VEHICLE GROUP CHAIRMAN'S

Attachment H
Bridgestone Tire Examination
(19 Pages)

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TIRE ANALYSIS REPORT

NTSB Accident Investigation

Description:	**Motorcoach Run Off Roadway Bridge and Rollover**
Location:	**U.S. Highway 75, Sherman, Texas**
Date of Accident:	**August 8, 2008**
NTSB Case No:	**HWY-08-MH-022**

The subject matter concerns a motor vehicle accident that occurred on August 8, 2008, at about 12:45am. The vehicle is a 2002 Motor Coach Industries ("MCI") J4500-series motorcoach that was traveling northbound on U.S. Highway 75 at/near milepost 208 in Sherman, Texas with a driver and 54 passengers when it reportedly experienced a tire failure at the right front steering axle position. Thereafter, the motorcoach moved to the right, overrode a curb and guard rail along the side of a bridge, fell over the edge, and came to rest on its side on the earthen bridge abutment. Numerous fatalities and injuries resulted.

At the request of the National Transportation Safety Board ("NTSB"), Bridgestone Americas Tire Operations, LLC ("Bridgestone Americas") agreed to assist in the investigation of the subject accident. As a member of the NTSB Vehicle Factors Group involved in the investigation, acting on behalf of Bridgestone Americas and its subsidiaries, I have been asked to examine and analyze the tire and wheel evidence involved the subject accident. My qualifications, background, and CV are attached in Appendix A.

This report contains opinions and conclusions based on my education, experience, research, and investigation to date regarding the subject matter. Since the investigation is ongoing by the NTSB and others, and as additional information may become available, I reserve the opportunity to modify or amend this report.

Examination and Material Review

On August 13, 2008, I met with NTSB and Sherman police investigators in Sherman, Texas. On August 14, 2008, I surveyed the accident scene along U.S. 75 and assisted in a field inspection of the tires/wheels from the motorcoach. During this time period, I took 445 photographs, which are included as contact sheets in Appendix B.

The right front tire and wheel evidence was delivered in a sealed crate to Bridgestone Americas' Akron, Ohio Technical Center on November 24, 2008. The crate was opened in the presence of an NTSB investigator on November 25, 2008 within the Product Analysis Laboratory. On November 25, 26, and 28, 2008, I conducted an examination of the tire, wheel, and detached tire pieces. In the presence of an NTSB investigator, all evidence was accounted for and re-sealed in the original crate on November 29, 2008. In this time period, I took 316 photographs of the tire and wheel evidence, including the unpacking/packing of same. Contact sheets of my photographs are included in Appendix C.

On January 21, 2009, the crate of evidence was shipped to the Sherman Police Department at the instruction of the NTSB. While at Bridgestone Americas, the tire/wheel evidence was always kept for safekeeping within a limited access, secured facility.

Among the materials I have reviewed are the NTSB Group Chairperson On-Scene Investigation Narrative reports with attachments/appendices, including those of the Highway, Human Performance, Motor Carrier, Survival Factors, and Vehicle Groups. I have also reviewed over 1,500 photographs taken by investigators and/or parties to the investigation of this accident. Additional reference materials are listed in Appendix D.

Tire Failure Description and Sequence

At the time of the accident on August 8, 2008 at about 12:45am, the subject 2002 MCI J4500-series motorcoach had been travelling for approximately 4.5 hours and 309 miles since departing Houston, Texas with a driver and 54 passengers. As the motorcoach approached Post Oak Creek Bridge, travelling northbound in the right-hand lane on U.S. Highway 75 at/near milepost 208 in Sherman, Texas, the vehicle experienced a failure condition of the right front tire known as tread/belt detachment.

