U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**



# Memorandum

**Vehicle Research and Test Center** **P.O. Box B37
East Liberty, Ohio 43319
(937) 666-4511**

Subject: FINAL REPORT: "Hammond, LA Workhorse-Bosch Trip Report"

Date:

From: Michael W. Monk
Director, Vehicle Research and Test Center

Reply to Attn. Of: NVS-310

To: Kathleen DeMeter
Director, Office of Defects Investigation

NVS-210

Attached are four (4) copies of the subject report. This completes the requirements for this program.

Attachment:
Final Report

#

# Hammond, LA Workhorse-Bosch Trip Report

**Date**: January 8, 2008

**Destination:** Ross Downing Chevrolet
600 South Morrison Boulevard
Hammond, LA 70403

**Participants:** Dave Smith, Engineering Manager of Foundation Brakes (Bosch)
Gerry Schaser, Senior Field/Fleet Rep of Brakes and Driveline Park Brakes (Bosch)
Hennie van Niekerk, Director of Engineering Services (Workhorse Custom Chassis)
Hilton Gray, Technician and RV Specialist (Ross Downing Chevrolet)
Peter Kivett, Investigator (Office of Defects Investigations)
Dan Pearse, Vehicle Safety Engineer (Vehicle Research and Test Center-DA Group)

**Purpose:** Examine a complaint vehicle that had experienced a thermal event at a wheel-end with representatives of the chassis and brake manufacturers.

**Background:** The complaint vehicle was a 2003 Allegro Bay motorhome built by Tiffin Motor Homes Inc of Red Bay, AL, with Vehicle Identification No. 5B4MP67G533376608 and 25,812 miles. The engine was a GM Vortec 8100. The Workhorse Vehicle and Service Information, supplied by the Workhorse representative, listed the Model No. as P32122, the wheelbase at 228 in, the GVWR at 22,000 lb, the GVWRF at 8,000 lb, the GVWRR at 14,500 lb, and the warranty start date was 03/10/04. The vehicle was equipped with 22.5 inch wheels and 66-mm diameter piston calipers on the front and rear axles. The brake linings were OEM and the brake system had not been previously serviced. The ABS EHCU is model 410 made by TRW. The vehicle is shown during the initial inspection in Figure 1. The VIN plate is displayed in Figure 2. A summary of the warranty repairs performed on this vehicle is shown below.

| | | |
|---|---|---|
| 10/21/04 | 3,136 mi | replace both front shock absorbers |
| 08/26/05 | 12,561 mi | replace instrument Actia cluster recall 50402-C |

**Results:** The dealership technician, representatives from the chassis and brake manufacturers, ODI, and VRTC met at the dealership and discussed the previous history of the vehicle. The dealership technician, who had worked at Ross Downing Chevrolet since 1989, reported that the owner was driving in stop-and-go traffic when he felt the vehicle "holding back". The ABS warning lamp on the instrument panel illuminated and there was a burnt smell. The owner pulled over and walked around his vehicle. The right rear wheel was the hottest. The left rear wheel was also very hot. The front wheels were only warm. The owner called the technician, told him he was parked in a precarious position, and asked his advice. The technician recommended letting the brakes cool off, then nurse the vehicle to a safe site. The vehicle has been parked at Ross Downing Chevrolet since 12/10/07.

The vehicle was visually inspected to check several obvious items and to insure it was safe to drive. The brake linkage bell crank was not equipped with a Zerk fitting but was found to operate normally. The brake fluid level was normal and appeared to not be contaminated. The ABS sensors were examined and appeared normal. The sliding pin accordion boots appeared in good condition at all four wheel-ends. The front brake linings appeared to be thinner than the rear brake linings. The brake pedal was found to have normal travel. The rear axle splash shields were removed for better viewing of the brake rotors. The rear brake rotors appeared to have some lining transfer, some

brake rotors. The rear brake rotors appeared to have some lining transfer, some corrosion on the friction surfaces, and the right rear rotor was slightly darker than the others. The Tech2 revealed that there were 2,224 significant key cycles, 16 key cycles since an error code was set, and the ABS had been activated 5 times. Fault codes found were: 0031 "right rear wheel speed sensor circuit open or shorted", 0032 "right rear wheel speed signal circuit sensor was missing", 0074 "excessive isolation time" (over 2 min), 0086 "ABS indicator lamp circuit shorted to battery". The fault codes were cleared.

