of the dual wheels. This was determined from photographs taken at the scene of the accident before the motorcoach was prepared to be moved. The panel was deformed and the lip along the perimeter had been flattened into the plane of the panel (Figure 33). The floor panel was sent back to the metallurgical laboratory in Washington DC, for further examination. The findings of that examination are included in separate report. There were triangular tabs of sheet metal from the floor panel still attached to the frame at 7 of the 16 weld locations (Figure 34). The welds were approximately 2 inch long lap joints. A lateral frame tube, to the rear of this opening was broken at the inboard weld, and bent down (Figure 34). The inboard longitudinal frame portion showed slight localized depressions on the bottom and outer face (Figure 35). The floor support welded to this frame was bent downward and the bottom lip of the return air duct opening was bent upward (Figure 35). The end cap of this return air duct was bent rearward (Figure 36). The wood floor above this panel was consumed by fire. The seat frame that was fastened in this area, above the rear drive axle, had been pulled from its fastening point. The seat track showed evidence of an upward pullout of the seat fastener (Figure 37). The steel seat leg was twisted out of plane, and free from the seat frame and the floor track.

Figure 32: Opening above rear right side dual wheels

Figure 33: Sheet metal floor panel

Figure 34: Torn sheet metal and a separated structural member

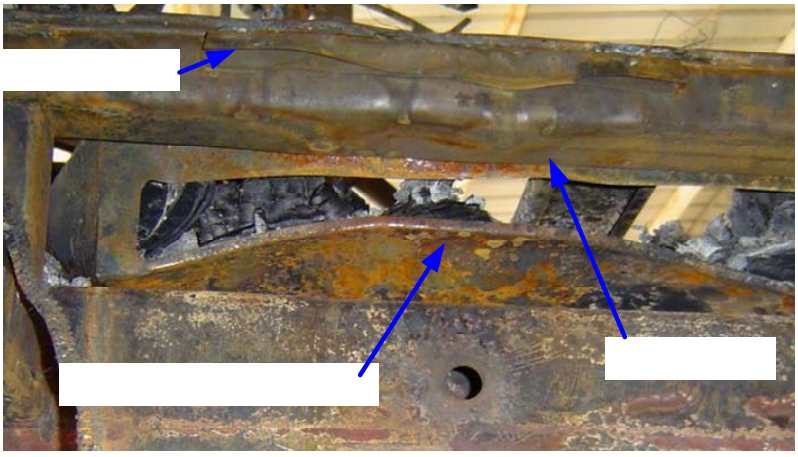

Figure 35: Damage above right side dual wheels

Figure 36: Damage to return air duct end cap

Figure 37: Seat track fastener pull out

Oxygen Cylinders

Eleven aluminum oxygen cylinders were found inside the passenger cabin. These cylinders were of the DOT-3AL[8] type. Seven intact cylinders were located in the right side baggage compartment behind the second door from the front, and were covered with soot. Of the 11 in the cabin, 5 were visibly damaged and 6 appeared intact. Of the 5 damaged bottles, three showed signs of severe melting (Figure 38), one had the top valve stem missing, and one showed signs of mechanical damage with sharp fracture surfaces (Figure 39). The locations of recovery of the cylinders found in the passenger cabin are shown in the following table.

[8] The specifications for DOT-3AL are found in 49CFR178.46

Table 1. Oxygen bottle recovery location in passenger cabin.

Cylinder #	Condition	Side	Seat #	Comments
1	Damaged	Left	Between 10,11	Severely melted
2	Intact	Left	Between 13,14	
3	Intact	Left	Between 13,14	
4	Damaged	Left	Under 14	Valve missing
5	Damaged	Right	Between 11,12	Originally found in left rear of motorcoach, relocated by Fire Marshal
6	Damaged	Right	Between 11,12	
7	Damaged	Right	Between 11,12	
8	Intact	Right	Between 11,12	
9	Intact	Right	Between 12,13	Originally found under seat 12, relocated by Fire Marshal
10	Intact	Right	Between 12,13	
11	Intact	Right	Behind 13	

Figure 38: Cylinders found in passenger compartment

Figure 39: Fracture surface on Aluminum O_2 cylinder

Evidence Recovered For Further Examination

At the time of the tire change in Corsicana, the right rear tag axel tire was changed. This exact location was visible on the roadway, identifiable by the terminus of the skid mark. At a position aft and center of this wheel location, a fluid spill was found (Figure 40), and a sample of contaminated asphalt from this spill area was recovered for analysis. A lock washer was also recovered from the roadway in this general area. At the maintenance depot where the examination took place, fluid and other material samples were removed from the accident motorcoach and shipped to headquarters for further examination and analysis. A complete list of these samples follows in table 2. The sheet metal floor panel from the right rear wheel well area, which was found separated from the vehicle, was sent to the Materials Laboratory at headquarters (Figure 33). Samples of fiberglass exterior body panel and the foam insulation located behind it were removed for future examination.

Figure 40: Liquid spill on roadway

Table 2. Material and liquid samples

Sample #	Description	Date Recovered	Comments
1	Asphalt soaked with an unknown liquid, found at location of first tire change	9/23/2005	Submitted by deputy Cummings
2	Lock washer found at site of first tire change	9/23/2005	Submitted by deputy Cummings
3	Driver's side TAG axle bearing lube	9/28/2005	
4	Front axle passenger side bearing lube	9/28/2005	
5	Fuel sample drawn from fuel tank	9/26/2005	
6	Engine coolant recovered from coolant filter	9/28/2005	
7	Engine oil recovered from foward filter	9/28/2005	
8	Engine oil recovered from rear filter	9/28/2005	
9	Driver's side TAG axle bearing lube	9/28/2005	
10	Driver's side TAG axle bearing lube	9/28/2005	
11	Power steering fluid recovered from master cylinder under drivers seat	9/29/2005	
12	Drive axle differential fluid	9/29/2005	
13	Transmission fluid, drawn through dip stick tube	9/28/2005	
14	Asphalt control sample	11/23/2005	Collected by Ronald Kaminski

Applicable Flammability Standards & Fire Suppression Systems

There is not much regulatory guidance for the selection of materials to be used inside of vehicles based on their flammability. In the design of highway vehicles, including motorcoaches, the materials that are selected for use in the passenger compartment must be tested according to the Federal Motor Vehicle Safety Standard 49CFR571.302. This standard pertains to the resistance of materials to short duration exposure to small ignition sources. These ignition sources are intended to represent matches, lighters, cigarettes, etc. This standard applies only to materials inside the passenger compartment. There are no other flammability standards for highway use vehicles.

Automatic fire detection and suppression systems for highway vehicles currently exist and are made by a variety of manufacturers. Generally these systems employ spot heat detectors and a fire suppression agent distribution network with individual nozzles in the proximity of the heat sensors. These systems target the engine compartment and electrical equipment. These systems have been successfully used in public use transit vehicles[9]. None of these systems has been specifically designed to protect against and extinguish a tire fire.

END OF REPORT

[9] New Jersey Transit has been installing fire detection and suppression systems in their fleet since 1994