The tire failure was initiated by steel belt separation, leading to belt edge lift, shoulder rubber tearing, and a detachment of the belts and tread within 600 feet of the bridge. During the detachment sequence, the casing ruptured and a rapid inflation pressure loss resulted. Flat tire marks on the highway start at approximately 85 feet from the bridge as shown in Figure 1. The marks extend approximately 130 feet and indicate a path of the motorcoach to the right until the point of impact with the concrete curb of the bridge, Figure 2. The right front tire

and wheel experienced additional damage in the accident sequence from running flat, road abrasion, and impacts with the curb and bridge guard rail.

Figure 1: Northbound View; Rapid Air Loss Initiation Location
DSC01363.JPG (Sherman PD)

The subject right front tire was retreaded approximately one year prior to accident. According to 49CFR§393.75(d), "[n]o bus shall be operated with regrooved, recapped or retreaded tires on the front wheels." Thus, the operation of the motorcoach with the subject tire applied to the steering axle was not in compliance with this regulation. However, as will be discussed in further detail within this report, the failure of the subject tire initiated and resulted from within the original tire casing due to damage inflicted during operation that was independent from the retread. Any other steel belted radial truck/bus tire subjected to the same operation and damage as the subject tire, whether retreaded or not, would likely fail in the same manner. The fact that the subject tire is retreaded is remarkable, but ultimately not particularly relevant to the failure itself.

The mere fact that a tread/belt detachment, or any other type of failure, occurs does not indicate that a tire is defective. All makes, models, and sizes of tires are subject to failure, which can occur for a number of reasons not related to the design

or manufacture of the tire. Conditions that can cause tire failure (such as a tread/belt detachment) include damage from an impact with a stationary object or a road hazard; improper inflation and/or overloading; puncture(s); improper mounting/demounting, repair, servicing, vehicle alignment, and/or rim components; and operator driving habits. Whether a tire is original or retreaded, these conditions result in physical changes to the tire and/or affect the stresses and strains subjected to the tire's components.

Figure 2: Southbound View; Impact Location
DSC01353.JPG (Sherman PD)

Tire Identification Summary

Appearance of the right front tire/wheel after the accident, prior to removal from the vehicle, is shown in Figure 3. The remaining tires ("companion tires") from the motorcoach are shown in Figure 4.

Referring to the graphic in Figure 5, see Table 1 for a summary of the identification of the tires and wheels on the subject motorcoach.

Figure 3: Right Front Tire/Wheel Prior to Removal from Motorcoach
dsc00595.jpg (Sherman PD)

Figure 4: Companion Tires (NTSB 081408 Sherman-B001.jpg)