Starting at 11:30 AM the vehicle was driven in a residential area with normal acceleration, and the brake stops were made after the transmission shifted into second gear. The ABS warning lamp was immediately illuminated and the Tech2 reported code 0032. After 20 minutes of driving, there was some hot brake smell and a slight brake squeak. After a complete stop the vehicle did not roll forward when the brake pedal was released. The vehicle was driven a short distance back to the shop, continuing the brake applications. The vehicle was quickly raised and the rotor temperatures and spinning torques required to turn each wheel were recorded. The ambient temperature was 78°F and the brake temperatures were RF: 702°F, LF: 617°F, LR: 570°F, and RR: 423°F when measured along the outer half of the brake rotor surface with an infrared pyrometer. The maximum torque required to turn each wheel was found with a VRTC-made crossbar[1] that engaged four of the eight wheel lug nuts. The maximum turning torques were RF: 120 ft-lb, LF: 115 ft-lb, LR: 90 ft-lb, and RR: 100 ft-lb using a dial torque wrench with a maximum torque indicator. The brake bleeder was opened on the caliper at each wheel-end and only a drip or two of brake fluid came out. The master cylinder reservoir brake line nuts were loosened and only a drip came out. These tests were completed within 10 minutes of the time the vehicle was parked at the work bay. The turning torques at two wheel-ends were rechecked and found to be RF: 55 ft-lb and RR: 55 ft-lb after this short cool down. The ABS code was cleared and the right rear ABS sensor was pushed inward to contact the rotor.

Starting at 12:17 PM the vehicle was driven for a second test drive in the residential area with the same input heating conditions. The ABS warning lamp was immediately illuminated and the Tech2 reported code 0032. After 17 minutes of driving, the brake drag was back and the vehicle was returned to the repair area. The vehicle was quickly raised and the rotor temperatures and spinning torque were found for each wheel. The brake temperatures were RF: 757°F, LF: 665°F, LR: 567°F, and RR: 438°F when measured along the outer half of the brake rotor surface with an infrared pyrometer. The maximum torque required to turn each wheel was RF: 95 ft-lb, LF: 145 ft-lb, LR: 142 ft-lb, and RR: 65 ft-lb[2]. The brake bleeders at the calipers and brake line nuts at the reservoir were opened and only a drip or two of brake fluid came out. The master cylinder reservoir brake line nuts were loosened and only a drip came out. These tests were completed within 10 minutes of the time the vehicle was parked at the work bay. The turning torques were retested after a one-hour cold soak and found to be RF: 15 ft-lb, LF: 3 ft-lb, LR: 25 ft-lb, and RR: 45 ft-lb. The connector to the right rear ABS wheel speed sensor was inspected and found to be okay, then the right and left rear ABS sensor wires were switched at the EHCU.

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1 As shown in *"Trip Report to Jerry Greer RV Dealership"* 12/28/2007 available at http://nhthqnwws111.odi.nhtsa.dot.gov/acms/docservlet/Artemis/Public/Pursuits/2007/EA/INME-EA07016-27536.pdf

2 The torque values found for a new vehicle in the *"Trip Report to Jerry Greer RV Dealership"* 12/28/2007 were between 5 to 8 ft-lb torque for the front wheels and 20 to 43 ft-lb for the rear wheels