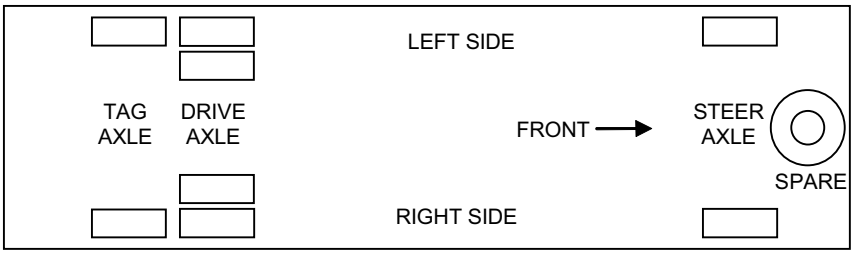

Figure 5: Motorcoach Tire Positions

Vehicle Position*			Left Side	Right Side
Steer Axle		Tire	Firestone FS400 315/80R22.5 Load Range J DOT 4D4D 35C 2407	Goodyear G409 MBA 315/80R22.5 154/151L Load Range J DOT MJ72 9MAW 4404 R ANC -B2 3507
		Wheel	22.5 X 9.00 03 28 06	22.5 X 9.00 05 04 01
Drive Axle	Inner Dual	Tire	Firestone FS400 315/80R22.5 Load Range J DOT 4D4D 35C 0107	Ling Long LLF02 315/80R22.5 154/150M Load Range J DOT 0URT CF 2308
		Wheel	22.5 X 9.00 01 17 03	22.5 X 9.00 03 09 06
	Outer Dual	Tire	Firestone FS400 315/80R22.5 Load Range J DOT 4D4D 35C 1307	Ling Long LLF02 315/80R22.5 154/150M Load Range J DOT 0URT CF 2308
		Wheel	22.5 X 9.00 01 07 05	22.5 X 9.00 03 28 06
Tag Axle		Tire	Goodyear G409 MBA 315/80R22.5 154/151L Load Range J DOT MJ72 9MAW 3604	Ling Long LLF02 315/80R22.5 154/150M Load Range J DOT 0URT CF 2208
		Wheel	22.5 X 8.25 10 16 00	22.5 X 8.25 04 15 98
Spare		Tire	Ling Long LLF02 315/80R22.5 154/150M Load Range J DOT 0URT CF 2308	
		Wheel	22.5 X 9.00 05 24 05	

*Refer to Figure 5

Table 1: Motorcoach Tire and Wheel Summary

Tire Application and Load Capacity

According to MCI, the subject motorcoach had axle load ratings and tire application specifications as shown in Table 2. Industry standards for tire load, inflation, and rim contour are shown in Table 3.

Vehicle Position*	GAWR	Tire Size	Wheel	Cold Inflation
Steer Axle	7,484 kg 16,500 lbs	315/80R22.5 Load Range J	22.5 X 9.00	830 kPa 120 psi
Drive Axle	10,432 kg 23,000 lbs	315/80R22.5 Load Range J	22.5 X 9.00	620 kPa 90 psi
Tag Axle	7,484 kg 16,500 lbs	315/80R22.5 Load Range J	22.5 X 9.00	830 kPa 120 psi

*Refer to Figure 5

Table 2: Subject Motorcoach Axle Ratings and Tire Specifications

Tire Size	Approved Rim Contours	Single Usage		Dual Usage	
		Max Load	@ Inflation	Max Load	@ Inflation
315/80R22.5 Load Range J (154/151)	8.25* 9.00 9.75	3030 kg 6670 lbs	620 kPa 90 psi	2750 kg 6070 lbs	620 kPa 90 psi
		3750 kg 8270 lbs*	830 kPa 120 psi	3450 kg 7610 lbs	830 kPa 120 psi

*Use of an 8.25 rim contour with a 315/80R22.5 tire is limited to 8,000 lbs. per tire in single usage, 7,610 lbs. per tire in dual usage, and inflation pressure of 120 psi.

Table 3: Industry Standards for 315/80R22.5 Load Range J Tires (Tire & Rim Association, Inc.)

Therefore, from inspection of the tires and the information in Tables 1-3, note the following:

1. Application of the right front retreaded tire to the subject motorcoach was not in compliance with 49CFR§393.75(d).
2. According to their DOT tire identification numbers, the four (4) Ling Long tires on the motorcoach were produced by Shangdong Linglong Rubber Co., Ltd. in China as follows:
    a. 22nd week of 2008 (June 1-7, 2008)
    b. 23rd week of 2008 (June 8-14, 2008)
3. The Ling Long tires were not properly marked for maximum load rating in kilograms (kg) and corresponding inflation pressure in kilopascals (kPa), apparently noncompliant with 49CFR§571.119 S6.5(d).

4. MCI specified suitable tire size, rim contour, and inflation pressures to carry the maximum rated axle loads of the subject motorcoach.
5. 315/80R22.5 tires mounted to 22.5 X 8.25 wheels were improperly applied to the subject motorcoach on the tag axle. A 315/80R22.5 tire mounted to a wheel with an 8.25 rim contour, inflated to a pressure of 120 psi, and utilized as a single has a maximum load capacity of 8,000 lbs. Thus, the two tires applied to the tag axle of the subject motorcoach could carry a maximum total load of 16,000 lbs. Considering the GAWR of 16,500 lbs., each of the tires on this axle could potentially be overloaded by 250 lbs. when properly inflated.
6. In addition to the tires on the tag axle being mounted to improper wheels for their application, inflation pressure measurements taken after the accident indicate that the tires on this axle were approximately 30 psi underinflated. (Inflation pressure measurements of the left and right tires on the tag axle were 88 psi and 89 psi respectively; *see* NTSB Vehicle Group On-Scene Information.) Thus, each tire was potentially overloaded by approximately 1,580 lbs., or 19%.

Analysis Summary of Subject Right Front Tire

Identification of the tire casing, tread rubber, retread manufacture, and wheel of the right front tire from the motorcoach involved in the accident is as follows:

Casing:	Goodyear G409 MBA 315/80R22.5 154/151L Load Range J DOT MJ72 9MAW 4404 R ANC –B2 3507	Tread:	Bandag 10.5 T4100 238 G7. . .
Wheel:	Accuride 22.5 X 9.00 05 04 01 single piece steel (welded rim and disc) 15° drop center		

- The casing of the subject tire was produced by The Goodyear Tire and Rubber Company at their plant in Topeka, Kansas in the 44th week of 2004.
- The pre-cured tread was produced by Bridgestone Bandag, LLC at their plant in Griffin, Georgia in the third quarter of 2007.
- The retreaded tire was produced by Henise Tire Service, Inc. at their retreading facility in or near Lebanon, Pennsylvania in the 35th week of 2007. This was the first retread of the subject tire.
- The wheel was produced by Accuride Corporation in May 2001.

Thus, the tire casing was less than three (3) years old at the time of retreading and less than four (4) years old at the time of the accident. The tread rubber was produced within about two (2) months prior to the manufacture of the retreaded tire, which was produced about 11 months prior to the accident. The chronological ages of the casing, tread rubber, and retreaded tire as a whole are consistent with typical truck/bus tire service and retreading intervals. The chronological age of the

subject tire is inconsequential to the tire failure; there is no indication of damage that contributed to the failure solely from environmental, chemical, or undefined "aging" conditions.

The subject tire failure initiated and propagated within the original casing. Separation began between the 2nd and 3rd steel belt plies and is most pronounced in the area between 8:30 clockwise to about 11:30, peaking at about 10:30. (Note regarding clock position protocol: All circumferential locations on the tire are referenced to the "DOT" symbol as 12:00, considering the serial side of the tire to be a clockface.) Belt edge lift and shoulder rubber tearing occurred along the serial side (outboard facing) shoulder as the tread/belt detachment initiated in this area due to the centrifugal force of highway speed tire rotation. The detachment occurred predominantly between the 2nd and 3rd steel belt plies and between the radial body ply and the 1st steel belt ply as it progressed. Before a full detachment of the belts and tread could occur, the casing ruptured at about 10:00 and the tire rapidly deflated (at location on the highway shown in Figure 1). Continued operation of the tire while flat and the subsequent impact with the bridge curb and guard rail resulted in additional damage to the tire, which is shown in Figure 6.

Examination of the separated and detached tread, belt, and casing surfaces reveals multiplane tear patterns, evidence of adequate adhesion and properties of fatigue, crack propagation, and tear resistance. Such an appearance is typical of a properly designed and manufactured tire that has sustained a tread/belt separation and/or detachment caused by damage or other external factors during use. In addition, numerous exposed rubber surfaces exhibit a blue-tint appearance, indicative of excessive heat generation during operation. Examples of multiplane tearing and blue-tint rubber appearance are shown in Figures 7 through 9.