Then the Ross Downing Chevrolet RV technician discussed his diagnosis procedures for this type of complaint. Have equipment and tools ready to be able to quickly raise the vehicle, loosen the caliper bleeder valves, remove the bolts in the caliper slide pins, and drop lights to work under the vehicle. Drive the motorhome in a residential area with little or no traffic. Accelerate at a normal rate until the transmission shifts into second gear (approximately 20 mph) then brake to a complete stop at a normal rate of deceleration (approximately 0.2 g). Repeat until the vehicle resists rolling forward at idle after the complete stop. Return to the shop while continuing the brake stop sequence (or reduce the stops as necessary to make it back to the shop). This portion of the test usually takes 20 to 25 minutes; do not conduct this driving cycle for more than 35 minutes. Immediately upon arriving at the shop, raise the vehicle and turn each wheel by hand. Determine which wheel-end is the most difficult to turn (accounting for the rear wheels normally being twice as hard to turn due to the drive-line drag). At the wheel with the most drag, open the 7/16-inch bleeder and look for a spurt of brake fluid indicating trapped pressure. A gravity-driven dribble of fluid is normal. Attempt to turn the wheel by hand again. If there was a spurt of fluid and the wheel turns freely now, the problem is trapped brake line pressure and the diagnosis needs to focus upstream at the brake lines/hoses, ABS unit, brake booster, or master cylinder. If the wheel does not turn freely, then proceed to the next step. Remove the 18-mm bolts securing the two slide pins to the anchor plate. On the front brakes, use an impact swivel socket to remove the bolts, and on the rear brakes the impact swivel and a long 18 mm wrench may be necessary. If the wheel now turns freely, then the pins were misaligned, corroded, or otherwise affecting the sliding and releasing of the caliper causing brake drag. If the wheel still does not turn, proceed to the next step. If the wheel did not spin, then it will rock back-and-forth for approximately 1/2-inch. Observe the caliper position on the rotor. The caliper is locked to the rotor and the caliper is hitting the anchor plate ends preventing the wheel from rotating. Allow the brakes to cool down for approximately 20 minutes and the wheels should turn freely again. This indicates that the caliper has an internal problem and the piston(s) is not retracting while the brake system was hot. Repeat the diagnostic portion of the test at all four wheel-ends as quickly as possible. The diagnostic process can be performed on all four wheels in less than 15 minutes. Identify the deficient calipers, and reassemble the brake components. Repeat the driving cycle and the diagnostic tests. After getting the same result that a brake problem is internal to the caliper, replace that caliper.

Starting at 2:00 PM the vehicle was driven for a third test drive in the residential area with the same input heating conditions. The ABS warning lamp was immediately illuminated and the Tech2 reported code 0036 "left rear wheel speed signal circuit sensor was missing". After 17 minutes the left front inner wheel bearing seal failed, probably from previous heating cycles, and leaked oil onto the left front brake rotor. The vehicle was driven back to the dealership without braking. The vehicle was quickly raised and the rotor temperature and spinning torque were found for each wheel. The brake temperatures were RF: 488°F, LF: 463°F, LR: 492°F, and RR: 413°F. The maximum torque required to turn each wheel was RF: 30 ft-lb, LF: 35 ft-lb, LR: 95 ft-lb, and RR: 70 ft-lb. The brakes were too cool and the torques too low to continue the test further. The testing was stopped while the left front inner wheel bearing seal was changed.

Starting at 3:41 PM the vehicle was driven for a fourth test drive in the residential area with the same input heating conditions. After 31 minutes of driving, the brake drag was back and the vehicle was returned to the repair area. The vehicle was quickly raised and the rotor temperature and spinning torque were found for each wheel. The brake temperatures were RF: 706°F, LF: 627°F, LR: 725°F, and RR: 523°F when measured with the "shotgun" pattern red sensor area lights encompassing the outer half of the brake rotor surface with an infrared pyrometer. The temperatures were also recorded at the same time with the red sensor area lights encompassing the entire rotor width, as the Workhorse representative reported he had measured the temperatures during the Pasadena, TX field trip, as shown in Figures 3 and 4. The brake temperatures were RF: 583°F, LF: 555°F, LR: 488°F, and RR: 509°F. The maximum torque required to turn each wheel was RF: 170 ft-lb, LF: 120 ft-lb, LR: 250+ ft-lb (could not be turned), and RR: 80 ft-lb. The brake bleeder at the RF caliper was opened and only a drip or two of brake fluid came out. The two bolts retaining the two slide pins were removed and the wheel still did not rotate easily. The wheel could be rocked back and forth approximately 1/2 inch indicating the problem was internal to the caliper, i.e. the piston(s) was stuck in an engaged position. This process was repeated on the LR wheel and again the problem was found to be internal to the caliper, i.e. a stuck piston(s).

The Bosch representative requested a continuous driving test after heating the brakes to the point of noticeable drag after a complete stop. The fifth test drive started at 5:07 PM. Approximately 24 minutes later the first indication of brake drag was observed. The rotor temperatures were found to be RF: 688°F, LF: 680°F, LR: 680°F, and RR: 581°F on the outer half of the brake rotor. The motorhome was driven through a short commercial strip area then on a rural highway. After approximately 15 minutes, at the point where the vehicle was turned back toward the dealership, the temperatures were RF: 380°F, LF: 329°F, LR: 568°F, and RR: 354°F on the outer half of the brake rotor. The drive back to the dealership was uneventful. The brake temperatures when the vehicle returned to the dealership at 6:00 PM were RF: 305°F, LF: 306°F, LR: 448°F, and RR: 319°F on the outer half of the brake rotor and no brake drag was noted by the driver.