Figure 6: Subject Right Front Tire, View Centered about 10:30, Serial Side Up
(08AA330-B104.jpg)

Figure 7: Torn Appearance Between 2nd and 3rd Belts, ~9:00 Clockwise to 11:00
(08AA330-B146.jpg)

Figure 8: Torn Appearance of 3rd Belt Edge, Serial Side, about 7:00
(08AA330-B142.jpg)

Figure 9: Torn Appearance of Shoulder Rubber, Serial Side, about 12:00
(08AA330-B185.jpg)

Examination of torn lower sidewall and bead areas reveals additional casing fatigue and heat-related damage. In Figure 10, incipient separation of the steel bead reinforcement ply, steel body ply, and fabric chafer is exposed. The beads also exhibit undulating deformations and compression grooving from the rim flange, an example shown in Figure 11.

Figure 10: Exposed Components of Lower Sidewall, Serial Side, about 10:00
(08AA330-B126.jpg)

Figure 11: Rim Flange Compression Grooving, Serial Side
(08AA330-B134.jpg)

The tread/belt tear patterns, heat discoloration, lower sidewall/bead fatigue, and rim compression grooves are indicative of tire operation in an over-deflected condition. Over-deflection is caused by underinflation, overloading, or a combination of the two. In this case, the most probable cause of over-deflection is underinflation due to an un-repaired puncture to the tire which lead to inflation pressure loss and damaging stress/strain and heat build-up. The puncture is located at 4:00 in the serial side shoulder, shown in Figure 12. The unknown puncturing object gouged and tore the tread surface (Figure 13) and the bulk of the rubber, but did not fully pass through the tire. However, with each deformation and compression of the tread in the contact patch as the tire rotated, the object was penetrated deep enough into the tire to create numerous tears through the innerliner (Figures 14 and 15), causing a gradual loss of inflation pressure. The puncturing object most likely ejected from the tire during the tread/belt detachment process.

Although it is difficult to state with precision how long the subject tire operated in an over-deflected manner, the tread/belt tear patterns and a lack of polishing of the separated surfaces indicate relatively short-term operation in such a condition, most likely for less than 1000 miles.

Figure 12: Puncture Location, about 4:00, Serial Side Shoulder Rib
(08AA330-B244.jpg)

Figure 13: Close View of Puncture Location, about 4:00, Serial Side Shoulder Rib
(08AA330-B255.jpg)

Figure 14: Penetration Tears to Innerliner, about 4:00, Serial Side Shoulder
(08AA330-B257.jpg)