**Recommendations:** Continued participation in the joint Workhorse/Bosch field inspections has resulted in a possible repeatable driving and diagnosis test for technicians to diagnose motorhomes with dragging brakes without further joint field inspections.

A joint Workhorse/Bosch/VRTC meeting to inspect warranty return calipers has been tentatively planned for later in January.

Daniel G. Pearse

Vehicle Safety Engineer
Defects Analysis Group
Vehicle Research and Test Center

**Photographs**

**Figure 1** – View of the Complaint Vehicle During the Initial Inspection
**Figure 2** - The Motorhome VIN Plate
**Figure 3** - Handheld Infrared Thermometer Temperature Sensing Area During this Field Trip
**Figure 4** - Handheld Infrared Thermometer Temperature Sensing Area During the Pasadena, TX Field Trip

**Acronyms**

| | |
|---|---|
| ABS | Antilock Brake System |
| EHCU | Electronic-Hydraulic Control Unit |
| °F | Fahrenheit scale of temperature measurement |
| GVWR | Gross Vehicle Weight Rating |
| GVWRF | Gross Vehicle Weight Rating Front axle |
| GVWRR | Gross Vehicle Weight Rating Rear axle |
| IR | Infrared pyrometer |
| LF | Left Front |
| LR | Left Rear |
| ODI | Office of Defects Investigations |
| RF | Right Front |
| RR | Right Rear |
| RV | Recreational Vehicle |
| Tech2 | GM Service Tool |
| TRW | manufacturer of auto/truck parts |
| VIN | Vehicle Identification Number |
| VRTC | Vehicle Research and Test Center |
| VRTC-DA | Vehicle Research and Test Center - Defects Analysis Group |


**Figure 1 - View of the Complaint Vehicle During the Initial Inspection**

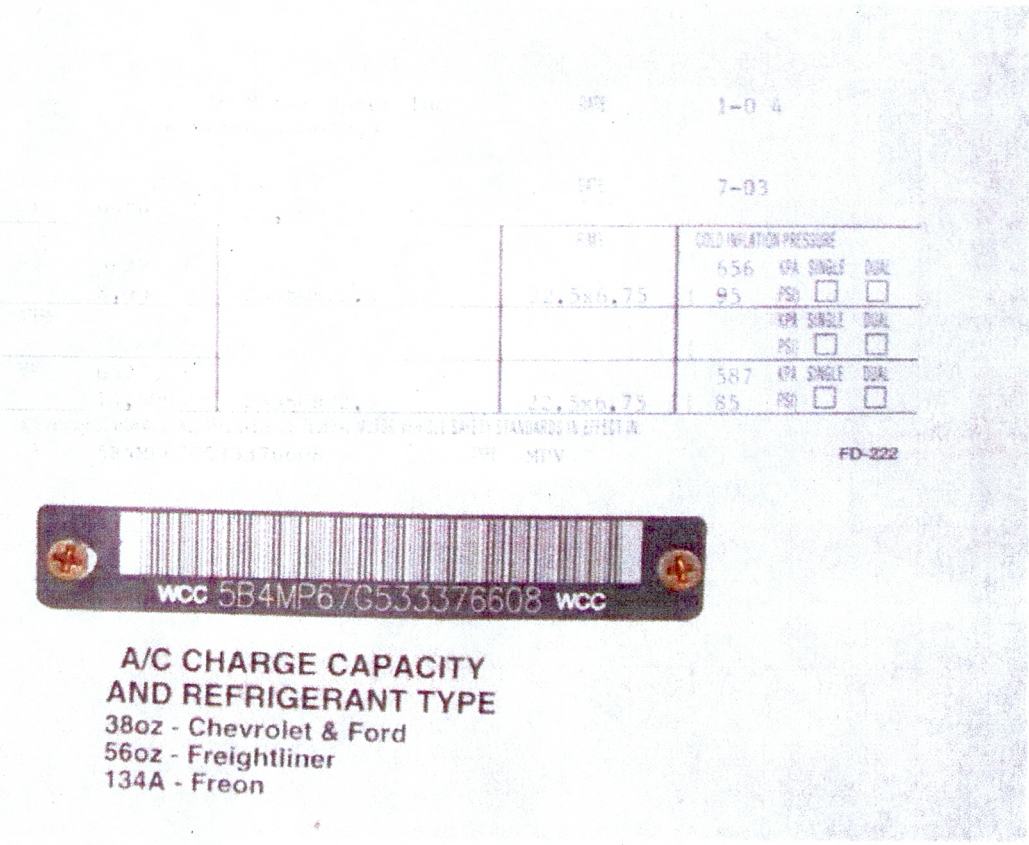


**Figure 2 - The Motorhome VIN Plate**

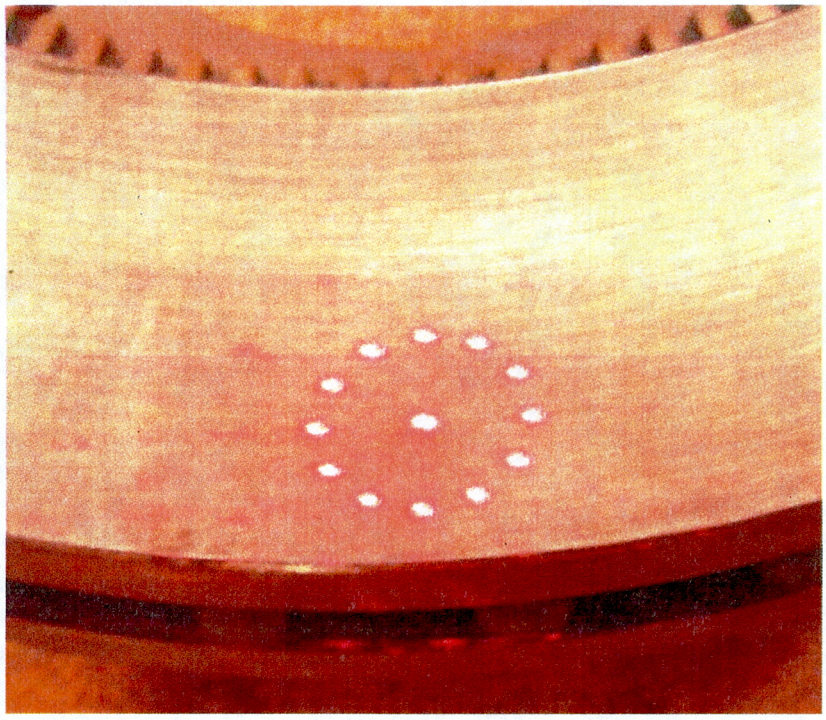

**Figure 3 - Handheld Infrared Thermometer Temperature Sensing Area During this Field Trip**

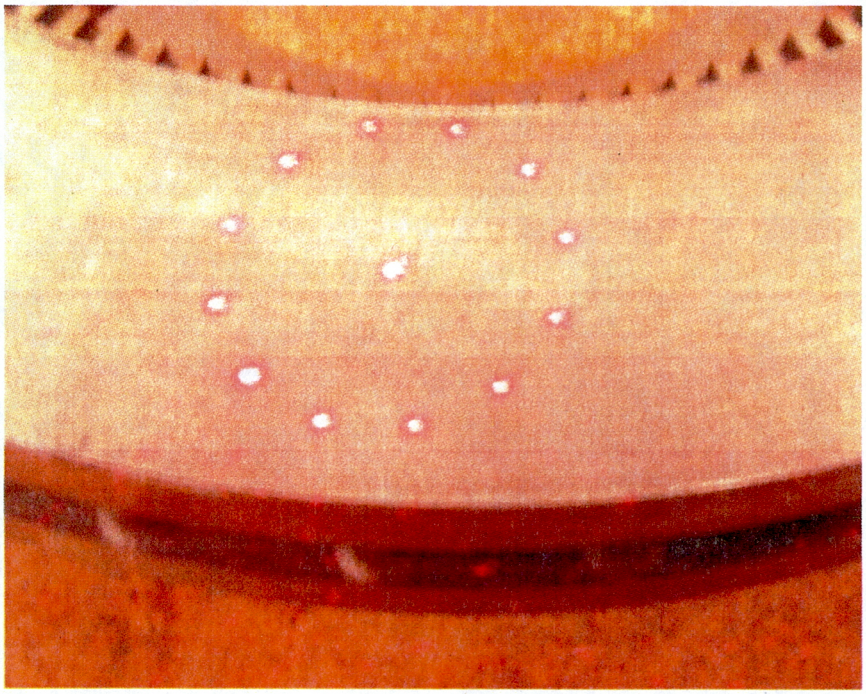

**Figure 4 - Handheld Infrared Thermometer Temperature Sensing Area During the Pasadena, TX Field Trip**