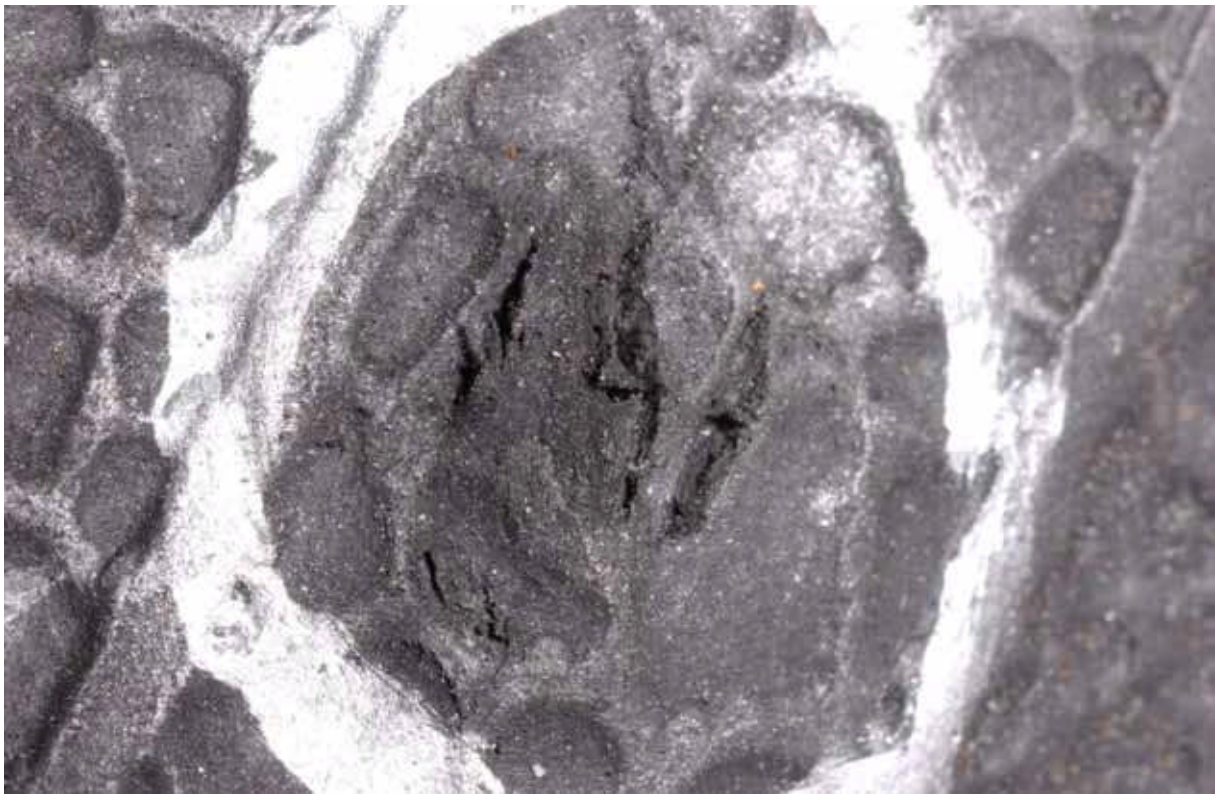

Figure 15: Close View of Penetration Tears to Innerliner
(08AA330-B259.jpg)

The Bandag brand tread applied to the subject tire is model T4100 with "MilEdges," which is a siping of the tread ribs for additional traction. This pre-cured tread is size 10.5, with a 9-3/8" (238mm) nominal width and 15/32" tread depth when new. Application of this size T4100 tread to a 315/80R22.5 Goodyear G409 MBA casing is appropriate. Intended use for a T4100-retreaded casing is in over-the-road trailer applications. Tread depth measurements indicate the subject tire was worn 1/32" to 2/32".

The subject tire exhibits proper retread manufacture and there is no indication of separation or detachment of retread material at the splice or along any surface of the casing buffed during retreading. There are no evident repairs. Tearing of the serial side shoulder through the tread splice at 8:30 as shown in Figure 16 reveals fully intact splice interfaces. Proper tread alignment and curing envelope venting at the splice is indicated in Figure 17. Both shoulders exhibit uniform and concentric application of the tread and cushion rubber as exemplified in Figure 18.

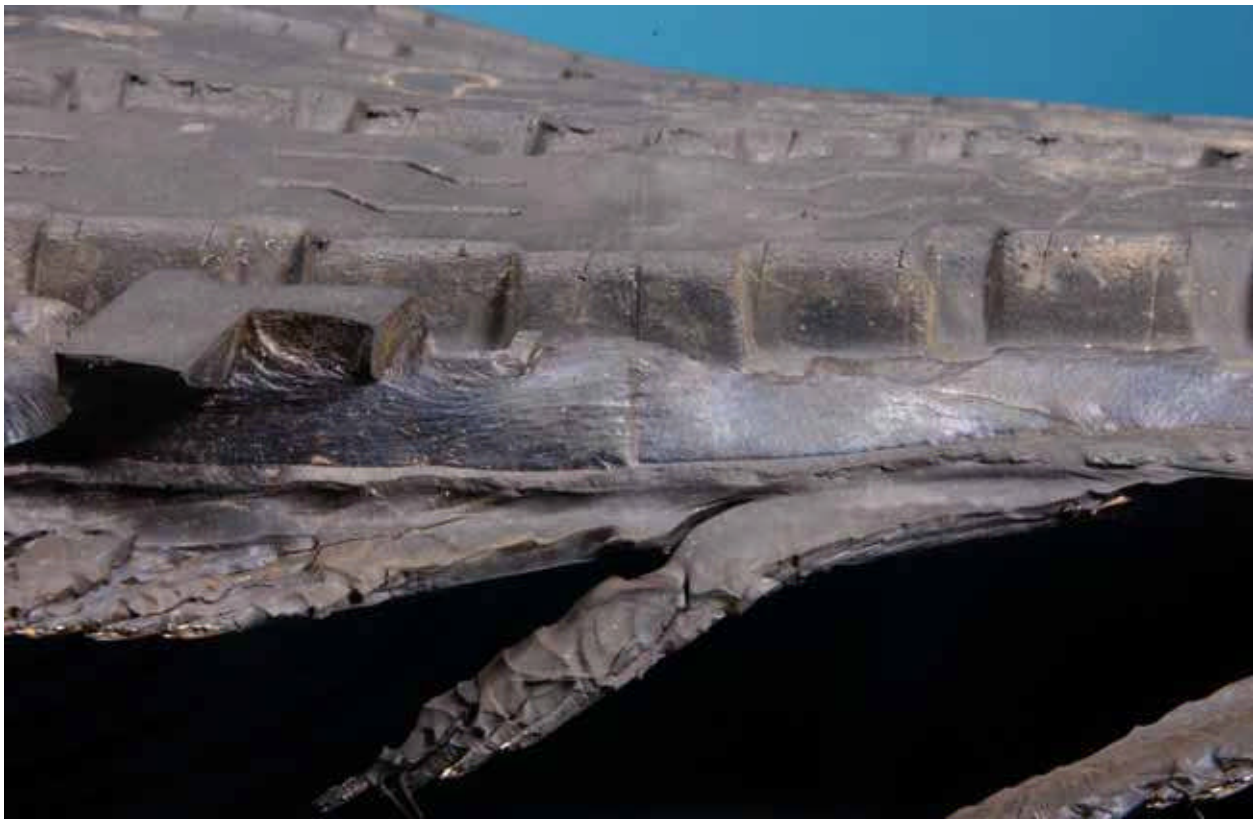

Figure 16: Exposed Tread Splice Due to Tearing, Serial Side Shoulder at 8:30
(08AA330-B162.jpg)

Figure 17: Tread Splice Alignment, Opposite Serial Side Shoulder at 8:30
(08AA330-B208.jpg)

Figure 18: Tread and Cushion, Opposite Serial Side Shoulder at 5:00
(08AA330-B243.jpg)

Conclusions

Based on my education and experience, I have reached the following conclusions in addition to those expressed elsewhere in this report:

1. The subject right front retreaded tire, comprised of a Goodyear G409 MBA casing in size 315/80R22.5 154/151L (Load Range J) with Bandag T4100 tread, does not exhibit a defective or unreasonably dangerous condition in design or manufacture. Construction and materials of the casing and retread are consistent with those found in the tire industry.
2. The tread/belt detachment of the right front tire occurred as a result of damage caused by over-deflected operation. In this case, the most probable cause of over-deflection is underinflation due to an un-repaired puncture to the tire which lead to inflation pressure loss and damaging stress/strain and heat build-up. The puncture which lead to the failure occurred after the tire was retreaded and put back into service.
3. The subject tire exhibits proper retread manufacture and there is no indication that the tire failed due to any reason related to the retreading.
4. In addition to application of a retreaded tire to the steering axle of the motorcoach against Federal regulation, the tag axle tires were improperly applied to the motorcoach and significantly underinflated.

In closing, this report summarizes my examination and analysis to date and my understanding of events and evidence presented to me during the on-going investigation by the NTSB and Sherman, Texas Police Department among others. If additional information becomes available regarding the subject accident, I reserve the opportunity to modify or amend opinions and conclusions contained in this report.

Photographs taken during the field inspections and laboratory examination have been previously provided to the NTSB and are considered incorporated herein.

Respectfully Submitted,

Brian J. Queiser